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Recommendations Regarding the Selection of Idle Emission Cutpoints for Inspection and Maintenance Programs Requiring Only Carbon Monoxide Emission Reductions

by

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Notice

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Preface

This report is a supplement to EPA-AA-IMS/81-1, "Recommendations Regarding the Selection of Idle Emission Inspection Cutpoints for Inspection and Maintenance Programs"[1]*, which was developed as a part of EPA's Model Program guidance. The original report described methods for selecting HC and CO cutpoints given an idle emission data base, and recommended specific HC and CO cutpoints by model year groupings for desired program failure rates. The recommended cutpoints in the original report were intended for use in I/M programs in areas which require only HC, or both HC and CO, emission reductions in order to attain the National Ambient Air Quality Standard for ozone, or ozone and CO. This report is intended to aid I/M programs which only require CO reductions in the selection of cutpoints, prediction of failure rates, and estimation of I/M emission benefits. Its recommendations are therefore applicable to I/M in areas that have already attained the ozone standard or that are projected to attain the ozone standard by 1982 without I/M.

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

1.0 INTRODUCTION

1.1 Previous EPA Cutpoint Selection Guidance

The recommendations presented in Reference 1 for pre-1981 vehicles were derived from a data base of vehicles which had undergone testing of idle HC and CO emissions. Failure rates for given cutpoints were predicted for 5 different technology types corresponding to model year groups (pre-1968, 1968-1971, 1972-1974, 1975-1979 and 1980) by a computer model which accounted for the increase in idle HC and CO scores with mileage. Failure rates for 1981 and future vehicles were predicted differently, due to their more sophisticated emission control technology. A high proportion of these vehicles will have computerized control of the air-fuel mixture, which is expected to make them less sensitive to cutpoint variations.

Failure rates for each model year grouping in the previous report were presented as the total percent of tested vehicles which fail the idle test for HC and/or CO, given certain sets of HC and CO cutpoints. This report will recommend CO cutpoints for desired failure rates for CO idle tests only. (As explained below, EPA has determined that HC cutpoints are not crucial for deriving a large CO-only emission benefit.) Naturally, some of these vehicles would also fail HC idle tests but it is not the purpose of this report to detail those failures. Failure rate predictions in this report will only apply to the first functioning year of an I/M program; as explained in Reference 1, failure rates for the following years can be estimated by data collected from the actual operation of the program.

1.2 Major Points Discussed In This Report

The following questions will be answered:

1) What, if any, should be the cutpoint locus; i.e., should there be an HC cutpoint in addition to a CO cutpoint? If so, what multiple of the CO cutpoint should it be?

2) How can states predict failure rates from specific CO cutpoints?

3) How can the emission benefits be calculated?

2.0 SHOULD AN HC CUTPOINT BE USED?

2.1 Pre-1981 Vehicles

EPA's investigation of CO benefits from HC-only failures of pre-1981 vehicles has shown that they typically amount to a small percent of total idle test failures, and that they receive essentially no CO emission benefit from repair. The lack of a CO benefit is due to the fact that these vehicles' FTP CO emission levels at inspection are already low (as their ability to pass the I/M CO cutpoint would suggest) and the fact that no CO-oriented repairs need to be performed for these vehicles to pass reinspection. Table 1 shows the as-received FTP CO emissions and the change in CO emissions for vehicles from repair of HC-only failures in EPA's Portland Study Sample.

Table 1

FTP CO Emission Change Resulting
From Maintenance On HC-Only Failures From
Elements II and III and Test Group 7
of the Portland I/M Fleet

Vehicle model year	Percent of idle test failures which are HC-only failures	As-received FTP CO emissions (g/mi)	Percent change in FTP CO emissions from HC-only failures after repair
1972-1974	6.3	27.98	- 2.2
1975-1977	7.4	16.70	+22.2

As can be seen, there was actually a small increase (3.7 g/mi) in CO emissions after repair for the 1975-1977 model year group.

