Technical Report

Evaluation of a Proposed Colorado State Inspection/Maintenance Program

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by

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Abstract

In response to a request from the State of Colorado through EPA Region VIII, a pilot test program was conducted to evaluate the effectiveness of a possible Inspection and Maintenance (I/M) program at high altitude. The work was performed in early 1978 by Automotive Testing Laboratories (ATL) in conjunction with the FY77 Emission Factor Passenger Car Program in Denver.

The vehicles which became part of this study were procured randomly from private owners in the Denver area. Included were seventy-five 1977 and twenty-four 1978 model year passenger cars. Thirty light duty trucks (up to 8500 lb. GVW) of the 1975 through 1978 model years were also included. These 129 vehicles became part of the evaluation which included the private repair facilities. The 1977 and 1978 automobiles represented the entire sample of these years in the Emission Factor Program. Particular makes and models were chosen on a sales-weighted basis. The trucks were procured separately from the Emission Factors Program but were also chosen using sales-weighting techniques.

Each vehicle was subjected to an underhood inspection and a series of emission tests both before and after maintenance. The maintenance was performed at one of 10 selected commercial repair facilities. Information on the costs associated with each maintenance action was also collected. For comparison, data on 1975 and 1976 passenger cars which underwent Restorative Maintenance as part of the basic Emission Factor Program were also included in this report although all maintenance and testing activities were performed by ATL. An additional fleet of thirty 1975 and 1976 models, each having accumulated more than 50,000 odometer miles were also tested in an as-received condition only.

The results of this pilot effort confirm the poor emission performance of relatively new, in-use passenger cars although 1977 and 1978 automobiles displayed better control than those prior to confirmatory testing at high altitude. High-mileage vehicles exhibited higher HC and CO emission levels than their lower-mileage counterparts but the budget of the program precluded maintenance and retesting to help assess the reasons. The underhood inspections revealed that many vehicles had been subjected to various forms of maladjustments, primarily ignition timing and idle mixture. The results of tests after maintenance at private garages showed that a reasonable I/M program at high altitude would be effective in identifying higher emitters and in reductions of HC and CO emission levels.

Introduction

Results of EPA's Emission Factor Testing Programs indicate that a large percentage of in-use vehicles fail to meet their emission standards when tested in an "as-received" condition. A major follow-up study, The Restorative Maintenance Evaluation, was conducted to determine the reasons for such failures. The results of this study indicate the major reason for such failures is the maladjustment and disablement of the control systems. One method which could minimize these actions is a compulsory Inspection and Maintenance (I/M) Program. The State of Colorado, in consideration of such a program in the Denver area, requested EPA's assistance in the investigation of its feasibility. The two major items which were to be evaluated were the reduction in atmospheric pollutants and the cost to the consumer of these reductions.

The basic approach to the performance of this pilot program was developed by the State of Colorado. At the present time, their primary plan is to allow private repair facilities such as car dealerships and independent garages to conduct emission inspections. This method would take advantage of the safety inspection process currently in place. Each facility would require a specific license to conduct these inspections and perform any maintenance required. A license would be issued to a facility after it was able to demonstrate appropriate capabilities both in equipment and personnel to perform emission related testing and maintenance. Mechanics would be required to undergo training such as that provided by Colorado State University.

This method would eliminate the need for the state itself to conduct the inspections or to contract for the performance of the inspections. There is, however, the question of "conflict of interest" to be resolved. With the private sector performing both the inspection and the maintenance, abuses could occur.

The program followed the same general strategy of past Restorative Maintenance Programs except that failure of the idle test rather than the FTP was the criteria used to enter a vehicle into the maintenance and retest portion of this effort. A tiered approach was followed to determine the reduction in idle emission levels at various stages in the garage operations. This approach was used for evaluation purposes only. Normally, a garage would perform any maintenance required to pass the vehicle. Charges were in accordance with prevailing rates at each shop. Repairs were generally limited to a maximum of $50.00 per vehicle for this contract although a total of five vehicles were repaired at costs ranging from $50 to $85.

