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Technical Report

Effect of Low Cost Repairs on I/M Failed Vehicles

by

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1.0 INTRODUCTION

Mechanics who repair vehicles which have failed an Inspection and Maintenance (I/M) test are usually advised to adjust these vehicles to manufacturer specifications, particularly for the idle mixture adjustment. This method is known to be effective in reducing emissions while maintaining or improving driveability and fuel economy. Most pre-1981 model year vehicles have adjustable idle mixtures. Manufacturer specifications for idle mixture have the disadvantage of being diverse among vehicle makes and model years, complex, and often difficult to locate in commonly available service publications. For this reason, it is quite probable that many if not most mechanics repairing I/M failed vehicles ignore manufacturer specifications for idle mixtures. Instead, it is likely that many mechanics simply adjust the idle mixture screws, while watching the idle CO level on an emissions analyzer, until the CO level is low enough to be sure the vehicle will pass the cutpoints during the reinspection. This study was designed to determine whether this simple carburetor adjustment approach is effective, whether a universal target idle CO level could be used, and what additional repairs are necessary to pass the I/M test.

This study* measured the effect on emissions of specific quick and low cost repairs which differed from manufacturer specifications. Repairs centered on a simple carburetor adjustment to a universal target idle CO level of 0.2% for 1976 and 1978 model year vehicles which initially failed a state I/M test. No manufacturer specifies a procedure this simple for any recent model year vehicle. Repairs were performed in two stages, when appropriate: Stage 1, where only the simplest repairs, mainly the carburetor adjustment to 0.2% idle CO were made; and Stage 2, where the correction of other problems were also made if Stage 1 repairs did not result in low idle emissions. The study period was October 1980 through January, 1981.

The vehicles used in this program were 1976 and 1978 model year passenger vehicles from Vancouver, Washington. They had been in a previous study (Test Group No. 9) and had failed the State I/M test in Portland. The vehicles were not screened in any way, such as for tampering. Selected vehicles were not restricted to those failing for idle CO, although all repaired vehicles did fail for idle CO; nearly all vehicles failed the state idle test for both HC and CO. After their initial tests, these I/M failed vehicles were given repairs by the contractor and subsequent retests. Since Vancouver does not have an I/M program, these vehicles are representative of ones which fail the I/M test in a newly instituted I/M program.

The two most important potential uses of the study results are: (1) to recommend to states specific low cost I/M repair procedures as a possible substitute for manufacturers specifications; and (2) to modify the mechanic training course for emission repairs developed by Colorado State University for EPA.

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* Contractually referred to as Test Group No. 10 of EPA Contract No. 68-03-2829 with Hamilton Test Systems in Portland, Oregon.

2.0 SUMMARY AND CONCLUSIONS

1. Substantial emission reductions were achieved by simple specific repairs. Stage 1 maintenance, mainly a carburetor adjustment to a universal idle CO target, was all that was needed to pass the State idle test for 29 of the 35 vehicles (83%) which were repaired. Stage 1 maintenance reduced average FTP HC emissions of all 35 vehicles by 40% and FTP CO emissions by 58%. Stage 2 maintenance, only performed on six vehicles, increased the average reduction for the 35 vehicles to 47% for HC and 71% for CO.

2. Study results indicate that the average reductions in FTP HC and CO emissions from specific idle CO adjustments can be as large as idle adjustments using manufacturer specifications. A recent EPA study in Houston also agrees with this (see Section 4.4). In most cases, adjustments using a target idle CO would be faster and easier for mechanics, resulting in cheaper repairs.

3. One might be concerned that a specific idle CO adjustment approach would not leave the vehicles with as good driveability as a manufacturer specifications approach. However, we found only two minor driveability problems resulting from the idle adjustment, one each on two of the 35 vehicles. One vehicle reportedly had an engine surge after the adjustments, and another vehicle experienced hard starting. The former vehicle needed further repairs and received a carburetor overhaul which then improved its driveability. It is uncertain whether adjustments on either car using the manufacturer specifications would have eliminated driveability problems. These were the only problems reported for all 35 vehicles on seven driveability measures. Therefore, it is reasonable to say that these adjustments did not significantly affect driveability.

4. An average city fuel economy improvement of 2.5% was gained from the Stage 1 repairs. Highway fuel economy was reduced by 0.4%. After Stage 2 repairs, the average fleet fuel economy improvement was 3.0% in the city and 0.9% on the highway.

