sierra research

Report No. EPA 460/3-88-010

Analytical Support for Emission Factors Development and Air Quality Assessment

Work Assignment No. 0-01:
Analysis of California I/M Review Committee Data

Task 5 Report:
Analysis of Inspection Inconsistencies Between Different I/M Test Sites

prepared for:

U.S. Environmental Protection Agency

September 30, 1988

prepared by:

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ANALYTICAL SUPPORT FOR EMISSION FACTORS DEVELOPMENT AND AIR QUALITY ASSESSMENT

EPA Contract No. 68-03-3474

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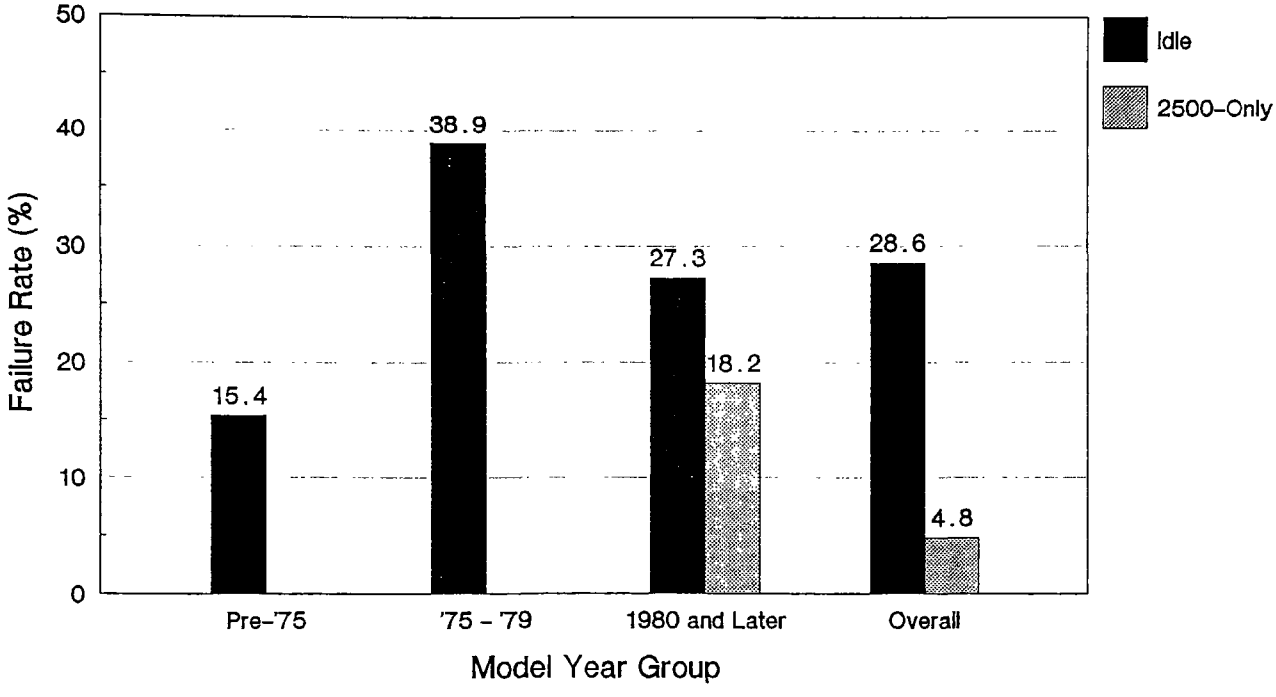
1. SUMMARY

During a recent evaluation of the California vehicle inspection and maintenance program, vehicles were tested at several different locations. Failure rates at a "screening facility" and at the California Air Resources Board (ARB) laboratory were much higher than those recorded at official Smog Check stations. The original analysis of the data suggested that "false passes" at Smog Check stations were due to incorrect underhood inspections of vehicles which failed only for underhood reasons when tested by ARB. Further analysis of the data has now been completed which confirms that inaccurate underhood inspection results at Smog Check stations were the principal reason for the difference in results between inspection facilities. However, the analysis also indicates that inconsistencies in tailpipe emission measurements were a contributing factor.

33% percent of the vehicles showed inconsistent tailpipe emission test results (i.e., fail vs. pass) when comparing the screening facility to the first Smog Check station the vehicles were taken to. However, about one-third of those vehicles had inconsistent tailpipe emission results when comparing the screening facility to the ARB laboratory tests. In general, the vehicles that showed inconsistent tailpipe results were primarily idle mode failures. In addition, there was a

Figure 1

Screening Facility Tailpipe Failure Rate For Vehicles That Passed at the First Smog Check Station



strong relationship between tailpipe test inconsistency and model year group. As illustrated in Figure 1, inconsistent results were much more frequent for 1980 and later models.

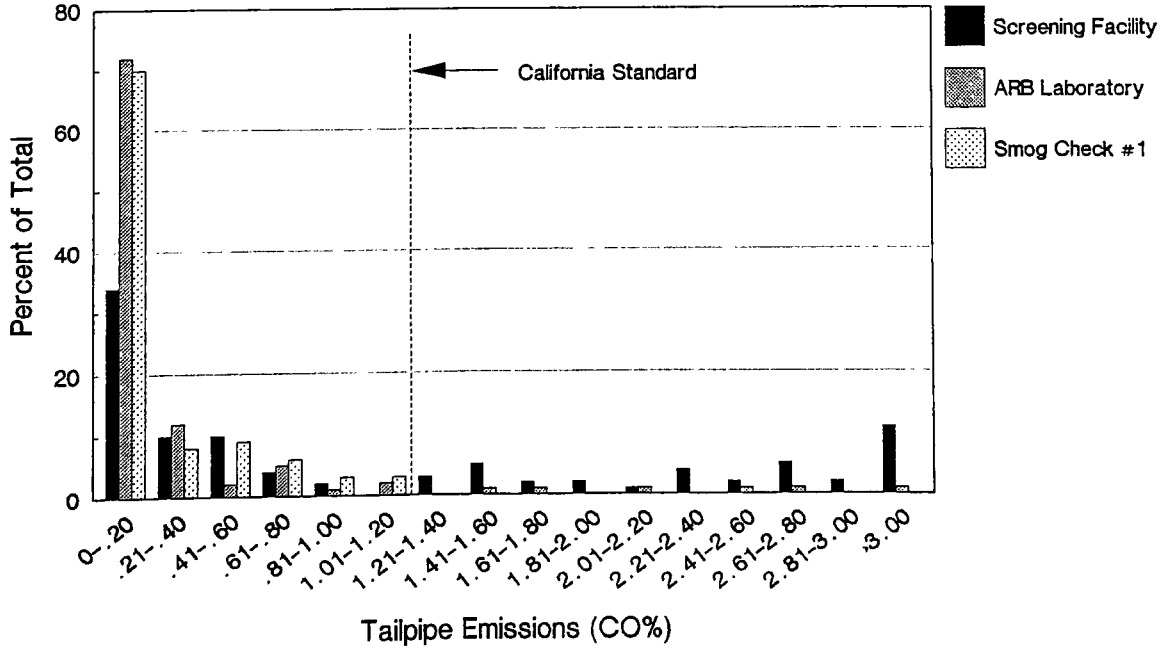
One reason why Smog Check stations often reported lower tailpipe emission levels for vehicles that failed the tailpipe test at the ARB laboratory or the Screening Facility is that Smog Check mechanics will sometimes perform repeated "initial" tests on a vehicle in an attempt to make it pass the standards. The additional preconditioning that occurs between tests may be contributing to a reduction in the number of improper or pattern failures that occurred at Smog Check stations. This hypothesis is supported by the fact that for 1975 and later

models there was no significant reduction in HC or CO emissions for vehicles that passed at the first Smog Check stations they were taken to and then subsequently failed at a second Smog Check station.

Figure 2 provides another illustration of the inconsistency in tailpipe emission measurements between the facilities. Under the 2500 RPM carbon monoxide test, 37% of the 1980 and later model vehicles failed the test when tested at the screening facility. At the ARB lab, the failure rate dropped to 6%; at the first Smog Check station, none of the vehicles failed. As shown in the figure, the results at Smog Check station #1 indicate a large increase in the number of vehicles in the lowest emission level range (0-0.2%). A significant

Figure 2

Distribution of 2500 RPM CO Emission Levels For Vehicles that Passed at Smog Check #1



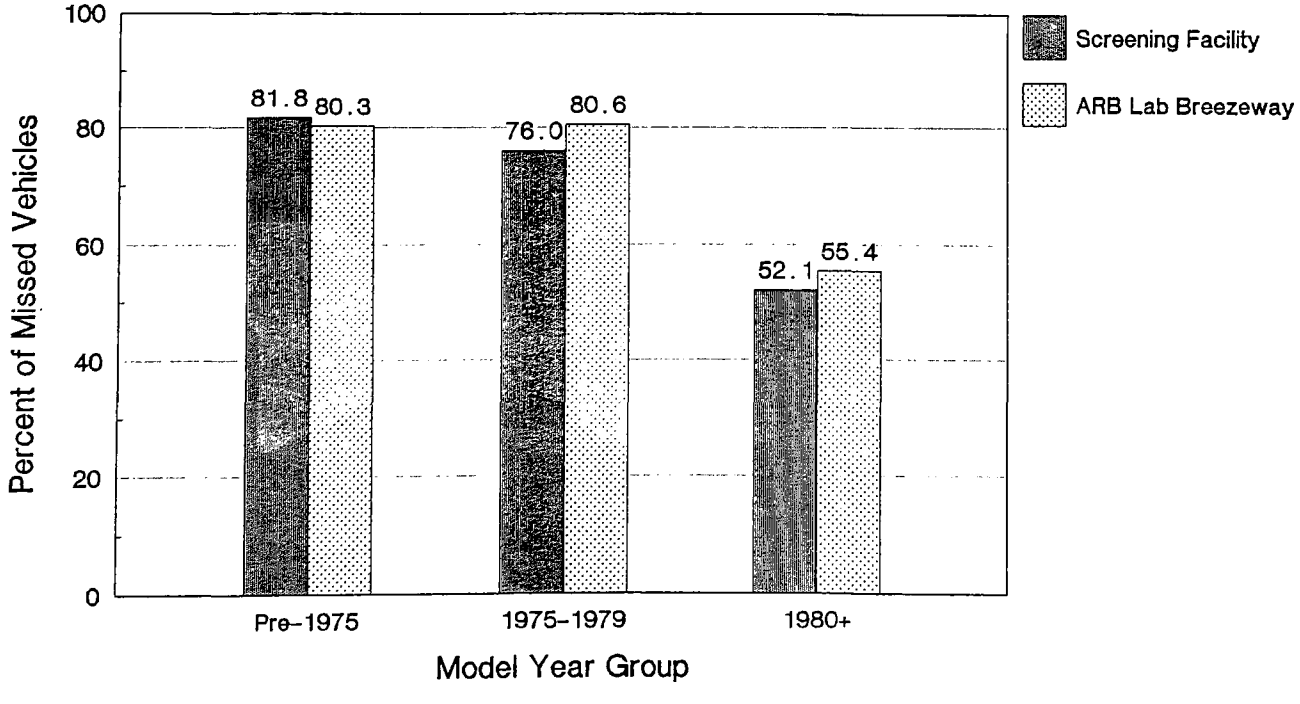
1980+ 3-way Catalyst Vehicles

number of vehicles that failed the test at the screening facility or at the ARB laboratory were well under the standard when tested at the Smog Check station. Preconditioning differences are the expected reason for the variability in failure rate.

As shown in Figure 3, most of the vehicles that passed at the first Smog Check station were "underhood-only" failures. Based on tests at the screening facility, about 80% of the pre-1980 vehicles that passed at the ARB lab or the first Smog Check station were underhood-only failures, this dropped to about 50% for the 1980 and later model vehicles, where pattern failures are more of a problem.