2.2 1981 and Future Vehicles

Emission control system failures of the 1981 and future fleet can be divided into two categories: 1) failures of the closed-loop computer control system, which result in rich operation and high HC and CO emissions 2) other failures which are also common to older vehicles, caused by tampering, malmaintenance, misfueling, and ignition-related problems. As explained in Reference 1, it is the failures of the first category which are expected to be the main cause of 1981 and later vehicles emitting significantly above the standard. The emission factors for this failure category, as predicted in MOBILE2 and shown in Table 2, demonstrate that both HC and CO emissions will be exceptionally high [4]. A CO-only cutpoint is expected to identify essentially all of these vehicles [3]. Failures of the second category will be similar to those of pre-1981 vehicles, and so the same arguments for the suitability of a CO-only cutpoint are applicable.

Table 2

Emission Rates for 1981 and Future Vehicles Which Experience Failure of the Closed-Loop Control System

Pollutant	New Vehicle Emission Rate (g/mi)
HC	3.74
CO	107.36

2.3 Undesirable Consequences of Emphasizing HC Idle Failures

EPA has found that there are certain characteristics associated with HC failures on the idle test which areas that need only CO reductions from the I/M program would logically wish to avoid if possible. Cutpoint sets for HC and CO which emphasize HC, for example, are accompanied by higher rates of errors of commission (vehicles which fail the idle test but actually meet federal emission standards). Also, idle failures for HC often necessitate costly ignition repairs, which could needlessly drive up the average repair cost in the I/M program with little resulting CO emission reduction. Yet another issue related to the choice of idle inspection type is that of fuel economy benefit from repair of failed vehicles. EPA has found that there is a net fuel economy benefit of 0.8% for pre-1981 vehicles repaired by mechanics who have been educated in conventional training programs. However, this fuel economy benefit rises to 4% for these same vehicles when mechanics only adjust carburetors to a specific idle CO level [2]. This would indicate that an I/M program where repairs for pre-1981 vehicles are limited to carburetor adjustments would yield the maximum CO and fuel economy benefit, at low cost. By using only a CO cutpoint, an I/M program can effectively limit repairs to carburetor adjustments[3]. (The fuel economy benefit for 1981 and later vehicles is not expected to be influenced by mechanic training [2].)

In summary, a program which consists of a CO-only idle inspection will deliver full CO emission reduction benefits, and may actually deliver a greater fuel economy benefit for pre-1981 vehicles since repairs can be limited to carburetor adjustments. Also, a CO-only program operating at a particular failure rate will deliver a greater CO benefit than an HC/CO program operating at that same failure rate [3].

Additional discussion of the ramifications of using only a CO cutpoint can be found in Reference 3.

3.0 HOW CAN STATES PREDICT FAILURE RATES FROM SPECIFIC CO CUTPOINTS?

As discussed in Reference 1, EPA recommends using data from a pilot program or a mandatory inspection/voluntary testing program in the intended geographic location, for the most accurate estimation of failure rates. For situations where this is not possible, EPA developed a model to predict failure rates for various cutpoints, based on data collected from EPA's I/M Demonstration Vans, EPA's Emission Factor Program and New Jersey's I/M program [1]. Tables 3 and 4 present predicted minimum, maximum and mean failure rates for CO-only cutpoints, based on this model. Table 3 is for programs beginning 1/1/82; Table 4 for those starting a year later. The minimum is the failure rate for the most recent and therefore the youngest and cleanest model year in the group; the maximum is the failure rate for the oldest and therefore the dirtiest model year; and the mean is the average for all the model years in the group, taking the national average registraton distribution of model years within model year groups at the projected time into account.

Based on these tables, EPA has estimated the CO cutpoints that would be needed at the beginning of an I/M program for a variety of failure rates. Table 5 presents these cutpoints for I/M programs beginning 1/1/82 and 1/1/83. As discussed in Reference 1, failure rates for pre-1981 vehicles should remain approximately constant during the first year of a program if vehicle inspections fall on vehicle birthdays. However, EPA's model predicts that vehicle model year group failure rates at the second inspection will decrease, for example, 4-14% for a given set of cutpoints designed to achieve an initial failure rate of 35% [1]. Also, the data base used for prediction of 1980 model year failure rates was limited, and so these predictions may be inaccurate [1]. Therefore, states will probably need to adjust cutpoints for pre-1981 vehicles yearly if they wish to maintain a constant failure rate. Also, it may be necessary for a state to revise cutpoints within the first few months of the start of a program, to correct for differences caused by local influences.

Failure rates for 1981 and later vehicles will be less sensitive to cutpoint variations, due to the nature of the typical failure of their computer-controlled emission control systems. As mentioned above, data from these vehicles indicate that these failures will cause a gross increase in CO emissions, which will be easily identified by any reasonable CO cutpoint.

