EPA-AA-IMS-81-18

Technical Report

Emissions Reductions From Inspection and Maintenance: Vancouver Versus Portland Snapshot

by

R. Bruce Michael

August, 1981

Notice

This Report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of the issue using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

Inspection and Maintenance Staff
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air, Noise, and Radiation
U.S. Environmental Protection Agency

Table of Contents

1.0 INTRODUCTION

Test Group No. 9 of EPA Contract No. 68-03-2829 with Hamilton Test Systems compared the emissions of similar cars in Portland, Oregon and Vancouver, Washington, which are neighboring cities. The purpose of this study was to compare the emissions from vehicles subject to Inspection/Maintenance (I/M) in Portland with emissions from non-I/M vehicles (Vancouver). EPA reasoned that the proximity of these two cities would make a suitable controlled comparison. No prior study had been performed which would yield a comparison with as much confidence.

The study design called for two groups of 100 vehicles each to be tested. One hundred vehicles were to be recruited from Vancouver and then one hundred from Portland, with vehicle pairs matching by both vehicle type and odometer. The vehicles were of 1976 and 1978 model years and were similar by type to the national population mix. These years were chosen so that Portland vehicles would have been inspected in the prior 12 months, thus representing an annual I/M program. This was necessary because the Portland I/M program is biennial. Portland vehicles were also to be evenly distributed over time since their last I/M inspection, representing a "snapshot" situation of an annual I/M program in which the vehicle fleet is evenly distributed over time since the last inspection. Testing was conducted in the latter part of 1980, so the 1976 model year vehicles were between four and five years old when tested and the 1978 vehicles were between two and three years old.

The Federal Test Procedure (FTP) and several emissions short tests were performed on each vehicle in the as-received condition only. Vancouver vehicles which failed the State Inspection Test entered Test Group No. 10, a task to investigate the effect of specific repairs on emissions.*

---

* "Effect of Specific Repairs on Emissions of Vehicles from Vancouver, Washington", EPA-AA-IMS/81-19, R. Bruce Michael, July, 1981.

2.0 SUMMARY AND CONCLUSIONS

Results indicate the following:

1. The comparison of maintenance, driving habits, and the similarity of the vehicles supports the use of Vancouver as a non-I/M version of Portland.

2. For the 1976 model year, Portland I/M vehicles had Federal Test Procedure (FTP) HC emissions 27% lower and CO emissions 22% lower than the non-I/M vehicles.*

3. Predictions for the emission levels of the 1976 model year using MOBILE2 agree closely with study results for both the I/M and non-I/M cities. This supports the accuracy of the MOBILE2 I/M emission reduction benefits.

4. Vancouver 1978 vehicles were unexpectedly clean, having as low emissions levels as the Portland 1978 vehicles. On the surface, this would suggest that there was no I/M effect on the Portland vehicles. However, the Vancouver vehicles were far cleaner than similar vehicles EPA has tested in other cities and far cleaner than EPA's MOBILE2 predictions. The reason for this is unknown and we do not try to hypothesize one. Whatever the reason, one can presume that it affects Vancouver and Portland vehicles equally.

The important question to consider is not why the Vancouver 1978 vehicles were so clean, but why the Portland 1978 vehicles were not even cleaner, as might be expected as a result of the I/M program. It is almost certain that the Portland 1978 vehicle emissions would have been as low as the Vancouver 1978 vehicle emissions even without I/M, due to the similarity of maintenance, social habits, mileage, etc. (see Section 3.0). These emissions averaged very close to the Federal standards. I/M then would not have had much chance to reduce the emissions of the Portland 1978 vehicles, since I/M can only correct emissions which are substantially higher than they should be. Therefore, the negative finding on the effect of I/M on the 1978 model year vehicles can be explained in light of the low non-I/M emission levels of these vehicles. The negative finding should not be taken to mean I/M cannot be effective on typical 1978 vehicles or on vehicles of this age (2-3 years old). Rather, it merely indicates that emphasis should be placed on the 1976 model year results.

---

* Since I/M is not intended to affect NOx emissions, comparisons of NOx emissions are omitted in the text, but do appear in the tables.

3.0 REPRESENTATIVENESS OF VANCOUVER VEHICLES FOR THIS COMPARISON

EPA believes that the comparison of vehicle emissions from these two cities is valid for several reasons, and that it produces valuable results about the impact of I/M.