Selection of Private Facilities

In order to best simulate the repair facility situation in a fully operational I/M area, local garages and dealerships were screened to identify those which possessed certain basic qualifications. These qualifications were a current license to perform the State Safety

Inspection, a heated work area, suitable HC/CO analyzer, tune-up tools, and the willingness to send at least one person to an approved mechanics training course. Of 120 facilities surveyed, 29 met the basic requirements and ten were ultimately selected. Three were new car dealerships, three were independent garages and four were gasoline service stations. ATL personnel assisted these facilities in the initial calibration and correlation of their analyzers and performed subsequent cross-checks during the program.

Selection of Test Vehicles

The vehicles which became part of this study were procured randomly from private owners in the Denver area. Included were seventy-five 1977 and twenty-four 1978 model year passenger cars. Thirty light duty trucks (up to 8500 lb. GVW) of the 1975 through 1978 model years were also included. These 129 vehicles became part of the evaluation which included the private repair facilities. In addition, thirty 1975 and 1976 passenger cars with high mileage (over 50,000) were procured and tested in "as-received" condition only due to budget constraints. The 1977 and 1978 automobiles represented the entire sample of these years in the Emission Factor Program. Particular makes and models were chosen on a sales-weighted basis. The trucks and the 1975 and 1976 model cars were procured separately from the Emission Factors Program but were also chosen using sales-weighting techniques.

Test Procedures

As standards or test procedures have not been established for an I/M program in Denver, the decision was made to use a neutral curb idle test. Based on experience with similar programs at low altitude, cutpoints of 150 ppm HC (as Hexane) and .5% CO were considered acceptable. These cutpoints were expected to fail about 50% of the sample. Of 129 vehicles tested, 55 failed using these cutpoints. Sample size was limited due to budget considerations.

The sequence of tests performed at the ATL laboratory included the 1975 Federal Test Procedure (FTP) for exhaust emissions only, the Highway Fuel Economy Test (HFET), and three short cycle tests. These were the Federal Three Mode, Federal Short Cycle, and the Two Speed Idle Test. A thorough underhood inspection and a limited driveability evaluation were also performed. The entire sequence was conducted both before and after maintenance. Flow diagrams for the various classes of vehicles tested in this program are shown in Figures 1, 2 and 3.

The garages performed only idle tests. "As-received" values and final values were recorded, as well as the description and cost of any maintenance performed. Some vehicles were also sent to the garages even though they passed the idle test at ATL. This was done to check their ability to detect failed vehicles. Participating repair facilities were given $5 in addition to the charges resulting from their normal repair rates to cover the cost of completing the forms. This fee is not included in the cost of maintenance figures. In other cases, failed vehicles were not sent to the garages because of the workload there or because the vehicle owner was not willing to allow ATL to retain his vehicle any longer.

Test Results

A summary of the test results for this program is found in tables at the end of this report. Results on individual vehicles as well as more details on the conduct of the program may be obtained from a copy of the EPA Final Report No. 460/3-78-001, "Colorado Motor Vehicle Emission Inspection - A Pilot Program." The State of Colorado, the customer for this work, is also expected to produce an extensive analysis of these results.

Table 1 describes the results obtained on the 1978 MY vehicles. Of the 24 vehicles included in the sample, 8 failed the idle test at the ATL laboratory and were sent to the commercial garages. An additional 9 vehicles were sent to the garages even though they passed at ATL. Of the 17 vehicles sent, 9 received maintenance (one vehicle received maintenance even though it had passed its idle test at ATL). In general, these vehicles performed poorly in relation to the federal standards but did show improvements in emission levels when they were repaired by the private facilities.

The results on the 1977 model year vehicles shown in Table 2 indicate a majority passed the idle test. Passenger cars of this model year were the only ones fully certified at high altitude and in most cases had idle CO levels below .5%. Although these vehicles were a year older than the 1978 models, a greater percentage of them were able to meet the applicable federal standards both before and after maintenance.

