sierra research

Report No. EPA 460/3-88-011

Analytical Support for Emission Factors Development and Air Quality Assessment

Work Assignment No. 0-01:

Analysis of California I/M Review Committee Data

Task 6 Report:

Supplemental Analysis of Random Roadside Survey Data

prepared for:

U.S. Environmental Protection Agency

September 30, 1988

prepared by:

Sierra Research, Inc.
1521 I Street
Sacramento, California 95814
(916) 444-6666

EPA 460/3-88-011

ANALYTICAL SUPPORT FOR EMISSION FACTORS DEVELOPMENT AND AIR QUALITY ASSESSMENT

EPA Contract No. 68-03-3474

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

Task 6 Report:
Supplemental Analysis of
Random Roadside Survey Data

prepared for:

U.S. Environmental Protection Agency

September 30, 1988

prepared by:

Thomas C. Austin
Thomas R. Carlson
Kathryn A. Gianolini

Sierra Research, Inc.
1521 I Street
Sacramento, CA 95814
(916) 444-6666

ANALYTICAL SUPPORT FOR EMISSION FACTORS DEVELOPMENT AND AIR QUALITY ASSESSMENT

Task 6 Report: Supplemental Analysis of Random Roadside Survey Data

Table of Contents

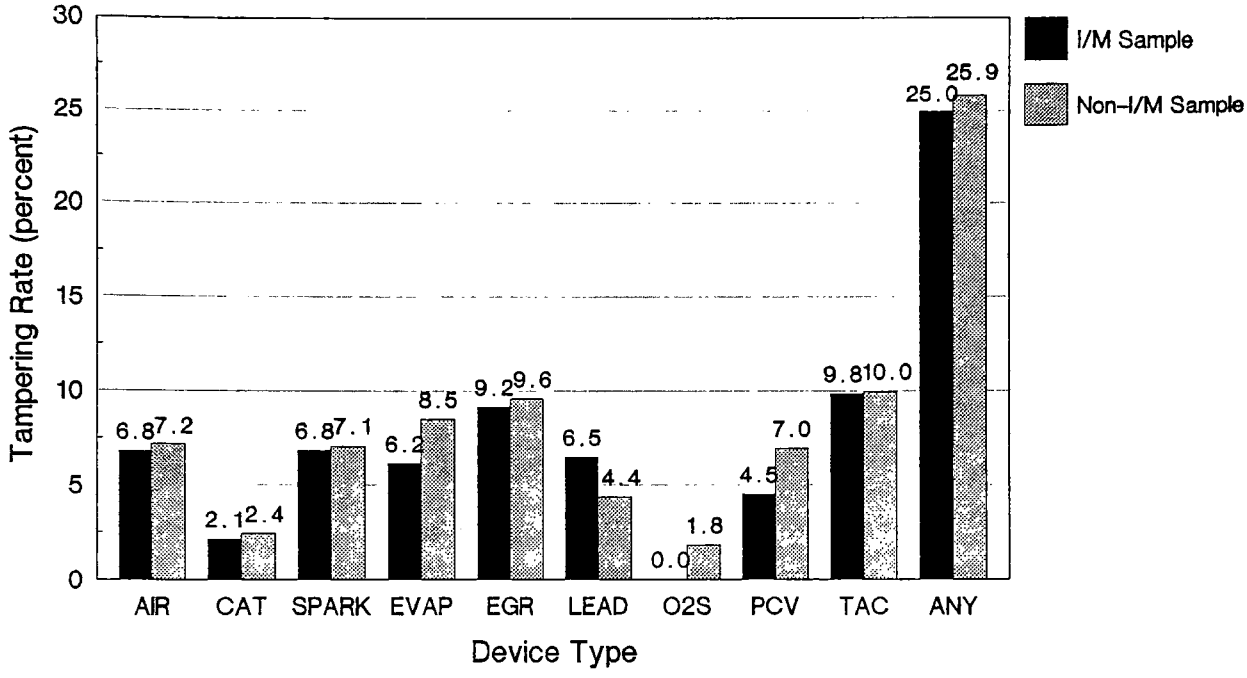
1. SUMMARY

During 1985 and 1986, the California Highway Patrol (CHP) detained a random sample of vehicles at the roadside so that they could be inspected by employees of the California Air Resources Board (CARB) and the California Bureau of Automotive Repair (BAR). The results of the "Random Roadside Surveys" appeared to show that the California vehicle inspection and maintenance (Smog Check) program was having a relatively minor impact on the overall rate of defects observed during "underhood" inspections.

In response to a task assigned by EPA, an analysis was conducted to determine whether the apparently small effect from I/M on underhood failure rates is caused by certain high failure rate components masking significant effects on lower-rate but more emission-critical components. The overall results of the analysis are illustrated in Figure 1. The results shown in the figure compare the observed tampering rates for vehicles that had already received an I/M test ("I/M Sample") to vehicles located in the same geographic area that had not yet been required to be inspected ("Non-I/M Sample"). As the figure shows, there does not appear to be a substantial and consistent reduction in tampering rates for individual components on the I/M Sample that is masked by one or more of the components. A similar analysis for non-tampering related defects shows the same trend.

Figure 1

Underhood "Tampering" Rates
I/M vs. Non-I/M Vehicles
1985 Roadside Survey



Note: 1984 and later models removed from sample to eliminate age bias.

Legend:

AIR = air injection

CAT = catalytic converter

SPARK = spark advance controls

EVAP = evaporative emission controls

EGR = exhaust gas recirculation

LEAD = fillpipe lead restrictor

O2S = exhaust oxygen sensor

PCV = positive crankcase ventilation

TAC = thermostatic air cleaner

Not shown in the figure are the results of a "Plumbtesmo" test for tailpipe lead deposits. (This is not one of the standard underhood inspections performed under the California I/M program.) During the Roadside Survey, Plumbtesmo results indicated a similar pattern to the lead restrictor check. Of those vehicles designed for the exclusive use of unleaded fuel, 7.0% of I/M vehicles showed tailpipe lead deposits and 4.6% of the non-I/M vehicles showed lead deposits. The reason for this anomalous result was not clear.

More detailed analysis of the available data shows that it is the pre-1975 model vehicles which appear to benefit the most from I/M (as far as underhood failure rates and tampering correction are concerned). However, the analysis indicates that all vehicle age groups experienced less of a reduction in underhood failure rates than would have been expected with properly performed inspections and repairs. Although the I/M program was having a beneficial effect on underhood failure rates, there appears to be room for significant improvements.

###

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 perform an analysis of California I/M data for the ECTD Technical Support Staff (TSS). Task number 6 of that Work Assignment required supplemental analysis of data obtained from a random sample of vehicles stopped by the California Highway Patrol.

With references to an earlier report that Sierra prepared for CARB ("Technical Appendix"), the general direction provided by TSS was as follows:

> Section 3 of the Technical Appendix presents roadside "underhood" inspection results by component and by I/M or non-I/M, but not by the combination. The contractor shall provide this breakdown of results for the 1985 and 1986 roadside surveys, and also show for comparison the Smog Check failure rates by component. The analysis should be performed on a statewide basis, unless the sample size distribution among regions is much different for the roadside sample than for the Smog Check sample, in which case the contractor shall apply weighting factors to one data set or the other. Adjustment for mileage differences is not required, but substantial mileage differences between corresponding I/M and non-I/M strata should be addressed. The purpose of the analysis is to determine whether the apparent lack of effect from I/M on an overall underhood basis is the result of high failure rate

components masking significant effects on lower-rate but more emission-critical components.

Background

Under a contract with the California Air Resources Board, Sierra obtained and analyzed data on the condition of vehicles in customer service from the results of inspections of thousands of vehicles detained at CHP roadblocks. Teams of technicians from ARB and BAR did the inspections, which came to be referred to as the "Random Roadside Surveys". In order to determine possible regional differences in the condition of the vehicle fleet, road blocks were set up in a variety of areas from San Diego north to Sacramento.