3.1 Maintenance Habits

One factor which can affect vehicle emissions is maintenance. Cars which have been well maintained and are in a proper state of tune will generally have lower emissions than vehicles poorly maintained. Several items may affect maintenance habits, such as social structure and economic conditions. Although the cities in this study are in two different states, the city limits are only about one mile apart. Many residents of Vancouver commute to work in Portland. Therefore, it is likely that social beliefs and behavior are similar for the cities. The economic status of the cities is also similar, which contributes to the likelihood that vehicle maintenance habits are similar.

Each vehicle owner was interviewed to find out when the vehicle had last received a tune-up. Table 1 shows the answer to this question for the Portland and Vancouver owners. The similarity in the owners' responses support the assumption that Vancouver can be used as a non-I/M control site for Portland.

Table 1

Recent Maintenance of Vancouver and Portland Vehicles

Question	Number of Responses					
	Not Due	Due, But Not Done	0-6 Months	6-12 Months	Over 1 Year	Don't Know
How Long Ago Was The Last Tune-Up?						
Vancouver	11	4	55	25	3	2
Portland	4	3	50	29	11	3

3.2 Driving Habits

A second factor affecting emissions is the type of driving performed. Vancouver is a smaller city with a less congested downtown area. It is therefore likely that the average Vancouver car is driven a smaller percentage of the time in stop-and-go city traffic and a larger percentage in suburban and highway driving than the average Portland car. The latter type of driving causes less wear and deposit accumulation on engines and tends to keep emissions low. This factor would therefore tend to make Vancouver cars cleaner than Portland vehicles (and vehicles in other large cities) in the absence of I/M. On the vehicle owner questionnaire, however, owners reported very similar driving patterns and amount of driving per year. For example, nearly all driving was performed mostly on major city streets, with 88% of Vancouver owners and 79% of Portland owners reporting this type. Table 2 shows the owner responses to several questions.

Table 2

Owner Response to Driving Habit Questions
For Vancouver and Portland (N=100 for both cities)

Questions	Number of Responses				
Thousands of miles driven per year	0-5	5-10	10-15	15-20	20-30
Vancouver	3	34	42	19	2
Portland	3	39	41	11	6

Where driving occurs *	Mostly Major City Streets	Some on Other City Streets	Some on City Expressways
Vancouver	88	87	92
Portland	79	86	89

How driving is done *	Mostly to Work	Some for Errands	Some for Other Reasons
Vancouver	53	61	90
Portland	47	57	91

* The responses do not add up to 100, because owners could respond to each question with varying answers, such as "most", "some", "little or none". Only the major responses are shown in the table.

3.3 Amount of Driving

A third factor affecting emissions is the amount of driving performed. Generally, vehicles with more mileage have higher emissions than vehicles with low mileage. This factor has no affect on the present comparison, however, due to the design requirement which made matched-pair vehicle mileages be similar. The average mileage of the two city groups, shown in Table 3 on page 11, is nearly identical.

3.4 Vehicle Age

A fourth factor affecting emissions is vehicle age. Because vehicles were matched by age (as well as several other things) this possible factor also has no affect on the comparison.

3.5 Effect of Knowledge of the Portland I/M Program on Vancouver Vehicle Repairs

A fifth factor which could affect the emissions of the Vancouver cars is that some of these cars may receive I/M-type low emission repairs despite the lack of an I/M program in Vancouver. This would be due to the proximity of the cities.

A few possibilities exist for Vancouver cars receiving low emissions repairs. First, Vancouver owners may want to get low emission repairs having heard of the I/M program and having an interest in clean air. However, it is very unlikely that Vancouver mechanics would have success with giving low emission repairs, because they are unfamiliar with the repairs and, mainly, because very few facilities have the emission analyzers to check the adjustments. Only one real possibility exists for their cars actually receiving low emission repairs: if they go to Portland repair facilities for normal maintenance. Since it is also unlikely that Vancouver residents would take their vehicles to Portland repair shops, this possibility should have an insignificant effect.

Second, Vancouver mechanics may want to tune for low emissions having heard of the Portland I/M program. For the reasons mentioned in the last paragraph, however, it is unlikely that they would have much success.

Third, if Vancouver owners buy cars from Portland dealers, the dealership warranty service may have an impact on emissions, since these dealers are experienced in I/M. Oregon officials who were questioned felt that very few Vancouver residents buy cars in Portland, however. There is no economic incentive to do so and, except for a larger variety of foreign car dealerships in Portland, there is a sufficient number of dealerships in Vancouver to serve the residents there.

