United States Environmental Protection Agency

Office of Air and Radiation

# MOTOR VEHICLE TAMPERING SURVEY - 1984

September 1985

Robert Greco

FIELD OPERATIONS AND SUPPORT DIVISION
OFFICE OF MOBILE SOURCES
Washington, D.C.

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## INTRODUCTION

Under the direction of the Field Operations and Support Division (FOSD) of the Environmental Protection Agency (EPA), contract personnel from Colorado State University (CSU) conducted a survey of light-duty motor vehicle tampering in 14 cities between April and October, 1984. The areas surveyed and the total number of vehicles inspected are listed below.

| | |
|---|---|
| Bakersfield, CA | 320 |
| Reno, NV | 83 |
| Dallas, TX | 268 |
| Birmingham, AL | 300 |
| Washington, DC | 300 |
| Cincinnati, OH | 325 |
| New Jersey | 270 |
| New York, NY | 308 |
| Boston, MA | 286 |
| Tampa, FL | 327 |
| St. Louis, MO | 314 |
| Portland, OR (two weeks) | 603 |
| El Paso, TX | 334 |
| Milwaukee, WI | 388 |
| TOTAL | 4,426 vehicles |

The objectives of this survey were:

1. To make local measurements of the types and extent of tampering and fuel switching.
2. To extend and update the knowledge gained from earlier surveys on:
    a. The rates of overall and component-specific tampering and fuel switching.
    b. The distribution of tampering by vehicle age, type, manufacturer, and other variables of interest.

c. The correlation between tampering and vehicle idle emissions.

d. The effect of vehicle inspection and maintenance (I/M) programs and antitampering programs (ATPs) on tampering and fuel switching.

To achieve these objectives, the inspection teams visually examined emission control devices and measured the idle hydrocarbon (HC) and carbon monoxide (CO) emissions of each vehicle. To provide information on fuel switching, the inspectors sampled gasoline from the tanks of vehicles (for later laboratory lead analysis), tested for lead deposits in tailpipes using Plumbtesmo® test paper, and checked the integrity of the fuel filler inlet restrictors. Four categories were used to summarize the condition of the inspected vehicles:

1. Tampered - at least one control device removed or rendered inoperative
2. Arguably Tampered - possible but not clear-cut tampering
3. Malfunctioning
4. Okay - all control devices present and apparently operating properly

These brief but thorough inspections were performed with the consent of the vehicle owners in a variety of settings more fully detailed elsewhere in this report.

## CONCLUSIONS

The surveyed vehicles were classified as follows: tampered - 22%; arguably tampered - 29%; malfunctioning - 4%; okay - 46% (overall survey averages). The 22% tampering rate is less than the 26% rate found in 1983 but greater than the rates from the other large surveys of 1978, 1979, and 1982. Since these surveys encompass different sites with different vehicle age distributions, truck proportions, and other characteristics, direct comparisons between surveys should be made cautiously. This survey is also heavily weighted with I/M + ATP areas, as is detailed later in this report. The overall tampering rate for 1984 increases to 26% when the data is weighted for the proportion of the national vehicle fleet covered by I/M-only programs and I/M + ATPs. The tampering rate for areas without an I/M program was 31%, while the rates for I/M-only and I/M + ATP areas were 17% and 11%, respectively.

The component-specific rates for selected critical components are shown in Figure 1. The results shown have not been weighted to compensate for I/M program representation; these rates probably underestimate the actual nationwide rates. The tampering rates for catalytic converters and filler inlet restrictors have increased steadily since 1978, while the rates for other components fluctuated over the years. The increasing tampering rates for catalytic converters and inlet restrictors may be partly due to the increasing age of the

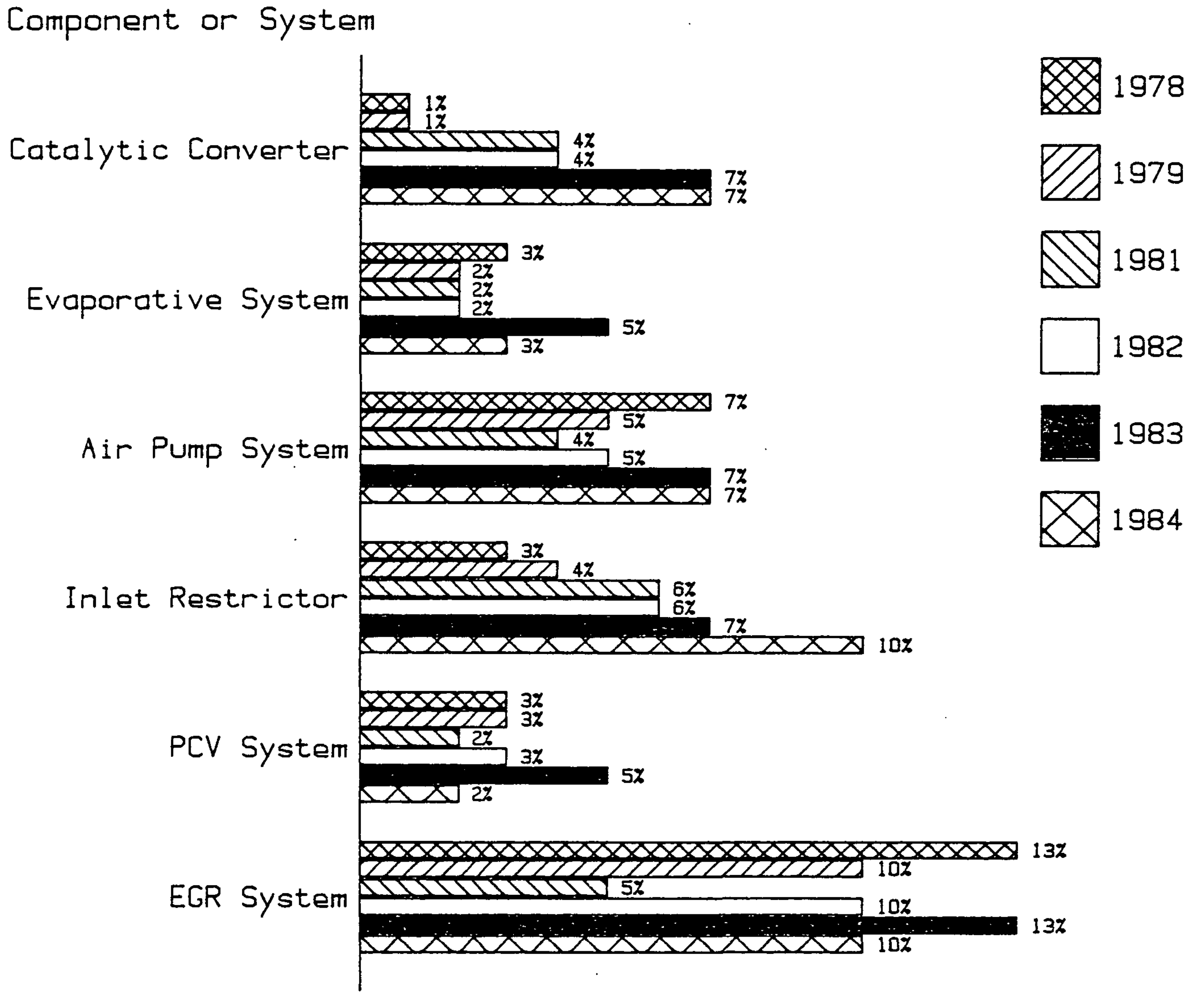

Figure 1. Component-specific tampering rates:
1978 - 1984 surveys.

vehicles surveyed. Areas with I/M programs had a 3% catalyst removal rate, while non-I/M areas had an 11% rate. Catalytic converter removal increases HC and CO emissions by an average of 475% and 425%, respectively.[1] For vehicles equipped with three-way catalysts, substantial increases in $NO_x$ emissions would also be expected to occur.

The fuel inlet restrictor and the exhaust gas recirculation (EGR) system were the most frequently tampered components (10%). EGR system tampering can increase $NO_x$ emissions by an average of 175%. The EGR tampering rates in I/M and non-I/M areas were 7% and 14%, respectively.

Fuel Switching

Fuel switching, defined as the presence of any of the three indicators[2], was found in 14% of the unleaded vehicles in the 1984 survey. This is the same rate found in the 1983 survey. The weighted fuel switching rate was 16%. The fuel switching rates in non-I/M, I/M-only, and I/M + ATP areas were 19%, 10%, and 8%, respectively. The pattern of overlap among the three indicators is discussed in detail later in this report. While the emissions impact of fuel switching depends upon its duration and certain vehicle characteristics, emission increases of 475% for HC and 425% for CO can easily occur.

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[1] The emissions increases mentioned in this report are from a study of three-way catalyst vehicles presented in Anti-Tampering and Anti-Misfueling Programs to Reduce In-Use Emissions from Motor Vehicles, EPA-AA-TTS-83-10, December 31, 1983.

[2] The three fuel switching indicators are: a tampered fuel filler inlet restrictor, a positive Plumbtesmo® tailpipe test, and a gasoline lead concentration of more than 0.05 grams per gallon.

### Age of Vehicle

A vehicle's age is clearly related to the probability that it has been tampered, as has also been shown in previous surveys. This is evident in Figure 2, which shows the rates by model year for both overall tampering and catalyst removal. Fluctuations in age-specific rates might be expected for very old (1975) vehicles because of the smaller sample size for that model year. These age-specific rates are investigated more thoroughly later in this report.

### Vehicle Types

The tampering rates for light-duty trucks was equal to or higher than for automobiles in every tampering category, as shown in Table 1. The difference in catalytic converter tampering is particularly striking -- nearly three times as prevalent for light-duty trucks as for passenger cars (14% vs 5%).

### I/M programs and tampering

The tampering rates in non-I/M areas were at least double those in I/M areas for every critical component. Those areas with I/M plus antitampering programs had lower tampering rates than the I/M-only areas. The deterrent effect of I/M programs, however, cannot be easily separated from the geographical influences on tampering rates. The differences in program status of the various I/M areas must be considered as well. These aspects are discussed more thoroughly later in this report.

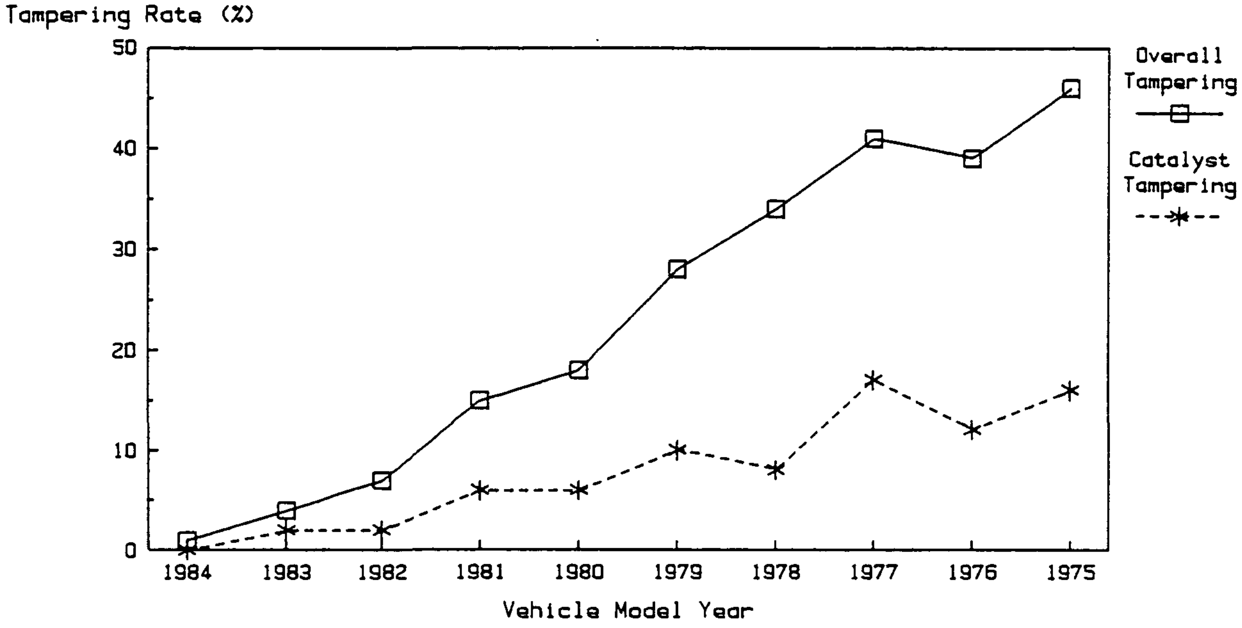

Figure 2. Overall and catalyst tampering by vehicle model year - 1984 survey.