Thirty trucks, up to a gross vehicle weight of 8500 pounds, were also tested in the I/M portion of this program. Only two of the 30 trucks passed the idle test. However, since it was originally intended to send only 15 through the inspection and maintenance procedure, no further trucks were sent after the first 19 were delivered. Cutpoints for these vehicles were too stringent. Where specified, most idle CO values were in excess of the cutpoints. These results are shown on Table 3.

The 1975 and 1976 model year passenger cars shown in Table 4 were not included in this pilot I/M evaluation but were maintained and retested at the ATL laboratory under the Restorative Maintenance portion of the basic EF contract. These results are provided for information only.

A group of 30 "high mileage" 1975 and 1976 model year passenger cars were procured for this program and underwent only an "as received" test sequence. This was due to cost constraints. The results of these tests are shown on Table 5. Each vehicle in this group was to have an odometer reading of at least 50,000 miles. The range was from 52,000 to 147,000 miles.

Conclusions

There are a number of conclusions which can be drawn from the results of this program. These are generally similar to those which were obtained in the Restorative Maintenance Evaluation Project:

1. The great majority of the 1975-1978 light duty vehicles tested for this pilot project were not able to meet federal standards when tested in an as-received condition, although the 1977 and 1978 passenger cars did display control typical of late model year cars at low altitude with 41% and 38% passing, respectively. However, only 4% of the 1975 and 1976 models met the standards for these years which preceded confirmatory Certification Testing under high altitude conditions.

2. A large number of vehicles exhibited some amount of maladjustment and disablement. Although a computer compilation of the data will be required to accurately define the extent of the problems, it is clear that basic timing advance is very prevalent in addition to the idle mixture maladjustment which has been shown to be the key problem at low altitude.

3. A proper I/M program at high altitude can be successful in reducing vehicle emission levels without adversely affecting fuel economy. The tables indicate a significant difference in the FTP and idle emissions from vehicles which passed the idle test and those which failed. Improvements after maintenance was performed on the groups are also shown. Although this pilot project was more carefully controlled and monitored than the "real-world" situation it was intended to simulate, the functions actually performed by the participating repair facilities were not outside the capabilities of typical garages equipped with a basic HC/CO instrument and a mechanic with a modest amount of I/M training.

4. The average cost to repair each vehicle which failed the idle test was approximately $20.00. This figure reflects the impact of maladjustments and disablements on emission levels and the ease of repair. Carburetor adjustments were the most common area.