Figure 3

Percent of Vehicles Missed at Smog Check #1 That Were Underhood-Only Failures



Although there was variability between model-year groups, repair of those vehicles that passed the first Smog Check after failing at the screening facility would have contributed to additional reductions of hydrocarbon and oxides of nitrogen emissions. Vehicles that passed at the first Smog Check station and then failed at the second station experienced FTP emission reductions of 32.6% HC and 11.8% NOx when repaired. Carbon monoxide emissions were essentially unaffected. However, the hydrocarbon emission benefits from the repair of these vehicles were almost exclusively from pre-1975 model vehicles. For 1975-1979 models, there were no significant benefit for any pollutant. For 1980 and later models, significant reductions in NOx emissions were recorded, but there were increases in HC and CO emissions. This is the effect that would be expected from the correction of EGR tampering that was missed during the visual inspection at the first Smog Check station.

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2. INTRODUCTION AND METHODOLOGY

Under a contract with the U.S. Environmental Protection Agency (EPA) for "Analytical Support for Emission Factors Development and Air Quality Assessment," Sierra Research, Inc. (Sierra) performs a variety of Work Assignments for the Emission Control Technology Division (ECTD) of EPA's Motor Vehicle Emissions Laboratory in Ann Arbor, Michigan. Work Assignment 0-01 directed Sierra to analyze California I/M data for the ECTD Technical Support Staff (TSS). Task number 5 of that Work Assignment required further evaluation of inspection inconsistencies that were observed during the course of the recently completed California I/M Evaluation Program.

The direction provided by TSS was as follows:

> The analysis of inspection inconsistencies on pages 41-47 of the Technical Appendix (to Sierra's previous report on the California I/M Evaluation Program) for the most part does not separate tailpipe inspection and underhood inspection as causes of failure. The analysis is sufficient to suggest that many or most "false passes" at the first smog check were due to incorrect underhood inspections of vehicles which failed only for underhood reasons at the ARB screening facility. The contractor shall perform an analysis which looks solely at the variation in tailpipe results between the four potential test sites for each vehicle (screening facility, ARB lab/breezeway, and the two smog check stations). Idle and 2500 rpm modes shall be distinguished, and the analysis shall consider both California and Federal (207(b)) cutpoints. The as-received FTP emission performance of the more- and less-variable vehicle groups should be given, as well as the emission reductions eventually delivered by repairs. Model year and technology effects should be explored.

Background

Under the California I/M Evaluation Program, "undercover" vehicles obtained from the general population were given both I/M and FTP tests at ARB's El Monte laboratory prior to being sent to a randomly selected Smog Check station. All of the undercover vehicles initially failed an inspection given by ARB technicians at the "screening facilities" that were established on a temporary basis in various locations throughout the South Coast Air Basin. Based on the screening test, these vehicles were expected to fail a properly conducted inspection at a Smog Check station.

Vehicles which either failed or received pre-inspection maintenance at the first Smog Check station to which they were taken were referred to as "F sample" vehicles. The emission reductions achieved through repair of these vehicles were subsequently used to estimate the benefits of the current Smog Check program.

Vehicles which passed at the first Smog Check station were taken to a second, randomly selected Smog Check station. If pre-inspection maintenance or a failure and repair occurred at the second station, then the vehicles were placed in what ARB refers to as the "G sample" category. Vehicles which passed at both Smog Check stations were referred to as "E sample" vehicles.

Differences Between Vehicles that Passed and Failed

Table 1 is a copy of Table 5-1 from Sierra's earlier study for the California I/M Review Committee ("Evaluation of the California Smog

Check Program - Technical Appendix," April, 1987). The table shows how the baseline Federal Test Procedure emissions compare for the undercover vehicles, based on whether they passed or failed at the Smog Check stations. As the table shows, vehicles which failed at the first Smog Check station generally had significantly higher emissions than those which passed. Similarly, vehicles which failed at the second Smog Check station generally had higher emissions than those which passed for a second time.

Table 1

Baseline FTP Emissions of Undercover Vehicles
That Failed at First Smog Check
vs. Vehicles That Passed

	Sample Name	I/M Test Results: Smog Check#1	Smog Check#2	FTP Grams/Mile: Model Year Group: Pre-'75s	1975-1979	Post-'79	All Vehicles
	F	Fail	NA	10.49	4.25	1.89	5.24
HC	G	Pass	Fail	7.16	2.02	0.99	3.41
	E	Pass	Pass	4.98	1.52	0.74	1.95
	F	Fail	NA	70.73	49.27	32.04	49.73
CO	G	Pass	Fail	53.44	31.80	12.59	33.55
	E	Pass	Pass	62.26	18.84	11.37	25.02
	F	Fail	NA	3.31	2.75	1.26	2.43
NOx	G	Pass	Fail	3.87	2.58	1.66	2.75
	E	Pass	Pass	3.25	2.86	1.42	2.43
	F	Fail	NA	139	195	160	494
Sample	G	Pass	Fail	13	16	11	40
Size	E	Pass	Pass	53	116	92	261
		Total Sample		205	327	263	795

Considering all model years together, hydrocarbon (HC), carbon monoxide (CO), and oxides of nitrogen emissions (NOx) from all of the vehicles that failed at the first Smog Check station were 5.24, 49.73, and 2.43 grams/mile, respectively.

The grams/mile emissions from vehicles which passed the first time and failed the second were 3.41 HC, 33.55 CO, and 2.75 NOx. NOx emissions for this group were 13% higher, but HC and CO emissions were lower by 35% and 33%, respectively.

Vehicles which passed both Smog Checks had average emissions of 1.95 HC, 25.02 CO, and 2.43 NOx. This is 63% lower for HC and 50% lower for CO than emissions from vehicles which failed at the first station. NOx emissions were the same.

The sample size information at the bottom of Table 1 indicates that 494 of a total of 795 undercover cars failed at the first Smog Check station. In other words, only 62% of the vehicles that were expected to fail actually did fail. However, the cars with the highest emissions, excluding NOx, were the ones that failed.

Table 2 (Table 5-2 from the earlier report) indicates why some cars passed and others failed at Smog Check stations. As the table shows, there were substantial differences in tailpipe failure rates between vehicles that failed at the first station and vehicles that passed.

Table 2

Tailpipe Failure Rate of Undercover Vehicles
That Failed at First Smog Check vs. Vehicles That Passed

Test Location	Sample Name	I/M Results Smog Chk#1	I/M Results Smog Chk#2	Tailpipe Failure Rate — Model Year Group Pre-'75s	1975-1979	Post-'79	All Vehicles
Smog Check Station #1	F	Fail	NA	63.8%	70.6%	75.6%	70.3%
	G	Pass	Fail	0.0%	0.0%	0.0%	0.0%
	E	Pass	Pass	0.0%	0.0%	0.0%	0.0%
ARB Lab (Breezeway)	F	Fail	NA	59.7%	60.0%	56.9%	58.9%
	G	Pass	Fail	15.4%	25.0%	18.2%	20.0%
	E	Pass	Pass	15.4%	12.1%	21.7%	16.2%
Screening Facility	F	Fail	NA	64.7%	62.1%	76.3%	67.4%
	G	Pass	Fail	15.4%	37.5%	45.5%	32.5%
	E	Pass	Pass	20.8%	19.8%	41.3%	27.6%

The group of vehicles that was passed at the first Smog Check station had significantly lower tailpipe emissions failure rates when tested by ARB. The Test Analyzer Systems used at Smog Check stations are known to be reliable and accurate, and observations by ARB employees proved that the test results reported are for the same vehicle. "Test-to-test variability" appears to be the reason why some vehicles failed the tailpipe standards when tested by ARB but not when tested by the Smog Check station. Further evidence that test-to-test variability is the problem can be seen from the difference between failure rates at the ARB laboratory and at the screening facility. ARB expects, and experience with repeated tests on a number of vehicles indicates, that "preconditioning" differences are one factor

affecting this test-to-test variability problem. Vehicles which are not thoroughly warmed-up tend to have higher failure rates.

Table 3 (Table 5-3 from the earlier report) indicates another reason why some vehicles failed when tested by ARB but not when tested at a Smog Check station. This table indicates that most of the vehicles contained visual or functional defects. According to inspection results at the ARB lab, 84.6% of all vehicles that passed at both Smog Check stations contained at least one visual or functional defect. Due to the poor quality of the inspections performed at the Smog Check stations, these defects were missed. When visual defects are missed and the tailpipe emission levels meet the I/M standards, the vehicle will obviously pass the test.

Table 3

Underhood Failure Rate of Undercover Vehicles
That Correctly Failed at First Smog Check
vs.
Vehicles That Passed

Test Location	Sample Name	I/M Results Smog Chk#1	I/M Results Smog Chk#2	Underhood Failure Rate — Model Year Group: Pre-'75s	1975-1979	Post-'79	All Vehicles
Smog Check Station #1	F	Fail	NA	55.8%	49.5%	35.6%	46.7%
	G	Pass	Fail	0.0%	0.0%	0.0%	0.0%
	E	Pass	Pass	0.0%	0.0%	0.0%	0.0%
ARB Lab (Breezeway)	F	Fail	NA	88.5%	88.2%	57.5%	78.3%
	G	Pass	Fail	84.6%	87.5%	90.9%	87.5%
	E	Pass	Pass	94.2%	93.1%	68.5%	84.6%
Screening Facility	F	Fail	NA	84.2%	84.1%	43.8%	71.1%
	G	Pass	Fail	92.3%	81.3%	81.8%	85.0%
	E	Pass	Pass	88.7%	92.2%	63.0%	81.2%

Supplemental Analyses Performed

The Database - To provide the additional information requested by TSS, Sierra utilized Test Analyzer System (TAS) data from the California I/M Evaluation vehicles for which ARB had coded data from all of the test locations (783 out of 795 vehicles). Although TSS wanted an analysis of data at the screening facility, the ARB laboratory "breezeway" and Smog Check stations #1 and #2, Sierra discovered that very little data from Smog Check station #2 was in the database (to date, ARB has coded a limited amount of data from Smog Check station #2). Therefore, the analysis was restricted to the screening facility, the ARB lab/breezeway and Smog Check station #1.

For the analysis of FTP emissions, the 783-vehicle sample was reduced to 704 when only vehicles with both baseline and after-repair FTP test data were included.

Analyses Conducted TAS data analysis involved disaggregation of the sample into different technology categories and different failure modes. Comparisons of the data subsets could then be used to determine the relationship between test results at the different facilities and the characteristics of the vehicles. In addition, distributions of tailpipe emissions for vehicles with inconsistent test results were constructed. Examples of changes in emission measurements for individual vehicles were also prepared.

FTP data were used to determine the difference between the emission reduction potential of vehicles that failed at the first Smog Check

station and that of vehicles that did not fail until the second station.

In the analysis conducted for the draft version of this report, a group of 65 vehicles referred to as the "X-sample" were excluded from the analysis.* These vehicles were originally deleted from the sample because they passed both the tailpipe and underhood portions of the I/M test at the ARB laboratory, even though they failed at the "screening facility". EPA speculated that these vehicles may have been "pattern failure" vehicles that only passed at the ARB laboratory because of differences in preconditioning. Depending on the relative performance of the ARB lab in avoiding pattern failures, keeping these vehicles in the sample could significantly affect the consistency between test locations, especially for the 2500 rpm test mode.

Further analysis by Sierra indicated that 17 of the 65 vehicles were (incorrect) underhood-only failures at the screening facility. These

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* As might be expected, the FTP emission characteristics of the 43 1980 and later model X-sample vehicles were different from the other vehicles that failed at the screening facility:

	grams/mile		
Sample	HC	CO	NOx
X-Sample	0.68	9.57	0.79
Others	1.46	24.30	1.34

In addition, the failure characteristics of the X-Sample vehicles were significantly different. While 14.4% of the other vehicles were 2500 rpm-only failures, the 2500-only failure rate for the X-Sample was 53.5%.

seventeen vehicles did not fail the tailpipe test, so they were not pattern failures. All the remaining 48 vehicles in the X-sample passed the tailpipe test at Smog Check station 1. 43 of the 48 were 1980 or later model vehicles.