For the reasons mentioned, it is unlikely that a significant number of Vancouver vehicles receive I/M-type repairs which would lower their emissions.

3.6 Summary of Factors

Vehicle age and mileage are generally considered to be the most important factors affecting emissions. Since these were controlled for the two groups of vehicles, we can say with confidence that the only important difference between the groups of vehicles from the two cities is that one group has been involved in I/M.

4.0 RESULTS

4.1 Atypically Low Emissions From 1978 Model Year Vehicles in Both Cities

4.1.1 Discussion

Study results show that emission levels of the 1978 model year in both cities were similar. They were both less than in other sites recently studied by EPA and also both less than predicted by MOBILE2, an EPA computer program which estimates fleet emissions with and without I/M. This phenomenon is discussed first, because it has implications as to the meaning of the other results.

The cause of the unexpectedly low emissions is unknown. For whatever reason, the meaning is that I/M had no significant opportunity to provide emission reductions in Portland on 1978 cars, since the 1978 model year cars there would have been relatively clean prior to their I/M test, as clean or cleaner than the Vancouver cars. I/M can only have an impact on cars with high emissions. Consequently, the 1978 model year results should be given little weight. Results will show the two model years separately, as well as the combined results.

4.1.2 Emission Comparison of Portland/Vancouver Vehicles With Non-I/M Vehicles in Other EPA Programs

In the ongoing EPA Emission Factors (EF) program, in-use vehicles are tested in their as-received condition at many sites around the country. Vehicles of the same model years as those tested in Vancouver and Portland were tested by EPA in four major cities during 1979/80 for the FY79 EF program. That EF program tested vehicles very similar to the Vancouver and Portland vehicles in terms of make and model, although it had a slightly broader cross-section of vehicle types and lower average mileage.

1976 Model Year - Emissions for each site are shown in Table 3 and Figure 1 for each model year. Emissions of the 1976 model year in Vancouver were higher than the average EF emissions. The average mileage was also higher in Vancouver, a factor which would tend to result in higher emissions, but not enough to account for the total difference. It is interesting to note that the Phoenix HC and CO emissions were quite a bit lower than the other EF sites, which is only partly due to the significantly lower mileage of the cars tested there. The I/M program in Phoenix may also explain some of the difference. If Phoenix is removed from the comparison, HC emissions in Vancouver are lower than the non-I/M EF sites, and CO emissions are nearly equal.

1978 Model Year - HC and CO emissions of the 1978 model year in Vancouver were much lower than the average EF emissions; its CO emissions were lower than any of the EF sites, a surprising change from the 1976 year. No reasons are apparent for this. Again, the average mileage was higher in Vancouver than the EF sites.