During the Random Roadside Surveys, each vehicle was subjected to the same visual and functional inspections specified under the California I/M (Smog Check) program. In addition, chemical tests (Plumbtesmo) of vehicle tailpipes were used to detect the use of leaded gasoline. Emissions from each vehicle were measured using the same idle and 2500 rpm test procedures used in the Smog Check program.

The results of the Random Roadside Surveys indicated that visual and functional inspection failure rates are very high. During the 1986 survey, about 40% of all vehicles inspected contained visual or functional defects. A 14.6% visual/functional defect rate for 1980 and later models was the lowest of the three model year groups analyzed. For 1975-1979 models and for pre-1975 models, visual and functional defects were much higher at 62.1% and 70.3%, respectively.

More detailed information from the 1985 Random Roadside Survey is shown in Table 1. Table 1 is a reproduction of Table 3-6 from Sierra's earlier report for CARB ("Evaluation of the Smog Check Program, Technical Appendix," Sierra Research, Inc., April, 1987). Individual component failure rates are presented for air injection systems (AIR), catalytic converters (CAT), spark advance control systems (SPARK), evaporative emission control systems (EVAP), fillpipe lead restrictors (LEAD), exhaust gas oxygen sensors (O2S), positive crankcase ventilation systems (PCV), and thermostatically controlled air cleaners (TAC). These are the same emission control related components that are required to be inspected visually under the Smog Check program. The sample sizes for the various categories of vehicles shown in the table were as follows:

Model Year Range	I/M Sample	Non-I/M Sample
pre-1975	236	216
1975-79	235	261
1980 and Later	174	246
Total Sample	645	723

The underhood failure rates shown in Table 1 are expressed in several different ways. For each category, the failure rate is shown for "broken" and "tampered" devices, as well as for the "total" defect rate. A "broken" component is one that was determined to be non-functional for reasons other than "tampering". In other words, there was no evidence that the device had been intentionally removed or disconnected. An example of a "broken" device would be an air pump

Table 1

Underhood Inspection Results - 1985 Roadside Survey

		----- Failure Percentage by Type of Broken or Tampered Device -----									
		AIR	CAT	SPARK	EVAP	EGR	LEAD	O2S	PCV	TAC	ANY
All Model Years With Device	Broken	3.32	0.08	1.80	2.60	14.58	0.17	0.19	2.55	8.76	
	Tamper	6.04	2.03	6.63	6.37	8.07	4.33	0.56	5.04	9.07	
	Total	9.36	2.11	8.43	8.97	22.65	4.50	0.75	7.59	17.83	
	Usage	63.2%	65.5%	89.2%	89.3%	71.2%	66.4%	29.6%	99.7%	88.3%	
All Model Years All Vehicles	Broken	2.10	0.06	1.60	2.32	10.39	0.11	0.06	2.54	8.76	22.15
	Tamper	3.31	1.33	5.91	5.69	5.75	2.87	0.17	5.03	8.01	22.65
	Total	5.91	1.39	7.51	8.01	16.14	2.98	0.23	7.57	15.74	37.24
Pre-75 Model Years With Device	Broken	**7.05**	--	3.45	**6.55**	**40.14**	--	--	**4.92**	13.97	
	Tamper	**23.08**	--	14.78	**19.37**	**23.81**	--	--	**13.07**	24.83	
	Total	**30.13**	--	18.23	**25.92**	**63.95**	--	--	**17.99**	38.80	
	Usage	29.4%	--	98.3%	66.2%	27.7%	--	--	99.6%	85.1%	
Pre-75 Model Years All Vehicles	Broken	2.08	--	3.40	4.34	11.13	--	--	4.91	11.89	30.75
	Tamper	6.79	--	14.53	12.83	6.60	--	--	13.02	21.13	42.08
	Total	8.87	--	17.93	17.17	17.73	--	--	17.93	33.02	60.38
75-79 Model Years With Device	Broken	**5.99**	0.00	1.62	**3.44**	**21.38**	0.41	0.00	**2.49**	12.23	
	Tamper	**6.22**	**4.43**	4.86	**5.43**	**12.83**	**9.13**	0.00	**3.37**	5.63	
	Total	**12.21**	**4.43**	6.48	**8.87**	**34.21**	**9.54**	0.00	**5.86**	18.86	
	Usage	77.0%	84.0%	98.4%	97.9%	87.1%	85.5%	4.26%	99.8%	91.3%	
75-79 Model Years All Vehicles	Broken	4.61	0.00	1.60	3.37	18.62	0.35	0.00	2.48	11.17	34.22
	Tamper	4.79	3.72	4.79	5.32	11.17	7.80	0.00	3.37	5.14	27.13
	Total	9.40	3.72	6.39	8.69	29.79	8.15	0.00	5.85	16.31	49.11
1980+ Model Years With Device	Broken	0.18	0.00	0.37	0.00	**3.69**	0.00	0.20	0.84	2.21	
	Tamper	1.08	0.28	0.56	0.70	0.92	0.98	0.40	0.42	0.63	
	Total	1.26	0.28	0.93	0.70	4.61	0.98	0.60	1.26	2.84	
	Usage	77.2%	98.9%	75.1%	99.6%	90.9%	99.4%	70.7%	99.6%	88.4%	
1980+ Model Years All Vehicles	Broken	0.14	0.00	0.28	0.00	3.35	0.00	0.14	0.84	1.96	6.28
	Tamper	0.84	0.28	0.42	0.70	0.84	0.98	0.28	0.42	0.56	4.75
	Total	0.98	0.28	0.70	0.70	4.19	0.98	0.42	1.26	2.52	10.75

that was "frozen" or an EGR valve that was stuck closed but still connected. An example of "tampering" would be an air pump that had been removed or disconnected, or an EGR system with a vacuum line removed or plugged.

The defect rates shown in Table 1 are also presented separately for vehicles "with device" and for "all vehicles". The "with device" failure rates are computed based on the number of vehicles that were supposed to have a particular device installed. That is, the failure rate for air pumps was calculated by dividing the number of vehicles with broken or tampered air pumps by the total number of vehicles that were factory equipped with air pumps. The failure rates for "all vehicles" were computed by dividing the number of vehicles with broken or tampered air pumps by the total number of vehicles, regardless of whether they were supposed to be equipped with air pumps.

The relationship between the "with device" failure rates and the "all vehicles" failure rates is determined by the percentage of inspected vehicles that were supposed to be equipped with a particular emissions control device. In Table 1, the rows entitled "usage" show the percentage of all vehicles in the sample that were supposed to be equipped with a particular device. For example 63.2% of all vehicles in the sample were factory-equipped with air injection systems and 65.5% of all vehicles were factory-equipped with catalytic converters. As Table 1 shows, usage rates are approaching 100% for evaporative emission control systems and PCV systems. The lowest overall usage rate for the devices listed is for exhaust oxygen sensors since the

first O_2 sensors were not introduced until 1977 (and not in substantial numbers until 1980).

Several of the defect rates shown in Table 1 are in boldface type. These are the defects that are believed to have the greatest effect on emissions. For pre-1975 model vehicles, boldface type is used for air injection, evaporative controls, EGR, and PCV. Defects in these components can have a large adverse effect on emissions, and the defect rates reported are very high, ranging from 17.99% for PCV to 63.95% for EGR. Tampering with thermostatically controlled air cleaner systems is also high; however, the effect on emissions of such tampering is small (unless it has resulted in driveability problems and further tampering).

For 1975-1979 models, defect rates are about half the rate for pre-1975 models, but still significant. In the 1985 survey, one year after the beginning of the Smog Check program, catalyst tampering was 4.43%. EGR defects were 34.21%, most of which is <u>not</u> related to tampering. Almost 10% of the catalyst equipped vehicles have fuel inlet restrictors large enough to allow the insertion of a leaded fuel nozzle.