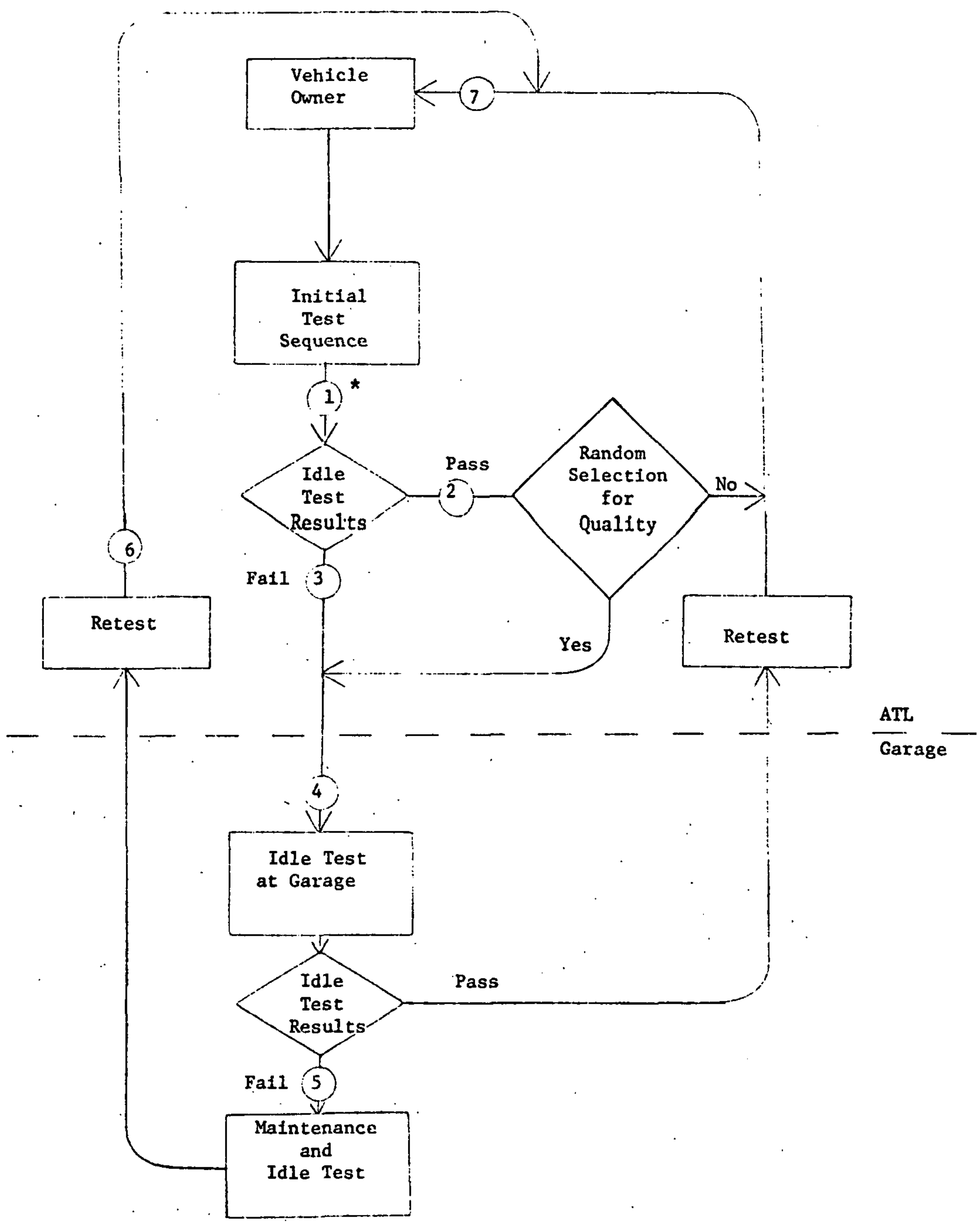
5. The automotive service industry in the Denver area is not immediately prepared for the full scale implementation of even a basic I/M program in the immediate future. The lack of proper equipment and training of mechanics in areas related to emission controls are the immediate drawbacks.

6. The 1975 and 1976 model passenger cars with higher mileage (over 50,000) exhibited higher emission levels than their lower mileage counterparts. Unfortunately, cost considerations in the design of this project ruled out maintenance and retesting. Thus, the mix of reasons between inherent deterioration and greater exposure to potential maladjustment and disablement actions cannot be determined at this time.