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TABLE 1

Tampering Prevalence by Vehicle Type for Critical Control Components

| Component/System | Tampering Rate (%)<br>Trucks | Cars | Overall |
|---|---|---|---|
| Catalytic Converter | 14 | 5 | 7 |
| Filler Neck Restrictor | 14 | 9 | 10 |
| AIR System | 12 | 7 | 7 |
| PCV System | 3 | 2 | 2 |
| Evaporative Control System | 5 | 2 | 3 |
| EGR System | 10 | 10 | 10 |
| OVERALL | 27 | 21 | 22 |
| Fuel Switching | 19 | 13 | 14 |

## BACKGROUND

Motor vehicle emissions in urban areas account for nearly 90% of the total carbon monoxide (CO) and airborne lead, over 30% of the hydrocarbons (HC), and nearly 40% of the oxides of nitrogen ($NO_x$) emitted into the atmosphere. As a result, a major focus of the nation's efforts to achieve compliance with clean air standards has been the control of emissions from mobile sources. In order to meet required emission standards, vehicle manufacturers have, since 1968, installed a variety of pollution control devices on new vehicles.

The 1977 amendments to the Clean Air Act (sections 203(a)(3)(A) and (B), found in Appendix A) make it illegal for automobile dealers, repair and service facilities, and fleet operators to disconnect or render inoperative emission control devices or elements of design. Regulations issued under section 211(c) of the Act (40 CFR Part 80) prohibit retailers and wholesale purchaser-consumers from introducing or allowing the introduction of leaded gasoline into vehicles labeled "unleaded gasoline only". The EPA's Field Operations and Support Division (FOSD), formerly the Mobile Source Enforcement Division (MSED), is responsible for enforcing the tampering and misfueling provisions of the Act.

Before 1978, the EPA had data suggesting that tampering with emission control devices and misfueling of "unleaded only" vehicles with leaded gasoline was occurring. Variability in the inspection procedures, however, prevented an accurate assessment of the nature and extent of the tampering. As a result, the Agency began conducting nationwide tampering surveys of light-duty motor vehicles in 1978 to determine the rates and types of tampering and fuel switching. These surveys were conducted in 1978[1], 1979[2], 1981[3], 1982[4], and 1983[5], either by FOSD directly or by EPA's National Enforcement Investigations Center (NEIC) under the direction of FOSD. Consistent inspection procedures were used throughout these surveys to permit comparisons and identification of trends.

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[1] Motor Vehicle Tampering Survey (1978), U.S. Environmental Protection Agency, Mobile Source Enforcement Division, November 1978.

[2] Motor Vehicle Tampering Survey (1979), U.S. Environmental Protection Agency, National Enforcement Investigations Center, May 1980, EPA-330/1-80-001.

[3] Motor Vehicle Tampering Survey - 1981, Chattanooga, Tennessee and Houston, Texas, U.S. Environmental Protection Agency, National Enforcement Investigations Center, March 1982, EPA-330/1-82-001.

[4] Motor Vehicle Tampering Survey - 1982, U.S. Environmental Protection Agency, National Enforcement Investigations Center, April 1983, EPA-330/1-83-001.

[5] Motor Vehicle Tampering Survey - 1983, U.S. Environmental Protection Agency, Field Operations and Support Division, August 1984, EPA-460/1-84-001.

The uses for the tampering surveys have evolved since the first survey was conducted in 1978. In 1983, the tampering survey results for some locations were used to calculate credits for State Implementation Plans (SIPs), the measures taken by State and local governments to achieve ambient air quality standards by reducing mobile source emissions. Data from the surveys is also used in the default database for the Agency's mobile source computer model (MOBILE3) to estimate both the emissions loading impact and the reductions that may be achieved by various control programs. Sites for the surveys are chosen in light of the need for data on specific areas considering programs, as well as the continuing need to monitor the types and extent of tampering and fuel switching nationwide.

The 1984 tampering survey was conducted for FOSD by the National Center for Vehicle Emissions Control and Safety, Colorado State University (CSU). The inspection procedures used were consistent with those of previous surveys. The objectives of this survey were:

1. To make local measurements of the types and extent of tampering and fuel switching.
2. To extend and update the knowledge gained from earlier surveys on:

a. the rates of overall and component-specific tampering and fuel switching.

b. the distribution of tampering by vehicle age, type, manufacturer, and other variables of interest.

c. the correlation between tampering and vehicle idle emissions.

d. the effect of vehicle inspection and maintenance (I/M) programs and antitampering programs (ATPs) on tampering and fuel-switching rates.

## SURVEY METHODS

The 1984 tampering survey was conducted in 14 cities between April and October, 1984. A goal of inspecting 300 vehicles in each location was established to ensure a statistically meaningful database; 4,426 total vehicles were actually inspected. The mix of vehicles inspected was assumed to be a self-weighting sample, and no attempt was made to approximate the national vehicle mix.

Each inspection team consisted of at least four members: three CSU personnel, one or two EPA representatives, and frequently a state or local agency representative. The CSU personnel, assisted by the state or local person, performed the actual inspections, while the EPA representative(s) supervised the survey. Each vehicle inspection included the following:

1. basic vehicle identification data recorded (year, make, model)
2. all emission control systems checked
3. idle HC and CO emissions measured
4. fuel sample collected from unleaded-only vehicles for lead analysis.
5. tailpipe tested for lead deposits using Plumbtesmo®[6] test paper
6. integrity of fuel inlet restrictor checked

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[6] Plumbtesmo® is a registered trademark, and appears hereafter without the ®. It is manufactured by Machery-Nagel, Duren, W. Germany, and marketed by Gallard-Schlesinger Chemical Corp., Carle Place, New York.

The inspection and recording procedures are detailed in Appendix B. The survey database has been reviewed by CSU, EPA, and the automotive manufacturers to ensure its accuracy.

The survey included only 1975 and newer light-duty cars and trucks fueled with gasoline. For the purposes of the tampering surveys, a vehicle is considered to be "unleaded" if a dash label, tank label, or filler inlet restrictor is observed at the time of the inspection. A vehicle's designation as "unleaded" or "leaded" may be changed upon subsequent review of the data. Fuel switching rates are thus calculated based only on the unleaded vehicles surveyed. Similarly, tampering rates for specific components are based only on the vehicles originally equipped with the component.

The inspections were performed with the consent of the vehicle owners at either roadside pullovers or inspection stations. The survey was designed to minimize the refusal rate of potential survey participants. A high refusal rate increases the uncertainty in the data gathered, and individuals who have tampered with or misfueled their vehicles are less likely to allow their vehicles to be surveyed. The overall refusal rate was relatively low (8%), but some survey sites had very high refusal rates (see below). The tampering and misfueling rates at these particular locations might be significantly higher than reported here. A brief description of each survey site follows.

### Bakersfield, California - Roadside Pullovers

Dates: April 2-5, 1984
Vehicles Surveyed: 320
Fuel Samples: 184
Refusal Rate: 2%
Tampering Rate: 31%
Misfueling Rate: 14%

The California Highway Patrol provided an officer to stop potential survey participants, and the inspectors solicited permission to conduct the inspections. Locations for pullovers were changed daily.

### Reno, Nevada - Inspection Stations

Dates: April 9-13, 1984
Vehicles Surveyed: 83
Fuel Samples: 37
Refusal Rate: 6%
Tampering Rate: 31%
Misfueling rate 22%

The Reno survey was conducted at the Reno DMV office and at privately-owned I/M inspection stations. Low vehicle volume at the I/M stations during the middle of the month led to the small survey sample.

### Dallas, Texas - Roadside Pullovers

Dates: April 30 - May 4, 1984
Vehicles Surveyed: 268
Fuel Samples: 204
Refusal Rate: 29%
Tampering Rate: 28%
Misfueling Rate: 18%

The Texas Department of Public Safety (TDPS) provided officers to stop potential survey participants. The survey was conducted in conjunction with a TDPS driver's license and insurance card check, which could have increased the refusal rate. Survey locations were changed daily.

### Birmingham, Alabama - Roadside Pullovers

| | |
|---|---|
| Dates: | May 7-11, 1984 |
| Vehicles Surveyed: | 300 |
| Fuel Samples: | 162 |
| Refusal Rate: | 4% |
| Tampering Rate: | 32% |
| Misfueling Rate: | 25% |

Roadside pullovers were conducted with the help of local law enforcement officers of municipalities in the Birmingham area. Inspection locations were changed daily and included Birmingham (three days), Hoover, and Homewood.

### Washington, D.C. - Inspection Stations

| | |
|---|---|
| Dates: | May 14 - 18, 1984 |
| Vehicles Surveyed: | 300 |
| Fuel Samples: | 213 |
| Refusal Rate: | 12% |
| Tampering Rate: | 23% |
| Misfueling Rate: | 10% |

The Washington, D.C. survey was conducted at two centralized I/M stations (three days at one location and two days at the other).

## Cincinnati, Ohio - Roadside Pullovers

Dates: May 21-25, 1984
Vehicles Surveyed: 325
Fuel Samples: 273
Refusal Rate: 12%
Tampering Rate: 28%
Misfueling Rate: 12%

The roadside pullovers were conducted with the help of Ohio State Highway Patrol officers throughout the greater Cincinnati area. Some participants actually sought out the survey as a result of extensive press coverage both prior to and during the survey, possibly resulting in an underestimation of tampering and misfueling rates.

## New Jersey - Roadside Pullovers and Inspection Stations

Dates: June 18-22, 1984
Vehicles Surveyed: 270
Fuel Samples: 155
Refusal Rate: 3%
Tampering Rate: 16%
Misfueling Rate: 8%

The New Jersey survey was conducted, in conjunction with a Department of Motor Vehicles' police pullover, over four days in the northeastern part of the state. On the remaining day, the survey was conducted at a State inspection station in Newark.

## New York City, New York - Roadside Pullovers

Dates: June 25-29, 1984
Vehicles Surveyed: 308
Fuel Samples: 187
Refusal Rate: 6%
Tampering Rate: 16%
Misfueling Rate: 13%

The New York City survey was conducted with the help of the New York Police Department at five different locations in the borough of Queens.

## Boston, Massachusetts - Roadside Pullovers

Dates: July 9-13, 1984
Vehicles Surveyed: 286
Fuel Samples: 208
Refusal Rate: 5%
Tampering Rate: 15%
Misfueling Rate: 9%

The Boston survey was conducted with the help of the Massachusetts Registry of Motor Vehicles Police at five locations in the greater Boston area.

## Tampa, Florida - Roadside Pullovers

Dates: July 23-27, 1984
Vehicles Surveyed: 327
Fuel Samples: 280
Refusal Rate: 3%
Tampering Rate: 38%
Misfueling Rate: 23%

The Tampa survey was conducted with the help of the Florida State Police at five locations in the greater Tampa area.

## St. Louis, Missouri - Roadside Pullovers

Dates: July 30 - August 3, 1984
Vehicles Surveyed: 314
Fuel Samples: 264
Refusal Rate: 13%
Tampering Rate: 14%
Misfueling Rate: 10%

The St. Louis survey was conducted with the help of the Missouri State Highway Patrol at five locations in the greater St. Louis area.

## Portland, Oregon - Inspection Stations and Roadside Pullovers

Dates: August 14-24, 1984
Vehicles Surveyed: 394/209[7]
Fuel Samples: 245/148
Refusal Rate: 3%/0%
Tampering Rate: 10%/4%
Misfueling Rate: 8%/1%

The Portland survey lasted two weeks and was divided into two parts. Seven days were used to survey vehicles at inspection stations in the Portland area (four different locations). The remaining two days were used to survey vehicles by roadside pullover, with the assistance of state and local police.