Given the observed pattern of failures for the X-sample, Sierra did not believe it was appropriate to include the 48 tailpipe failure vehicles in the sample with equal weighting. In fact, an argument could be made that they should not be included at all because the way vehicles were preconditioned at the screening facility does not represent the Smog Check station environment. (Routine analysis of Smog Check station data indicates that it is common for mechanics to run repeated "initial" tests on failing vehicles until they pass.) In this analysis, however, the 1980 and later model X-sample vehicles with tailpipe failures were included in the sample with a one-third weighting factor to account for the fact that they failed at one-third of the test sites. This increased the total sample of 1980 and later models from 243 to 286.

All of the analyses conducted are summarized in the following section of the report. Although not "F" sample cars by definition, the 48 "X" sample cars were included with the "F" cars (fail Smog Check #1) in the tables that follow (except Table 10). This is consistent with treatment of X cars as vehicles which fail at a 1/3 detection rate.

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3. RESULTS

Emission Measurement Variability Table 4 provides more detail on the tailpipe failure patterns for undercover vehicles than was presented in the Technical Appendix to the California I/M Evaluation Program study. The data presented in the table make it possible to distinguish between idle and 2500 rpm-only failures. Several data points in the table are preceded by an asterisk (*), indicating a coding error. The failure rate should have been 0% for all vehicles that were reported as passing the test at Smog Check station #1. However, our latest analysis of the data included a routine under which measured tailpipe emission levels were compared to the standards. In a few cases, it is apparent that ARB had coded vehicles as having passed at Smog Check station #1 when they actually failed.

As can be seen in Table 4, there were a significant number of 1980 and later model vehicles (the only models subject to a 2500 rpm test) that failed the 2500 rpm tailpipe test at the screening facility and at ARB laboratory, but later passed the test at Smog Check station #1. Inconsistencies in the tailpipe emission measurements at the various inspection sites are more clearly illustrated in Figures 4, 5, 6, and 7. These four figures show the distribution of tailpipe emission

Table 4

Modal Tailpipe Failure Rates of
Undercover Vehicles that Failed at First Smog Check
vs. Vehicles that were Incorrectly Passed,
By Model Year Range

Sample Group	Test Location	Sample† Size	I/M Test Results Smog #1	Smog #2	Tailpipe Failure Rates (%) Idle	2500 Only	Idle and/or 2500
All Vehicles		1414	F	-	62.2	7.2	69.4
	Smog Check #1	123	P	F	*7.3	0.0	*7.3
		744	P	P	*0.4	*0.4	*0.8
	ARB Lab (Breezeway)	1522	F	-	51.8	4.1	56.0
		126	P	F	16.7	4.8	21.4
		750	P	P	13.6	2.4	16.0
	Screening Facility	1514	F		61.2	7.1	68.4
		126	P	F	28.6	4.8	33.3
		753	P	P	20.3	3.6	23.9
pre-1975 models		393	F	-	65.6	0.0	65.6
	Smog Check #1	39	P	F	0.0	0.0	0.0
		156	P	P	0.0	0.0	0.0
	ARB Lab (Breezeway)	420	F	-	57.1	0.0	57.1
		39	P	F	15.4	0.0	15.4
		153	P	P	11.8	0.0	11.8
	Screening Facility	417	F	-	64.0	0.0	64.0
		39	P	F	15.4	0.0	15.4
		153	P	P	17.7	0.0	17.7

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).

Table 4 (continued)

Modal Tailpipe Failure Rates of
Undercover Vehicles that Failed at First Smog Check
vs. Vehicles that were Incorrectly Passed,
By Model Year Range

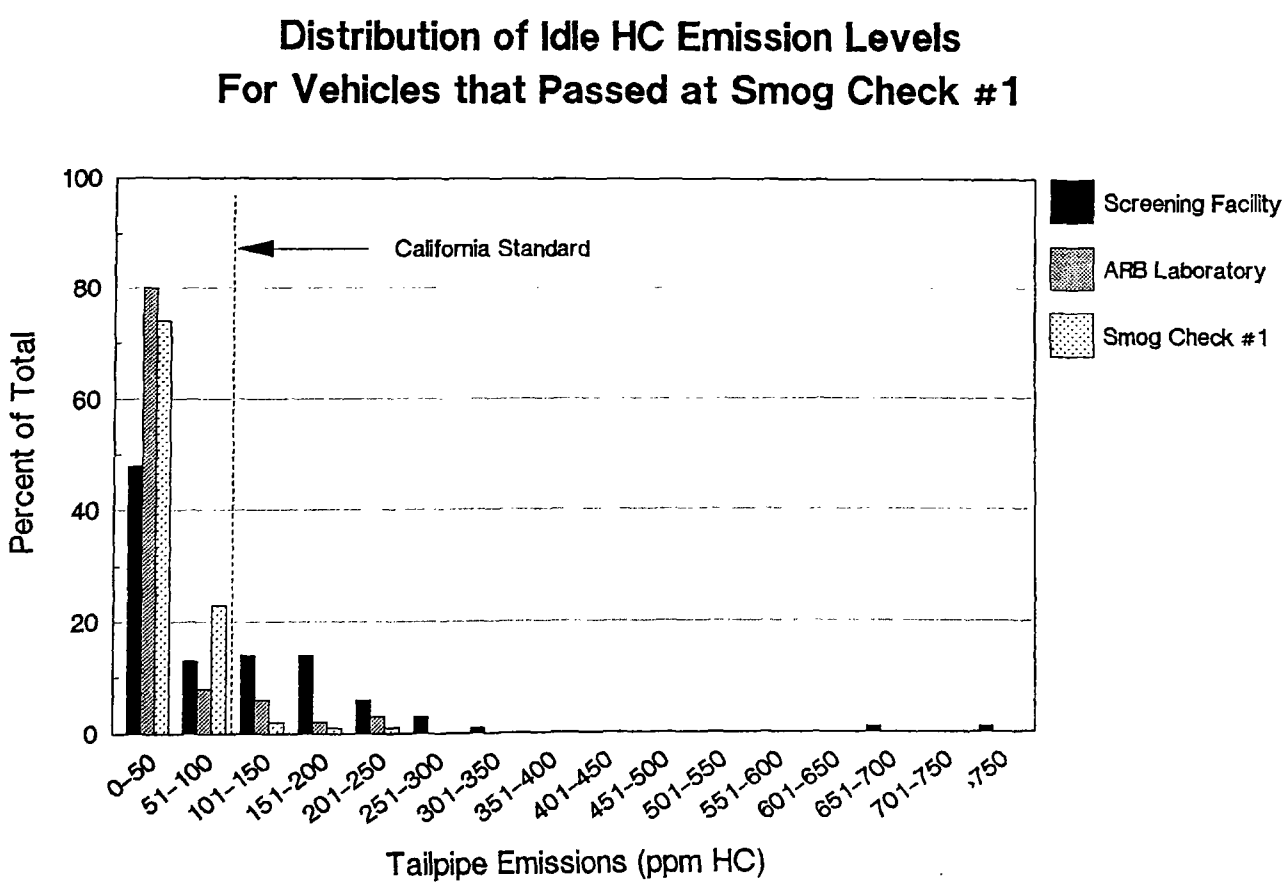
Sample Group	Test Location	Sample† Size	I/M Test Results Smog #1	Smog #2	Tailpipe Failure Rates (%) Idle	2500 Only	Idle and/or 2500
1975 to 1979 models	Smog Check #1	531	F		70.1	0.0	70.1
		54	P	F	*16.7	0.0	*16.7
		330	P	P	0.0	0.0	0.0
	ARB Lab (Breezeway)	583	F	-	58.2	0.0	58.2
		54	P	F	22.2	0.0	22.2
		336	P	P	11.6	0.0	11.6
	Screening Facility	583	F		62.9	0.0	62.9
		54	P	F	38.9	0.0	38.9
		336	P	P	17.0	0.0	17.0
1980 and later models	Smog Check #1	490	F		50.8	20.8	71.6
		30	P	F	0.0	0.0	0.0
		258	P	P	*1.2	*1.2	*2.3
	ARB Lab (Breezeway)	519	F		40.5	12.1	52.6
		33	P	F	9.1	18.2	27.3
		261	P	P	17.2	6.9	24.1
	Screening Facility	514	F	-	57.0	21.0	78.0
		33	P	F	27.3	18.2	45.5
		264	P	P	26.1	10.2	36.4

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).
* Data coding errors.

measurements for HC and CO at each test condition (idle and 2500 rpm) for 1980 and later model year vehicles equipped with 3-way catalysts.

Figure 4 indicates that there were many more vehicles that failed the idle hydrocarbon standard at the screening facility than at either the ARB laboratory or the first Smog Check station. As the figure shows, there is a significant difference in the percent of vehicles with HC emissions measured in the 0-50 ppm range at the screening facility and at the other two locations. It should also be noted that two vehicles passed at the Smog Check station and failed at the other two sites

Figure 4



1980+ 3-way Catalyst Vehicles

because the Smog Check station improperly recorded the vehicle as being equipped with an oxidation catalyst. As indicated in Table 5, this changed the idle HC standard from 100 ppm to 150 ppm.

