sierra research

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Analytical Support for Emission Factors Development and Air Quality Assessment

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

Task 1 Report:
Supplemental Analysis of Emissions Reductions and Post-I/M Deterioration

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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I/M Review Committee Data

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1. SUMMARY

During a recent evaluation of the California vehicle inspection and maintenance program, laboratory tests using the Federal Test Procedure were conducted before and after repairs at "Smog Check" stations. A sample of the repaired vehicles was tested again after being "recaptured" from customer service. In order to determine how the emission reductions achieved under the current California program might compare to that under alternative programs, EPA requested further analysis of the California data to calculate the change in emission reductions achieved on failed vehicles if certain vehicles were removed from the sample. The vehicles removed from the sample were those that were not fully repaired (i.e., vehicles receiving waivers), those that failed only the underhood (visual or functional) inspection, and those that failed only the 2500 rpm test.

The results of the analysis are summarized in Figure 1. As shown in the figure, when vehicles receiving waivers or vehicles failing only an underhood inspection are excluded from the sample, the average emission reduction for the remaining repaired vehicles is higher for HC and CO and lower for NOx. This is true both for the initial emissions reduction and after some period of customer service.

Figure 1

Emissions Reductions and Post I/M Deterioration

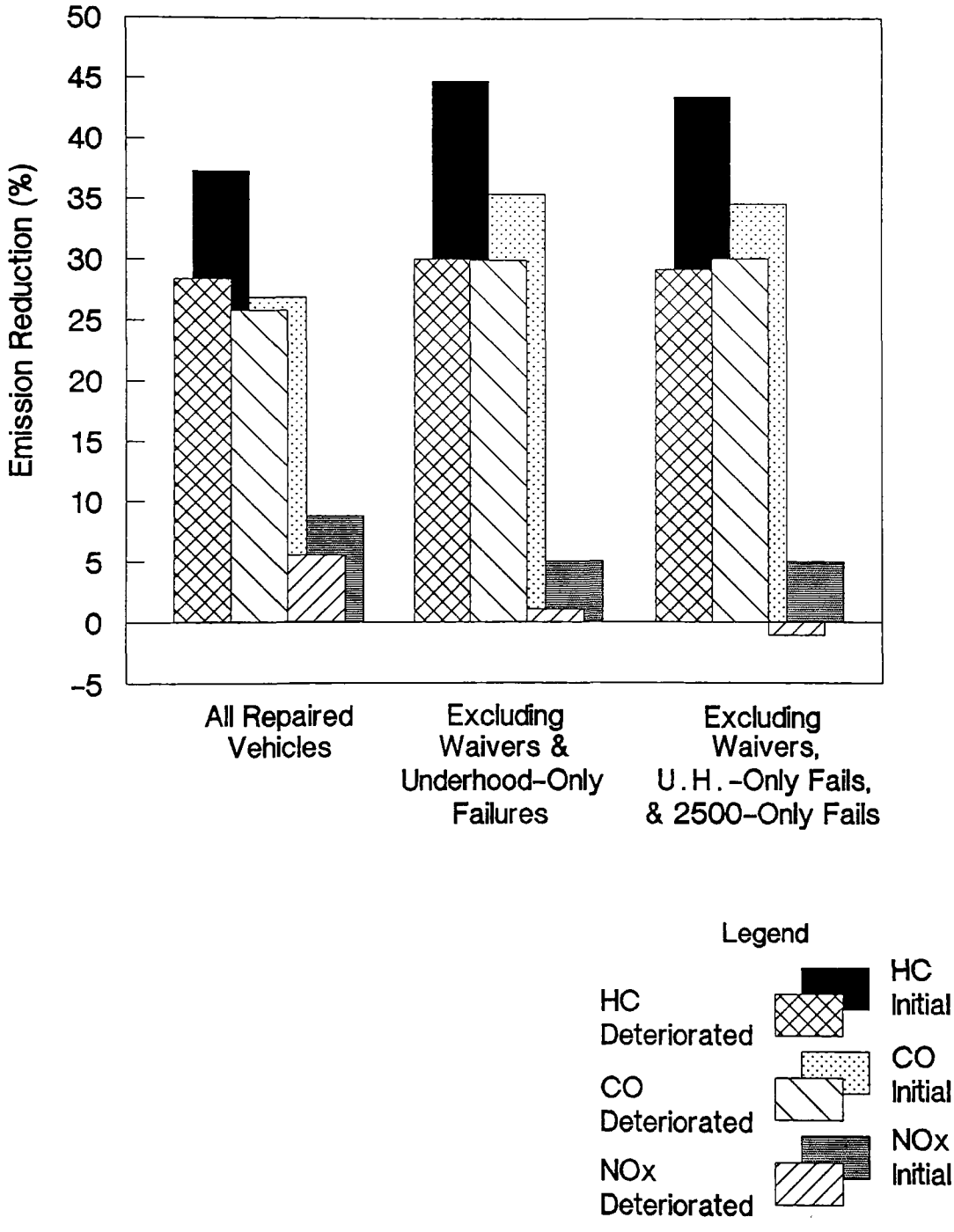

Table 1

Analysis of Emissions Reductions
and Post-I/M Deterioration

	---- Emission Change ---- HC	CO	NOx
All Repaired Vehicles			
initial	-37.3%	-26.9%	-8.8%
deteriorated	-28.4%	-25.8%	-5.5%
Excluding Waivers & Underhood-Only Failures			
Idle and/or 2500 Failures			
initial	-44.7%	-35.3%	-4.9%
deteriorated	-30.1%	-30.0%	-1.1%
Idle Failures Only			
initial	-43.5%	-34.6%	-5.0%
deteriorated	-29.2%	-30.1%	+1.1%

Table 1 presents the results of the analysis in tabular form. The initial hydrocarbon emission reduction for repaired vehicles increases from 37.3% to 44.7% when waivers and underhood-only failures are excluded. After experiencing some deterioration in customer service, the hydrocarbon emission reduction for repaired vehicles increases from 28.4% to 30.1% when waivers and underhood-only failures are excluded.