## El Paso, Texas - Roadside Pullovers

Dates: September 10-14, 1984
Vehicles Surveyed: 334
Fuel Samples: 259
Refusal Rate: 6%
Tampering Rate: 30%
Misfueling Rate: 23%

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[7] Inspection Stations/Roadside Pullovers

The El Paso survey was conducted with the help of the El Paso Police Department at five different locations in the greater El Paso area. A number of vehicles registered in Mexico were also surveyed, but have not been included in El Paso's rates.

## Milwaukee, Wisconsin - Inspection Stations

| | |
|---|---|
| Dates: | October 1-5, 1984 |
| Vehicles Surveyed: | 388 |
| Fuel Samples: | 295 |
| Refusal Rate: | 26% |
| Tampering Rate: | 11% |
| Misfueling Rate: | 7% |

The Milwaukee survey was conducted at four centralized I/M stations in the Milwaukee area. The vehicles were surveyed at the exit of the inspection station on four days, and at the entrance to the station on one day. The refusal rate was significantly lower when the vehicles were surveyed at the entrance to the station.

# RESULTS

## A. VEHICLE TAMPERING

### 1. Site and Aggregate Totals

The vehicles surveyed have been classified into four categories established by previous surveys: tampered, arguably tampered, malfunctioning, and okay. Each vehicle was classified by the worst state of any component in the vehicle. For example, a vehicle would be classified as "tampered" if any one component had been tampered, even if all other components were functioning properly. A vehicle classified as "okay" must have all observed components functioning properly[1]. The criteria used for component classification are presented in Appendix B.

The proportion of inspected vehicles with at least one tampered component was 22%. More than half of the vehicles surveyed displayed some form of malfunction, arguable tampering, or clear tampering of emission control components. The specific distribution of surveyed vehicles among these categories is depicted in Figure 3.

The frequency distribution of tampering instances for those vehicles classified as "tampered" is also shown in Figure 3. Nearly half of the tampered vehicles had multiple components tampered, and 13% had four or more instances of tampering.

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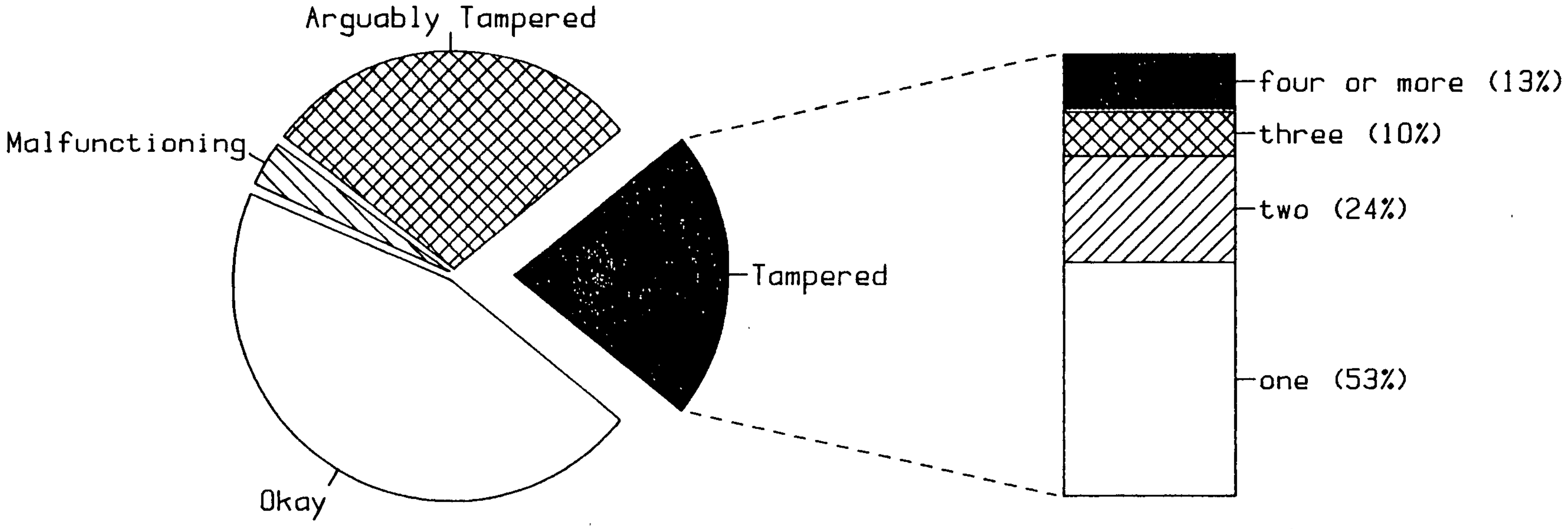
[1] An "okay" vehicle, however, may still be classified as fuel switched (see section B.1., Fuel Switching Indicators and Overlap of this report).



Condition of Surveyed Vehicles

Number of Tampered Components

Figure 3. Breakdown of surveyed vehicles by condition and extent of tampering.

Tables 2 and 3 summarize the 1984 survey data by site. Table 2 is a general survey summary, while Table 3 shows the vehicle condition classification by site. Unlike the 1983 survey, the overall tampering rates in 1984 vary considerably from site to site. This can be attributed to the variety of I/M-only and I/M + ATPs covered by this survey.

Table 2 also contains the refusal rate at each survey site. While the overall refusal rate for the survey was relatively low (8%), five survey sites had refusal rates exceeding 10%. The actual tampering rates at these sites were probably higher than is reported here, since individuals who tamper with or misfuel their vehicles are less likely to allow their vehicles to be surveyed.

## 2. Tampering Trends 1978-1984

Table 4 shows the overall rates found in each of the past five surveys. The percentage of okay vehicles in 1984 (46%) is higher than in any previous survey. It also appears that the tampering rate has declined to 22% from the 26% rate found in 1983. Such direct comparisons between survey years, however, are not entirely appropriate. The surveys, for example, covered different sites, and had different age and car/truck distributions. More importantly, because of the 1984 survey's specific goals, it greatly overrepresents the percentage of the national vehicle fleet under I/M + ATP (see Table 5). I/M + ATP areas

## TABLE 2

### 1984 Tampering Survey Summary

| Survey Location | Number of Vehicles | Tampering Rate (%) | Misfueling Rate (%) | Survey Type* | Refusal Rate (%) |
|---|---|---|---|---|---|
| Bakersfield, CA | 320 | 31 | 14 | R | 2 |
| Reno, NV | 83 | 31 | 22 | D | 6 |
| Dallas, TX | 268 | 28 | 18 | R | 29 |
| Birmingham, AL | 300 | 32 | 25 | R | 4 |
| Washington, DC | 300 | 23 | 10 | C | 12 |
| Cincinnati, OH | 325 | 28 | 12 | R | 12 |
| New Jersey | 270 | 16 | 8 | R, C** | 3 |
| New York, NY | 308 | 16 | 13 | R | 6 |
| Boston, MA | 286 | 15 | 9 | R | 5 |
| Tampa, FL | 327 | 38 | 23 | R | 3 |
| St. Louis, MO | 314 | 14 | 10 | R | 13 |
| Portland, OR*** | 394 | 10 | 8 | C | 3 |
| Portland, OR | 209 | 4 | 1 | R | 0 |
| El Paso, TX | 334 | 30 | 23 | R | 6 |
| Milwaukee, WI | 388 | 11 | 7 | C | 26 |
| TOTAL | 4,426 | 22 | 14 | - | 8 |

*R = roadside pullovers, C = centralized I/M stations,
D = decentralized I/M stations

**four days roadside, one day centralized I/M station

***survey was conducted for two weeks in Portland

## TABLE 3

### Classification of Vehicle Condition by Survey Site

| Survey Site | Tampered (%) | Arguably Tampered (%) | Malfunctioning (%) | Okay (%) |
|---|---|---|---|---|
| Bakersfield, CA | 31 | 11 | 3 | 54 |
| Reno, NV | 31 | 18 | 0 | 51 |
| Dallas, TX* | 28 | 26 | 7 | 39 |
| Birmingham, AL | 32 | 20 | 6 | 41 |
| Washington, DC | 23 | 34 | 5 | 37 |
| Cincinnati, OH | 28 | 22 | 6 | 44 |
| New Jersey | 16 | 23 | 3 | 59 |
| New York, NY | 16 | 25 | 3 | 56 |
| Boston, MA | 15 | 19 | 12 | 54 |
| Tampa, FL | 38 | 35 | 1 | 26 |
| St. Louis, MO | 14 | 25 | 6 | 56 |
| Portland, OR** | 10 | 47 | 2 | 40 |
| Portland, OR*** | 4 | 33 | 2 | 61 |
| El Paso, TX | 30 | 31 | 1 | 37 |
| Milwaukee, WI | 11 | 43 | 2 | 45 |
| OVERALL | 22 | 29 | 4 | 46 |

*The rates do not total 100% for some sites because of rounding
**I/M Stations
***Roadside Pullovers

## TABLE 4

### Trends in Vehicle Condition Classification

| Survey Year | Tampered (%) | Arguably Tampered(%) | Malfunctioning (%) | Okay (%) |
|---|---|---|---|---|
| 1978 | 19 | 48 | 2 | 31 |
| 1979 | 18 | 47 | 2 | 33 |
| 1981* | 14 | 45 | 3 | 38 |
| 1982 | 17 | 38 | 1 | 44 |
| 1983 | 25 | 30 | 3 | 42 |
| 1984 | 22 | 29 | 4 | 46 |

*Because the 1981 survey involved only two sites and a very limited sample size, these results may exhibit more variance than the other larger surveys.

## TABLE 5

### Comparison of 1984 Survey Sample to Actual Nationwide Vehicle Fleet

| Program Type | Percentage within Survey Sample (%) | Approx. Percentage of Nationwide Fleet (%)** |
|---|---|---|
| non-I/M | 42 | 66 |
| I/M only | 31 | 27 |
| I/M + ATP | 27 | 7 |

** Based on 1980 population data from the U.S. Census Bureau.

comprised 27% of the survey sample (half of which came from Portland alone), while only approximately 7% of the national vehicle fleet were under such programs. Since vehicles in I/M and I/M + ATP areas traditionally have lower tampering rates, the 1984 survey probably underestimates the extent of tampering nationwide.

This discrepancy can be compensated for by applying a weighting factor to the tampering rates found under each program type. This causes the overall 1984 tampering rate to increase from 22% to 26%. Applying weighting factors to all the previous surveys would be difficult, since some surveys contained no I/M areas. For the sake of clarity, only the actual, unweighted rates found during the surveys will be reported. Useful comparisons, however, can still be made between program types within a given year (e.g., I/M vs. non-I/M) or between the same program type in different years (e.g., non-I/M in 1983 and 1984).

## 3. Types of Tampering

The tampering rates for specific emission control components and systems for the various survey years are presented in Table 6. The component-specific tampering rates for the 1984 survey are presented by survey site in

## TABLE 6

### Prevalence of Tampering by Component and Survey Year

| | Survey Year | | | | | |
|---|---|---|---|---|---|---|
| Component/System | 1978 | 1979 | 1981* | 1982 | 1983 | 1984 |
| Catalytic Converter | 1% | 1% | 4% | 4% | 7% | 7% |
| Filler Neck Restrictor | 3 | 4 | 6 | 6 | 7 | 10 |
| Air Pump System | 7 | 5 | 4 | 5 | 7 | 7 |
| Air Pump Belt | 6 | 4 | 4 | 5 | 7 | 7 |
| Air Pump/Valve | 3 | 2 | 4 | 4 | 3 | 4 |
| Aspirator** | *** | 2 | 0 | 1 | 1 | 1 |
| PCV System | 3 | 3 | 2 | 3 | 5 | 2 |
| Evaporative Control System | 3 | 2 | 2 | 2 | 5 | 3 |
| EGR System | 13 | 10 | 5 | 10 | 13 | 10 |
| EGR Control Valve | 12 | 5 | 5 | 7 | 9 | 7 |
| EGR Sensor | 5 | 7 | 5 | 7 | 12 | 6 |
| Heated Air Intake | 1 | 1 | 0 | 1 | 1 | 1 |
| Vacuum Spark Retard | 11 | 2 | 1 | 0 | 1 | 5 |
| Idle Stop Solenoid | 1 | 1 | 0 | 0 | 1 | 1 |

*The 1981 survey was of limited scope, covering only two sites and 399 vehicles.