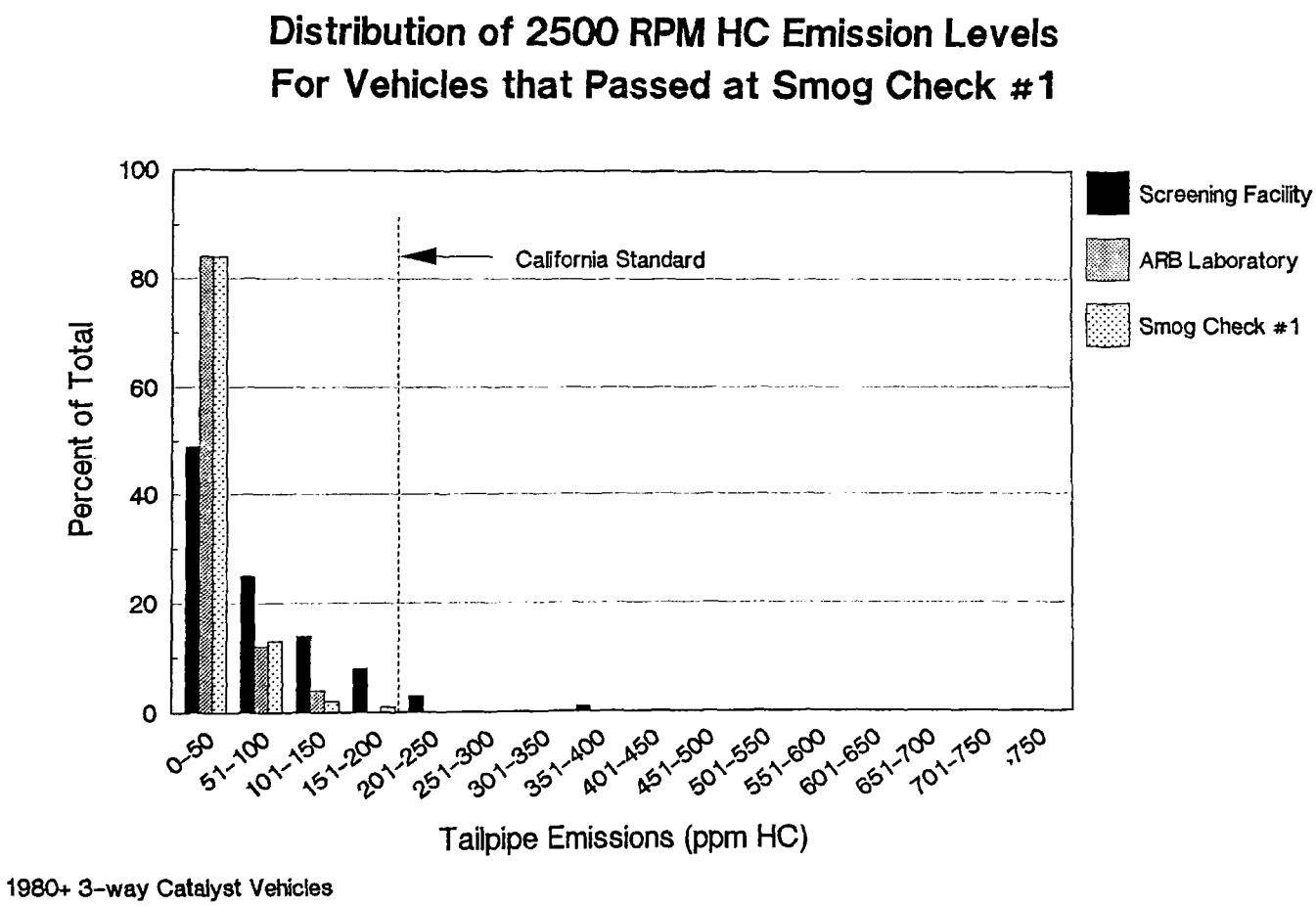
Table 5

Tailpipe Emission Standards
for the California Smog Check Program

Category/Description	Idle HC (ppm)	Idle CO (%)	2500 HC (ppm)	2500 CO (%)
01 '55-'65, >4 CYL	800	8.0	---	---
02 '66-'70, >4 CYL, w/ AIR	400	4.5	---	---
03 '66-'70, >4 CYL, w/o AIR	500	6.5	---	---
04 '71-'74, >4 CYL, w/ AIR	300	3.5	---	---
05 '71-'74, >4 CYL, w/o AIR	400	6.5	---	---
06 '55-'67, 4 CYL	1200	7.5	---	---
07 '68-'71, 4 CYL, w/ AIR	450	5.5	---	---
08 '68-'71, 4 CYL, w/o AIR	700	7.0	---	---
09 '72-'74, 4 CYL, w/ AIR	350	5.0	---	---
10 '72-'74, 4 CYL, w/o AIR	350	6.5	---	---
11 '75-'79, NO CAT	200	3.5	---	---
12 '75-'79, OX CAT, w/o AIR	250	4.5	---	---
13 '75-'79, OX CAT, w/ AIR	150	1.5	---	---
14 '75-'79, 3WY CAT	100	1.5	---	---
15 '80+ , NO CAT	150	2.5	220	1.2
16 '80+ , OX CAT, w/o AIR	150	2.5	220	1.2
17 '80+ , OX CAT, w/ AIR	150	1.2	220	1.2
18 '80+ , 3WY CAT	100	1.2	220	1.2

Figure 5 indicates that there were fewer failures at the 2500 rpm test point. Only 4% of the vehicles that passed at Smog Check station #1 failed this test at the screening facility and none of the vehicles failed the 2500 rpm HC test when tested at the ARB laboratory.

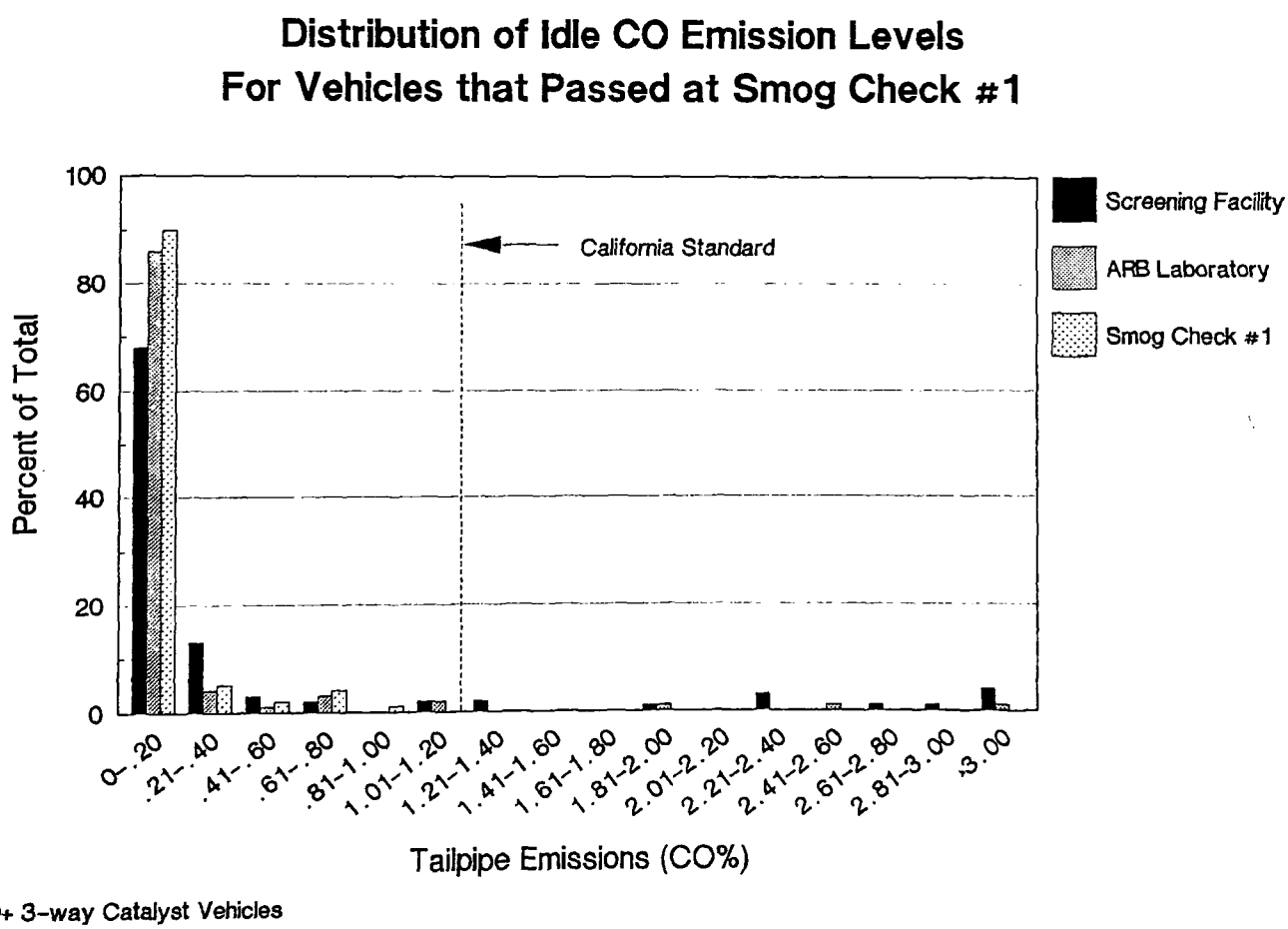
Figure 5



1980+ 3-way Catalyst Vehicles

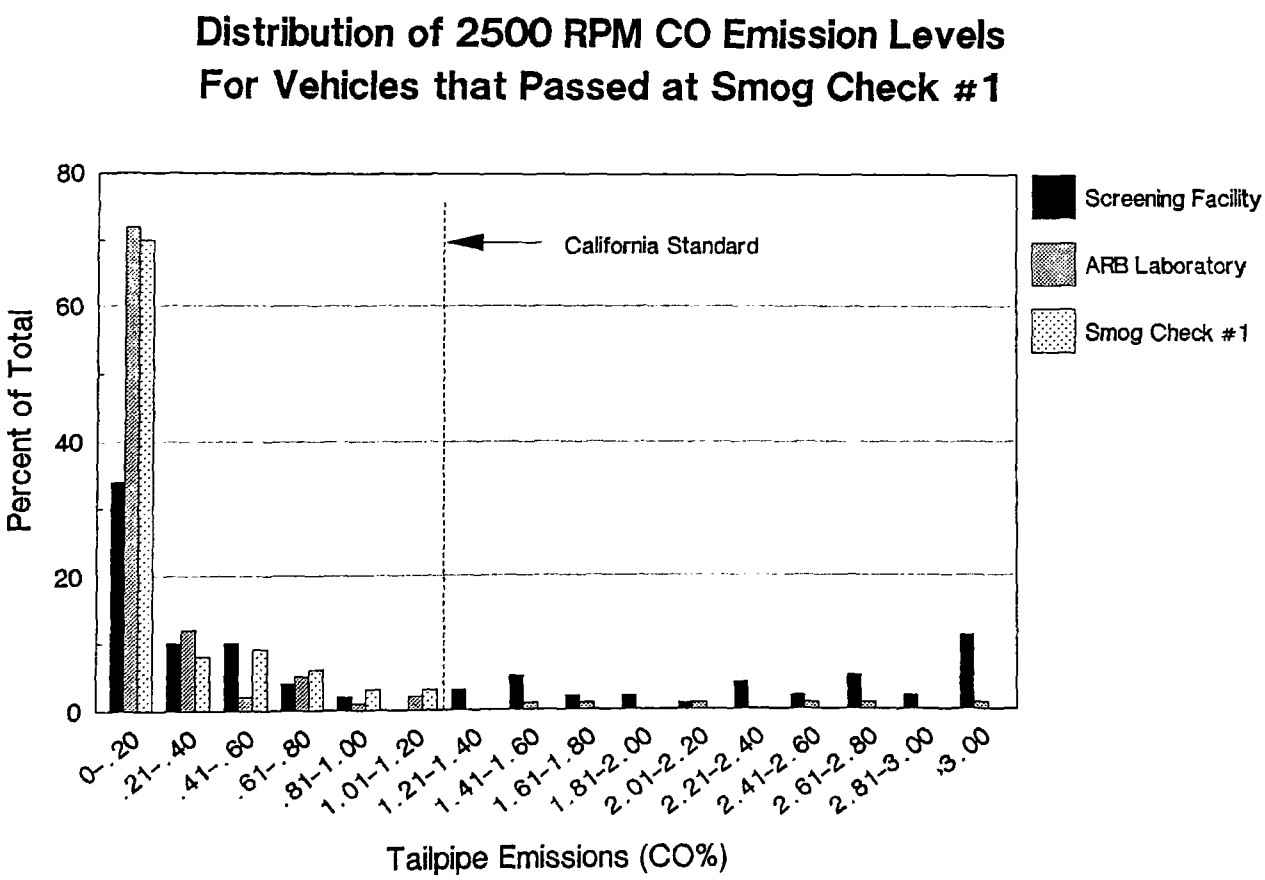
Figure 6 indicates that idle-mode CO failures occurred more frequently at the screening facility and the ARB lab than at the first Smog Check station. However, Figure 7 indicates that 2500 rpm CO failures were much more of a problem. Thirty-seven percent of the vehicles failed the 2500 rpm CO standards when tested at the screening facility. This failure rate dropped to 6% at the ARB lab and to 0% at the first Smog Check station.

Figure 6



As shown in Figure 7, the results at Smog Check station #1 indicate a large increase in the number of vehicles in the lowest emission level range (0-0.2%). A significant number of vehicles that failed the test at the screening facility or the ARB laboratory were well under the standard when tested at the Smog Check station. Preconditioning differences are the expected reason for the variability in failure rate.

Figure 7



1980+ 3-way Catalyst Vehicles

Figure 8 indicates why some of the vehicles that passed when they were tested at the first Smog Check station failed when they were taken to a second station. For 1980 and later models, 36.4% of the vehicles failing at the second station had underhood defects that were missed at the first station and detected at the second station. 63.6% of the vehicles failed at the second station because of higher tailpipe emissions.