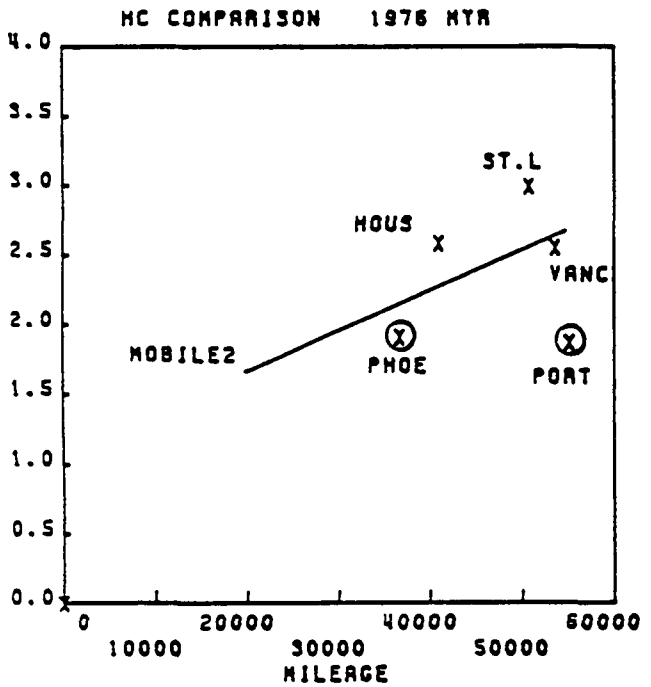
Table 3

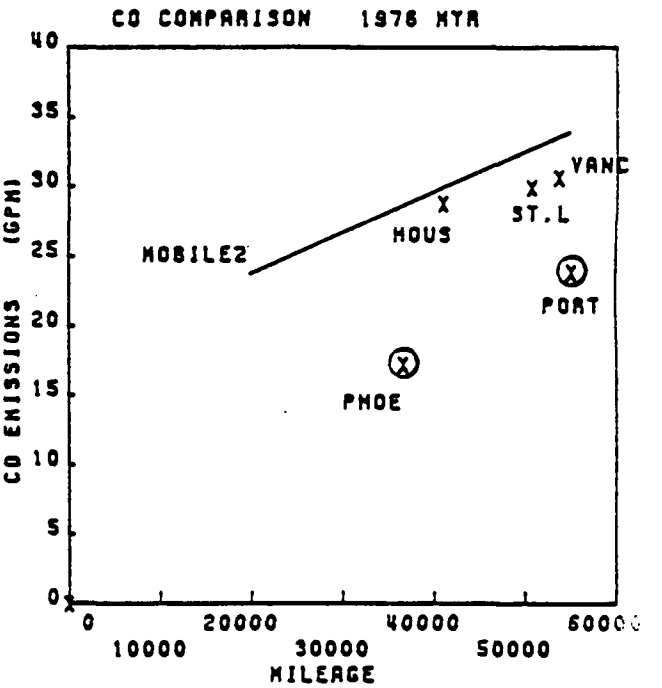
Emission Factors Program Compared With Vancouver and Portland
FTP Emissions by Model Year and Site

	1976 Model Year					1978 Model Year				
Site	N	Mileage	HC	CO	NOx	N	Mileage	HC	CO	NOx
Phoenix	25	36,693	1.92	17.3	2.79	75	13,258	1.12	16.4	1.83
St. Louis	25	50,715	3.00	30.0	2.31	75	23,543	1.94	27.8	1.34
Wash. D.C.	0	-	-	-	-	75	20,383	1.68	20.6	1.92
Houston	25	40,985	2.59	28.8	3.41	75	27,529	1.73	23.8	2.26
EF Average	75	42,798	2.50	25.4	2.84	300	21,170	1.62	22.2	1.96
EF Average Without Phoenix	50	45,850	2.80	29.4	2.86	225	23,818	1.78	24.1	2.01
Vancouver	50	53,650	2.56	30.7	2.90	50	32,705	1.33	15.1	2.45
Portland	50	55,169	1.88	24.0	3.25	50	33,177	1.30	15.3	2.41

Figure 1

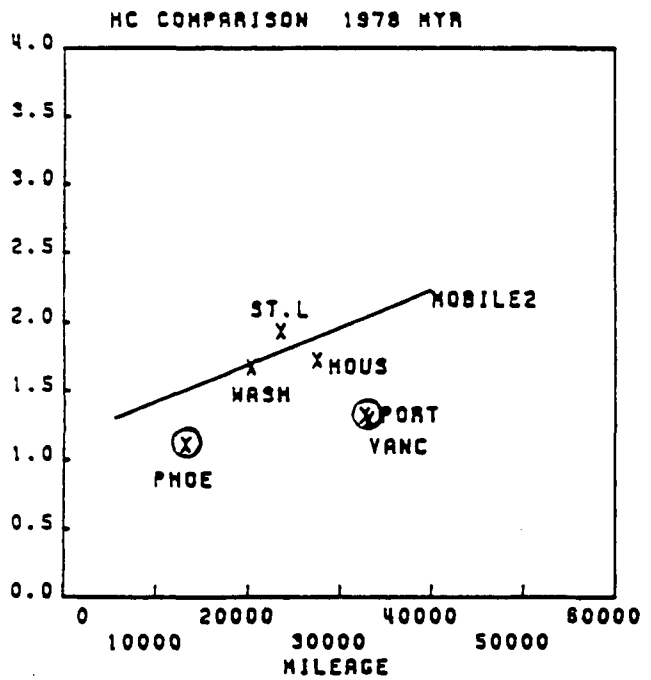
Emission Factors Program Compared With Vancouver and Portland
FTP Emissions by Model Year and Site