A similar trend is shown for carbon monoxide. The initial CO emission reduction for repaired vehicles increases from 26.9% to 35.3% when waivers and underhood-only failures are excluded. After experiencing some deterioration in customer service, the CO emission reduction for

repaired vehicles increases from 25.8% to 30.0% when waivers and underhood-only failures are excluded.

NOx emission reduction percentages are affected in the opposite manner. The initial NOx emission reduction for repaired vehicles decreases from 8.8% to 4.9% when waivers and underhood-only failures are excluded. After deterioration in customer service, the NOx emission decrease for repaired vehicles changes from 5.5% to 1.1% due to the exclusion of these vehicles.

Figure 1 and Table 1 also indicate that the exclusion of vehicles that fail only the 2500 rpm test has no significant effect on the percent emission reductions achieved from repaired vehicles. However, after deterioration in customer service, the NOx emission effect for repaired vehicles changes from a decrease of 5.5% to an <u>increase</u> of 1.1% due to the exclusion of these vehicles.

The prospect for higher reductions in HC and CO emissions with the elimination of waivers is apparent from the analysis. The adverse effect on NOx reductions is not unexpected as the exclusion of the underhood inspection results in some of the NOx emissions defects (e.g., disconnected EGR valves) being missed. Without loaded-mode testing, tailpipe emission tests are only able to detect HC and CO emission problems. In addition, since some repairs of HC and CO defects tend to increase NOx emissions, there can be a net increase in NOx associated with the elimination of the underhood inspection.

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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 perform analysis of California I/M data for the ECTD Technical Support Staff (TSS). Task number 1 of that Work Assignment required an evaluation of how alternative I/M test procedures would affect the emission reductions achieved from failing vehicles and the post-I/M deterioration of those vehicles.

The general direction provided by TSS was as follows:

> The Technical Appendix (to Sierra's previous report on the California I/M Evaluation Program) shows mean data for 290 cars that failed their California smog check, were repaired, and then retested after a period of deterioration. The sample includes vehicles which may not have been fully repaired, cars that failed only for tampering, and vehicles which had inconsistent emissions test results between ARB and the smog check station(s). The contractor shall repeat the analysis, and any relevant more detailed analysis, for the subset of vehicles which were as-received emissions failures at the first smog check station (with and without consideration of 2500 rpm status) and which were emission passes after commercial repair.