**Vehicles with aspirated air systems are not equipped with other listed air-injection components, nor do conventional systems include aspirators.

***Aspirators were not checked during the 1978 survey.

Table 7. The arguable tampering percentages by component for the 1978-1984 surveys are presented in Table 8. Only those vehicles originally equipped with a particular component are considered when computing the tampering or arguable tampering rate for that component. The heated air intake was the only component that could be classified as either tampered or arguably tampered, based on its condition in a surveyed vehicle (see Appendix B).

Table 6 shows that tampering with the filler inlet restrictor and vacuum spark retard has increased since the 1983 survey. Tampering rates for other components have remained unchanged or have declined since the 1983 survey, but have generally remained higher than the rates found in 1982 and earlier surveys. As was mentioned previously, the 1984 data underestimates the nationwide tampering rates because of the overrepresentation of I/M + ATP areas in the survey.

Table 7 shows the wide variation in tampering rates for any given component from site to site. Inlet restrictor tampering, for example, ranged from 1% in Portland (roadside check) to 19% in Birmingham. This range is partly due to the effectiveness of I/M and antitampering programs, as will be investigated later in this report.

## TABLE 7

### Component-Specific Tampering Rates (percent) by Survey Location - 1984 Survey

|  | Emission Control Component or System |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| Survey Location | Catalytic Converter | Inlet Restrictor | Air Pump System | PCV System | EGR System | Evaporative System | Any Component |
| Bakersfield, CA | 8 | 11 | 10 | 3 | 18 | 4 | 31 |
| Reno, NV | 13 | 15 | 12 | 4 | 20 | 6 | 31 |
| Dallas, TX | 10 | 12 | 8 | 5 | 9 | 5 | 28 |
| Birmingham, AL | 16 | 19 | 14 | 1 | 14 | 5 | 32 |
| Washington, DC | 1 | 9 | 7 | 1 | 14 | 1 | 23 |
| Cincinnati, OH | 8 | 8 | 8 | 3 | 17 | 3 | 28 |
| New Jersey | 5 | 5 | 3 | 1 | 11 | 1 | 16 |
| New York, NY | 4 | 2 | 6 | 0 | 10 | 1 | 16 |
| Boston, MA | 3 | 5 | 4 | 2 | 4 | 3 | 15 |
| Tampa, FL | 13 | 17 | 14 | 1 | 17 | 6 | 38 |
| St. Louis, MO | 5 | 7 | 5 | 1 | 4 | 1 | 14 |
| Portland, OR* | 2 | 6 | 1 | 1 | 3 | 1 | 10 |
| Portland, OR** | 1 | 1 | 0 | 0 | 2 | 0 | 4 |
| El Paso, TX | 11 | 17 | 16 | 7 | 11 | 5 | 30 |
| Milwaukee, WI | 2 | 5 | 3 | 1 | 3 | 1 | 11 |
| OVERALL | 7 | 10 | 7 | 2 | 10 | 3 | 22 |

*I/M Stations
**Roadside Pullovers

## TABLE 8

Prevalence of Arguable Tampering by Component
and Survey Year

| Survey Year | Limiter Cap | Fuel Tank Cap | Tank Label | Dash Label | Heated Air Intake |
|---|---|---|---|---|---|
| 1978 | 65% | 0% | 5% | 1% | 9% |
| 1979 | 62 | 1 | 4 | 1 | 8 |
| 1981 | 83 | 1 | 4 | 0 | 9 |
| 1982 | 54 | 2 | 4 | 1 | 6 |
| 1983 | 54 | 3 | 9 | 1 | 14 |
| 1984 | 49 | 1 | 12 | 3 | 8 |

Table 8 shows that idle limiter caps remain the item arguably tampered most frequently (49%). The arguable tampering rate for limiter caps, however, was lower in 1984 than in any previous survey. The tank label and dash label were removed more in 1984 than in previous surveys, and the heated air intake showed a lower but still significant arguable tampering rate.

## 4. Vehicle Characteristics and Tampering

The next section of this report investigates the impact on tampering of three vehicle characteristics: type (car or truck), age, and manufacturer.

Vehicle Type. The tampering prevalence for light duty trucks was higher than for automobiles, as was mentioned previously (Table 1). The tampering rate for each emissions component on trucks was equal to or greater than on passenger cars, continuing the pattern observed in previous surveys. The catalytic converter tampering rate for trucks was nearly three times that for automobiles (14% vs. 5%). The fuel switching rate for trucks (19%) was also considerably higher than for automobiles (13%).

Vehicle Age. Table 9 correlates vehicle age and model year with tampering prevalence for the 1978-1984 surveys. Catalytic converter removal rates are similarly related to vehicle age and model year in Table 10. The results from any given survey are entered diagonally in each table.

TABLE 9

Tampering Percentage (and Sample Size) by Model Year and Vehicle Age at Time of Survey

| Model Year | Year of Vehicle Life | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | Seventh | Eighth | Ninth | Tenth |
| 1984 | 1(462) | | | | | | | | | |
| 1983 | 7(182) | 4(471) | | | | | | | | |
| 1982 | 1(250) | 4(226) | 7(466) | | | | | | | |
| 1981 | 2(57) | 7(448) | 13(206) | 15(458) | | | | | | |
| 1980 | | 5(63) | 9(454) | 15(211) | 18(516) | | | | | |
| 1979 | 6(371) | | 9(59) | 18(477) | 31(288) | 28(503) | | | | |
| 1978 | 7(298) | 14(502) | | 15(79) | 21(430) | 39(238) | 34(559) | | | |
| 1977 | | 10(457) | 15(476) | | 21(66) | 26(316) | 44(190) | 41(408) | | |
| 1976 | | | 18(395) | 19(374) | | 29(52) | 26(317) | 40(171) | 39(385) | |
| 1975 | | | | 22(274) | 22(271) | | 32(22) | 37(183) | 55(89) | 46(197) |
| 1974 | | | | | 33(276) | 27(242) | | | | |
| 1973 | | | | | | 32(253) | 36(251) | | | |

## TABLE 10

### Percentage of Catalyst Removal (and Sample Size) among Catalyst-equipped Vehicles by Model Year and Vehicle Age at Time of Survey

| | Year of Vehicle Life | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model Year | First | Second | Third | Fourth | Fifth | Sixth | Seventh | Eighth | Ninth | Tenth |
| 1984 | 0(462)* | | | | | | | | | |
| 1983 | 1(179) | 2(471) | | | | | | | | |
| 1982 | 0(250) | 1(225) | 2(465) | | | | | | | |
| 1981 | 0(57) | 2(441) | 5(204) | 6(457) | | | | | | |
| 1980 | | 2(61) | 2(428) | 3(200) | 6(487) | | | | | |
| 1979 | 0(326) | | 4(55) | 6(429) | 12(252) | 10(455) | | | | |
| 1978 | 0(291) | 0(445) | | 0(71) | 4(362) | 8(213) | 8(486) | | | |
| 1977 | | 1(417) | 1(417) | | 2(59) | 2(271) | 11(166) | 14(357) | | |
| 1976 | | | 2(377) | 2(305) | | 10(48) | 6(257) | 12(139) | 12(314) | |
| 1975 | | | | 2(242) | 2(204) | | 26(19) | 12(139) | 23(75) | 16(174) |

*Tampering rates have been rounded to the nearest whole percent. A zero does not necessarily indicate a total absence of tampering, but rather a level of tampering that rounded to zero.

The results in Tables 9 and 10 indicate that vehicle tampering rates increase directly with vehicle age. Examining Table 9 diagonally (by survey) shows a fairly linear increase in the tampering rate with vehicle age for each survey. In the 1984 survey, for example, the tampering rate increases from 1% for first year vehicles to 46% among the 1975 vehicles surveyed. Table 10 shows a similar, though less pronounced, increase in catalyst removal. Examining these tables in this manner has the advantage of comparing data collected during one survey in one set of locations, but ignores the possible effects of model year differences (i.e., technology) on tampering.

Two additional ways of analyzing Tables 9 and 10 address the impact of model year on tampering rates. Analyzing the tables horizontally (holding the model year constant) provides a look at the tampering rates over time for the vehicles of a particular model year. This approach shows the same distinct increase in tampering with vehicle age for all model years since 1975. (The 1974 and 1973 data sets are too small to permit any conclusions.) For example, the tampering incidence for 1979 vehicles increased from 6% in their first year to 28% by their sixth year of use. This increase in tampering with vehicle age also seems to lessen once the vehicles of a model year are five years old or more, with the tampering rates leveling off at higher levels in older model years. This type of analysis involves observations made from different survey sites at different times; nevertheless, the relationship between tampering rate and vehicle age is readily apparent.

Tables 9 and 10 can also be analyzed vertically (holding vehicle age constant), which provides a look at the tampering rates for different model year vehicles of the same age. This approach suggests that improvements in automotive technology, such as closed loop emission control systems, have not significantly affected overall tampering rates. A 1983 vehicle, for example, was as tamper-prone as a 1978 vehicle when both were new (first year of use). A similar vertical analysis of Table 10 shows that catalytic converters are as susceptible to tampering on new vehicles as on older ones at a given vehicle age. Analyzing Tables 9 and 10 vertically introduces the same variability as the horizontal analysis, which might obscure any slight decrease in tampering resulting from improved technology.

The influence of vehicle age on tampering can be more clearly seen when the data in Tables 9 and 10 is presented graphically. Figures 4 and 5 plot the overall and catalyst tampering rate, respectively, as a function of vehicle age for the 1978-1984 surveys. This is equivalent to the diagonal method of analysis used for Tables 9 and 10 that was outlined previously. Figure 4 demonstrates that

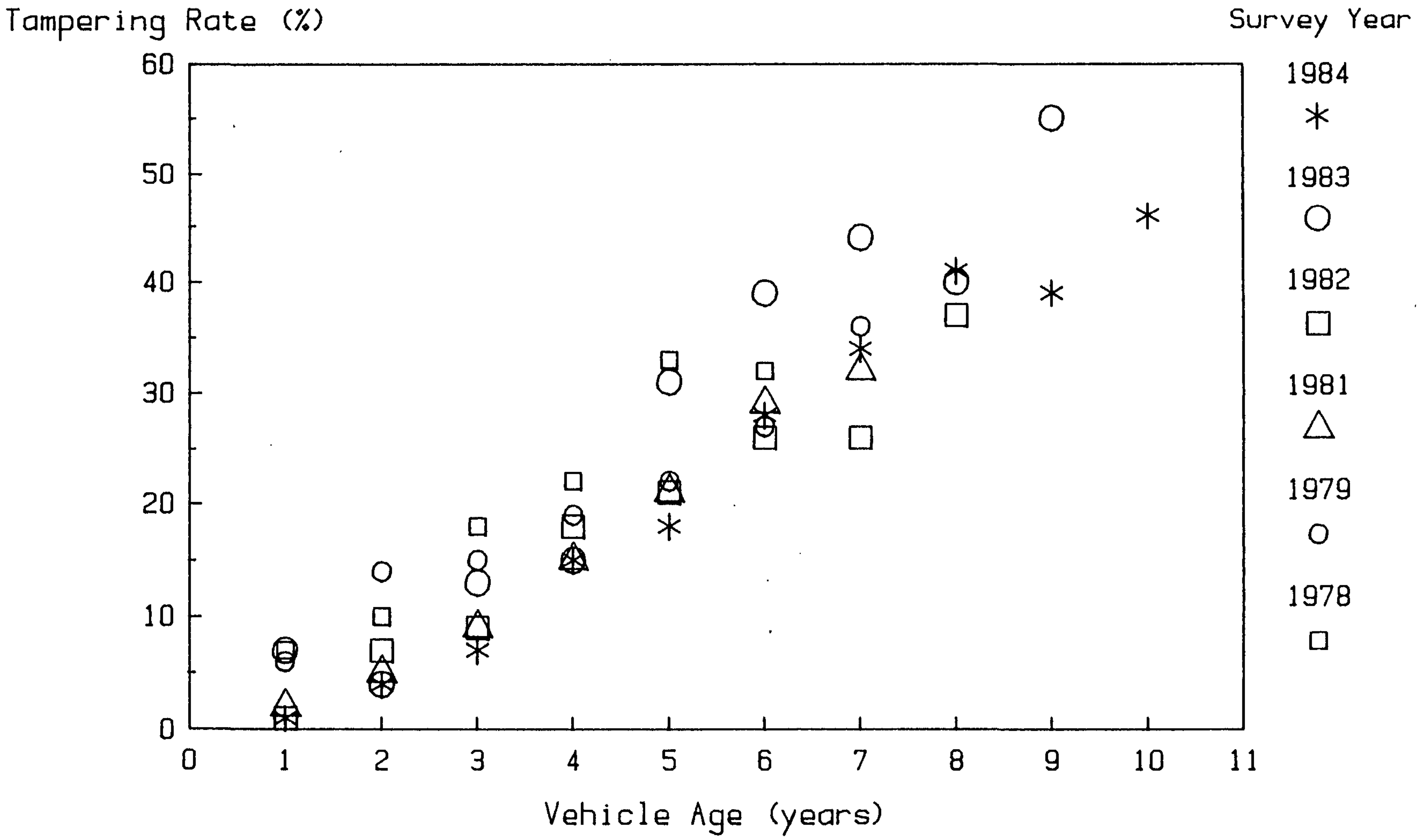


Figure 4. Cumulative tampering prevalence as a function of vehicle age for the 1978 - 1984 surveys.