   The six vehicles needing more than just Stage 1 maintenance benefited greatly in fuel economy from receiving both stages of repair. Stage 1 repairs resulted in fuel economy improvements of 3.2% in the city and 7.5% on the highway compared to their as-received levels. After Stage 2 repairs, these six vehicles received an average 8.3% fuel economy improvement in the city and 9.2% improvement on the highway, compared to their as-received levels.

5. The city fuel economy improvement from the idle adjustments of Stage 1 is not as large as observed from similar adjustments in two other EPA programs; the two other programs showed improvements of over 5%. No obvious reason exists for the difference. A possible reason would be that vehicles in Vancouver may be better maintained with respect to fuel economy, which if true would be a result of local maintenance habits. Sampling variations may also be a reason for the difference.

The fuel economy improvements of vehicles receiving both repair stages are larger than those seen in a recent study from vehicles receiving adjustments plus carburetor overhauling or replacing (see Section 4.2.2). That study showed that 17 vehicles receiving contractor repairs had fuel economy improvements of 3.3% in the city and 5.5% in the highway compared to their as-received levels. A comparison between that study and the present study is complicated by the fact, though, that the former study vehicles had received repairs by commerical facilities prior to contractor repairs and also received more extensive repairs by the contractor. Because of this discrepancy in repairs between the two studies and the fact of the small number of vehicles (six) receiving both repairs in the present study, the reader should not assume that the large fuel economy improvements observed after completion of both repair stages will always be achieved.

3.0 DESCRIPTION OF TEST PROGRAM

3.1 Test Vehicles

Test vehicles consisted of 35 light-duty passenger vehicles from Vancouver, Washington which failed the Portland, Oregon State Inspection Test in their as-received condition. Model years were 1976 and 1978. These vehicles were initially tested in a previous test program (see footnote in Section 4.2.1.) which compared emissions from similar Portland and Vancouver vehicles. Therefore, the as-received levels of the vehicles in this program were the same as in the prior test program. All repairs were performed by contractor mechanics.

3.2 Stage 1 Maintenance

All vehicles went through this stage. The main portions of the repair sequence are listed below.

a. If the idle CO is greater than 0.2%, adjust the fuel metering system to 0.2% or as close as possible.

b. Adjust idle speed only if the engine is running roughly; if that is the case, adjust the idle speed for a smooth idle.

c. If idle HC is less than 225 ppm, do not perform any more adjustments. If idle HC is greater than 225 ppm, check vacuum hoses, specified parts of the ignition system, and basic timing adjustment, stopping repairs as soon as idle HC is less than 225 ppm.

3.3 Stage 2 Maintenance

Vehicles only went through this stage if repairs in the first stage did not lower idle emissions acceptably. The following items were to be repaired as necessary.

a. PCV system.

b. Carburetor (if the 2500 rpm CO level is over 1.0% and no other causes than the carburetor can be detected, overhaul the carburetor).

c. Heated air intake system.

d. Dilution of the oil with gasoline (repair is to change the oil).

e. Ignition system.

f. EGR system (check to make sure the valve is not open at idle).

3.4 Tests Performed

The following tests were performed on the vehicles at each repair stage.

1. Federal Test Procedure
2. 50 mph Cruise Test
3. Highway Fuel Economy Test
4. Four-Mode Idle Test
5. Loaded Two-Mode
6. Diagnostic Inspection

4.0 TEST RESULTS

4.1 Types of Repairs Needed to Pass the I/M Test

Stage 1 maintenance is designed to cover simple maintenance items only. Repairs stop as soon as the idle levels are acceptably low. Generally, the only maintenance which needs to be performed in this stage is the simple carburetor adjustment to reach the idle CO target of 0.2%. This was the expectation when the study was designed. Stage 2 maintenance is only begun if idle emissions can not be reduced to 0.2% CO in the first stage or if emissions at 2500 rpm exceed 1.0% CO.

Table 1 shows the frequency of repairs in each stage. The reason for the "Not Applicable" column is that after the carburetor adjustment in Stage 1 no other diagnoses or repairs were performed if idle emissions were acceptable; this was the case for 29 vehicles. At the end of the second stage, no vehicles still had high idle emissions.