The 290 vehicles referred to above were "undercover" vehicles used in an ARB-sponsored study to evaluate the emissions effects of the California Smog Check program. As described in Sierra's previous report to ARB ("Evaluation of the California Smog Check Program - Technical Appendix," April 1987), these 290 vehicles were "repaired" vehicles that had been "recaptured". Each vehicle in the sample received repairs at a Smog Check station and subsequently passed the test. In most cases the repair was sufficient to get the vehicle to pass the I/M standards. In other cases, the vehicle was not repaired to the point where tailpipe emission levels met the I/M test standards and the vehicle received a "certificate of compliance" by virtue of getting a "waiver". Sierra's previous analysis showed how the immediate emission changes associated with repair of these 290 vehicles compared to the emissions after the vehicles were recaptured from customer service some months later.

Table 2 presents the results of Sierra's earlier analysis with the addition of a column entitled "Weighted Composite". This new column presents the average emission results for all model year groups after they have been weighted to reflect the population and estimated annual VMT of each model year group. (The original analysis was for the 290 vehicle sample with no weighting factors applied to reflect annual VMT differences.) The weighting factors were developed from the VMT estimates contained in Table 8-15 (pg. 118) of Sierra's earlier report and the frequency of "initial" tests for various model year groups computed from a random sample of Test Analyzer System data. The vehicle population was estimated to be 20% pre-1975, 30% 1975-1979,

Table 2

Changes in Emissions by Model Year Group
For All Vehicles
(Immediate and Deteriorated)

	Pre-1975	75-79	Post-1979	All	Weighted Composite
HC Emissions (g/mi)					
before I/M	10.29	4.61	2.08	5.15	3.73
after repair	5.97	3.03	1.37	3.19	2.34
deteriorated	7.66	3.59	1.34	3.82	2.67
% Emission Changes					
initial	-42.0%	-34.3%	-34.1%	-38.1%	-37.3%
deteriorated	-25.6%	-22.1%	-35.6%	-25.8%	-28.4%
CO Emissions (g/mi)					
before I/M	72.01	48.29	34.41	49.38	42.43
after repair	63.04	39.18	21.83	39.08	31.03
deteriorated	65.83	40.36	21.59	40.17	31.50
% Emission Changes					
initial	-12.5%	-18.9%	-36.6%	-20.9%	-26.9%
deteriorated	- 8.6%	-16.4%	-37.3%	-18.7%	-25.8%
NOx Emissions (g/mi)					
before I/M	3.33	2.77	1.22	2.36	1.82
after repair	3.07	2.39	1.15	2.12	1.66
deteriorated	2.83	2.50	1.26	2.15	1.72
% Emission Changes					
initial	- 7.8%	-13.7%	- 5.7%	-10.2%	- 8.8%
deteriorated	-15.0%	- 9.8%	+ 3.3%	- 8.9%	- 5.5%
Mean Mileages					
baseline	103,359	86,228	50,875	78,106	
deteriorated	108,427	92,996	59,147	84,975	
Δ Mileage	5,068	6,768	8,272	6,869	
Sample Size	73	115	102	290	

and 50% post-1979 models. Combining the vehicle population fractions with the annual VMT estimates for each model year group, the relationship between model year group and travel fraction was computed to be as follows:

Model Year Range	Travel Fraction
pre-1975	14.1%
1975-1979	19.5%
post-1979	66.4%
all	100.0%

To conduct the requested analysis, it was necessary to eliminate the following vehicles from the full sample of 290 vehicles that received repairs at Smog Check stations:

- ⊙ Vehicles which failed only because of a visual or functional inspection, and
- ⊙ Vehicles that were not fully-repaired (i.e., vehicles that received "waivers").

After recomputation of the emissions with these vehicles removed, it was necessary to repeat the analysis after removing vehicles that only failed the 2500 rpm test.

The results of the analysis are contained in the following section of the report.

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3. RESULTS

As explained in the previous section, to conduct the supplemental analysis of emission reductions and I/M deterioration, it was necessary to eliminate certain vehicles from the full sample of 290 vehicles that received repairs at Smog Check stations. For the first recomputation of the results:

- sixty-two vehicles were eliminated because they experienced underhood failures only, and
- sixty-four vehicles were eliminated because they received waivers.