Figure 8

Reasons Why Vehicles Failed 2nd Smog Check After Passing First Smog Check (1980 and Later Models)

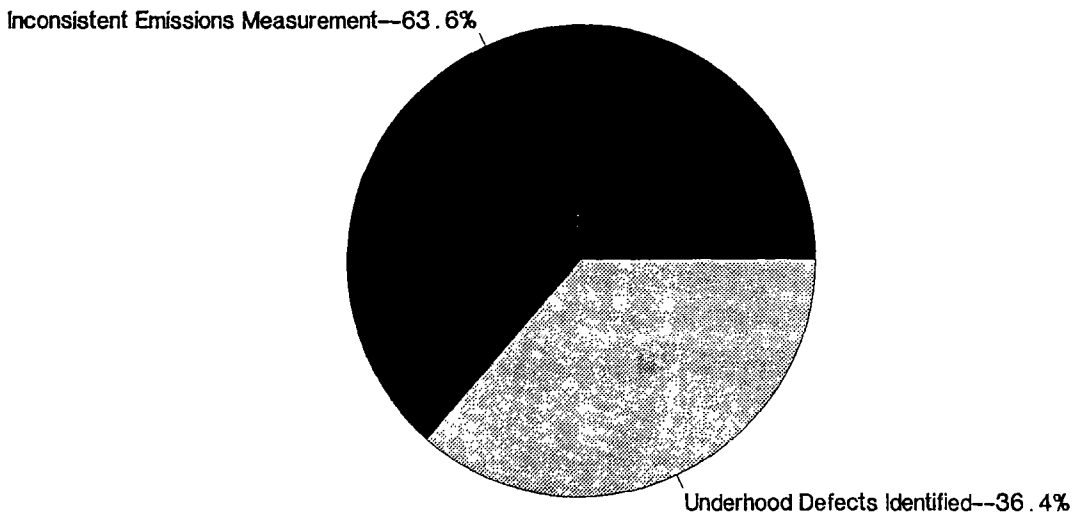
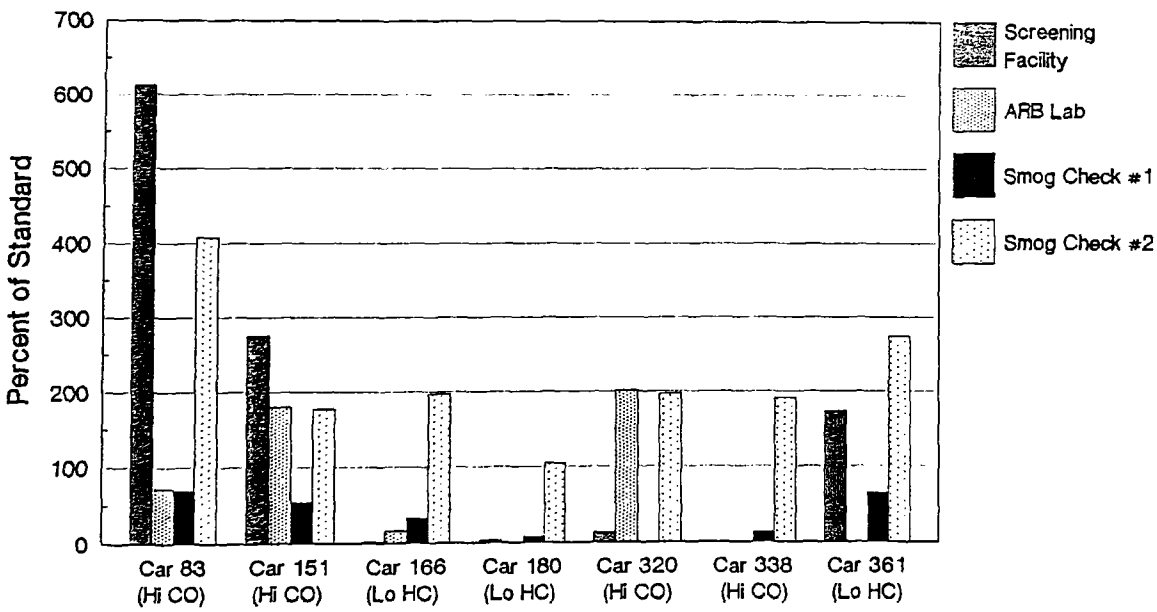


Figure 9 illustrates how variable the tailpipe emission measurements of seven different vehicles* were from site-to-site. The results shown in the figure are for 1980 and later model vehicles that passed at the first Smog Check station and failed at the second one. Note that in some cases the passing results at the first Smog Check station are almost identical to the results at the ARB lab or the screening facility. In other cases the failing results at the second station are more like those at the ARB lab or the screening facility. Note also that the variability between the screening facility and the ARB

Figure 9

Examples of Tailpipe Measurement Inconsistency Between Inspection Sites (1980 and Later Models)



"Hi CO" means 2500 rpm CO standard.
"Lo HC" means idle HC standard.

* #83 = '82 Ford Fairmont, 3.3L, 6-cyl, carb, AIR, 3-way, open-loop
#151 = '81 Toyota Corolla, 1.8L, 4-cyl, carb, AIR, closed-loop
#166 = '81 Nissan 200SX, 2.0L, 4-cyl, FI, no-AIR, closed-loop
#180 = '80 Honda 1500DX, 1.5L, 4-cly, carb, no-AIR, open-loop
#320 = '80 Chrysler Cordoba, 5.2L, 8-cyl, carb, AIR, closed-loop
#338 = '81 Ford Fairmont, 4.9L, 8cyl, carb, AIR, closed-loop
#361 = '82 Pontiac Firebird, 2.5L, 4-cyl, FI, no-AIR, closed-loop

lab appears to be as great as the variability between Smog Check Stations. This a clear indication that the variability is in the vehicles rather than the instrumentation.

Table 6 contains the results of an analysis of the TAS data by technology group. It should be noted that the sample size is too small to draw conclusions for several of the groups. Figure 10 summarizes the analysis for three technology groups that had a sample size of more than thirty vehicles. As the figure shows, there does not appear to be a major difference between the identification of defective vehicles by Smog Check stations based on these technology differences.

Table 6

Modal Tailpipe Failure Rates of
Undercover Vehicles that Failed at First Smog Check
vs. Vehicles that were Incorrectly Passed,
By Technology Group (1980 and Later Models Only)

Sample Group	Test Location	Sample† Size	I/M Test Results Smog #1	Smog #2	Tailpipe Failure Rates (%) Idle	2500 Only	Idle and/or 2500
No Catalyst	Smog Check #1	12	F	-	25.0	50.0	75.0
		0	P	F	-	-	
		6	P	P	0.0	0.0	0.0
	ARB Lab (Breezeway)	12	F	-	50.0	50.0	100.0
		0	P	F	-		-
		6	P	P	0.0	0.0	0.0
	Screening Facility	12	F	-	50.0	50.0	100.0
		0	P	F	-	-	-
		6	P	P	0.0	0.0	0.0

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).

Table 6 (continued)

Modal Tailpipe Failure Rates of
Undercover Vehicles that Failed at First Smog Check
vs. Vehicles that were Incorrectly Passed
By Technology Group (1980 and Later Models Only)

Sample Group	Test Location	Sample† Size	I/M Test Results Smog #1	Smog #2	Tailpipe Failure Rates (%) Idle	2500 Only	Idle and/or 2500
		19	F	-	31.6	15.8	47.4
	Smog Check #1	6	P	F	0.0	0.0	0.0
		24	P	P	0.0	0.0	0.0
CARB/	ARB Lab	19	F	-	0.0	31.6	31.6
OXD/NoAIR	(Breezeway)	6	P	F	0.0	0.0	0.0
		24	P	P	0.0	0.0	0.0
	Screening	19	F	-	15.8	36.8	52.6
	Facility	6	P	F	0.0	0.0	0.0
		24	P	P	0.0	0.0	0.0
		104	F	-	63.5	23.1	86.5
	Smog Check #1	0	P	F	-	-	-
		75	P	P	0.0	0.0	0.0
CARB	ARB Lab	107	F	-	47.7	16.8	64.5
OXD/AIR	(Breezeway)	0	P	F	-	-	-
		78	P	P	15.4	7.7	23.1
	Screening	101	F	-	58.4	23.8	82.2
	Facility	0	P	F	-	-	-
		81	P	P	18.5	11.1	29.6
		43	F	-	48.8	7.0	55.8
	Smog Check #1	3	P	F	0.0	0.0	0.0
		6	P	P	0.0	0.0	0.0
CARB/	ARB Lab	49	F	-	42.9	6.1	49.0
3WAY/OXD	(Breezeway)	3	P	F	0.0	0.0	0.0
		6	P	P	0.0	0.0	0.0
	Screening	49	F	-	55.1	26.5	81.6
	Facility	3	P	F	0.0	100.0	100.0
		6	P	P	50.0	0.0	50.0

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).
* Data coding errors.

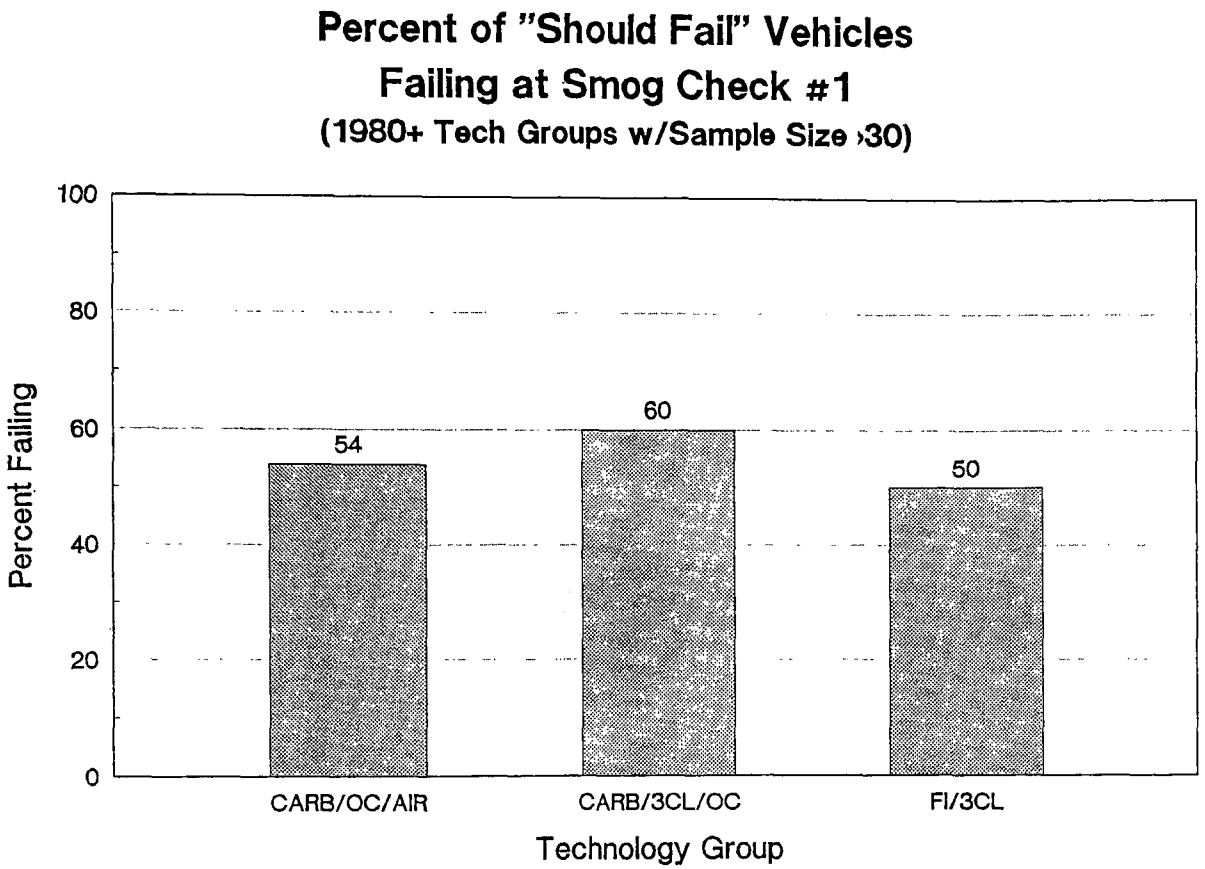
Table 6 (continued)