Table 1

Repairs Performed

	Repair or Adjust	Replace	OK	Not Applicable
Stage 1				
Oil diluted with gasoline	-	-	35	-
Choke Operation	-	-	35	-
Carburetor	35 (adjust)	-	-	-
Vacuum hoses	-	-	6	29
Spark plugs	-	3	3	29
Spark wires	-	-	6	29
Distributor cap or rotor	1	1	4	29
Basic Timing	2	-	4	29
Idle Speed	2	-	4	29
Stage 2				
Oil Change	-	-	6	-
Carburetor	3 (rebuild)	2	1	-
Heated Air Intake System	1	-	5	-
EGR valve	-	-	6	-

4.2 Federal Test Procedure Emissions, Idle Emissions, and Fuel Economy Results

4.2.1 All Vehicles Receiving the First Repair Sequence

Results show that the simple Stage 1 repairs had a large FTP emissions benefit on the 29 vehicles which only needed simple adjustments. Only a small benefit was observed from Stage 1 repairs for the six vehicles needing more complex maintenance (mainly carburetor overhauling), however. The amount of improvements for the two groups is reversed when it comes to fuel economy changes, though. Stage 1 repairs resulted in a small fuel economy improvement for the 29 vehicle group, but a more substantial one for the six vehicle group.

Average results are shown in Table 2 for all vehicles receiving Stage 1 maintenance. Vehicles which received only the Stage 1 repairs and vehicles which later received the Stage 2 repairs are shown separately in parts A and B. Idle emissions were measured with a commercial garage quality instrument. Fuel economy is shown for both the Federal Test Procedure (FTP) and Highway Fuel Economy Test (HFET).

The study which tested the as-received emission and fuel economy levels of 200 Vancouver and Portland vehicles reported that 1978 model year Vancouver vehicles had atypical results.* Emissions were lower than have been measured from 1978 models in other non-I/M cities. In order to see if this had an effect on the results of the repair stages, vehicles were separated by model year. Table 3 presents the FTP and fuel economy results of the Stage 1 repairs by model year. Results show that the first repair stage had nearly an equal effect on each model year; therefore model year is not an important factor for the repairs. The remainder of the report results are not separated by model year.

* "Emissions Reductions from Inspection and Maintenance: Vancouver Versus Portland Snapshot," EPA-AA-IMS-81-18, R. Bruce Michael, August, 1981.

Table 2

Effect of Stage 1 Maintenance on Emissions and Fuel Economy

	N	Odometer	Federal Test Procedure Emissions (g/mi) HC	CO	NOx	Idle Emissions HC (ppm)	(CO (%)	Fuel Economy (miles per gallon) FTP	HFET
A. Vehicles Receiving Only The First Repair Sequence									
Before First Repair	29	49,795	3.31	44.0	2.85	365	2.93	14.77	20.77
After First Repair	29		1.84	14.7	3.12	177	0.22	15.05	20.59
Percent change			-44%	-67%	+9%	-52%	-92%	+1.9%	-0.9%
B. Vehicles Later Receiving The Second Repair Sequence									
Before First Repair	6	62,498	2.91	55.7	2.43	250	1.73	13.23	18.03
After First Repair	6		2.46	40.3	2.77	110	0.38	13.88	18.31
Percent change			-15%	-28%	+14%	-56%	-78%	+4.9%	+1.6%
C. All Vehicles									
Before First Repair	35	51,973	3.24	46.0	2.78	345	2.72	14.48	20.24
After First Repair	35		1.95	19.1	3.06	165	0.25	14.84	20.16
Percent change			-40%	-58%	+10%	-52%	-91%	+2.5%	-0.4%
Federal Test Procedure Standards	35		1.50	15.0	2.82				
Portland Idle Test Standards	35					231	1.09		

Table 3

Effect of Stage 1 Maintenance on FTP Emissions and Fuel Economy by Model Year

		FTP Emissions (g/mi)		Fuel Economy	
	N	HC	CO	FTP	HFET
1976 Model Year					
Before Repair	26	3.61	51.2	13.81	19.23
After Repair	26	2.16	20.9	14.14	19.14
Percent Change		-40%	-59%	+2.4%	-0.5%
1978 Model Year					
Before Repair	9	2.17	31.2	16.86	23.85
After Repair	9	1.33	13.7	17.28	23.84
Percent Change		-39%	-56%	+2.5%	0.0%

4.2.2 Vehicles Receiving Stage 2 Maintenance

Six vehicles received both the first and second repair stages. Results at each stage are shown in Table 4. Five of the six vehicles mainly received either a carburetor rebuild or replacement at the second repair stage. As can be seen, this type of repair greatly improved fuel economy. It is interesting to note that the five vehicles needing carburetor work all had high mileages: the range was 43,000 to 85,000 miles.

The improvements in fuel economy are larger than the improvements seen in an earlier study in Portland which analyzed the effects of carburetor rebuilds and replacements for 17 vehicles. These latter vehicles had improvements of 3.3% on the FTP and 5.6% on the HFET relative to their before repair levels.* Many other repairs were included in this latter study, however, which hinders an exact comparison.