Figure 1

Colorado Pilot I/M Program

Test Vehicle Flow Diagram
1977 and 1978 Model Year Passenger Cars

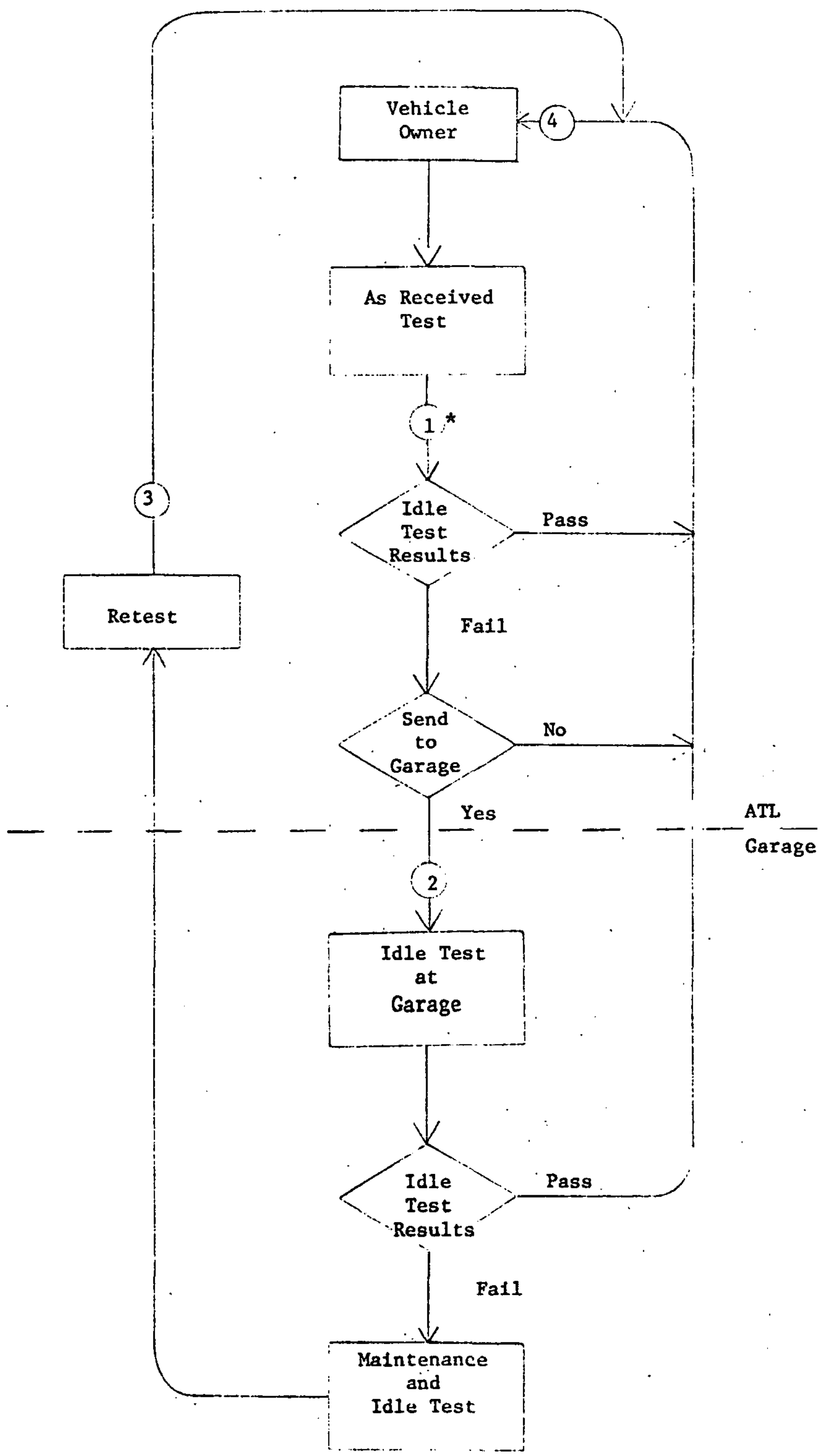


* These encircled numbers refer to line numbers on Tables 1 and 2 . They relate to fleet average emission levels at various steps in the program.

Figure 2

Colorado Pilot I/M Program

Test Vehicle Flow Diagram
1975-1978 Light Duty Trucks (up to 8500 lbs GVW)