Modal Tailpipe Failure Rates of
Undercover Vehicles that Failed at First Smog Check
vs. Vehicles that were Incorrectly Passed,
By Technology Group (1980 and Later Models Only)

Sample Group	Test Location	Sample† Size	I/M Test Results Smog #1	Smog #2	Tailpipe Failure Rates (%) Idle	2500 Only	Idle and/or 2500
		24	F	-	62.5	0.0	62.5
	Smog Check #1	0	P	F	-	-	
		6	P	P	0.0	0.0	0.0
CARB/	ARB Lab	27	F	-	55.6	0.0	55.6
3CL	(Breezeway)	0	P	F	-		
		6	P	P	50.0	0.0	50.0
	Screening	27	F		74.1	3.7	77.8
	Facility	0	P	F	-		
		6	P	P	00.0	0.0	100.0
		221	F		40.7	27.2	67.9
	Smog Check #1	15	P	F	0.0	0.0	0.0
		87	P	P	0.0	*3.5	*3.5
CARB/	ARB Lab	237	F	-	35.4	11.4	46.8
3CL/OXD	(Breezeway)	18	P	F	16.7	33.3	50.0
		87	P	P	10.3	13.8	24.1
	Screening	238	F		50.0	24.0	74.0
	Facility	18	P	F	33.3	16.7	50.0
		87	P	P	17.2	20.7	37.9
		67	F		76.1	4.5	80.6
	Smog Check #1	6	P	F	0.0	0.0	0.0
		54	P	P	*5.6	0.0	*5.6
FI/	ARB Lab	68	F	-	48.5	4.4	52.9
3CL	(Breezeway)	6	P	F	0.0	0.0	0.0
		54	P	P	38.9	0.0	38.9
	Screening	68	F	-	86.8	0.0	86.8
	Facility	6	P	F	50.0	0.0	50.0
		54	P	P	55.6	0.0	55.6

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).
* Data coding errors.

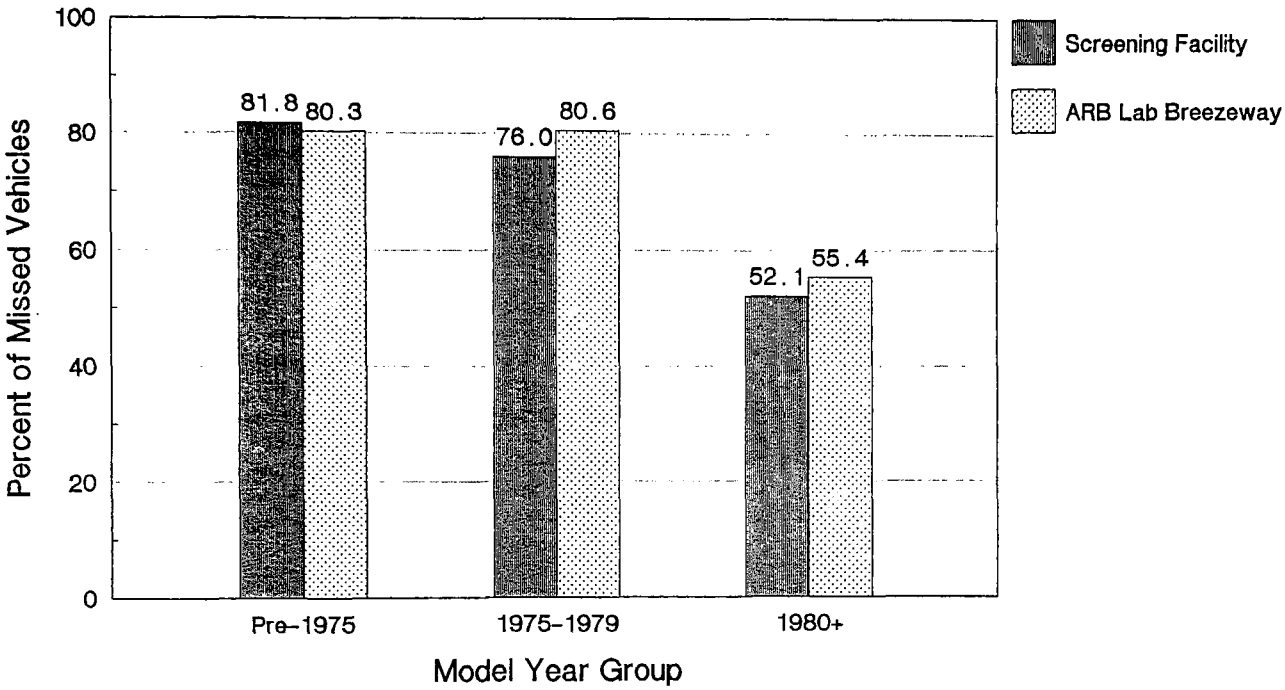
Figure 10



Underhood Inspection Variability - It is apparent from the preceding subsection that significant differences in tailpipe emission measurements occurred at the three different inspection sites. However, it is also clear from the data that most of the vehicles that passed at Smog Check station #1, after failing at the screening facility or the ARB laboratory, must have been underhood-only failures. The percentage of the vehicles that were underhood-only failures has now been precisely computed and is shown in Figure 11.

Figure 11

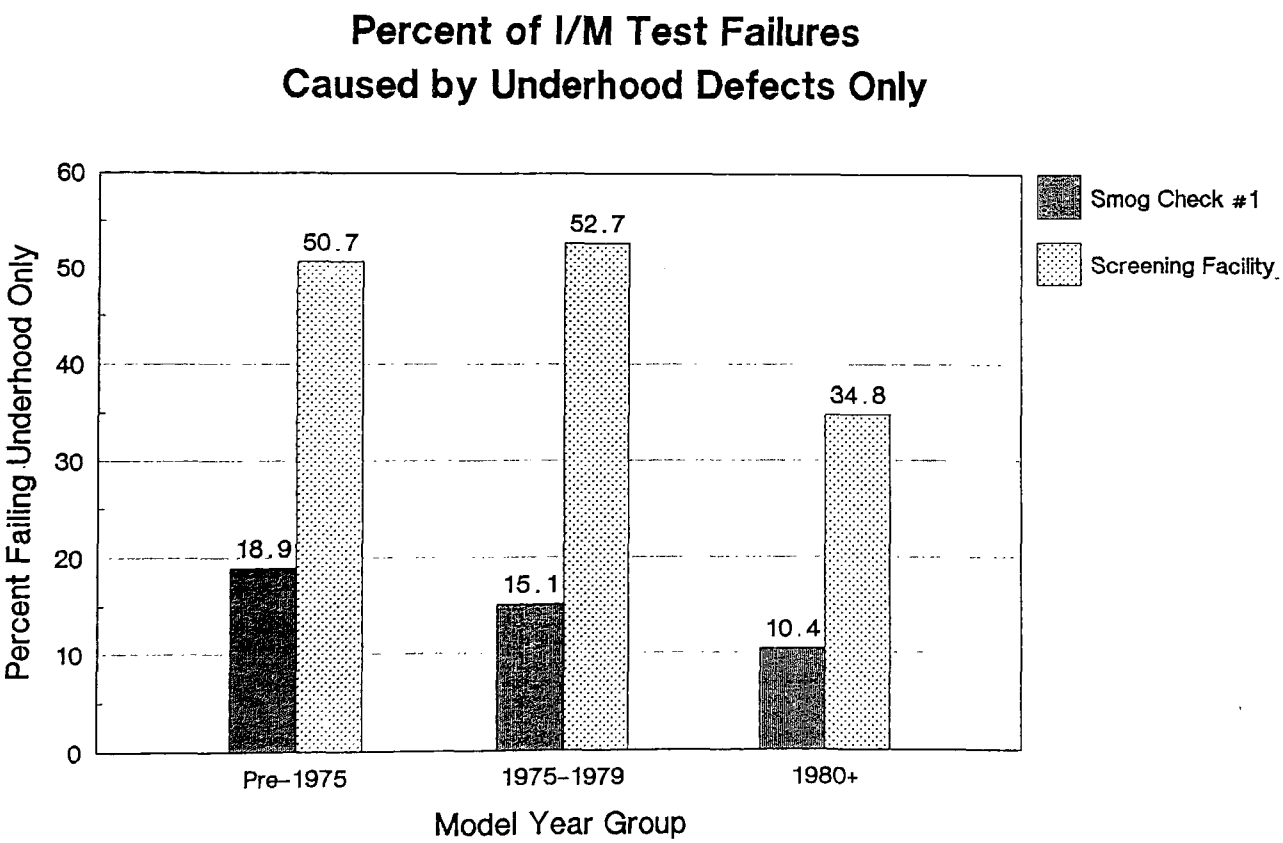
Percent of Vehicles Missed at Smog Check #1 That Were Underhood-Only Failures



Based on tests at the screening facility, 52.1% of the 1980 and later model vehicles that passed the test at Smog Check station #1 were underhood-only failures. Based on tests at the ARB laboratory, almost the same portion (55.4%) of these vehicles were underhood-only failures.

Figure 12 indicates that the Smog Check stations did catch some of the vehicles that contained only underhood defects. Of those vehicles that failed at the screening facility, over 50% of the pre-1980 models contained only underhood defects. For 1980 and later models, the underhood-only failures were just about 35% of the failing vehicles. As the figure shows, less than half as many underhood-only failures occurred at the first Smog Check station.

Figure 12



Emission Reductions Table 7 shows the emission reductions that were recorded for vehicles repaired at Smog Check stations. (Note that no data are available for vehicles which passed at both Smog Check stations because they were never repaired.) The data contained in Table 7 have been translated into grams per mile changes, and both the percent reductions and mass emission changes are illustrated for each model-year range in Figures 13, 14, and 15. As the figures show, model-year range seems to have a significant effect on the emissions reductions achieved for vehicles that do not fail until the second Smog Check station. On both a percent reduction and a mass emissions

Table 7

Baseline FTP Emissions and Average Emission Reductions of Undercover Vehicles that Failed at First Smog Check vs. Vehicles that were Incorrectly Passed By Model Year Range

Sample Group	Sample† Size	I/M Test Results	Baseline FTP Emissions (g/mi) HC	CO	NOx	Emissions Reductions (in %) HC	CO	NOx
All Vehicles	1532	Fail/N.A.	5.09	48.41	2.37	32.5	18.6	8.5
	129	Pass/Fail	3.43	34.89	2.70	29.9	-5.8	12.0
	573	Pass/Pass	1.91	27.54	2.17	--	--	--
Pre-1975	422	Fail/N.A.	10.39	69.99	3.30	36.8	9.2	9.4
	33	Pass/Fail	8.06	58.52	3.78	53.5	10.8	18.2
	108	Pass/Pass	4.92	71.88	3.06	--	--	--
1975-1979	583	Fail/N.A.	4.23	49.02	2.74	25.9	20.5	9.8
	57	Pass/Fail	2.40	36.40	2.84	3.8	-1.4	3.5
	213	Pass/Pass	1.66	21.78	2.66	--	--	--
1980+	527	Fail/N.A.	1.80	30.44	1.21	30.2	32.4	3.3
	39	Pass/Fail	1.04	12.68	1.58	-37.2	-89.1	21.9
	252	Pass/Pass	0.82	13.40	1.37	--	--	--