In addition, twenty-five vehicles were eliminated from the sample because the the failure mode at the Smog Check station could not be accurately determined.* One more vehicle was eliminated because ARB apparently lost or never received the data from the after repair test performed at the Smog Check station. (In this case, it was not clear whether a waiver had been issued or not.)

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* The total number of vehicles deleted from the full sample was the same in the draft version of this report. However, the availability of a revised and cleaned-up data base from ARB enabled a more accurate classification of the status of the vehicles that were deleted from the sample because they were, or may have been, underhood-only failures, or because they received waivers.

Due to the adjustments listed above, the sample size was reduced from 290 to 138. Recalculation of the emission reductions and post-I/M deterioration for these 138 vehicles is shown in Table 3.

Table 3

Changes in Emissions by Model Year Group
For Successfully Repaired Vehicles
Failing California Idle and/or 2500 Standards
(Immediate and Deteriorated)

	Pre-1975	75-79	Post-1979	All	Weighted Composite
HC Emissions (g/mi)					
before I/M	10.07	4.81	1.87	4.89	3.69
after repair	5.65	2.77	1.06	2.77	2.04
deteriorated	8.23	2.95	1.27	3.56	2.58
% Emission Changes					
initial	-44.0%	-42.4%	-43.6%	-42.0%	-44.7%
deteriorated	-18.3%	-38.5%	-32.2%	-26.1%	-30.1%
CO Emissions (g/mi)					
before I/M	80.10	53.07	30.59	50.44	41.97
after repair	64.37	37.40	16.23	35.30	27.16
deteriorated	65.57	38.49	19.04	37.13	29.40
% Emission Changes					
initial	-19.6%	-29.5%	-46.9%	-30.0%	-35.3%
deteriorated	-18.1%	-27.5%	-37.7%	-26.4%	-30.0%
NOx Emissions (g/mi)					
before I/M	3.08	2.82	1.26	2.24	1.82
after repair	2.89	2.47	1.28	2.08	1.73
deteriorated	2.77	2.59	1.36	2.12	1.80
% Emission Changes					
initial	- 6.0%	-12.2%	+ 1.8%	- 6.9%	- 4.9%
deteriorated	-10.1%	- 8.2%	+ 8.0%	- 5.1%	- 1.1%
Mean Mileages					
baseline	109,042	86,748	50,290	77,182	
deteriorated	113,671	93,514	58,859	84,166	
Δ Mileage	4,629	6,766	8,569	6,984	
Sample Size	34	47	57	138	

The results from Table 3 are compared to the full 290 vehicle sample in Table 4. When vehicles receiving waivers and vehicles failing only an underhood inspection are excluded from the sample, the average emission reduction for the remaining repaired vehicles is higher for HC and CO and lower for NOx. The initial hydrocarbon emission reduction for repaired vehicles increases from 37.3% to 44.7% when waivers and underhood-only failures are excluded. After experiencing some deterioration in customer service, the hydrocarbon emission reduction for repaired vehicles increases from 28.4% to 30.1% when waivers and underhood-only failures are excluded.

Table 4

Effect of Eliminating Underhood-Only Failures and Waiver Vehicles on I/M Emission Reductions

		---- Emission Change ---- HC	CO	NOx
All Repaired Vehicles				
	initial	-37.3%	-26.9%	-8.8%
	deteriorated	-28.4%	-25.8%	-5.5%
Excluding Waivers & Underhood-Only Failures				
Idle and/or 2500 Failures				
	initial	-44.7%	-35.3%	-4.9%
	deteriorated	-30.1%	-30.0%	-1.1%

A similar trend is shown for carbon monoxide. The initial CO emission reduction for repaired vehicles increases from 26.9% to 35.3% when waivers and underhood-only failures are excluded. After experiencing some deterioration in customer service, the CO emission reduction for

repaired vehicles increases from 25.8% to 30.0% when waivers and underhood-only failures are excluded.