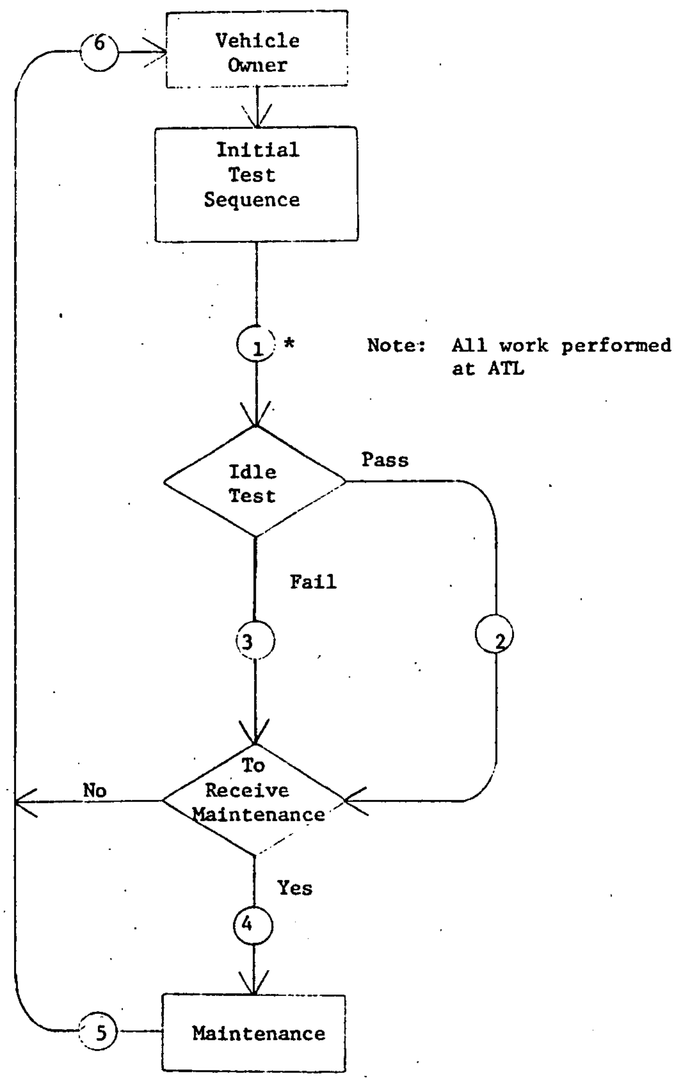


* These encircled numbers refer to line numbers on Table 3 . They relate to fleet average emission levels at various steps in the program.

Figure 3

Colorado Pilot I/M Program

Test Vehicle Flow Diagram
1975 and 1976 Model Year Passenger Cars



* These encircled numbers refer to line numbers on Table 4 . They relate to fleet average emission levels at various steps in the program.

Table 1

Colorado Pilot I/M Program

1978 Model Year Passenger Cars

			FTP			Fuel Economy		Met FTP	Lab Idle		Garage Idle		Average
	N	Odom	HC	CO	NOxc	FTP	HFET	Standards	HC	CO	HC	CO	Cost
1 As Received	24	3924	2.19	26.9	1.14	15.1	21.3	38%	194	1.07			
2 Passed Idle Test	16	3437	1.41	27.9	1.01	14.7	20.5	50	19	.04			
3 Failed Idle Test	8	4898	3.75	24.9	1.40	16.0	23.1	13	544	3.13			
4 Sent to Garages	17	4315	2.59	42.3	1.17	15.3	21.9	29	263	1.49	371	1.21	
5 Received Maintenance	9	4431	3.70	56.2	1.31	15.6	22.3	11	483	2.81	664	2.24	
6 After Maintenance	9	4431	2.52	25.1	1.13	15.9	22.4	22	277	.50	307	.13	$23.17
7 Fleet Average after Maintenance	24	3924	1.77	24.6	1.20	15.3	21.3	33	177	.20			

NOTE: FTP results are in grams/mile
Fuel economy values are in miles per gallon
Idle HC results are in ppm (Hexane equivalent)
Idle CO results are in mole percent
Numbers preceding each line refer to a portion of the fleet as described in Figure 1

Table 2

Colorado Pilot I/M Program

1977 Model Year Passenger Cars

			FTP			Fuel Economy		Met FTP	Lab Idle		Garage Idle		Average
	N	Odom	HC	CO	NOxc	FTP	HFET	Standards	HC	CO	HC	CO	Cost
(1) As Received	75	12046	1.32	23.8	1.52	14.9	20.6	41%	95	1.02			
(2) Passed Idle Test (As received)	56	11549	1.06	18.6	1.57	14.6	20.1	48	21	.03			
(3) Failed Idle Test	19	13511	2.09	39.1	1.37	15.9	22.2	21	313	3.97			
(4) Sent to Garages	18	14648	2.24	41.0	1.33	16.4	23.1	16	254	3.53	323	3.11	
(5) Received Maintenance	16	14104	2.38	44.4	1.34	16.9	23.8	19	283	3.97	354	3.48	
(6) After Maintenance	16	14104	1.84	33.7	1.19	16.7	24.1	38	78	.48	105	.26	$19.97
(7) Fleet Average after Maintenance	75	12046	1.22	22.1	1.48	14.8	20.5	45	51	.27			