For 1980 and later models, defect rates are much lower. Catalyst tampering is almost non-existent, but EGR defects total 4.61%. Evaporative emission control system defects are over 90% lower than for 1975-1979 models.

Table 2 is a reproduction of Table 3-7 from the earlier Sierra report. Table 2 shows an analysis of the 1985 Roadside data in which cars that had already been through the Smog Check program are compared to those which had not yet had an inspection. For 1979 and earlier models, vehicles which had already been through the Smog Check program had consistently lower failure rates. This trend is not apparent for newer cars.

Table 2

1985 Roadside Survey Results
I/M vs. No I/M Vehicles

		Failure Rate		
		Tailpipe	Underhood	Overall
Pre-1975 Models	I/M	36.6%	56.4%	66.8%
	No I/M	39.8%	60.6%	72.7%
1975-1979 Models	I/M	26.3%	53.6%	60.3%
	No I/M	34.1%	54.3%	64.3%
1980-1983 Models	I/M	19.5%	15.7%	31.4%
	No I/M	15.1%	16.4%	26.6%
All Model Years	I/M	27.7%	42.5%	53.4%
	No I/M	30.1%	44.8%	55.5%

Methodology

As shown in Table 2, there does not appear to be a major reduction in underhood failure rates associated with a vehicle having been through

the I/M program. However, without any more detailed information, it is not clear whether the results are consistent for all types of underhood defects. To investigate the possibility that some types of defects are being corrected with greater efficiency, Sierra performed a new analysis of the Random Roadside Survey data.

The objective of the analysis required that the sample of vehicles captured in the Random Roadside Surveys be divided into those which had already been through the Smog Check program before being captured in the roadside sample (the "I/M" group), and those which had not yet been subject to inspection and repair requirements (the "Non-I/M" group). However, it should be noted that many of the "Non-I/M" vehicles were tested under earlier (pre-1984) versions of the I/M program when they went through change of ownership.

To segregate the vehicles in this manner, Sierra developed a methodology under which vehicles from the Random Roadside programs were tagged as "I/M" or "Non-I/M" based on the "Renewal Month", "Year Due" and "Model Year" fields entered during the roadside inspection. Renewal Month was presumably ascertained from the registration sticker on the license plate. Year Due ("E" for even or "O" for odd) was coded from the last digit of the each vehicle's vehicle identification number (VIN). (In California's biennial program, vehicles are "called" for inspection every other year based on the last digit of their VIN: odd in odd years, etc.)

Tables 3 and 4 detail the algorithms that were employed to produce the I/M and non-I/M samples for the 1985 and 1986 surveys. The algorithms were based on the fact that both the 1985 and the 1986 surveys were conducted between March and May.

Table 3

Algorithm for Segregating 1985
I/M vs. Non-I/M Vehicles

1985 Roadside Survey

Model Year	VIN	Renewal Month	Inspection Month	I/M?	Comments
65 - 82	E	1-4	-	No	'84 renewal prior to I/M start
		5-12	-	Yes	1st cycle 5/84-12/84
	O	1-2	-	Yes	1st cycle 1/85-2/85
		3	3	?	Uncertainty w/in month
		3	4,5	Yes	1st cycle 3/85
		4	3,4	?	Uncertainty, IM=3 included due to renewal notice lead
		4	5	Yes	Car had I/M 4/85
		5	-	?	Uncertainty, renewal notice lead
		6-12	-	No	Not till later in '85
83	E	1-4	-	No	Renewal before I/M
		5-12	-	No	No I/M req'd for 1st renewal
	O	1-2	-	Yes	1st cycle 1/85-2/85
		3	3	?	Uncertainty
		3	4,5	Yes	1st cycle 3/85
		4	3,4	?	Uncertainty, renewal notice lead time
		4	5	Yes	Car had I/M 4/85
		5	-	?	Uncertainty, lead time
		6-12	-	No	Not till later in '85
84 - 85		-	-	No	Not yet

Table 4

Algorithm for Segregating 1986
I/M vs. Non-I/M Vehicles

1986 Roadside Survey

Model Year	VIN	Renewal Month	Inspection Month	I/M?	Comments
66 - 82	E	1-2	-	Yes	1st cycle 1/86-2/86
		3	3	?	Uncertainty w/in month
		3	4,5	Yes	1st cycle 3/86
		4	3,4	?	Uncertainty, renewal notice lead time
		4	5	Yes	1st cycle 4/86
		5	-	Yes	1st cycle 5/84
		6-12	-	Yes	2nd cycle 6/86-12/86, 1st cycle 6/84-12/84
	O	-	-	Yes	Had I/M in 1985
83	E	1-2	-	Yes	1st cycle 1/86-2/86
		3	3	?	Uncertainty
		3	4,5	Yes	1st cycle 3/86
		4	3,4	?	Uncertainty
		4	5	Yes	1st cycle 4/86
		5	-	?	Uncertainty
		6-9	-	No	1st I/M will be 6/86-9/86
		10	-	?	Uncertainty,w/year of purchase (82or83) assumed
		11-12	-	Yes	1st cycle 11/84-12/84 (purchase in 82)
	O	-	-	Yes	Had I/M in 1985
84	E	1-2	-	Yes	1st cycle 1/86-2/86
		3	3	?	Uncertainty
		3	4,5	Yes	1st cycle 3/86
		4	3,4	?	Uncertainty
		4	5	Yes	1st cycle 4/86
		5	-	?	Uncertainty
		6-12	-	No	Not until 6/86-12/86
	O	1-9	-	No	Assume veh purchased '84, no I/M till '87
		10	-	?	Some veh's purchased '83, some '84
		11-12	-	Yes	Assume purchased '83, 1st cycle 11/85-12/85
85 - 86		-	-	No	Not yet

The algorithm shown in Table 3 represents and improvement over the algorithm used in Sierra's earlier analysis of the Roadside Survey data for the California I/M Review Committee. The earlier algorithm did not accurately treat 1983 model vehicles with "even" Vehicle Identification Numbers. None of the "even" VIN 1983s should have been in the I/M sample because no I/M test was required before their first registration renewal. In addition, the old algorithm lumped the "odd" VIN vehicles with March-May renewal months together and treated them all as "uncertain". The new algorithm uses the inspection month information to estimate whether the vehicle is likely to have completed an I/M cycle.

Table 5 summarizes the results of the segregation effort. It is apparent that the "Non-I/M" sample for 1986 is very small as most of the vehicles old enough to be subject to I/M would have already been through the program. The sample sizes for the various categories of vehicles in the 1986 survey were as follows:

Model Year Range	I/M Sample	Non-I/M Sample
pre-1975	469	0
1975-79	677	0
1980 and Later	562	103
Total Sample	1708	103

Obviously, it was only possible to do "I/M" vs. "Non-I/M" comparisons for 1980 and later models using the 1986 Roadside Survey.

EPA's direction to Sierra was that "The analysis should be performed on a statewide basis, unless the sample size distribution among regions is much different for the roadside sample than for the Smog Check sample, in which case the contractor shall apply weighting factors to one data set or the other." To determine whether weighting of the results would be required, the geographical distribution of Random Roadside data was compared to the geographical distribution of Test Analyzer System (TAS) data recorded at Smog Check stations.

Table 5

Description of Random Roadside Survey Sample

	1985 Roadside Survey	1986 Roadside Survey
Identified as "I/M"	645	1708
Identified as "Non-I/M"	723	103
Other	442	602
Total	1810	2413

Where:

"I/M" = Vehicles expected to have had an I/M test before the roadside inspection.

"Non-I/M" = Vehicles expected to have not had an I/M test before the roadside inspection (See Other).