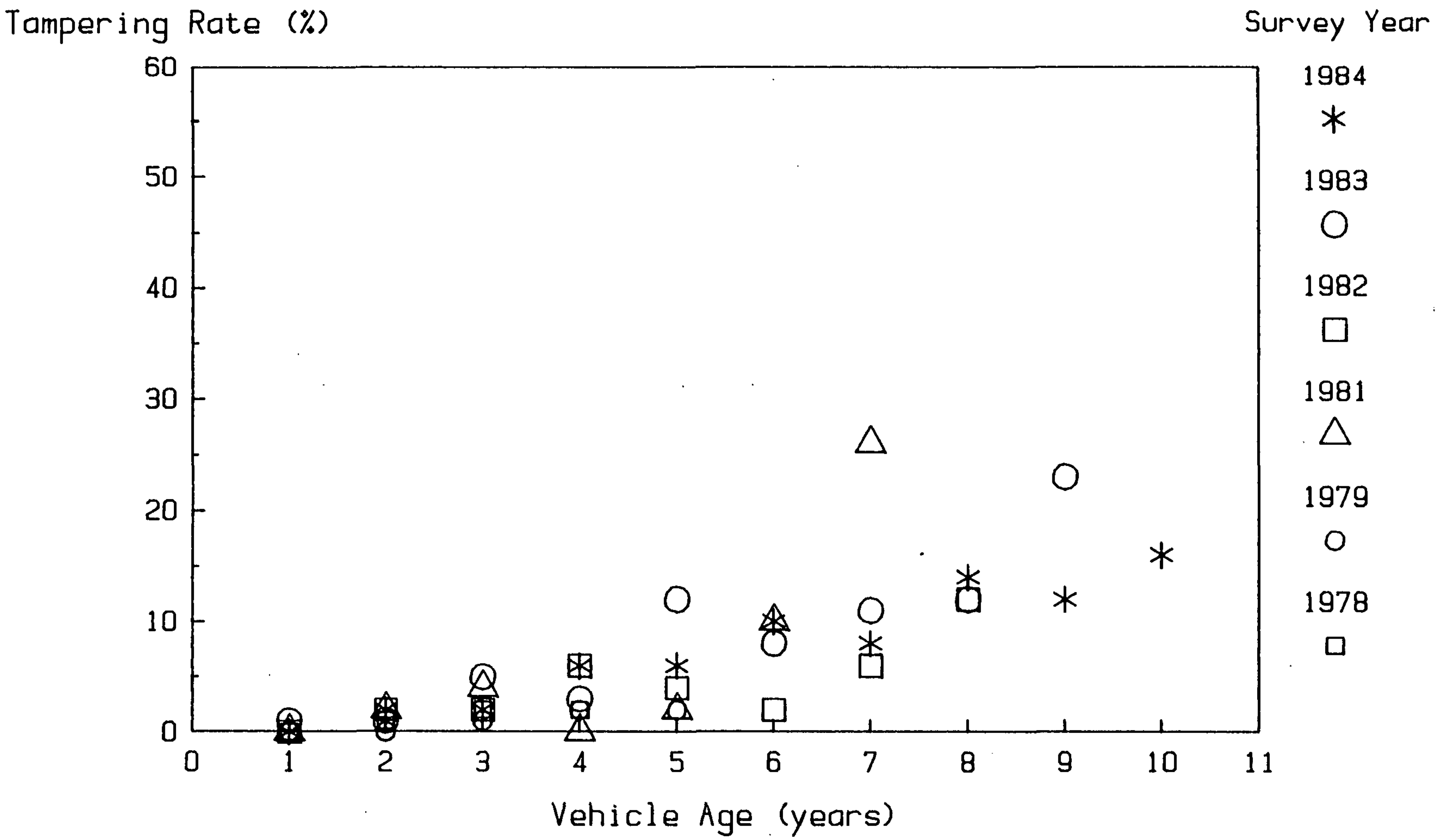


Figure 5. Cumulative catalyst tampering rate as a function of vehicle age for the 1978 - 1984 surveys.

the relationship between tampering rate and vehicle age is not only linear, but has remained nearly constant since the first survey in 1978. The strong correlation is obvious despite the different sizes, vehicle compositions, and locations of the surveys. In Figure 5 the catalyst tampering rate remains negligible for the first two to three years of a vehicle's life, and then increases thereafter. This delay in catalyst tampering is understandable, since the catalytic converters on all new vehicles are warranted for 5 years/50,000 miles by the manufacturer, providing an incentive to maintain the catalysts on vehicles still under warranty.

If the relationship between vehicle age and tampering has not changed markedly, what accounts for the general increase in overall tampering from earlier surveys? Figure 6 charts both the overall and catalyst tampering rate and compares these to the proportion of surveyed vehicles five years old or more in each survey. Figure 6 shows that the proportion of older vehicles surveyed has increased steadily from 27% in 1978 to 58% in the 1984 survey sample. Since the 1981-1984 surveys covered 1975 and newer vehicles, each successive survey reflects the increasing age of the catalyst-equipped vehicle population. (The 1981 survey covered vehicles up to seven years old, while the 1984 survey included vehicles up to ten years old.)

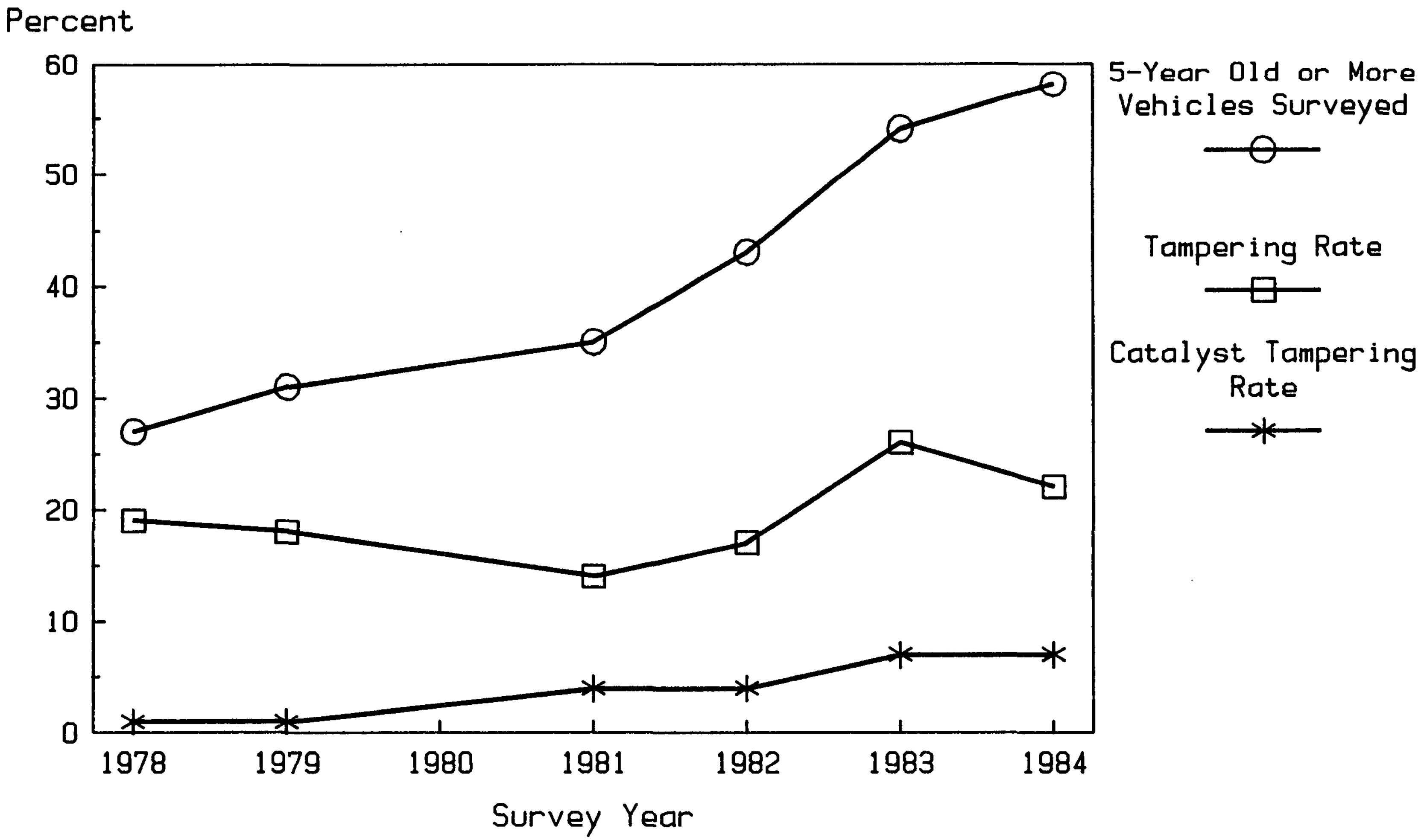


Figure 6. Comparison of catalyst and overall tampering rates with vehicle age as a function of survey year.

The increase in the proportion of older vehicles surveyed coincides with increases in the overall and catalyst tampering rate. Thus, the vehicles comprising the survey sample are older in each successive survey, and as such are more likely to have been tampered with, causing the overall tampering rate to increase.

Manufacturer. Figure 7 presents the 1984 tampering rates for each major manufacturer. Since the number of vehicles surveyed for each individual foreign manufacturer is small, foreign vehicles have been combined into two groups, European and Japanese. As in previous surveys, the tampering rate is higher among domestic than foreign manufacturers.

Figure 8 shows the trend in tampering rates for each manufacturer over time. The American vehicles are at or consistently above the overall tampering rate, while the European and Japanese vehicles have a tampering incidence consistently lower than the overall rate.