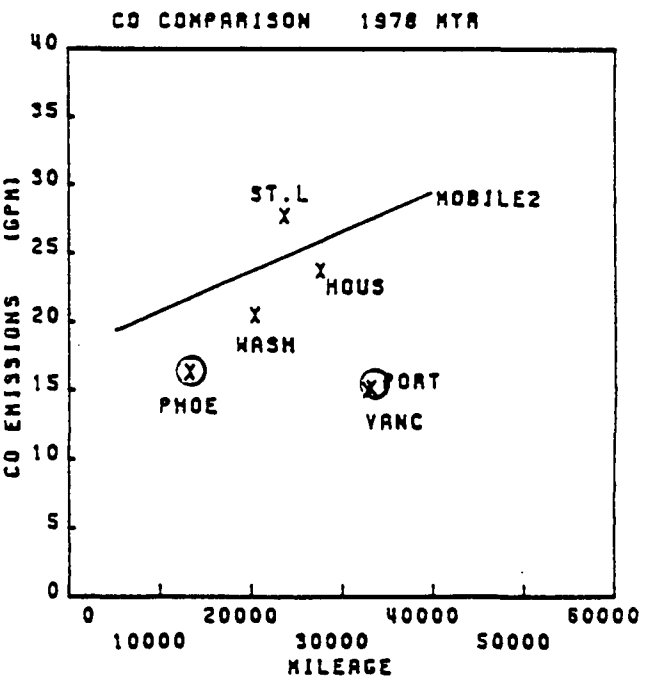




x = Emission Testing Site with no I/M

⊗ = Emission Testing Site with I/M





Other evidence also shows that the 1978 model year vehicles in Portland and Vancouver had lower as-received emissions than expected. In the EF programs, vehicles are sometimes given maintenance by contractor personnel in order to lower their FTP emissions. Many vehicles from the FY77 EF program are appropriate for comparison to the Portland and Vancouver 1978 model year vehicles. These EF vehicles were all certified to the same HC and CO standards as the Portland and Vancouver vehicles, and had nearly identical average mileages, although they were of 1975-77 model years. The EF vehicles used for comparison all would have failed the Portland idle standards in their as-received condition. Table 4 shows that the emissions of the EF vehicles after repair were very similar to the Portland and Vancouver vehicle emissions as-received. This supports the contention that the Portland and Vancouver vehicles had unusually low emissions in their as-received condition and that there was little or no room for improvement from I/M repairs, thus the observed similarity of emissions of the Portland and Vancouver vehicles.

Table 4

Comparison of Repaired Emission Factor Vehicles
With 1978 Model Year Portland and Vancouver vehicles

Group	N	Mileage	FTP HC	FTP CO
EF Before Repair	142	31,970	3.09	44.8
EF After Repair	142	31,970	1.59	15.9
Vancouver	50	32,705	1.33	15.1
Portland	50	33,177	1.30	15.3

4.2 Federal Test Procedure, Idle Emissions and Fuel Economy Results

The average vehicle inertia weight is 3795 pounds for all Vancouver vehicles and 3793 pounds for Portland vehicles. The time since the last State Inspection Test (SIT) for all Portland vehicles averages 6.3 months. Vehicles are matched by make, model year, engine size, transmission type, fuel system and (generally) odometers within 5000 miles of each other. A listing of each group of 100 vehicle types is shown in Appendix A.

Average results of the Portland and Vancouver vehicle groups are shown in Table 5. A statistical test at the .05 confidence level shows that the HC emissions are significantly different between Portland and Vancouver, but CO and NOx emissions are not.

Table 6 presents the FTP emissions by model year. Note that essentially all of the FTP HC and CO differences shown in Table 5 come from the 1976 model year, as shown in Table 6. As stated earlier, the Portland I/M program has had little opportunity to create a difference in the emissions of 1978 vehicles, because even without I/M these vehicles are remarkably clean.

Table 5

As-Received Emissions and Fuel Economy Levels
(100 Matched Pairs)

	Odometer	Federal Test Procedure Emissions (grams per mile) HC	CO	NOx	Idle Emissions * (Using Garage-Type Analyzer) HC (ppm)	CO (%)	Fuel Economy (miles per gallon) FTP	HFET
Vancouver	43,178	1.95	22.9	2.68	230.0	1.53	15.81	22.24
Portland	44,173	1.59	19.6	2.83	166.4	1.18	15.75	22.00
Percent Difference	+2.3%	-18.5%**	-14.4%	+5.6%	-27.6%	-22.9%	-0.4%	-1.1%

Table 6

As-Received FTP HC and CO Emissions by Model Year

	1976 Model Year N	HC	CO	1978 Model Year N	HC	CO
Vancouver	50	2.56	30.7	50	1.33	15.15
Portland	50	1.88	24.0	50	1.30	15.31
Percent Difference		-27%**	-22%		-2%	+1%

* From the second idle portion of the State Inspection Test.