Table 3

Initial Model Year Group Failure Rates
Predicted by EPA CO Cutpoint Model
At I/M Program Start Date 1/1/82

CO Idle Cutpoint (%)	Model Year Group Failure Rates (%)													
	Pre-1968			1968-71			1972-74			1975-79			1980 4/	1981+ 5/
	Min1/	Max2/	Mean3/	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Mean	
1.0							74.4	77.4	75.7	46.3	65.2	53.5	33.8	
1.2														1.0-3.0
1.5							69.2	71.6	70.5	39.6	47.5	44.0	30.0	
2.0							62.6	65.1	63.8	34.9	42.3	38.7	25.6	
2.5							55.7	58.5	57.0	30.8	37.9	34.5	21.7	
3.0	64.3	64.6	64.4	58.4	58.4	58.4	51.0	53.6	51.9	27.2	33.5	30.6	18.7	
3.5	60.9	61.5	61.2	53.4	54.1	53.9	45.4	48.3	46.8	23.7	30.2	27.2	14.9	
4.0	55.3	55.3	55.3	48.9	50.0	49.0	40.8	43.6	42.0	20.6	26.7	23.9	12.7	
4.5	49.6	51.8	50.7	43.0	44.4	43.9	36.2	47.7	47.3	17.3	23.7	20.9	10.5	
5.0	43.9	45.1	44.4	37.2	37.8	37.8	31.6	35.0	32.8	14.5	20.9	18.0	8.6	
5.5	39.1	39.8	39.6	32.7	33.9	33.0	26.3	29.2	27.8	12.6	18.3	15.4	6.6	
6.0	36.3	36.9	36.6	27.2	28.6	27.8	22.1	25.0	23.6	10.4	15.4	13.0	5.2	
6.5	30.7	31.8	31.4	22.1	24.3	23.2	18.6	21.0	19.7	8.7	13.3	11.2	3.7	
7.0	25.0	26.2	25.7	19.6	20.4	19.7	15.5	17.4	16.2	7.0	11.6	9.5	2.7	
7.5	20.5	22.2	21.4	14.9	15.9	15.3	11.9	14.7	13.1	5.7	9.9	7.9	1.9	
8.0	15.8	17.8	16.8	11.0	13.3	11.9	9.5	11.5	10.4	4.1	8.4	6.4	1.0	
8.5	11.1	13.5	12.4											
10.0	1.8	2.5	2.2											
Registration Fraction		.038			.110			.184			.449		.095	.124

(1) Minimum model year failure rate within model year groups.
(2) Maximum model year failure rate within model year groups.
(3) Average failure rate in model year groups weighted by projected model year registration fractions.
(4) EPA predictions for 1980 vehicles are based on limited data and therefore may be less accurate than those for pre-1980 vehicles.
(5) EPA recommends use of a 207(b) short test standard of 1.2% CO.
EPA expects that the failure rate from these cutpoints will never exceed 1-3%.

Table 4

Initial Model Year Group Failure Rates
Predicted by EPA CO Cutpoint Model
At I/M Program Start Date 1/1/83