A number of factors might explain the discrepancy in tampering rates among manufacturers. Differences in design may make some vehicles more tamper-prone than others. Changing market share history results in different age distributions for vehicles of different makes, and vehicle age is clearly related to tampering prevalence. Tampering rates probably vary with geographic location and socioeconomic

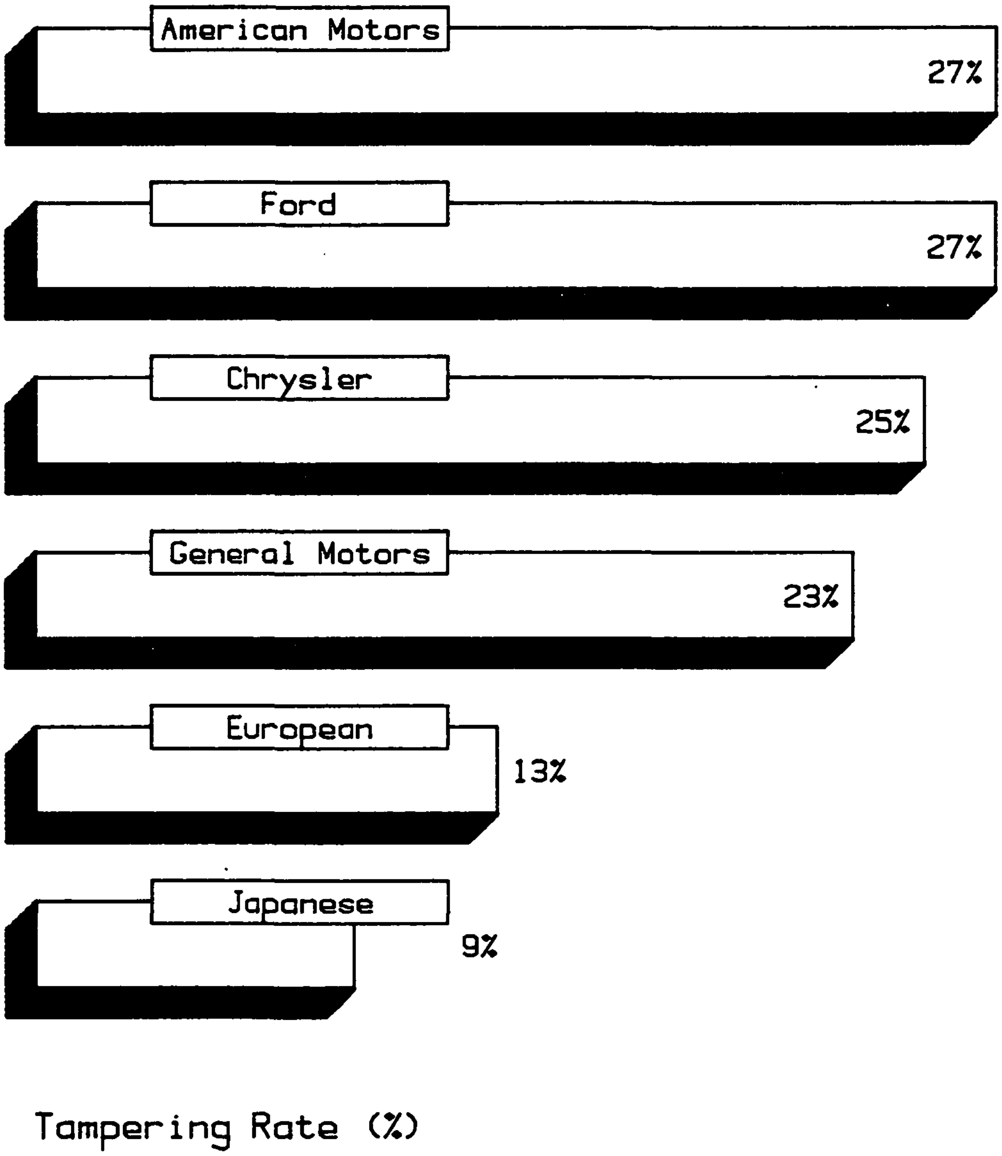


Figure 7. Tampering rates by manufacturer - 1984 survey.

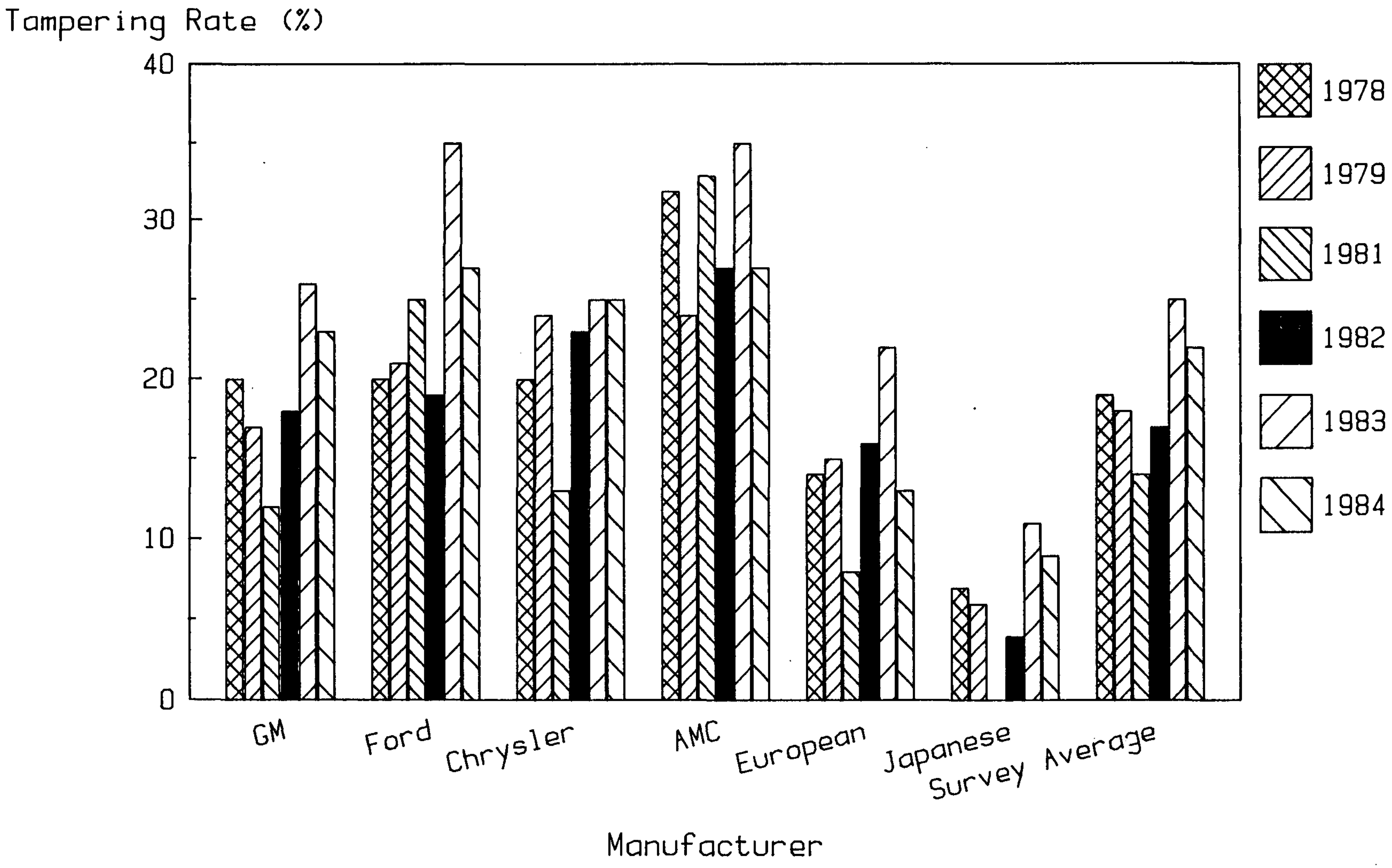


Figure 8. Tampering prevalence by manufacturer for the 1978 - 1984 surveys.

background, so the owner demographics for different makes may affect the likelihood of tampering. Finally, certain types of vehicles (trucks, for instance) are more likely to be tampered, and thus manufacturers with production concentrated in these types can be expected to have higher tampering rates.

## 5. Effect of I/M Programs on Tampering

Inspection and maintenance (I/M) programs require vehicles to meet specific idle emission standards. Vehicles registered in these areas are required to be periodically tested to assure that they comply with the specific idle emission cutpoints established by these jurisdictions. In addition to reducing emission levels by stimulating better owner maintenance, I/M programs may deter some tampering with emission control components. Data from previous surveys has tended to support this proposition, since tampering in I/M areas has been lower than in non-I/M areas.

Some I/M areas have also instituted antitampering programs (ATPs), which involve periodic vehicle inspections to check the integrity of specific emission control components. Antitampering programs vary greatly in the components inspected and the vehicle model years covered, so that a vehicle which would be inspected in one program area might not be inspected in a different program area. Successful antitampering programs should directly deter tampering with the components and model years covered by the program, and may have an indirect deterrent effect on the rest of the vehicle population.

The 1984 survey encompassed six non-I/M areas, five I/M-only areas, and three I/M + ATP areas. The proportion of the survey sample covered under each program type was discussed earlier (Table 5).

Table 11 compares the tampering rates in non-I/M, I/M-only, and I/M + ATP areas. The tampering rates in non-I/M areas were significantly higher than the rates in I/M-only areas, which were in turn higher than the rates in I/M + ATP areas. This is the same relationship found in previous surveys, although the degree of program effectiveness in 1984 exceeds that of earlier surveys. Table 11 also shows that the tampering rate in non-I/M areas has increased by over 50% since the first survey in 1978.

The component-specific tampering rates for cars and trucks in each program area are presented in Table 12. The tampering rates in non-I/M areas were greater than in I/M-only areas for every component in both cars and trucks. Except for the PCV system in trucks, the I/M-only rates exceeded the I/M + ATP rates in every case as well. It should be noted that certain I/M areas have weight limits that exclude some light-duty trucks from their programs.

## TABLE 11

### Tampering Prevalence in I/M and non-I/M Areas

| Survey Year | Tampering Rate (%)<br>non-I/M | I/M-only | I/M + ATP | Overall |
|---|---|---|---|---|
| 1978 | 19 | NS | NS | 19 |
| 1979 | 20 | 13 | NS | 18 |
| 1981* | 14 | NS | NS | 14 |
| 1982 | 19 | 15 | 10 | 17 |
| 1983 | 29 | 24 | 16 | 26 |
| 1984 | 31 | 17 | 11 | 22 |

NS = None Surveyed

*1981 survey was of limited scope, covering only two sites and 399 vehicles

## TABLE 12

### Tampering and Fuel Switching Prevalence by Vehicle Type in I/M and non-I/M Areas

| Tampering Category | non-I/M Areas | | I/M-only Areas | | I/M + ATP Areas | | Overall | |
|---|---|---|---|---|---|---|---|---|
| | cars(%) | trucks(%) | cars(%) | trucks(%) | cars(%) | trucks(%) | cars(%) | trucks(%) |
| At least one component tampered | 31 | 33 | 16 | 25 | 11 | 14 | 21 | 27 |
| Catalytic Converter | 9 | 18 | 3 | 11 | 3 | 5 | 5 | 14 |
| Inlet Restrictor | 14 | 17 | 6 | 9 | 5 | 8 | 9 | 14 |
| Air Pump System | 11 | 14 | 4 | 11 | 2 | 6 | 7 | 12 |
| Evaporative Control System | 4 | 6 | 1 | 3 | 1 | 2 | 2 | 5 |
| PCV System | 3 | 5 | 1 | 1 | 1 | 2 | 2 | 3 |
| EGR System | 15 | 13 | 9 | 13 | 3 | 2 | 10 | 10 |
| Fuel Switched | 19 | 25 | 10 | 16 | 8 | 9 | 13 | 19 |

The effect of I/M programs on catalyst tampering is investigated more thoroughly in Table 13, where catalyst tampering rates in each program area are presented for each vehicle model year and vehicle type. The same trend in program effectiveness is evident for cars and trucks of a specific model year. The small sample sizes for some model years and vehicle types, however, prevent some comparisons from being made. For example, the truck rates by model year in I/M-only and I/M + ATP areas are based on very small sample sizes. These rates have been included in Table 13 for the sake of completeness and should not be considered meaningful. Table 13 also shows the strong relationship between vehicle age and catalyst tampering in cars and trucks, particularly in non-I/M areas and in the overall database.

## 6. Effect of Antitampering Programs on Tampering

The impact of antitampering programs on tampering rates is presented in Table 14, which compares the tampering rates for components checked in the three I/M + ATP areas surveyed. Boston, whose yearly inspection program covers filler neck restrictors and catalysts on 1980 and later vehicles, had very high tampering rates for these components on 1980 and 1981 model year vehicles. Boston's program had been in effect over a year at the time of the survey. St. Louis had significant tampering rates for a number of components on 1981 and 1982 model year vehicles. St. Louis' yearly

## TABLE 13

## Catalytic Converter Tampering Prevalence* by Vehicle Type in I/M and non-I/M Areas - 1984 Survey

| | non-I/M Areas | | | | I/M only Areas | | | |
|---|---|---|---|---|---|---|---|---|
| | Automobiles | | Light-Duty Trucks | | Automobiles | | Light-Duty Trucks | |
| Model Year | Number Surveyed | Tampering Rate(%) | Number Surveyed | Tampering Rate(%) | Number Surveyed | Tampering Rate(%) | Number Surveyed | Tampering Rate(%) |
| 1975 | 77 | 23 | 5 | 100 | 70 | 5 | 7 | 20 |
| 1976 | 150 | 16 | 13 | 50 | 114 | 9 | 4 | 0 |
| 1977 | 167 | 21 | 16 | 50 | 129 | 7 | 4 | 0 |
| 1978 | 222 | 11 | 16 | 33 | 155 | 2 | 8 | 43 |
| 1979 | 177 | 10 | 42 | 39 | 132 | 4 | 24 | 17 |
| 1980 | 158 | 8 | 50 | 23 | 135 | 2 | 19 | 0 |
| 1981 | 145 | 6 | 43 | 21 | 139 | 1 | 15 | 21 |
| 1982 | 147 | 1 | 55 | 7 | 111 | 0 | 14 | 7 |
| 1983 | 138 | 1 | 66 | 6 | 115 | 0 | 24 | 8 |
| 1984 | 130 | 0 | 56 | 2 | 108 | 0 | 22 | 0 |

* Many Light-Duty Trucks manufactured between 1975-79 were not originally equipped with catalysts, and thus were excluded from this table.