** Emission differences were statistically significant at the .05 confidence level using a paired t-test.

4.3 State Inspection Test Failure Rate

The overall State Inspection Test (SIT) idle emission failure rates were 39% for Vancouver vehicles and 27% for Portland vehicles. Table 7 shows the number of vehicles by pass-fail status for SIT idle HC and CO and their associated FTP emission levels.

The 39 out of 100 Vancouver vehicles which failed the SIT ("Fail Any" column) accounted for 60% of the total Vancouver HC emissions and 72% of the total CO emissions. The 27 Portland vehicles which failed the SIT accounted for 41% of the total Portland HC emissions and 49% of the total CO emissions. Concerning the identification of excess emissions (emissions above the FTP standards), the idle test identified 76% of the excess FTP HC emissions and 81% of the excess FTP CO emissions from the total sample of 200 cars.

Table 7

Pass-Fail Status of State Inspection Test, and Associated FTP Emissions
FTP Standards: HC=1.5, CO=15.0

		Fail HC, Pass CO	Pass HC, Fail CO	Fail Both	Fail Any	Pass Both
1976 Model Year						
Vancouver	No. Vehicles	0	6	22	28	22
Total N=50	FTP HC	-	1.89	3.74	3.34	1.57
	FTP CO	-	33.0	51.1	47.2	9.77
Portland	No. Vehicles	2	8	10	20	30
Total N=50	FTP HC	3.16	2.01	2.88	2.56	1.43
	FTP CO	28.2	33.5	39.7	36.1	15.9
1978 Model Year						
Vancouver	No. Vehicles	2	1	8	11	39
Total N=50	FTP HC	2.27	2.04	2.22	2.21	1.08
	FTP CO	23.4	18.0	32.4	29.5	11.1
Portland	No. Vehicles	0	1	6	7	43
Total N=50	FTP HC	-	2.28	2.11	2.13	1.17
	FTP CO	-	42.1	31.7	33.2	12.3
1976 and 1978 Combined						
Vancouver	No. Vehicles	2	7	30	39	61
Total N=100	FTP HC	2.27	1.91	3.33	3.02	1.26
	FTP CO	23.4	30.9	46.1	42.2	10.6
Portland	No. Vehicles	2	9	16	27	73
Total N=100	FTP HC	3.16	2.04	2.59	2.44	1.28
	FTP CO	28.2	34.5	36.7	35.3	13.8

4.4 Effect of Time Since Last State Inspection Test on Emissions of Portland Vehicles

Portland test vehicles are evenly distributed by time since their last State inspection. The average time since inspection is 6.3 months with a standard deviation of 3.5 months. The correlation between time and odometer is extremely low; thus, odometer does not influence the calculations.

A total of 107 vehicles were tested in Portland and 105 in Vancouver in order to end up with the 100 matched pairs. For Section 4.4 all vehicles will be used in analysis, since the importance of the matched sample is not present in the regression equations of these sections.

I/M substantially reduces FTP emissions at the time of inspection and repair. A logical assumption is that emissions then increase over time until the next inspection. This behavior has in fact been observed by EPA in previous studies conducted in Portland.* It is of interest to see if this behavior can also be observed among the Portland vehicles in this study. In order to check the emission deterioration of the Portland vehicles in this study, regression equations were calculated for emissions versus time since inspection. Table 8 shows the constants and regression slopes for the Portland vehicles including the 1976 model year separately. Regression equations show the expected positive slope for both FTP HC and CO versus time since inspection. However, none of the slopes are statistically significant, which is a common result with relatively low sample sizes and quite variable emission levels. The previous EPA studies were able to observed significant slopes because the same vehicles were tested several times since inspection, resulting in much less variability.

---

* 1. "Portland Study Element III Post-I/M Deterioration Study", EPA Contract No. 68-03-2513, by Hamilton Test Systems, Inc., July, 1979.

2. "Analysis of Oregon's Inspection and Maintenance Program", Becker and Rutherford, APCA No. 79-7.3, presented at 72nd Annual Meeting and Exhibition, June 25, 1979.