"Other" = Vehicles for which the occurrence of an I/M test before the roadside inspection is uncertain. Also, newer vehicles known to have not had an I/M test which were removed from the analysis to avert a data bias. For the 1985 Survey, this category would include '84 & later vehicles, for 1986 Roadside, '85 & later vehicles.

Table 6 shows the distribution of the sample of vehicles obtained through the Random Roadside Survey. Note that the first three areas (Los Angeles, San Francisco, and San Diego) listed for the 1985 survey have a similar fraction of the Random Roadside Survey Vehicles even though they have substantially different populations.

Table 6

Distribution of Roadside Vehicles by District

District	I/M	Non-I/M	Total	Fraction
1985 Survey:				
Los Angeles	166	200	366	0.268
San Francisco	183	197	380	0.278
San Diego	146	162	308	0.225
Sacramento	66	85	151	0.110
Ventura	84	79	163	0.119
Fresno	0	0	0	0.000
Total	645	723	1,368	1.000
1986 Survey:				
Los Angeles	380	20	400	0.221
San Francisco	492	36	528	0.292
San Diego	264	22	286	0.158
Sacramento	132	11	143	0.079
Ventura	137	5	142	0.078
Fresno	303	5	308	0.170
Total	1,708	103	1,811	1.000

To compare the Random Roadside Survey sample to a vehicle population weighted sample, Sierra performed an analysis of TAS data. As shown in Table 7, the fraction of the TAS total records in each district is consistent with what might be expected from population differences. For example, about twice as many Smog Check tests are performed in Los

Angeles as in San Francisco. Based on this analysis, weighting of the sample was done using the factors shown in Table 7.

Based on the direction received from EPA, "Adjustment for mileage differences is not required, but substantial mileage differences between corresponding I/M and non-I/M strata should be addressed."

Table 7

Development of District Weighting Factors

	TAS Sample Size By District					
Dist (ARB)	April 87	May 87	June 87	July 87	Aug 87	Sept 87
1 (LA)	337,817	325,185	233,196	448,947	300,666	328,906
2 (SF)	280,253	143,371	103,972	194,018	174,053	165,146
3 (SD)	65,401	61,301	57,407	85,806	65,790	
4 (SACTO)	88,411	28,026	18,138	33,334	42,160	26,953
5 (VENT)	5,045	23,282	17,111	20,173	20,159	26,373
6 (FRESNO)	29,288	29,936	16,161	18,069	12,510	17,849

TOTALS (w/Fresno)			TOTALS (w/o Fresno)		
Dist	N	Fraction	Dist	N	Fraction
1	1,974,717	0.5048	1	1,974,717	0.5213
2	1,060,813	0.2712	2	1,060,813	0.2801
3(x6/5)	402,846	0.1030	3(x6/5)	402,846	0.1064
4	237,022	0.0606	4	237,022	0.0626
5	112,513	0.0288	5	112,513	0.0297
6	123,813	0.0317			
Total	3,911,724		Total	3,787,911	

Table 8 shows mileage distributions of the four Roadside samples (I/M and non-I/M for both years). No significant differences in mileage distribution are observed between the I/M & non-I/M samples for the 1985 Survey vehicles. Therefore, no weighting factors were required.

For the 1986 Survey, the substantial mileage difference between I/M & non-I/M vehicles occurs because almost all vehicles (excluding new models) had been I/M tested by the time of the 1986 Survey (3/86 through 5/86). However, the 1986 survey has so few non-I/M vehicles that it provides no meaningful information about differences between I/M and non-I/M vehicles regardless of whether weighting factors are applied.

Table 8

Distribution (in %) of
Roadside Data by
Mileage Interval

	1985 Roadside Survey		1986 Roadside Survey	
	I/M	Non-I/M	I/M	Non-I/M
Sample Size	645	723	1708	103
Mileage Interval				
0-10,000	0.0%	0.1%	0.0%	2.9%
10,000-20,000	0.2%	2.6%	0.6%	15.5%
20,000-30,000	3.9%	4.8%	1.8%	23.3%
30,000-40,000	3.4%	7.3%	4.0%	23.3%
40,000-50,000	7.0%	6.4%	4.7%	17.5%
50,000-60,000	9.5%	7.9%	7.9%	8.7%
60,000-70,000	7.4%	8.9%	8.6%	1.9%
70,000-80,000	8.2%	7.1%	8.5%	2.9%
80,000-90,000	8.5%	7.6%	8.7%	1.0%
90,000-100,000	8.7%	8.7%	8.8%	1.0%
100,000-150,000	29.6%	28.4%	34.3%	1.9%
> 150,000	13.6%	10.2%	12.0%	0.0%

###

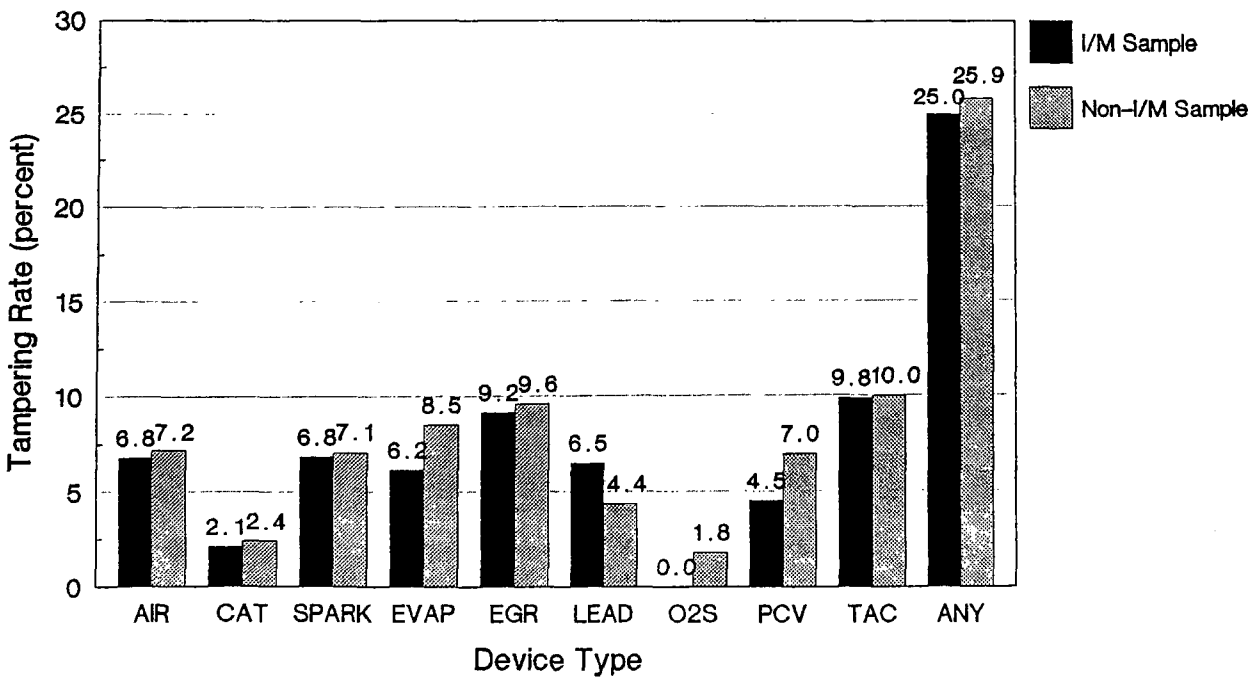
3. RESULTS

Detailed results from the Random Roadside Survey underhood inspections for both the "I/M" and "Non-I/M" cases are presented in Tables 9-12. The format is the same as the component-specific results presented in the earlier analysis, however, the samples have been segregated into "I/M" and "non-I/M" subgroups.

Figure 1, repeated from the Summary, and Figures 2-4 show the comparison for all model years and three different model year groups based on the 1985 Random Roadside Survey. Readers should note that

Figure 1

Underhood "Tampering" Rates
I/M vs. Non-I/M Vehicles
1985 Roadside Survey



Note : 1984 and later models removed from sample to eliminate age bias.