TABLE 13 (cont'd)

Catalytic Converter Tampering Prevalence by Vehicle Type in I/M and non-I/M Areas - 1984 Survey

| | I/M + ATP Areas | | | | Overall | | | |
|---|---|---|---|---|---|---|---|---|
| | Automobiles | | Light-Duty Trucks | | Automobiles | | Light-Duty Trucks | |
| Model Year | Number Surveyed | Tampering Rate(%) | Number Surveyed | Tampering Rate(%) | Number Surveyed | Tampering Rate(%) | Number Surveyed | Tampering Rate(%) |
| 1975 | 34 | 10 | 4 | 0 | 181 | 14 | 16 | 50 |
| 1976 | 99 | 1 | 5 | 0 | 363 | 10 | 22 | 35 |
| 1977 | 87 | 8 | 5 | 0 | 383 | 13 | 25 | 38 |
| 1978 | 148 | 7 | 10 | 0 | 525 | 7 | 34 | 32 |
| 1979 | 114 | 1 | 14 | 29 | 423 | 6 | 80 | 30 |
| 1980 | 127 | 3 | 27 | 4 | 420 | 4 | 96 | 14 |
| 1981 | 110 | 3 | 6 | 0 | 394 | 4 | 64 | 19 |
| 1982 | 119 | 0 | 20 | 5 | 377 | 1 | 89 | 7 |
| 1983 | 107 | 0 | 21 | 0 | 360 | 1 | 111 | 5 |
| 1984 | 113 | 0 | 33 | 0 | 351 | 0 | 111 | 1 |

## TABLE 14

Tampering Rates (percent) for Components Checked in I/M + ATP Areas - 1984 Survey

| Survey Site | Component or System | Model Year 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|
| Boston, MA | Filler Neck Restrictor | 11 | 7 | 3 | 0 | 0 |
| | Catalyst | 7 | 2 | 0 | 0 | 0 |
| | Filler Neck or Catalyst | 15 | 10 | 3 | 0 | 0 |
| Portland, OR | PCV System | 0 | 0 | 1 | 0 | 0 |
| | Air System | 0 | 0 | 0 | 0 | 0 |
| | EGR System | 1 | 0 | 0 | 0 | 0 |
| | Catalyst | 1 | 0 | 0 | 0 | 0 |
| | Filler Neck Restrictor | 0 | 0 | 0 | 0 | 0 |
| | Filler Neck or Catalyst | 1 | 0 | 0 | 0 | 0 |
| | Any of Above | 2 | 0 | 1 | 0 | 0 |
| St. Louis, MO | PCV System | * | 0 | 3 | 0 | 0 |
| | Air System | * | 3 | 5 | 0 | 0 |
| | EGR System | * | 0 | 4 | 0 | 0 |
| | Catalyst | * | 5 | 3 | 0 | 0 |
| | Any of Above | * | 7 | 3 | 0 | 0 |

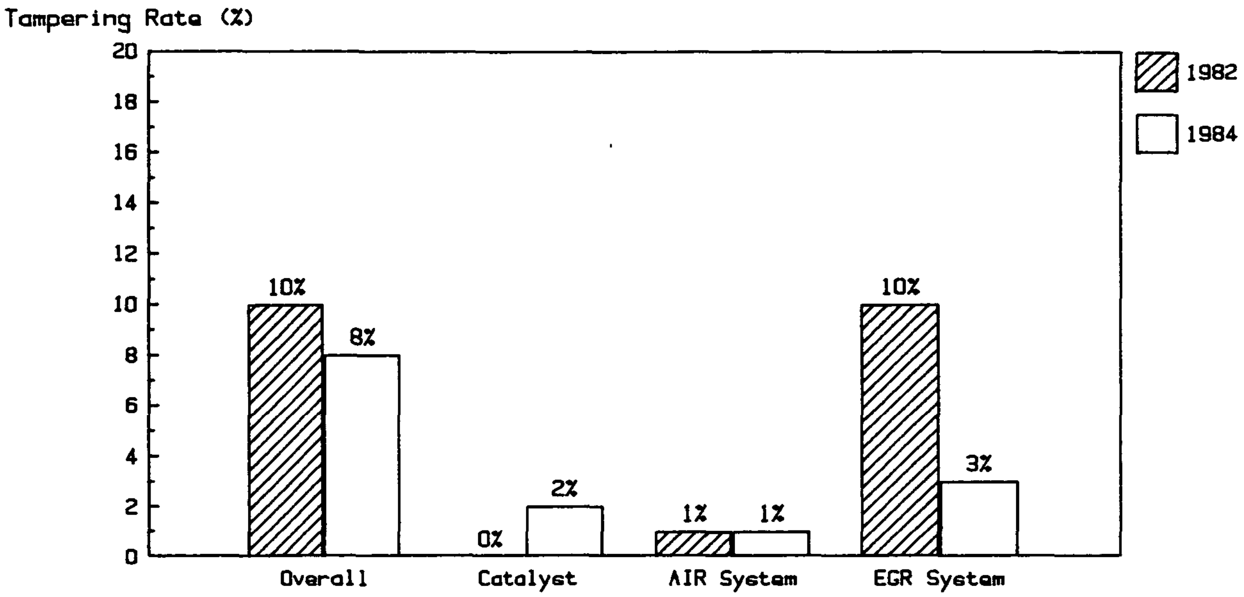
*Component/model year not covered by antitampering program.

program, however, had only been implemented seven months prior to the survey. Portland's antitampering program appears to be the most effective, with negligible tampering rates for all components covered by the program.

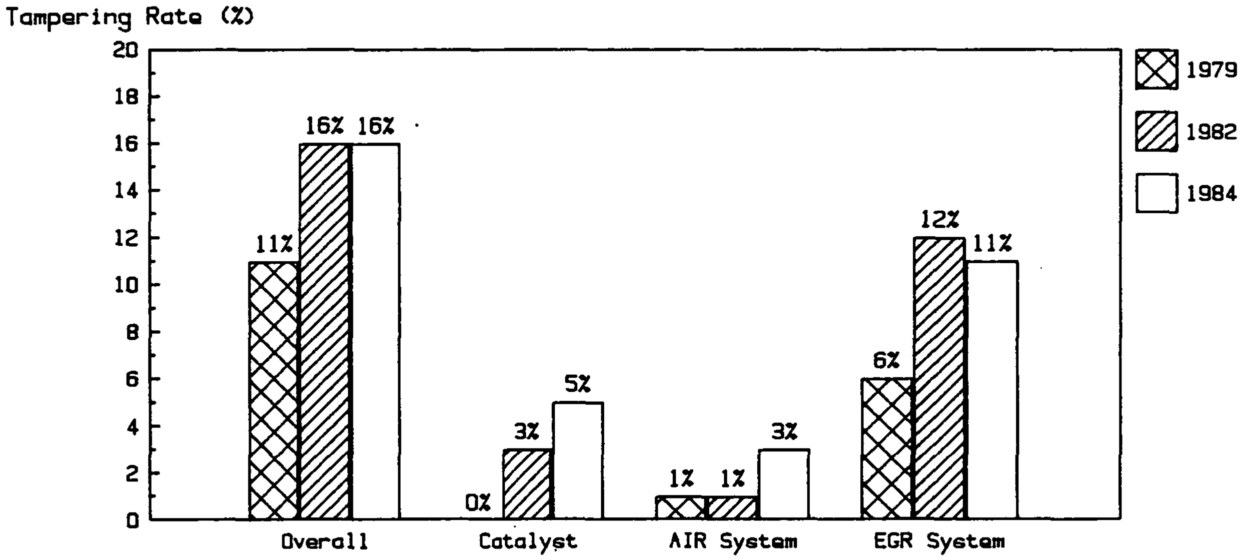
### 7. Effectiveness of I/M-only vs. I/M + ATP

Figures 9(a) and (b) compare the effectiveness of I/M-only programs and I/M + ATP in preventing tampering. Tampering rates for Portland and New Jersey have been selected since these sites represent long-standing I/M + ATP and I/M-only programs, respectively. New Jersey instituted its I/M program in February, 1974, and Portland's I/M + ATP program began in July, 1975. Additionally, these are the only two 1984 survey sites that had been surveyed in previous years. Figure 9(a) shows that Portland's I/M + ATP has reduced overall tampering and EGR tampering between 1982 and 1984 while AIR system and catalyst tampering have remained very low. Over the same period of time New Jersey's I/M-only program has had no impact on overall tampering rates, and over the past five years the tampering rates for catalyst, AIR, and EGR systems have all increased markedly.

Half of the catalyst removals found in Portland in 1984 were from out-of-state vehicles not previously subjected to the local inspection program. In contrast, all of the vehicles with missing catalysts in New Jersey were in-state vehicles



a) Portland, OR



b) New Jersey

Figures 9(a) and (b). Comparison of data from 1984 survey sites that had been surveyed previously.

subject to the state's I/M program. The difference in EGR tampering rates for the two sites in also noteworthy because EGR reduces $NO_x$ emissions, a pollutant not checked by idle emissions testing. These results suggest that I/M-only programs are not as effective as I/M + ATP in reducing tampering rates, and that many tampered vehicles are apparently able to pass an idle emissions test undetected.

## 8. I/M Programs and Geographic Bias

Determining the impact of I/M and I/M + ATP programs on tampering and misfueling may be complicated by a possible geographic bias in the survey data. The 1984 survey sites are listed below by program type.

| Non-I/M | I/M-Only | I/M + ATP |
|---|---|---|
| Bakersfield, CA | Reno, NV | Boston, MA |
| Dallas, TX | Washington, DC | St. Louis, MO |
| Birmingham, AL | New Jersey | Portland, OR |
| Cincinnati, OH | New York, NY | |
| Tampa, FL | Milwaukee, WI | |
| El Paso, TX | | |

It is apparent that the geographic regions of the U.S. are not equally represented in each program type. The northern states are disproportionately represented in the I/M areas, while only one northern non-I/M site (Cincinnati) was surveyed. Similarly, no southern I/M sites were surveyed, while four southern non-I/M sites (Dallas, Birmingham, Tampa, and El Paso) were included. Also four of the northern survey areas (Boston, New York City, New Jersey, and Washington) are concentrated within 500 miles of each other.