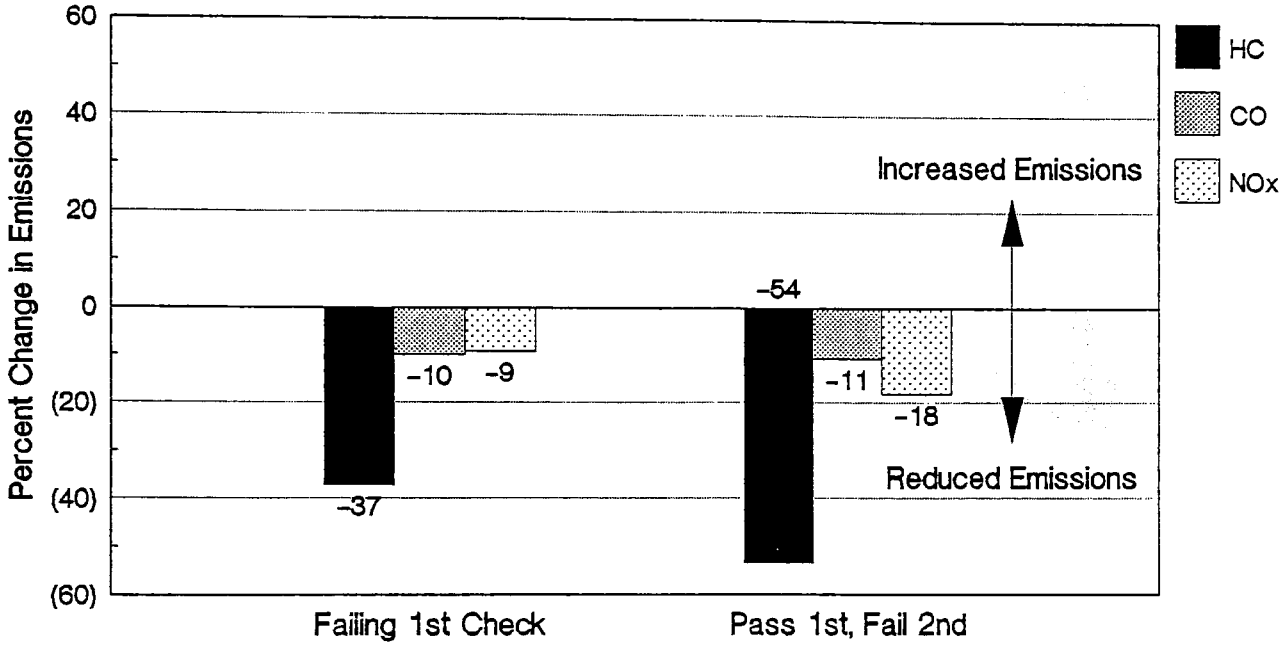
† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).

basis, pre-1975 models that fail at the second Smog Check station achieve just as great an emissions reduction as those that fail the first time. However, Figure 14 indicates that 1975-1979 models that pass the first Smog Check receive no significant benefit from repairs performed at the second Smog Check station. Figure 15 indicates that 1980 and later models exhibit yet another trend. They obtain significant NOx emission reductions when they are repaired after failing at the second Smog Check station, but HC and CO emissions are higher after repair.

The significant emission reductions achieved with pre-1975 vehicles that do not fail until the second Smog Check might be expected to result from the correction of underhood-only defects such as air injection tampering and EGR disconnects. A greater percentage of EGR problems could cause the simultaneous HC and CO increases and NOx reductions observed after repair of the 1980 and later models. Review of the individual vehicle data indicates that such defect identification trends did, in fact, occur. Half of the 1980 and later models which had underhood-only defects identified at the second Smog Check station had EGR tampering corrected. The other half had minor problems (such as disconnected heat stoves) identified and corrected that would not be expected to contribute to significant emission reductions. However, the sample sizes are just too small to draw any firm conclusions about model-year range differences.

Figure 13

Change in Emissions Due to Repairs Pre-'75 Vehicles Failing 1st Smog Check vs. Vehicles Passing 1st Check, Failing 2nd



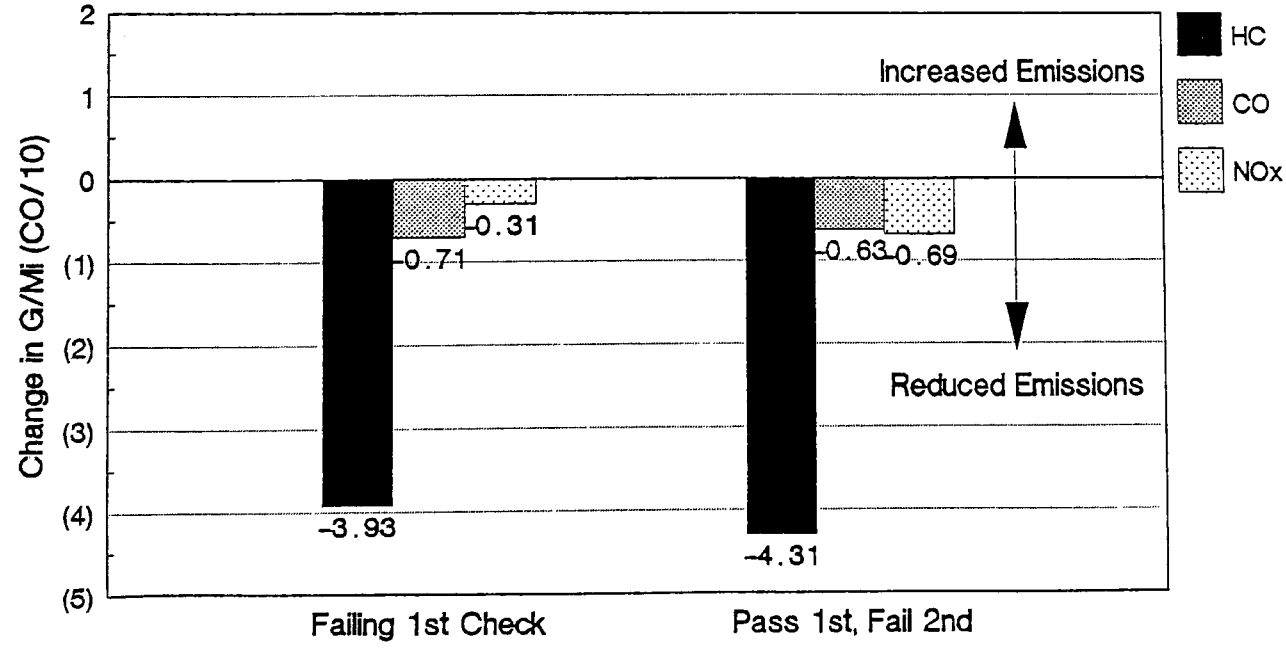
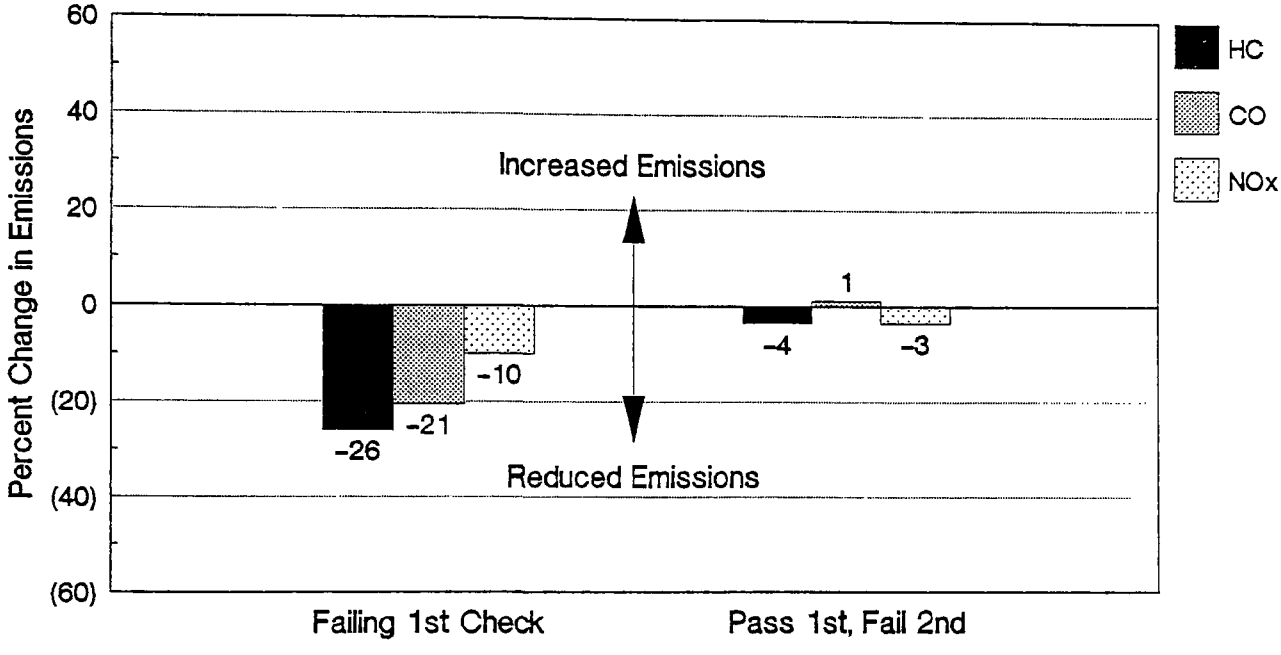


Figure 14

Change in Emissions Due to Repairs '75–'79 Vehicles Failing 1st Smog Check vs. Vehicles Passing 1st Check, Failing 2nd