3. "Update on EPA's Study of the Oregon Inspection/Maintenance Program", Rutherford and Waring, APCA No. 80-1.2, presented at 73rd Annual Meeting and Exhibition, June 24, 1980.

Table 8

FTP Emissions
Regression Equation Results for
FTP HC and CO Versus Months Since
State Idle Test - Portland Vehicles

Sample	Emission	Constant	Regression Slope
1976 MYR	HC	1.71	.020
N=52	CO	20.9	.266
All Portland	HC	1.48	.016
N=107	CO	16.3	.464

Regression equations were calculated for idle emissions versus months since inspection for all cars and cars by model year. The second idle portion of the SIT was used in the calculations. Results are shown in Table 9.

As before, none of the equations shows a statistically significant relationship between emissions and months since inspection. This again merely indicates that the large vehicle-to-vehicle variations in idle emissions overshadow any deterioration effect.

Table 9

Idle Emissions
Regression Equation Results for
Idle HC and CO Versus Months Since
State Idle Test - Portland Vehicles

Sample	Emission	Constant	Regression Slope
All Portland	HC	169	-.252
N=107	CO	0.70	.027
1976 MYR	HC	252	-5.98
N=52	CO	1.26	.011
1978 MYR	HC	116	1.50
N=55	CO	0.38	.009

5.0 COMPARISON OF ACTUAL EMISSIONS VERSUS PREDICTED EMISSIONS FROM MOBILE2 PROGRAM

An EPA computer program named MOBILE2 models the emissions performance of a vehicle fleet over time, both with and without I/M. The I/M case assumes an annual program. To estimate the emissions of the Portland vehicles, a modification was made to the program, since Portland vehicles are subject to inspection only once every two years. Table 10 presents the FTP HC and CO emission comparisons for the vehicles in the study versus MOBILE2 predictions.*

Results show a similar phenomenon that was seen in Table 3, i.e., emissions of the 1978 model year in Vancouver are much lower than expected making the average Vancouver emissions also substantially lower than expected. Emissions of 1978 vehicles in Portland are also lower than expected, making the average Portland emissions slightly lower than expected. Emissions from the 1976 model year from both cities are very close to the predicted levels.

Table 10

Actual Versus Predicted
FTP Emissions for Portland and Vancouver Vehicles

	Vancouver (No I/M)		Portland (I/M)	
	HC	CO	HC	CO
1978 MYR				
Actual	1.33	15.1	1.30	15.3
Predicted by MOBILE2	2.10	28.0	1.60	20.7
1976 MYR				
Actual	2.56	30.7	1.88	24.0
Predicted by MOBILE2	2.85	35.3	1.85	23.1
Total				
Actual	1.95	22.9	1.59	19.6
Predicted	2.48	31.8	1.72	21.9

* The MOBILE2 predictions shown here differ from published standard MOBILE2 predictions in that an adjustment to account for misfueling has been excluded here. This is appropriate if the MOBILE2 predictions are to be compared to vehicle samples without evidence of any misfueling, such as the Portland and Vancouver samples in this study.

APPENDIX A

VEHICLE LIST FOR EACH GROUP

1976 Model Year

Mfr	Make	Qty	Descr.
AMC		2	258-A1
GM	Buick	2	350-A4
	Cadillac	2	500-A4
	Chevrolet	1	085-M1
	Chevrolet	1	250-A1
	Chevrolet	3	305-A2
	Chevrolet	4	350-A2
	Chevrolet	2	400-A4
	Olds	1	260-A2
	Olds	4	350-A4
	Pontiac	2	350-A2
	Pontiac	1	400-A2
Ford		1	140-A2
		1	140-M2
		2	250-A1
		3	302-A2
		4	351-A2
Chrysler		3	225-A1
		3	318-A2
Datsun		2	085-M2
Honda		1	091-M3
Toyota		3	097-M2
VW		2	097-M2
		50	

1978 Model Year

Mfr	Make	Qty	Descr.
AMC		1	258-A1
GM	Buick	2	231-A2
		1	350-A4
		1	403-A4
	Cadillac	2	425-A4
	Chevrolet	1	098-M1
	Chevrolet	1	151-A2
	Chevrolet	1	200-A1
	Chevrolet	1	250-A1
	Chevrolet	5	305-A2
	Chevrolet	2	350-A2
	Olds	2	260-A2
	Olds	2	350-A4
	Pontiac	1	231-A2
	Pontiac	2	301-A2
	Pontiac	1	305-A2
	Pontiac	1	400-A4
Ford		1	098-M2
		2	140-M2
		1	171-M2
		2	250-A2
		3	302-A2
		2	351-A2
		1	460-A4
Chrysler		1	105-A2
		2	225-A2
		2	318-A2
Datsun		2	085-M2
Honda		1	091-M3
Toyota		2	097-M2
VW		1	089-MO
		50	

APPENDIX B

TESTS PERFORMED

The following tests were performed on the vehicles in the as-received condition only. All tests except No. 6 were performed by contractor personnel.