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* A study of the Effectiveness of Mechanic Training For Vehicle Emissions Inspection and Maintenance Programs, EPA-AA-IMS/81-11, R. Bruce Michael, April, 1981, Table 12.

Table 4

Vehicles Receiving
Two Repair Sequences

	N	Odometer	Federal Test Procedure Emissions (g/mi) HC	CO	NOx	Idle Emissions HC (ppm)	(CO (%)	Fuel Economy (miles per gallon) FTP	HFET
Before Repair	6	62,498	2.91	55.7	2.43	250	1.73	13.23	18.03
After First Repair	6		2.46	40.3	2.77	110	0.38	13.88	18.31
After Second Repair	6		1.11	7.9	3.81	82	0.00	14.33	19.68
Percent Change Stage 1 Maintenance vs. As-Received			-15%	-28%	+14%	-56%	-78%	+4.9%	+1.6%
Percent Change Stage 2 Maintenance vs. Stage 1 Maintenance			-55%	-80%	+38%	-25%	-100%	+3.2%	+7.5%
Percent Change Stage 2 Maintenance vs. As-Received			-62%	-86%	+57%	-67%	-100%	+8.3%	+9.2%

4.2.3 Emissions and Fuel Economy of All Vehicles at Each Repair Stage

Results of all vehicles at the first and the final repair stages are shown in Table 5. The "final" repair stage means the first repair for 29 vehicles and the second repair for 6 vehicles. The final repair gave modest further fleet reduction in HC and CO and slight fuel economy benefits.

Table 5

Emissions and Fuel Economy of
All Vehicles After Final Repair

			Federal Test Procedure Emissions (g/mi)			Idle Emissions		Fuel Economy (miles per gallon)	
	N	Odometer	HC	CO	NOx	HC (ppm)	(CO (%)	FTP	HFET
Before Repair	35	51,973	3.24	46.0	2.78	345	2.72	14.48	20.24
After First Repair	35		1.95	19.1	3.06	165	0.25	14.84	20.16
After Final Repair	35		1.71	13.5	3.24	161	0.18	14.92	20.43
Percent Change Stage 1 Maintenance vs. As-Received			-40%	-58%	+10%	-52%	-91%	+2.5%	-0.4%
Percent Change Final Repair vs. As-Received			-47%	-71%	+17%	-53%	-93%	+3.0%	+0.9%

4.3 Excess Emissions Reduced by Repairs

Excess emissions are defined as FTP emissions above the Federal standards. For example, if a vehicle has FTP CO emissions of 20 grams per mile (g/mi) and the Federal standard for that vehicle is 15, then it has 5 g/mi excess CO emissions.

The analysis of excess emissions before and after repair provides valuable information on the repairs. Table 6 presents the excess HC and CO emissions before and after the first repair stage. For comparison, excess emissions before and after commercial I/M repair are also shown from the EPA Portland study, which evaluated the effectiveness of the Portland I/M program.* The vehicles analyzed from the Portland study were 1975-77 model years. The vehicles which are compared in Table 6 all had the same Federal standards for HC and CO.

* "Portland Study Element II - I/M Effectiveness Study", EPA-460/3-79-003, May, 1979; "Portland Study Element III - Post I/M Deterioration Study", EPA-460/3-79-009, July, 1979; and "Update on EPA's Study of the Oregon Inspection/Maintenance Program", by Rutherford and Waring, APCA 80-1.2, presented at Air Pollution Control Association 73rd Annual Meeting, June 24, 1980.

Results show substantial reductions in excess emissions from the simple repairs of Stage 1. The reductions also compare favorably with the I/M repairs from the Portland study. As expected, the HC reductions from the simple repairs of the first repair stage are not quite as large as from the Portland study (64% vs. 74%), because the simple repairs focused primarily on idle CO. The CO reductions from the simple repairs are larger than from the Portland study, however (74% vs. 68%). The second repair stage further increased the emission reductions, equalling the Portland study for HC and further bettering the Portland study results for CO.

The cost-effectiveness of these simple repairs would be high, because they approximately equal the emission reductions of the more common repairs and should be cheaper to perform. EPA does not currently have data to estimate what the simple repairs performed by the contractor mechanics in this study would cost if performed by a commercial repair facility, however, so an accurate comparison of cost-effectiveness cannot be made.