Cutpoint (%) CO Idle	Model Year Group Failure Rates (%)													
	Pre-1968			1968-71			1972-74			1975-79			1980 4/	1981+ 5/
	Min1/	Max2/	Mean3/	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Mean	
1.0							75.7	79.1	77.1	48.1	67.1	56.9	35.8	
1.2														1.0-3.0
1.5							71.1	72.9	71.7	42.3	50.6	45.8	32.0	
2.0							64.2	67.0	65.2	37.2	44.1	40.2	27.4	
2.5							57.2	60.2	58.5	33.3	38.6	35.7	24.6	
3.0	64.3	64.6	64.5	58.4	58.4	58.4	51.4	54.9	53.0	29.1	34.5	31.8	20.9	
3.5	60.9	61.5	61.3	54.1	54.1	54.1	47.3	49.5	48.2	25.6	31.7	28.5	18.2	
4.0	55.3	55.3	55.3	48.9	50.0	49.2	41.9	44.5	43.1	22.2	28.0	25.1	14.5	
4.5	49.6	51.8	51.2	44.4	45.1	44.5	38.1	40.1	38.9	19.1	25.0	22.1	12.6	
5.0	43.9	45.1	44.7	37.8	38.7	38.2	32.4	36.1	34.2	16.5	21.7	19.1	10.5	
5.5	39.6	39.8	39.7	32.7	33.9	33.2	28.2	30.0	29.0	13.9	19.1	16.5	8.7	
6.0	36.3	36.9	36.7	27.8	28.6	28.1	24.1	25.7	24.8	11.9	16.5	14.0	7.1	
6.5	31.4	31.8	31.7	23.1	24.5	23.8	19.9	21.5	20.7	10.1	14.2	12.1	5.7	
7.0	25.4	26.2	26.0	19.6	20.4	19.9	16.2	18.6	17.2	8.4	12.6	10.4	4.2	
7.5	21.1	22.2	21.8	15.3	17.0	15.7	13.2	15.1	14.2	6.6	10.5	8.7	3.0	
8.0	16.2	17.8	17.2	11.9	13.3	12.4	10.4	11.9	11.1	5.5	9.2	7.2	2.2	
8.5	11.7	13.5	12.4											
10.0	2.1	2.5	2.4											
Registration Fraction		.027			.084			.152			.447		.073	.217

(1) Minimum model year failure rate within model year groups.
(2) Maximum model year failure rate within model year groups.
(3) Average failure rate in model year groups weighted by projected model year registration fractions.
(4) EPA predictions for 1980 vehicles are based on limited data and therefore may be less accurate than those for pre-1980 vehicles.
(5) EPA recommends use of a 207(b) short test standard of 1.2% CO.
EPA expects that the failure rate from these cutpoints will never exceed 1-3%.

Table 5

EPA Recommended I/M CO Cutpoints

Cutpoints predicted to give constaht failure rates among pre-1981 vehicles for I/M starting 1/1/82 and 1/1/83 in initial year inspections by EPA CO cutpoint model.

I/M Start Date	Nominal Failure Rate (%)	Recommended CO Cutpoints for Model Year Groups				
		Pre-1968 CO (%)	1968-71 CO (%)	1972-74 CO (%)	1975-79 CO (%)	1980 1/ CO (%)	1981+ 2/ CO (%)
1/1/82							
	20	7.5	7.0	6.5	4.5	3.0	1.2
	25	7.0	6.5	6.0	4.0	2.0	1.2
	30	6.5	6.0	5.5	3.0	1.5	1.2
	35	6.0	5.5	5.0	2.5	1.0	1.2
1/1/83							
	20	7.5	7.0	6.5	5.0	3.0	1.2
	25	7.0	6.5	6.0	4.0	2.5	1.2
	30	6.5	6.0	5.5	3.5	1.5	1.2
	35	6.0	5.5	5.0	2.5	1.0	1.2

1/ EPA's predictions for 1980 vehicles are based on limited data and therefore may be less accurate than those for pre-1980 vehicles.

2/ All I/M programs should use the 207(b) cutpoint for 1981 and later vehicles for all program years. EPA expects that the failure rate from this cutpoint will never exceed 1-3%.

4.0 HOW CAN THE EMISSION BENEFITS BE CALCULATED?

The MOBILE2 emission factors model can be used, with modifications. Once a state has decided on the failure rate desired, it must choose the appropriate CO cutpoints for each pre-1981 model year group based on data from the local vehicle sample, or based on the recommendations in this report. These CO cutpoints should then be matched to appropriate hypothetical HC cutpoints from EPA's locus pairs as described in Table 1 of Reference 1. These HC/CO cutpoint pairs should then be applied to the local data sample to find a total failure rate for pre-1981 vehicles; or they should be used to look up a total failure rate among pre-1981 vehicles in Tables 3 or 4 of Reference 1, by weighting the failure rate for each pre-1981 model year group by its registration fraction. This failure rate should then be used in MOBILE2 as the stringency for the I/M program for pre-1981 vehicles. For 1981 and later vehicles, the effect of an I/M program is calculated by inputting an identification (ID) rate instead of a stringency rate. The ID rate describes the fraction of gross HC and CO emitters (caused by closed-loop system failure, as described in Reference 4) which will be identified by the I/M test. If the basic idle-in-neutral test will be used for an area's I/M program, then a 50% ID rate should be inputted into MOBILE2. (This ID rate is the default value when the input flag IMFLG=1, therefore, only the pre-1981 stringency value needs to be entered in this case.) If the I/M program will use a two-speed idle or loaded mode test and will pass and fail on both modes of the test, then an ID rate of 70% should be entered for 1981 and later vehicles.