NOTE: FTP results are in grams/mile
Fuel economy values are in miles per gallon
Idle HC results are in ppm (Hexane equivalent)
Idle CO results are in mole percent
Numbers preceding each line refer to a portion of the fleet as described in Figure 1

Table 3

Colorado Pilot I/M Program

1975 through 1978 Model Year Light Duty Trucks

Under 6000 lb GVW

	N	Odom	FTP HC	FTP CO	FTP NOxc	Fuel Economy FTP	Fuel Economy HFET	Met FTP Standards	Lab Idle HC	Lab Idle CO	Garage Idle HC	Garage Idle CO	Average Cost
(1) As Received	8	21946	3.89	70.7	1.69	13.5	18.7	0%	139	3.13			
(2) Sent to Garages	5	14744	4.67	77.7	2.09	13.5	18.3	0	186	3.90	226	3.50	
(3) After Maintenance	5	14744	3.92	59.8	2.01	13.5	18.5	0	129	1.58	68	.19	$41.29
(4) Fleet Average after Maintenance	8	21946	3.42	59.5	1.65	13.5	18.8	0	104	1.68			

Over 6000 lb GVW

	N	Odom	FTP HC	FTP CO	FTP NOxc	Fuel Economy FTP	Fuel Economy HFET	Met FTP Standards	Lab Idle HC	Lab Idle CO	Garage Idle HC	Garage Idle CO	Average Cost
(1) As Received	22	21650	7.70	111.3	2.85	12.2	16.6	0	348	4.39			
(2) Sent to Garages	14	18932	8.28	118.9	3.09	11.8	16.1	0	362	4.51	574	5.74	
(3) After Maintenance	14	18932	6.04	92.4	3.00	12.0	16.1	0	172	1.83	132	1.13	$24.76
(4) Fleet Average after Maintenance	22	21650	6.27	94.5	2.79	12.4	16.6	0	227	2.69			

NOTE: FTP results are in grams/mile
Fuel economy values are in miles per gallon
Idle HC results are in ppm (Hexane equivalent)
Idle CO results are in mole percent
Numbers preceding each line refer to a portion of the fleet as described in Figure 2

Table 4

Colorado Pilot I/M Program

1975 and 1976 Model Year Passenger Cars

	N	Odom	FTP HC	FTP CO	FTP NOxc	Fuel Economy FTP	Fuel Economy HFET	Met FTP Standards	Lab Idle HC	Lab Idle CO
1 As Received	114	29663	3.13	55.7	1.83	14.7	20.2	4%	252	2.57
2 Passed Idle Test (as received)	31	27362	2.01	34.1	1.65	14.0	18.7	13	45	.07
3 Failed Idle Test	83	30522	3.55	63.8	1.90	15.0	20.8	1	329	3.50
4 Before Maintenance	68	33882	3.28	57.5	1.89	14.7	20.4	0	241	2.46
5 After Maintenance	68	33882	2.55	40.1	1.77	14.9	20.5	0	124	.30
6 Fleet Average after Maintenance	114	29663	2.69	45.3	1.76	14.8	20.3	4	182	1.28

NOTE: FTP results are in grams/mile
Fuel economy values are in miles per gallon
Idle HC results are in ppm (Hexane equivalent)
Idle CO results are in mole percent
Numbers preceding each line refer to a portion of the fleet as described in Figure 3

Table 5

Colorado Pilot I/M Program

High Mileage 1975/1976 Model Year Passenger Cars

			FTP			Fuel Economy		Met FTP	Lab Idle	
	N	Odom	HC	CO	NOxc	FTP	HFET	Standards	HC	CO
As Received	30	66302	4.33	88.5	1.69	12.2	17.1	0	351	3.36

NOTE: FTP results are in grams/mile
Fuel economy values are in miles per gallon
Idle HC results are in ppm (Hexane equivalent)
Idle CO results are in mole percent