1. Federal Test Procedure
2. 50 mph Cruise Test
3. Highway Fuel Economy Test
4. Four-Mode Idle Test
5. Loaded Two-Mode
6. State Inspection Test at a State Department of Environmental Quality (DEQ) station
7. State Inspection Test at HTS laboratory.
8. Four-Mode Idle Test with one spark plug disconnected*
9. Four-Mode Idle Test on gasohol fuel*
10. Diagnostic Inspection

---

* These tests were performed for purposes unrelated to the Portland versus Vancouver comparison. Results from the tests will be reported in later reports.

APPENDIX C

BRIEF DESCRIPTION OF TESTS

1. Federal Test Procedure

The Federal Test Procedure (FTP) is a non-repetitive driving cycle simulating urban driving. The cycle covers 7.5 miles in 1372 seconds with an average speed of 19.6 mph. The maximum speed in the cycle is 57 mph. Because the FTP simulates some stop-and-go city driving, there is also considerable time spent at idle - about 19% of the time.

Each vehicle is driven on a chassis dynamometer which reproduces vehicle inertia with flywheels, and road load with a water brake system. Vehicle exhaust is collected, diluted, and mixed with filtered background air to a known constant volume flow. This procedure is known as Constant Volume Sampling (CVS). The exhaust is analyzed for mass emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), and carbon dioxide (CO_2). Fuel economy calculations are also made from the exhaust measurements, using a carbon balance technique.

2. 50 MPH Cruise Test

This test is run as part of the 3 minute 50 mph preconditioning for the Highway Fuel Economy Test. Undiluted concentrations of HC, CO and NOx emissions were measured.

3. Highway Fuel Economy Test

For this test, the vehicle starts from a warm, but engine-off condition and then accelerates to highway speed. It maintains high speed until the cycle ends in a deceleration back to idle. The high speed portion is not a steady cruise condition, but varies slightly. Average speed is 48.2 mph and the cycle length is 10.2 miles. CVS mass emissions are sampled from the start of the engine until the vehicle is brought back to idle. Fuel economy is calculated from the emissions.

4. Four-Mode Idle Test

This test has four modes for vehicles with automatic transmissions, and three modes for others. The order of testing is: 1) idle in neutral (gear), 2) 2500 engine rpm unloaded, 3) idle in neutral and 4) idle in drive (for automatics). Undiluted HC, CO and NOx emissions are sampled at all modes.

5. Loaded Two-Mode

This test consists of two operating conditions. The first condition is constant 30 mph with a dynamometer load of 9.0 hp for all vehicles. Following sampling in this mode the vehicle is returned to idle in neutral. Undiluted HC, CO and NOx emissions are sampled at both modes.

6. State Inspection Test (SIT) at a Department of Environmental Quality (DEQ) Station

Vehicles were taken by contractor personnel to a State operated inspection station for this test. This test is the same as the first three portions of the Four-Mode Idle Test, i.e., idle neutral, 2500 engine rpm, idle neutral. Undiluted HC and CO emissions are sampled by State personnel.

7. State Inspection Test (SIT) at the Hamilton Test Systems (HTS) Laboratory

The laboratory personnel perform an identical test to the one at the DEQ station. Undiluted HC, CO and NOx emissions are sampled.

8. Four-Mode Idle Test With One Spark Plug Disconnected

This test is the same as the normal Four-Mode Idle Test except with one spark plug disconnected.

9. Four-Mode Idle Test With Gasohol

Commercial gasohol fuel was used for this test.

10. Diagnostic Inspection

An engine diagnostic check was conducted using an Autosense Diagnostic System. This system checks many parameters such as the electrical system, engine timing, idle speed and emissions, and cylinder power contribution.

FTP & HWY ARE ONLY PROCEDURES USING DILUTED EXHAUST.