Table 9

Underhood Inspection Results - 1985 Roadside Survey
I/M Vehicles

		----- Failure Percentage by Type of Broken or Tampered Device -----									
		AIR	CAT	SPARK	EVAP	EGR	LEAD	O2S	PCV	TAC	ANY
All Model Years With Device	Broken	2.61	0.00	2.67	3.07	17.62	0.26	0.87	3.26	9.49	
	Tamper	6.79	2.12	6.84	6.15	9.15	6.49	0.00	4.50	9.84	
	Total	9.40	2.12	9.51	9.22	26.77	6.75	0.87	7.76	19.33	
	Usage	59.4%	58.4%	92.9%	85.7%	67.8%	59.7%	17.8%	99.8%	88.2%	
All Model Years All Vehicles	Broken	1.55	0.00	2.48	2.64	11.94	0.16	0.16	3.26	8.37	24.34
	Tamper	4.03	1.24	6.36	5.27	6.20	3.88	0.00	4.50	8.68	24.96
	Total	5.58	1.24	8.84	7.91	18.14	4.04	0.16	7.76	17.05	42.33
Pre-75 Model Years With Device	Broken	6.45	--	4.33	6.04	36.11	--	--	3.83	13.64	
	Tamper	16.13	--	13.42	14.77	22.22	--	--	10.21	22.73	
	Total	22.58	--	17.75	20.81	58.33	--	--	14.04	36.37	
	Usage	26.3%	--	97.9%	63.1%	30.5%	--	--	99.6%	83.9%	
Pre-75 Model Years All Vehicles	Broken	1.69	--	4.24	3.81	11.02	--	--	3.81	11.44	29.24
	Tamper	4.24	--	13.14	9.32	6.78	--	--	10.17	19.07	38.56
	Total	5.93	--	17.38	13.13	17.80	--	--	13.98	30.51	58.05
75-79 Model Years With Device	Broken	3.30	0.00	2.19	3.48	20.67	0.48	0.00	3.83	11.11	
	Tamper	7.69	3.40	4.39	4.78	10.58	9.09	0.00	2.13	4.63	
	Total	10.99	3.40	6.58	8.26	31.25	9.57	0.00	5.96	15.74	
	Usage	77.4%	87.7%	97.0%	97.9%	88.5%	88.9%	4.70%	100%	91.9%	
75-79 Model Years All Vehicles	Broken	2.55	0.00	2.13	3.40	18.30	0.43	0.00	3.83	10.21	31.06
	Tamper	5.96	2.98	4.26	4.68	9.36	8.09	0.00	2.13	4.26	24.68
	Total	8.51	2.98	6.39	8.08	27.66	8.52	0.00	5.96	14.47	46.38
1980+ Model Years With Device	Broken	0.00	0.00	0.71	0.00	5.10	0.00	0.98	1.72	1.94	
	Tamper	1.44	0.59	0.00	0.57	1.27	2.89	0.00	0.00	0.65	
	Total	1.44	0.59	0.71	0.57	6.37	2.89	0.98	1.72	2.59	
	Usage	79.9%	97.7%	80.5%	100%	90.2%	99.4%	58.6%	100%	89.1%	
1980+ Model Years All Vehicles	Broken	0.00	0.00	0.57	0.00	4.60	0.00	0.57	1.72	1.72	8.62
	Tamper	1.15	0.57	0.00	0.57	1.15	2.87	0.00	0.00	0.57	6.90
	Total	1.15	0.57	0.57	0.57	5.75	2.87	0.57	1.72	2.29	15.52

Table 10

Underhood Inspection Results - 1985 Roadside Survey
Non-I/M Vehicles

		----- Failure Percentage by Type of Broken or Tampered Device -----									
		AIR	CAT	SPARK	EVAP	EGR	LEAD	O2S	PCV	TAC	ANY
All Model Years With Device	Broken	5.23	0.00	1.05	2.63	15.97	0.22	0.00	2.23	9.49	
	Tamper	7.19	2.44	7.06	8.50	9.58	4.35	1.82	6.95	9.95	
	Total	12.42	2.44	8.11	11.13	25.55	4.57	1.82	9.18	19.44	
	Usage	63.5%	62.4%	92.1%	89.5%	69.3%	63.6%	22.8%	99.4%	88.9%	
All Model Years All Vehicles	Broken	3.32	0.00	0.97	2.35	11.07	0.14	0.00	2.21	8.44	24.07
	Tamper	4.56	1.52	6.50	7.61	6.64	2.77	0.41	6.92	8.85	25.86
	Total	7.88	1.52	7.47	9.96	17.71	2.91	0.41	9.13	17.29	40.80
Pre-75 Model Years With Device	Broken	5.97	--	1.88	6.08	46.30	--	--	4.65	14.05	
	Tamper	26.87	--	14.55	24.32	22.22	--	50.00	15.81	24.86	
	Total	32.84	--	16.43	30.40	68.52	--	50.00	20.46	38.91	
	Usage	31.0%	--	98.6%	68.5%	25.0%	--	--	99.5%	85.6%	
Pre-75 Model Years All Vehicles	Broken	1.85	--	1.85	4.17	11.57	--	--	4.63	12.04	30.09
	Tamper	8.33	--	14.35	16.67	5.56	--	0.46	15.74	21.30	42.13
	Total	10.18	--	16.20	20.84	17.13	--	0.46	20.37	33.34	60.19
75-79 Model Years With Device	Broken	9.50	0.00	1.16	3.15	20.54	0.47	0.00	1.92	12.66	
	Tamper	5.50	4.81	5.41	6.30	14.73	8.92	0.00	5.00	6.75	
	Total	15.00	4.81	6.57	9.45	35.27	9.39	0.00	6.92	19.41	
	Usage	76.6%	79.7%	99.2%	97.3%	85.8%	81.6%	4.20%	99.6%	90.8%	
75-79 Model Years All Vehicles	Broken	7.28	0.00	1.15	3.07	17.62	0.38	0.00	1.92	11.49	36.40
	Tamper	4.21	3.83	5.36	6.13	12.64	7.28	0.00	4.98	6.13	30.27
	Total	11.49	3.83	6.51	9.20	30.26	7.66	0.00	6.90	17.62	51.72
1980+ Model Years With Device	Broken	0.52	0.00	0.00	0.00	4.04	0.00	0.00	0.41	2.26	
	Tamper	2.08	0.41	1.03	1.22	1.35	0.41	1.32	1.23	0.90	
	Total	2.60	0.41	1.03	1.22	5.39	0.41	1.32	1.64	3.16	
	Usage	78.0%	98.8%	78.9%	99.6%	90.7%	99.2%	61.8%	99.2%	89.8%	
1980+ Model Years All Vehicles	Broken	0.41	0.00	0.00	0.00	3.66	0.00	0.00	0.41	2.03	5.69
	Tamper	1.63	0.41	0.81	1.22	1.22	0.41	0.81	1.22	0.81	6.91
	Total	2.04	0.41	0.81	1.22	4.88	0.41	0.81	1.63	2.84	12.20