Table 6

Excess Emissions Reduced by Repairs
Comparison of Specific Repairs and Common I/M Repairs

	Odometer	Average Excess Emissions Above Federal Standards (grams per mile) HC	CO
Low Cost Repairs (Present Study, N=35)			
As-Received	51,973	1.77	31.2
After Stage 1		0.65	8.1
After Stage 2		0.47	3.5
Percent Change Stage 1 vs. As-Received		-64%	-74%
Percent Change Stage 2 vs. As-Received		-74%	-89%
Commercial I/M Repairs (Portland Study, N=233)			
As-Received	30,929	1.29	25.6
After Repair		0.34	8.1
Percent Change		-74%	-68%

4.4 Comparison of Results With Three Other Programs

Three earlier EPA studies examined the effect of repairs similar to the ones discussed in this study. Two different EPA Restorative Maintenance (RM) studies tested 1975-80 model year vehicles.* One of the repair stages contained just the adjustment of idle speed and mixture, which is nearly identical to the adjustments performed in the first repair stage for most vehicles in the present study except that adjustments in the RM studies were performed according to manufacturer specifications.

The third of the earlier studies was part of an I/M test program in Houston, in which many vehicles received only an idle CO adjustment and then were retested.** This is exactly the same type of adjustment as made in the present study except that a slightly different idle CO target (0.5% instead of 0.2%) was used. The four studies (including the present one) all had repairs performed by contractor personnel and tested vehicles which were similar in terms of model years and mix of makes and models.

The four programs selected vehicles for repair differently, however. In Houston vehicles above 3.0% CO received an adjustment to a target of 0.5% CO. In the two RM studies, vehicles failing the Federal Test Procedure standards received carburetor adjustments to the specifications of the manufacturers. In the present study vehicles failing the State Inspection Test (SIT) for idle emissions received an idle CO adjustment to a target of 0.2% CO; all 35 vehicles initially failed the SIT for CO, the CO limit being 1.0% for nearly all vehicles. Therefore, in order to compare the results most effectively, only vehicles from the present study and the RM programs which would have initially failed the Houston program cutpoints of 3.0% idle CO were used. Also, vehicles in Vancouver which had any parts replaced during the Stage 1 repairs were not included, thus leaving 16 cars which received only idle speed and mixture adjustments.

Table 7 presents the emissions and fuel economy results from the different programs. Results from the two RM programs are combined. Emission reductions are very similar for the three programs. This similarity in emission reductions supports the conclusion that simple low cost carburetor adjustments are as effective as more complicated adjustments to manufacturer specifications. The fuel economy improvements are not the same in the three studies, however. Both the Houston and RM programs show larger improvements in FTP fuel economy due to repair than the present study shows. No reason for this is apparent, although it is possible that different maintenance habits contribute to the discrepancy.

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*1. "An Evaluation of Restorative Maintenance on Exhaust Emissions of 1975-76 Model Year In-Use Automobiles", EPA-460/3-77-021, December, 1977.
2. "FY79 study of Emissions From Passenger Cars in Six Cities", EPA-460/3-80-020, October, 1980.

** "Testing Support for an Evaluation of a Houston I/M Program", EPA-460/3-80-021, October, 1980.

Table 7

Comparison of Results With Other Programs
All Vehicles Had Initial Idle CO Greater Than 3.0%

		Federal Test Procedure Emissions		Idle Emissions		Fuel Economy (miles per gallon)	
		HC	CO	HC (ppm)	CO (%)	FTP	HFET
Vancouver (N=16)	Before Repair	3.35	49.2	382	3.94	14.79	21.13
	After Repair*	1.65	12.9	158	0.23	15.15	21.06
	Percent Change	-51%	-74%	-59%	-94%	+2.4%	-0.3%
Houston (N=85)	Before Repair	3.14	59.1	290	4.35	13.79	20.57
	After Repair	1.31	23.3	130	0.52	14.61	21.01
	Percent Change	-58%	-61%	-55%	-88%	+5.9%	+2.1%
Restorative Maintenance (N=66)	Before Repair	2.48	48.1	375	5.17	14.25	20.71
	After Repair	1.09	10.6	105	0.29	15.08	21.07
	Percent Change	-56%	-78%	-72%	-94%	+5.8%	+1.7%

4.5 Driveability Evaluation

Driveability did not significantly change as a result of either of the repair stages. In their as-received condition all 35 vehicles reportedly had satisfactory driveability on seven measures: engine start, surge, stumble, backfire, stretchiness, miss and diesel (run-on). After the first repair stage, two of the vehicles each had one driveability problem. One vehicle had hard starting and another had an engine surging condition. The latter vehicle needed a carburetor overhaul, though, which gave it satisfactory driveability again. None of the six vehicles which received the second repair had problems after repair.

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* Only carburetor adjustments. No vehicles were included which had any parts replaced.