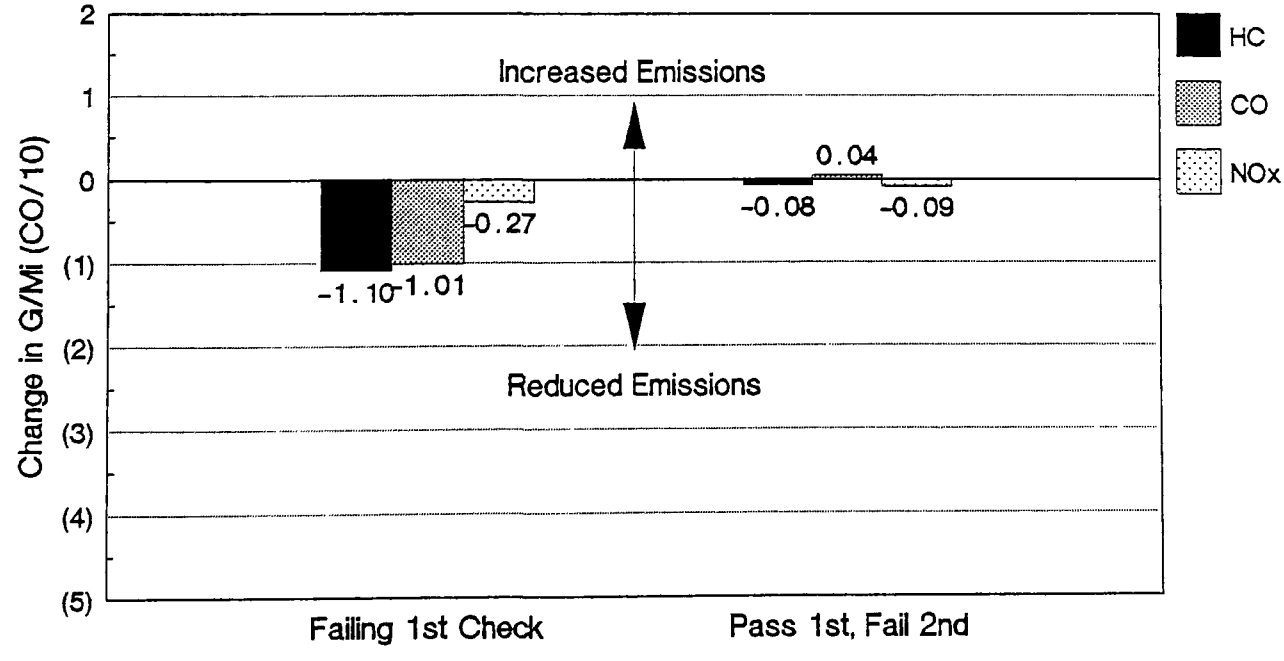
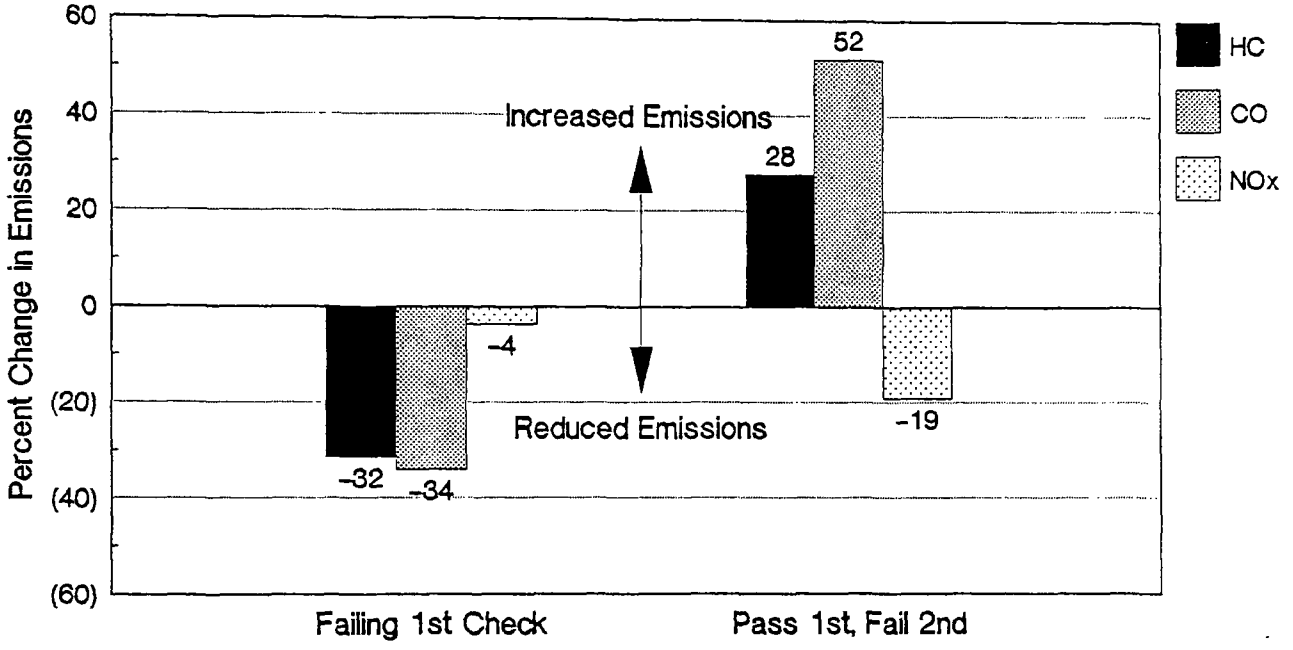
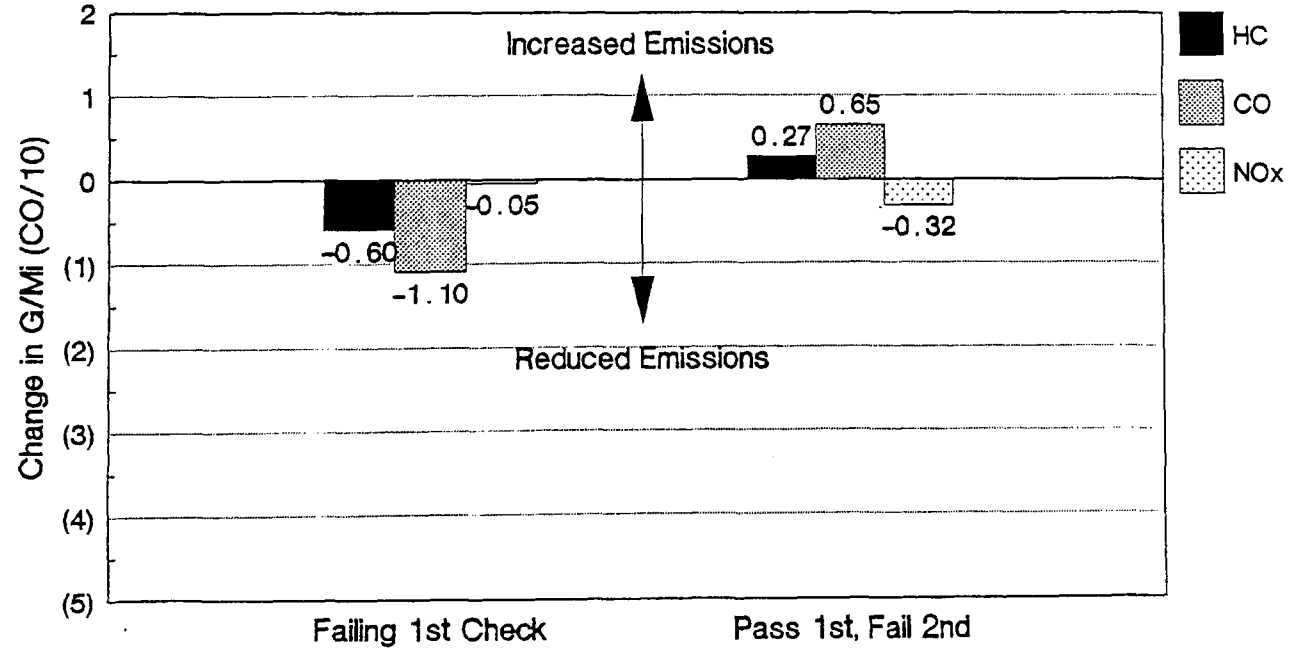


Figure 15

Change in Emissions Due to Repairs
1980+ Vehicles Failing 1st Smog Check vs. Vehicles Passing 1st Check, Failing 2nd





Similar problems with small sample size frustrate analysis of technology-specific differences in achieved emission reductions when comparing vehicles that failed the first Smog Check with those that passed the first Smog Check and failed the second. The results for seven technology categories are shown in Table 8.

Table 8

Baseline FTP Emissions and Average Emission Reductions of Undercover Vehicles that Failed at First Smog Check vs. Vehicles that Incorrectly Passed By Technology Group (1980 and Later Model Only)

Tech. Group	Sample† Size	I/M Test Results	Baseline FTP Emissions (g/mi) HC	CO	NOx	Emissions Reductions (in %) HC	CO	NOx
No Catalyst	12	Fail/N.A.	2.43	32.29	1.76	12.3	14.0	0.0
	0	Pass/Fail	-	-		--	--	--
	3	Pass/Pass	2.23	20.18	2.00	--	--	--
CARB/ OXD/NoAIR	19	Fail/N.A.	0.54	7.82	1.50	2.9	11.2	17.6
	9	Pass/Fail	0.63	6.08	0.97	10.9	-8.6	8.4
	24	Pass/Pass	0.49	4.83	1.09	--	--	--
CARB/ OXD/AIR	110	Fail/N.A.	2.16	35.12	1.33	28.4	21.5	-13.3
	0	Pass/Fail	-		-	--	--	--
	72	Pass/Pass	0.99	21.06	1.63	--	--	--
CARB/ 3WAY/OXD	48	Fail/N.A.	1.82	32.19	1.26	6.7	21.6	3.0
	3	Pass/Fail	1.95	31.75	1.29	34.6	28.3	6.0
	3	Pass/Pass	1.02	20.18	0.57	--	--	--
CARB/ 3CL	29	Fail/N.A.	1.75	28.60	0.96	37.9	47.1	12.7
	0	Pass/Fail	-	-		--	--	--
	6	Pass/Pass	0.33	5.04	0.71	--	--	--
CARB/ 3CL/OXD	240	Fail/N.A.	1.53	25.23	1.13	32.1	34.1	11.5
	21	Pass/Fail	1.25	14.91	1.84	-58.6	-143.5	23.0
	87	Pass/Pass	0.77	13.42	1.25	--	--	--
FI/ 3CL	69	Fail/N.A.	2.38	46.59	1.17	43.2	47.1	-1.4
	6	Pass/Fail	0.43	5.25	1.71	-86.9	-43.7	35.5
	57	Pass/Pass	0.80	7.48	1.40	--	--	--

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).

Effect of 207(b) Standards - Table 9 shows how the federal 207(b) standards (220 ppm HC, 1.2% CO) failure rates for 1980 and later model year vehicles at the various test sites compare to the failure rates for California standards. As expected, fewer vehicles would have failed if the less stringent 207(b) standards had been used.

Table 9

Comparison of California and 207(b) Failure Rates
for Failed Vehicles Taken to Smog Check Stations

Site	Sample† Size	I/M Test Results	Failure Rate — California Standards Idle Only	California Standards 2500 Only	California Standards Idle and/or 2500	207(b) Standards Idle Only	207(b) Standards 2500 Only	207(b) Standards Idle and/or 2500
Smog Check #1	490	Fail/N.A.	50.8	20.8	71.6	41.0	22.0	63.1
	30	Pass/Fail	0.0	0.0	0.0	0.0	0.0	0.0
	258	Pass/Pass	*1.2	*1.2	*2.3	0.0	1.2	1.2
ARB Lab	519	Fail/N.A.	40.5	12.1	52.6	35.3	12.7	48.0
	33	Pass/Fail	9.1	18.2	27.3	0.0	18.2	18.2
	261	Pass/Pass	17.2	6.9	24.1	6.9	6.9	13.8
Screening Facility	514	Fail/N.A.	57.0	21.0	78.0	41.1	24.3	65.4
	33	Pass/Fail	27.3	18.2	45.5	18.2	18.2	36.4
	264	Pass/Pass	26.1	10.2	36.4	14.8	12.5	27.3

† Sample size is the "weighted" sample: ("X" cars) + 3 x (non-"X" cars).
* Data coding errors.

Table 10 shows what the effect of the 207(b) standards would have been on the average emissions of failing vehicles and the emission reductions achieved as a result of repair. (Vehicles that failed based on underhood inspection defects are included in both samples, regardless of their emission levels.) As the table shows, the average emissions of the vehicles failing the 207(b) standards are somewhat higher but the percent reduction resulting from repair is almost identical to the vehicles failing the California standards. Note, however, that the total emission reduction achieved with the California standards is 8.7% higher for HC, 1.9% higher for CO, and 51.7% higher for NOx. This is due to the fact that more vehicles fail under the California standards (159 vs. 131).

Table 10

Effect of Emission Standards
on I/M Emission Reductions*
(1980 and Later Models)

	California Standards			207(b) Standards		
	HC	CO	NOx	HC	CO	NOx
Before I/M	1.89	32.2	1.25	2.11	37.1	1.32
After Repair	1.29	21.2	1.20	1.44	24.0	1.28
Reduction	31.5%	34.1%	3.7%	31.9%	35.4%	3.3%
Number of Failing Vehicles	159			131		
Increased Mass Emissions	8.7%	1.9%	51.7%			

* X sample cars did not receive I/M repair since they did not fail at Smog Check #1. This table contains only "F" car reductions.

Finally, Table 11 indicates that the more stringent California idle cutpoints contributed to the inconsistencies that were observed. For vehicles that failed at the screening facility, a greater percentage passed at the ARB breezeway and/or the first Smog Check station under the California standards. The results presented in Table 11 are consistent with the distribution of the idle hydrocarbon emissions shown earlier in Figure 4. That figure showed that a significant number of vehicles had emissions just slightly above 100 ppm HC at the screening facility.

Table 11

Percentage of Inconsistent
Tailpipe Test Results
for 1980 and Later Models

	Type of Inconsistency	
	S/B*	S/B/F†
California Stds.		
Idle	21.9	31.6
2500	16.0	25.4
Idle and/or 2500	46.5	49.5
Fed. 207(b) Stds.		
Idle	13.3	20.3
2500	16.4	26.1
Idle and/or 2500	27.0	39.5

Note: S = Screening facility.
B = ARB breezeway.
F = Field inspection (Smog Check #1).

*Vehicles with inconsistencies between screening facility and ARB breezeway, irrespective of Smog Check #1 results

†Vehicles with inconsistencies between any two test locations

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