Table 11

Underhood Inspection Results - 1986 Roadside Survey
I/M Vehicles

		----- Failure Percentage by Type of Broken or Tampered Device -----									
		AIR	CAT	SPARK	EVAP	EGR	LEAD	O2S	PCV	TAC	ANY
All Model Years With Device	Broken	3.25	0.00	1.19	3.21	22.30	1.37	0.00	2.76	10.45	
	Tamper	8.21	2.59	8.26	8.19	12.94	4.78	0.84	7.57	9.02	
	Total	11.46	2.59	9.45	11.40	35.24	6.15	0.84	10.33	19.47	
	Usage	64.9%	67.9%	88.6%	93.0%	76.9%	68.6%	20.8%	99.7%	90.2%	
All Model Years All Vehicles	Broken	2.11	0.00	1.05	2.99	17.15	0.94	0.00	2.75	9.43	30.21
	Tamper	5.33	1.76	7.32	7.61	9.95	3.28	0.18	7.55	8.14	30.21
	Total	7.44	1.76	8.37	10.60	27.10	4.22	0.18	10.30	17.57	50.18
Pre-75 Model Years With Device	Broken	3.68	--	1.31	7.41	41.42	--	--	4.50	13.29	
	Tamper	25.74	--	17.65	19.37	29.59	--	--	14.99	19.81	
	Total	29.42	--	18.96	26.78	71.01	--	--	19.49	33.10	
	Usage	29.0%	--	97.9%	74.8%	36.0%	--	--	99.6%	88.3%	
Pre-75 Model Years All Vehicles	Broken	1.07	--	1.28	5.54	14.93	--	--	4.48	11.73	31.56
	Tamper	7.46	--	17.27	14.50	10.66	--	--	14.93	17.48	46.91
	Total	8.53	--	18.55	20.04	25.59	--	--	19.41	29.21	65.67
75-79 Model Years With Device	Broken	4.27	0.00	1.06	2.81	28.92	1.48	0.00	2.96	12.50	
	Tamper	8.93	3.64	5.88	8.00	15.67	8.22	4.55	7.11	8.06	
	Total	13.20	3.64	6.94	10.81	44.59	9.70	4.55	10.07	20.56	
	Usage	76.1%	89.4%	97.9%	99.7%	91.4%	89.8%	3.20%	99.7%	89.8%	
75-79 Model Years All Vehicles	Broken	3.25	0.00	1.03	2.81	26.44	1.33	0.00	2.95	11.23	40.18
	Tamper	6.79	3.25	5.76	7.98	14.33	7.39	0.15	7.09	7.24	34.12
	Total	10.04	3.25	6.79	10.79	40.77	8.72	0.15	10.04	18.47	59.23
1980+ Model Years With Device	Broken	1.97	0.00	1.28	1.07	8.37	1.25	0.00	1.07	5.78	
	Tamper	2.19	1.45	1.28	1.42	4.37	1.07	0.60	1.96	1.54	
	Total	4.16	1.45	2.56	2.49	12.74	2.32	0.60	3.03	7.32	
	Usage	81.3%	98.4%	69.8%	100%	93.6%	99.5%	59.3%	99.8%	92.3%	
1980+ Model Years All Vehicles	Broken	1.60	0.00	0.89	1.07	7.83	1.25	0.00	1.07	5.34	17.08
	Tamper	1.78	1.42	0.89	1.42	4.09	1.07	0.36	1.96	1.42	11.57
	Total	3.38	1.42	1.78	2.49	11.92	2.32	0.36	3.03	6.76	26.33

Table 12

Underhood Inspection Results - 1986 Roadside Survey
Non-I/M Vehicles

		----- Failure Percentage by Type of Broken or Tampered Device -----									
		AIR	CAT	SPARK	EVAP	EGR	LEAD	O2S	PCV	TAC	ANY
All Model Years With Device	Broken	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	
	Tamper	1.45	0.00	0.00	0.97	1.16	0.00	0.00	0.00	0.00	
	Total	1.45	0.00	0.00	0.97	1.16	0.00	0.00	0.98	0.00	
	Usage	67.0%	100%	44.7%	100%	83.5%	100%	89.3%	99.0%	82.5%	
All Model Years All Vehicles	Broken	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.97
	Tamper	0.97	0.00	0.00	0.97	0.97	0.00	0.00	0.00	0.00	1.94
	Total	0.97	0.00	0.00	0.97	0.97	0.00	0.00	0.97	0.00	2.91
Pre-75 Model Years With Device	Broken	--	--	--	--	--	--	--	--	--	
	Tamper	--	--	--	--	--	--	--	--	--	
	Total	--	--	--	--	--	--	--	--	--	
	Usage	--	--	--	--	--	--	--	--	--	
Pre-75 Model Years All Vehicles	Broken	--	--	--	--	--	--	--	--	--	--
	Tamper	--	--	--	--	--	--	--	--	--	--
	Total	--	--	--	--	--	--	--	--	--	--
75-79 Model Years With Device	Broken	--	--	--	--	--	--	--	--	--	
	Tamper	--	--	--	--	--	--	--	--	--	
	Total	--	--	--	--	--	--	--	--	--	
	Usage	--	--	--	--	--	--	--	--	--	
75-79 Model Years All Vehicles	Broken	--	--	--	--	--	--	--	--	--	--
	Tamper	--	--	--	--	--	--	--	--	--	--
	Total	--	--	--	--	--	--	--	--	--	--
1980+ Model Years With Device	Broken	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	
	Tamper	1.45	0.00	0.00	0.97	1.16	0.00	0.00	0.00	0.00	
	Total	1.45	0.00	0.00	0.97	1.16	0.00	0.00	0.98	0.00	
	Usage	67.0%	100%	44.7%	100%	83.5%	100%	89.3%	99.0%	82.5%	
1980+ Model Years All Vehicles	Broken	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.97
	Tamper	0.97	0.00	0.00	0.97	0.97	0.00	0.00	0.00	0.00	1.94
	Total	0.97	0.00	0.00	0.97	0.97	0.00	0.00	0.97	0.00	2.91

Figure 2

Underhood "Tampering" Rates
Pre-'75 I/M vs. Non-I/M Vehicles
1985 Roadside Survey

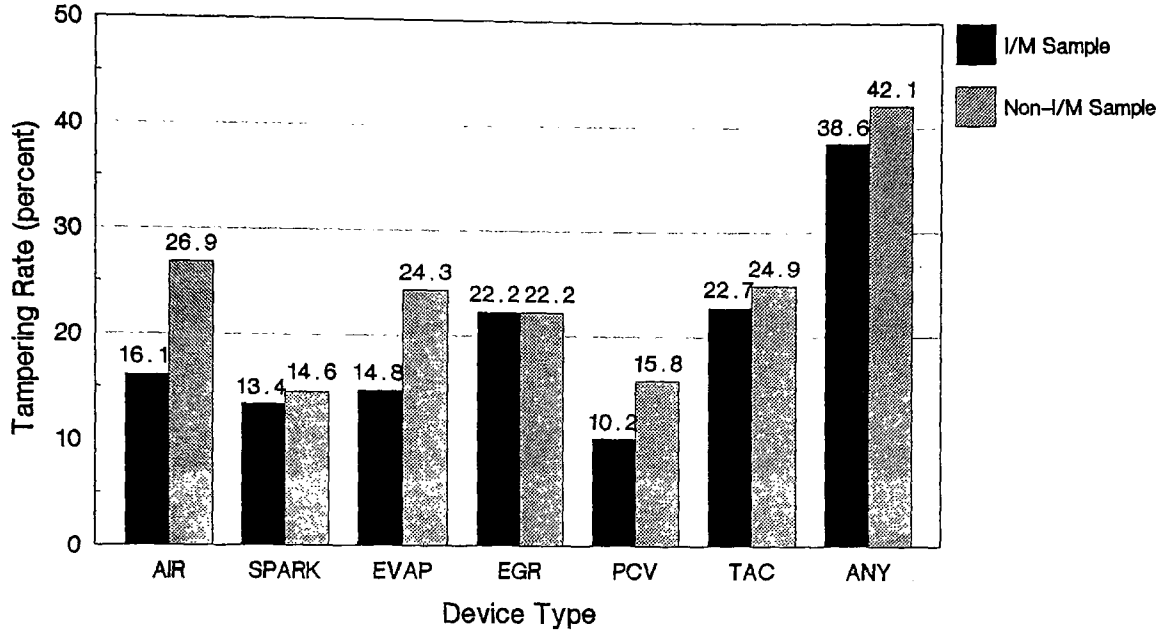


Figure 3

Underhood "Tampering" Rates
1975-79 I/M vs. Non-I/M Vehicles
1985 Roadside Survey