NOx emission reduction percentages are affected in the opposite manner. The initial NOx emission reduction for repaired vehicles decreases from 8.8% to 4.9% when waivers and underhood-only failures are excluded. After deterioration in customer service, the NOx emission decrease for repaired vehicles changes from 5.5% to 1.1% due to the exclusion of these vehicles.

Finally, it was necessary to repeat the analysis after removing vehicles that only failed the 2500 rpm test. There were fourteen such vehicles in the sample, reducing the total sample size to 124. These results are shown in Table 5. When the results shown in Table 5 are compared to the previous results, it is apparent that the exclusion of vehicles that fail only the 2500 rpm test has no significant effect on the percent emission reductions achieved from repaired vehicles. However, after deterioration in customer service, the NOx emission effect for repaired vehicles changes from a decrease of 5.5% to an increase of 1.1% due to the exclusion of these vehicles.

The performance of the fourteen vehicles that were 2500 rpm-only failures is shown in Table 6. After mileage accumulation in customer service, these vehicles (all post-1979 models) had 8.9% lower NOx emissions than their "before I/M" levels. This compares to 12.6% higher NOx emissions for the post-1979 models that failed the idle test (see Table 5).

Table 5

Changes in Emissions by Model Year Group
For Successfully Repaired Vehicles
Failing California Idle Standards Only
(Immediate and Deteriorated)

	Pre-1975	75-79	Post-1979	All	Weighted Composite
HC Emissions (g/mi)					
before I/M	10.07	4.81	2.13	5.32	3.77
after repair	5.64	2.77	1.20	3.01	2.13
deteriorated	8.23	2.95	1.41	3.86	2.67
% Emission Changes					
initial	-44.0%	-42.4%	-43.5%	-43.4%	-43.5%
deteriorated	-18.3%	-38.5%	-34.1%	-27.4%	-29.2%
CO Emissions (g/mi)					
before I/M	80.10	53.07	34.40	54.01	44.49
after repair	64.37	37.40	19.16	38.47	29.10
deteriorated	65.57	38.49	21.60	40.06	31.10
% Emission Changes					
initial	-19.6%	-29.5%	-44.3%	-28.8%	-34.6%
deteriorated	-18.1%	-27.5%	-37.2%	-25.8%	-30.1%
NOx Emissions (g/mi)					
before I/M	3.08	2.82	1.23	2.34	1.80
after repair	2.89	2.47	1.23	2.16	1.71
deteriorated	2.77	2.59	1.39	2.22	1.82
% Emission Changes					
initial	- 6.0%	-12.2%	- 0.2%	- 7.8%	- 5.0%
deteriorated	-10.1%	- 8.2%	+12.6%	- 5.0%	+ 1.1%
Mean Mileages					
baseline	109,042	86,748	52,208	80,883	
deteriorated	113,671	93,514	60,158	87,474	
Δ Mileage	4,629	6,766	7,950	6,591	
Sample Size	34	47	43	124	

Table 6

Changes in Emissions by Model Year Group
For Sucessfully Repaired Vehicles
Failing 2500 RPM Only
(Immediate and Deteriorated)

	Pre-1975	75-79	Post-1979	All	Weighted Composite
HC Emissions (g/mi)					
before I/M	---	---	1.08	1.08	---
after repair	---	---	0.64	0.64	---
deteriorated	---	---	0.90	0.90	---
% Emission Changes					
initial	---	---	-40.7%	-40.7%	---
deteriorated	---	---	-16.7%	-16.7%	---
CO Emissions (g/mi)					
before I/M	---	---	18.82	18.82	---
after repair	---	---	7.22	7.22	---
deteriorated	---	---	11.18	11.18	---
% Emission Changes					
initial	---	---	-61.6%	-61.6%	---
deteriorated	---	---	-40.6%	-40.6%	---
NOx Emissions (g/mi)					
before I/M	---	---	1.35	1.35	---
after repair	---	---	1.37	1.37	---
deteriorated	---	---	1.23	1.23	---
% Emission Changes					
initial	---	---	+ 1.5%	+ 1.5%	---
deteriorated	---	---	- 8.9%	- 8.9%	---
Mean Mileages					
baseline	---	---	44,402	44,402	
deteriorated	---	---	54,867	54,867	
Δ Mileage	---	---	10,465	10,465	
Sample Size	0	0	14	14	