Presented below is a sample calculation for a hypothetical area which plans a CO-only I/M program and which will use the idle-in-neutral test. The area wants a failure rate of 25% for the first year of its I/M program, which will begin on January 1, 1983. Based on Table 5 of this report, the following CO cutpoints should be used for the first year of the program for pre-1981 vehicles:

Vehicle model year	CO idle cutpoint, %
pre-1968	7.0
1968-1971	6.5
1972-1974	6.0
1975-1979	4.0
1980	2.5

These CO cutpoints are then matched to their hypothetical HC cutpoints from Table 1 of Reference 1, to yield the following pairs:

Vehicle model year	HC (ppm)	CO(%)
pre-1968	700	7.0
1968-1971	650	6.5
1972-1974	600	6.0
1975-1979	400	4.0
1980	275	2.5

The HC/CO cutpoint pairs are then used to look up the failure rates for each model year group in Table 4 of Reference 1. The failure rates are then weighted by the registration fraction of each model year group. Note that the registration fractions listed in Table 4 must be normalized to account for the absence of the 1981 and later vehicles.

Vehicle model year	Mean Failure rate	Registration fraction
pre-1968	52.0	.027/.783 = .035
1968-1971	38.9	.084/.783 = .107
1972-1974	34.5	.152/.783 = .194
1975-1979	37.1	.447/.783 = .571
1980	35.2	.073/.783 = .093

The failure rates are then multiplied by their respective registration fractions and summed to yield the total theoretical failure rate for pre-1981 vehicles:

Mean failure rate		Registration fraction		
52.0	x	.035	=	1.82
38.9	x	.107	=	4.16
34.5	x	.194	=	6.69
37.1	x	.571	=	21.18
35.2	x	.093		3.27
		Total failure rate		37.12

Therefore, a stringency of 37 will be used for pre-1981 vehicles in the MOBILE2 program, and the default ID rate of 50% will be used for 1981 and later vehicles. Comparison of the CO composite emission factor from this MOBILE2 run with the CO composite emission factor from a "no-I/M" run will enable the user to calculate the CO emission benefit for this particular program. (The HC emission factors from these MOBILE2 runs are meaningless, and should be discarded.)

5.0 CONCLUSIONS

CO cutpoints are sufficient to obtain essentially all of the normal CO emission reduction benefit possible from an I/M program, and a CO-only program operating at a given failure rate will deliver a greater CO benefit than an HC/CO program operating at that same failure rate. Cutpoints needed for a desired initial program failure rate can be chosen from the recommendations in this report, or can be determined from analysis of the results of a local trial I/M program. Cutpoints for future program years may need to be altered to insure a constant failure rate, and cutpoint selection should be based on results from the first year of the program. CO emission benefits can be calculated from MOBILE2, but not in the same manner as for an HC/CO I/M program. The chosen CO cutpoints for each pre-1981 model year group are matched to hypothetical HC cutpoints from the recommended locus pairs in Reference 1; these pairs are used to calculate a total failure rate for pre-1981 vehicles which is input as the program stringency in MOBILE2. Effectiveness of the I/M program for 1981 and later vehicles is represented in the input by an ID rate of 50 or 70 percent, depending on the type of emission test used. CO emission factors from MOBILE2 are used to calculate emission benefits, and the corresponding HC emission factor outputs are ignored.

References

[1] U.S. EPA. January, 1981. Recommendations Regarding the Selection of Idle Emission Inspection Cutpoints for Inspection and Maintenance Programs. EPA-AA-IMS/81-1.

[2] U.S. EPA. April, 1981. Update on the Fuel Economy Benefits of Inspection and Maintenance Programs. EPA-AA-IMS/81-10.

[3] U.S. EPA. April, 1981. Low-Cost Approaches to Vehicle Emissions Inspection and Maintenace. EPA-AA-IMS/81-7.

[4] U.S. EPA. November, 1980. Derivation of 1981 and Later Light Duty Vehicle Emission Factors for Low Altitude, Non-California Areas. EPA-AA-IMS/80-8.