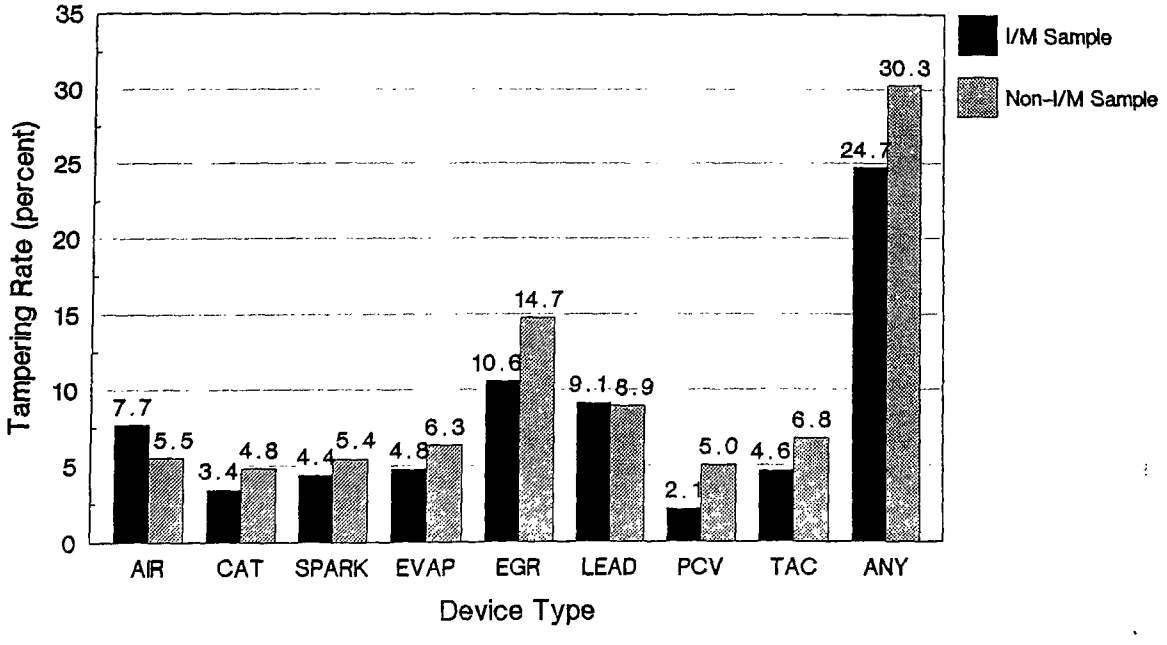
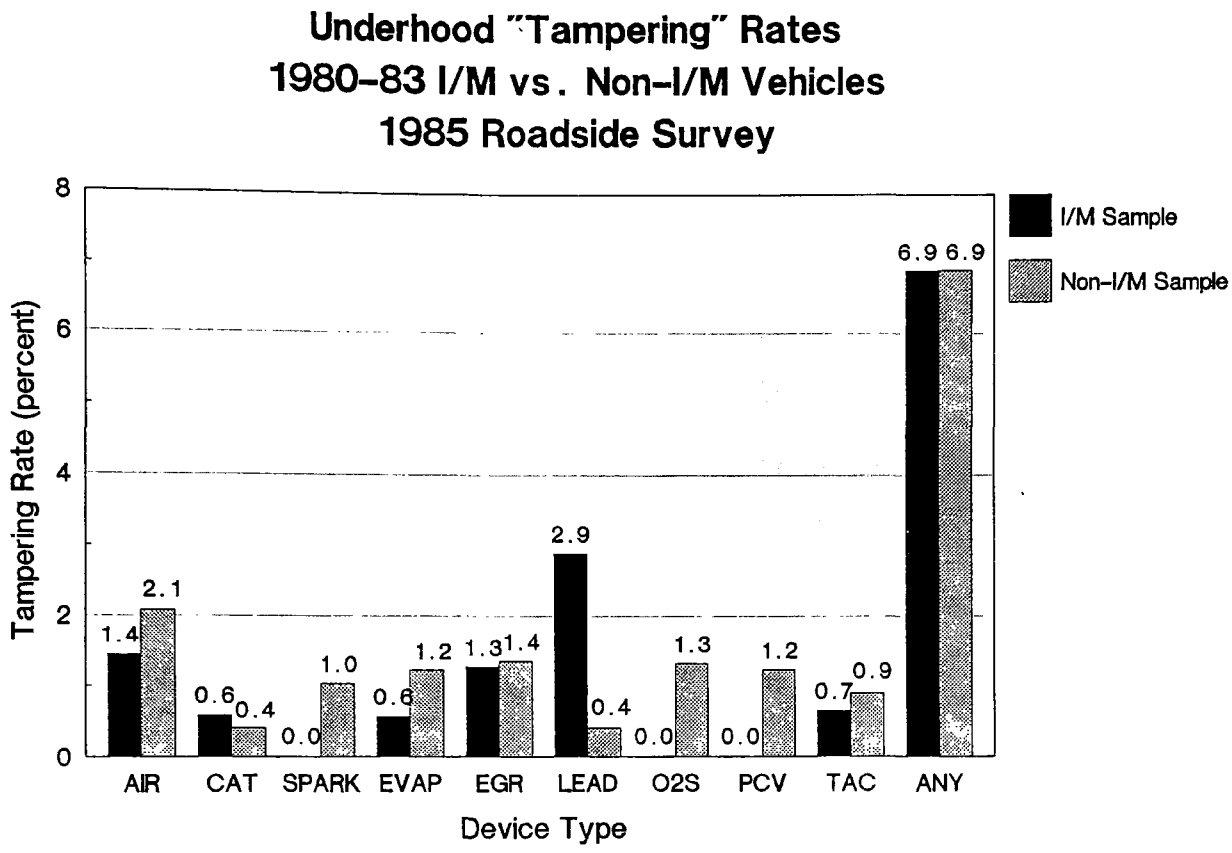


Figure 4



these figures show only those underhood defects classified as "tampering". The detailed results shown in Tables 9-12 contain the defect rates for non-tampering and "total" defects as well.

As illustrated in Figure 2, the tampering rates for pre-1975 models are consistently lower for vehicles that have already been through the I/M program. However, Figures 3 and 4 indicate that the results are mixed for 1975 and later models.

As illustrated earlier in Tables 6 and 7, there was a substantial discrepancy between the fraction of the Random Roadside sample that was drawn from each region and the fraction of the total number of

Table 13

Underhood Inspection Results Weighted by District

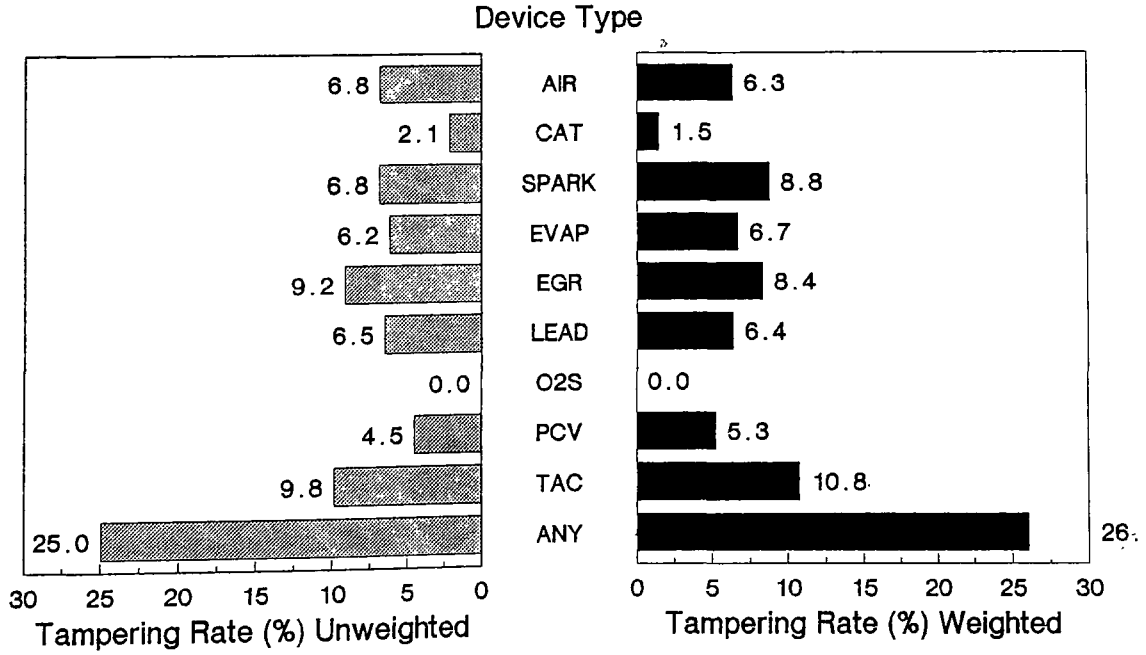
		----- Failure Percentage by Type of Broken or Tampered Device -----									
		AIR	CAT	SPARK	EVAP	EGR	LEAD	O2S	PCV	TAC	ANY
					1985 Roadside Survey- I/M Vehicles						
All Model Years With Device	Broken	2.96	0.00	3.48	3.72	16.50	0.57	0.72	2.77	8.44	
	Tamper	6.34	1.48	8.80	6.71	8.35	6.38	0.00	5.25	10.77	
	Total	9.30	1.48	12.28	10.42	24.85	6.95	0.72	8.02	19.21	
All Model Years All Vehicles	Broken	1.68	0.00	3.21	3.17	11.05	0.31	0.15	2.76	7.42	23.82
	Tamper	3.60	0.83	8.17	5.73	5.64	3.70	0.00	5.24	9.38	26.05
	Total	5.28	0.83	11.38	8.90	16.70	4.01	0.15	8.00	16.79	42.47
					1985 Roadside Survey - Non I/M Vehicles						
All Model Years With Device	Broken	3.99	0.00	0.60	2.68	15.46	0.41	0.00	2.01	9.92	
	Tamper	7.76	2.09	7.93	9.29	10.28	4.02	2.48	6.14	10.67	
	Total	11.75	2.09	8.53	11.98	25.74	4.43	2.48	8.15	20.59	
All Model Years All Vehicles	Broken	2.54	0.00	0.58	2.42	10.78	0.26	0.00	2.00	8.76	22.94
	Tamper	4.92	1.32	7.20	8.41	7.27	2.54	0.66	6.11	9.43	27.10
	Total	7.46	1.32	7.78	10.83	18.05	2.80	0.66	8.11	18.19	40.93
					1986 Roadside Survey - I/M Vehicles						
All Model Years With Device	Broken	3.44	0.00	1.20	3.91	22.43	1.91	0.00	3.07	10.05	
	Tamper	8.39	2.59	9.65	9.37	13.73	4.69	0.74	8.61	9.43	
	Total	11.83	2.59	10.85	13.28	36.16	6.60	0.74	11.68	19.47	
All Model Years All Vehicles	Broken	2.24	0.00	1.05	3.63	17.15	1.30	0.00	3.06	9.15	30.09
	Tamper	5.47	1.75	8.37	8.70	10.50	3.20	0.14	8.57	8.62	31.95
	Total	7.70	1.75	9.41	12.33	27.65	4.50	0.14	11.63	17.77	50.64
					1986 Roadside Survey Non I/M Vehicles						
All Model Years With Device	Broken	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	
	Tamper	0.45	0.00	0.00	0.55	0.40	0.00	0.00	0.00	0.00	
	Total	0.45	0.00	0.00	0.55	0.40	0.00	0.00	2.52	0.00	
All Model Years All Vehicles	Broken	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	2.52
	Tamper	0.35	0.00	0.00	0.55	0.35	0.00	0.00	0.00	0.00	0.90
	Total	0.35	0.00	0.00	0.55	0.35	0.00	0.00	2.52	0.00	3.43

Smog Check tests performed in each region. In order to eliminate any possible biases in the data due to differences in underhood failure rates between I/M districts in California, the Random Roadside sample was weighted by the number of Smog Check tests performed in each district. The weighted component failure rates at the roadside for I/M and non-I/M vehicles (all model years) are shown in Table 13.

Figures 5 and 6 show how the tampering rates are affected by the use of "unweighted" vs. "weighted" samples. As these figures show, there is no significant difference between the tampering rates for vehicles that have been through the I/M program and those that have not.

Figure 5

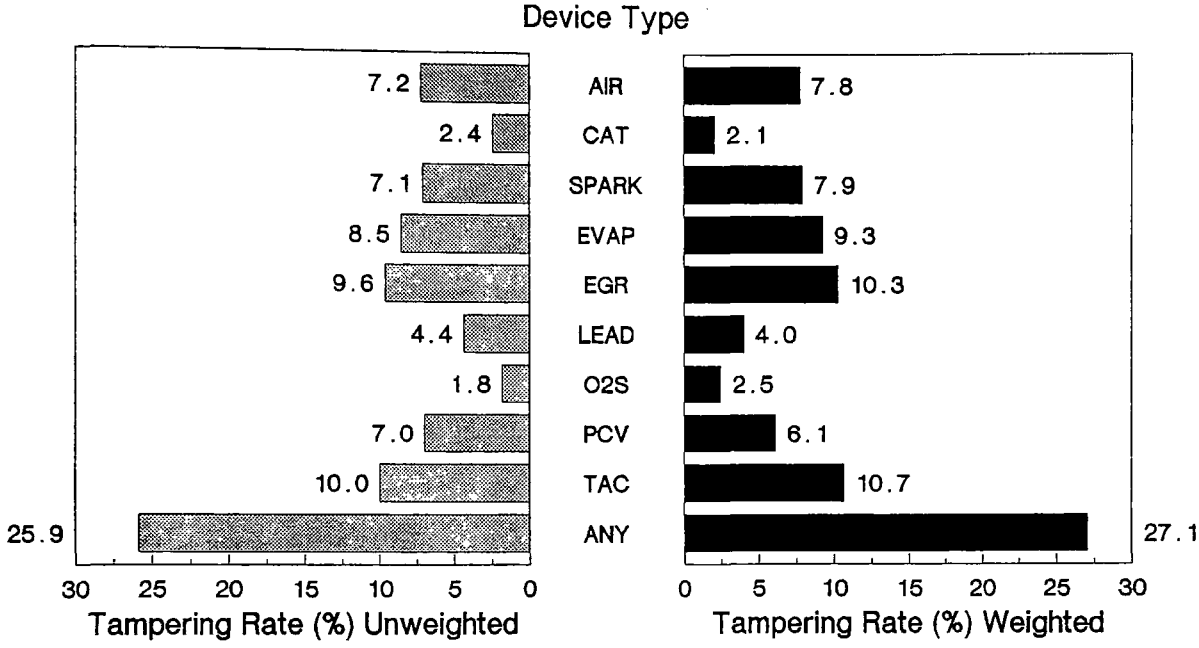
Weighted and Unweighted "Tampering" Rates for Vehicles Already Subject to I/M 1985 Roadside Survey



Note: 1984 and later models removed from sample to eliminate age bias.

Figure 6

Weighted and Unweighted "Tampering" Rates for Vehicles Not Yet Subject to I/M 1985 Roadside Survey



Note: 1984 and later models removed from sample to eliminate age bias.