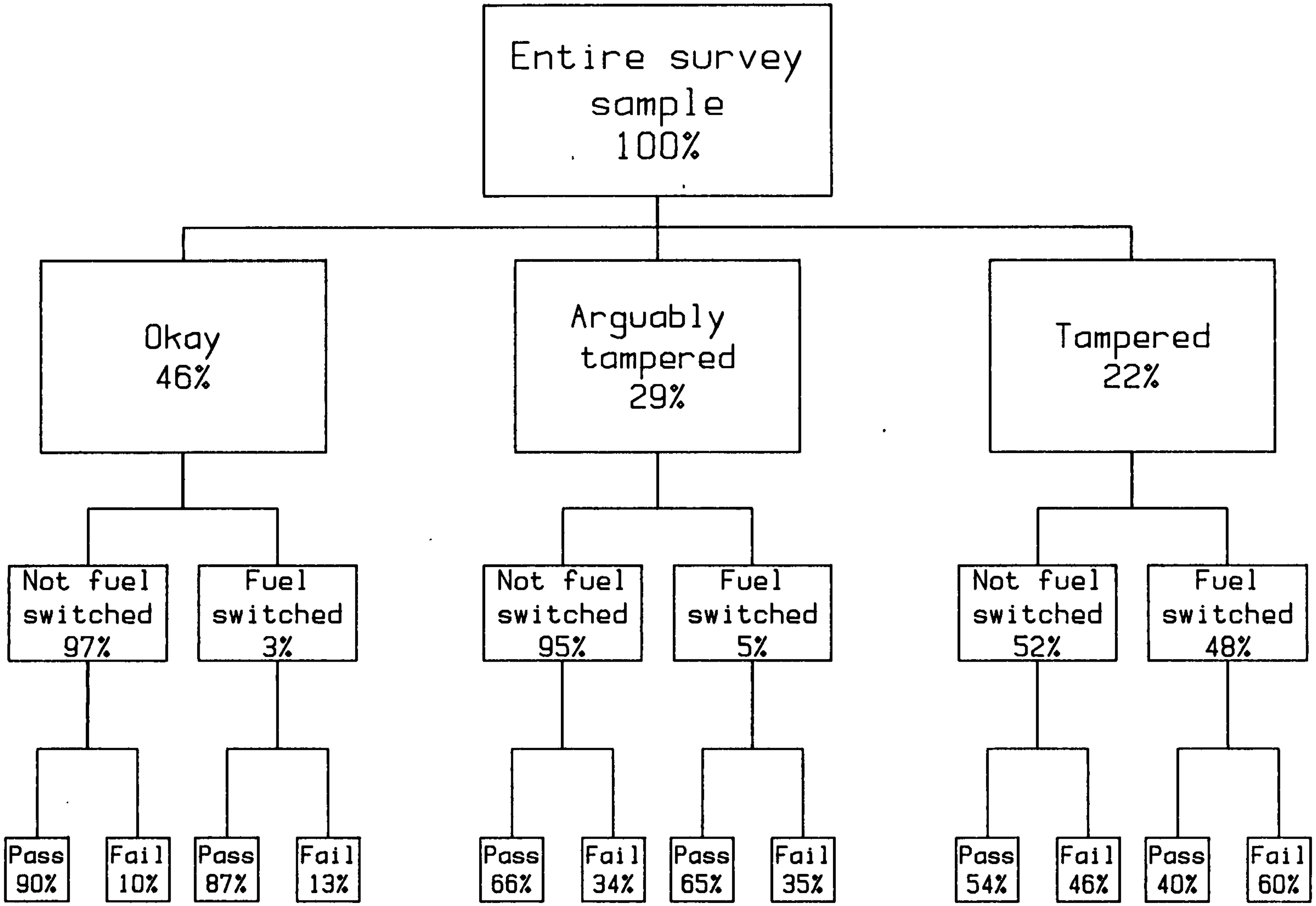
The southern states appear to have higher tampering rates than the northern states, which would increase the discrepancy between the I/M and non-I/M tampering rates as surveyed. In comparing the data from non-I/M sites in Table 7, the component-specific tampering rates in Cincinnati are lower than in the four southern cities surveyed for every component except the PCV and EGR systems. Cincinnati also has a much lower misfueling rate (Table 2). The possibility of a geographic influence cannot be further investigated readily using the 1984 survey data, but it may influence site selection in future surveys.

### 9. Correlation between Tampering and Idle Emissions

As was mentioned previously, vehicles which are subject to an I/M program must meet specific idle emissions cutpoints. To assess the relationship between tampering and fuel switching and idle failure rates, the idle emissions from vehicles have been tested against the cutpoints established by the I/M program where they were sampled. Vehicles in non-I/M areas were tested against the cutpoints specified by the New Jersey I/M program. The cutpoints for each I/M area are listed in Appendix C.

The results of the idle tests are presented in Figure 10 for vehicles in the various tampering and fuel switching categories. Only 10% of the survey vehicles free of tampering and fuel switching failed an idle test, while 60% of the

Figure 10
Distribution of Survey Sample Among Tampering*, Fuel Switching, and Idle Test Categories



*excludes malfunctioning vehicles (4% of total) tampered and fuel switched vehicles failed that test. These results indicate that a substantially larger proportion of tampered and fuel switched vehicles than of okay vehicles fail an idle test at typical I/M cutpoints. This is partly due to the tendency for tampered vehicles to have misadjusted carburetors, as is shown in Figure 11. This Venn diagram shows that 71% of the tampered vehicles with conventional carburetors also had missing sealed plugs or limiter caps. It must be noted from Figure 10, however, that 40% of these tampered and misfueled vehicles were still able to pass the idle test.

Table 15 shows the percentage of vehicles that failed the idle emissions test for each vehicle condition. Over one-third of the tampered vehicles failed the idle emissions test for either HC or CO, while only 7% of the okay vehicles exceeded limits for HC or CO. Over one-third of the vehicles that either had been fuel switched or had their catalysts removed also exceeded HC and CO limits. Conversely, nearly two-thirds of the vehicles with inoperative or missing catalysts were still able to pass an idle emissions test. Interestingly, a significant number of arguably tampered vehicles also produced excess idle emissions. Since the majority of arguable tampering involves idle speed limiter caps, the high failure rate demonstrates the adverse idle emissions impact of improperly adjusted carburetors.

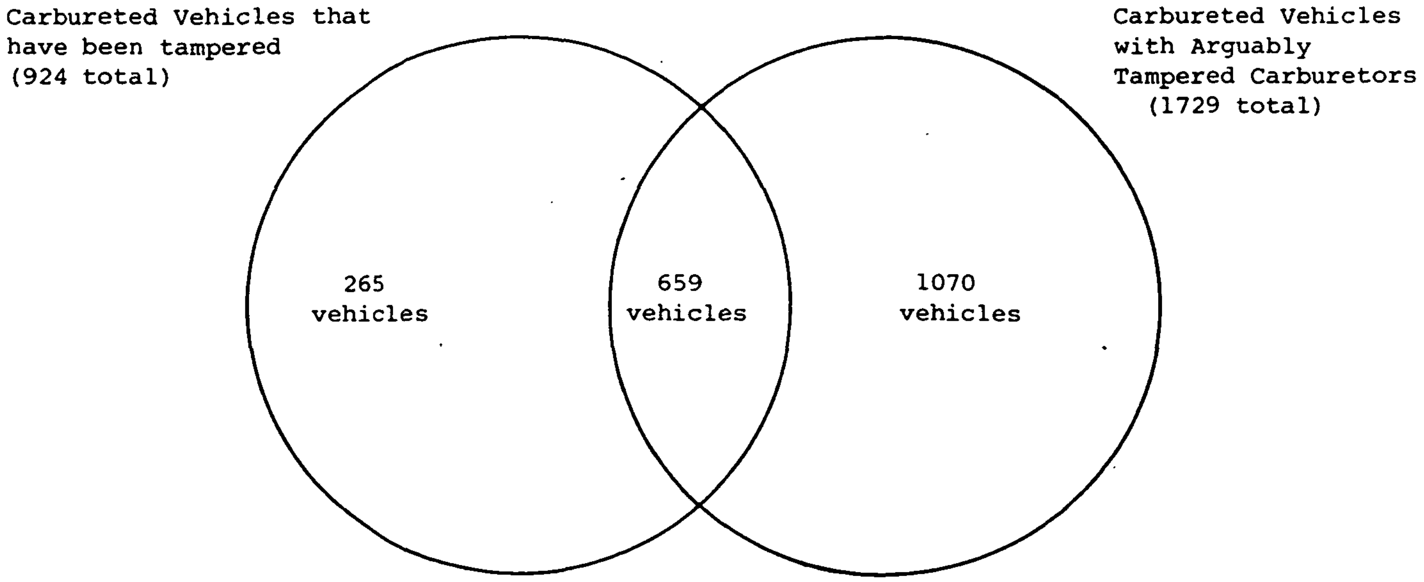


Figure 11. Overlap of Tampering and carburetor misadjustment among conventionally carbureted vehicles - 1984 Survey.

## TABLE 15

### Idle Test Failure Rates (percent) by Pollutant and Vehicle Condition

| | Vehicle Condition | | | |
|---|---|---|---|---|
| Pollutant | Okay | Tampered | Arguably Tampered | Cat. Removed/ Misfueled |
| HC | 7 | 38 | 23 | 40 |
| CO | 7 | 36 | 26 | 35 |

---

## TABLE 16

### Mean Idle Emissions by Vehicle Condition

| Survey Sites | HC emissions(ppm) | | CO emissions(%) | |
|---|---|---|---|---|
| | Tampered | Okay | Tampered | Okay |
| non-I/M | 430.0 | 65.6 | 3.0 | 0.4 |
| I/M only | 287.2 | 60.1 | 2.4 | 0.4 |
| I/M + ATP | 323.4 | 60.4 | 2.1 | 0.3 |
| OVERALL | 381.7 | 62.3 | 2.7 | 0.4 |

The mean idle emissions for tampered and okay vehicles are presented in Table 16 by program type. The mean idle emissions from tampered vehicles were considerably higher than from okay vehicles. Overall HC emissions were 513% higher, while overall CO emissions were 575% higher. The means for non-I/M areas were higher than for I/M-only and I/M + ATP areas.

To investigate the impact of I/M programs on idle emissions, the emissions from okay and tampered vehicles in each program type can be compared. The data indicates that idle HC emissions from okay vehicles in I/M areas were only 8% lower than from vehicles in non-I/M areas, and that the idle CO emissions were not affected by I/M programs. Anti-tampering programs had no additional impact on idle HC and CO emissions of okay vehicles (Table 16). These findings agree with Table 15, which shows that nearly all okay vehicles would pass the idle emissions test. Idle HC and CO emissions from tampered vehicles, however, were 33% and 20% lower, respectively, in I/M-only area than in non-I/M areas, suggesting that idle emissions may be reduced from vehicles for which tampering is not successfully deterred. It should be noted that a vehicle's idle emissions are only loosely related to its emissions under normal driving conditions.

## B. FUEL SWITCHING

### 1. Fuel Switching Indicators and Overlap

Fuel switching is more easily defined than measured, since no single indicator can accurately determine its prevalence. Since 1981 the surveys have used a combination of three indicators to measure fuel switching more accurately: a tampered fuel filler inlet restrictor, a positive Plumbtesmo test for lead deposits in the tailpipe, and a gasoline lead concentration of more than 0.05 grams per gallon (gpg). Of these three indicators, only a tampered inlet restrictor is also considered tampering, and as such is used to calculate both tampering and fuel switching rates. Since false positive indications should be extremely rare for these measures, the percentage of vehicles with at least one positive indicator is a reasonable minimum estimate of fuel switching.

The presence of any of these three indicators suggests that a given vehicle has been misfueled; their absence, however, does not rule it out. For example, fuel samples could only be obtained from 70% of the unleaded vehicles surveyed, limiting the scope of this variable. A vehicle misfueled repeatedly with leaded gasoline may also have little detectable lead in its fuel tank due to subsequent proper fueling. Similarly, a vehicle with an untampered fuel filler inlet restrictor may have been fueled at a leaded pump equipped with a smaller nozzle, or by using a funnel or similar device.

The tailpipe lead test, due to the difficulties of field administration, may also fail to identify misfueling, and older vehicles may have had their tailpipes replaced since last operated on leaded fuel. The uncertainty in these measures, then, is always toward underestimating the number of vehicles misfueled.

The limitations of the fuel switching indicators can be seen in their incomplete overlap. The results from these indicators would be expected to overlap significantly, since they are three indicators of the same phenomenon. This has not held true, however, in the 1984 survey or in previous surveys. The Venn diagram (Figure 12) illustrates the degree of overlap in the 1984 results. For example, only 73% of the vehicles having leaded fuel in their tank also registered a positive Plumbtesmo test. Additionally, only 35% of the vehicles with tampered inlet restrictors actually had leaded gasoline in their tanks at the time of the survey. The incomplete overlap reflects the limitations of each indicator as well as the different aspects of fuel switching each indicator identifies.

## 2. Fuel Switching Rates

Of the vehicles requiring unleaded fuel, 14% were identified as misfueled by at least one of the indicators discussed above. The fuel switching incidence by survey site and program type is listed in Table 17. Since fuel samples

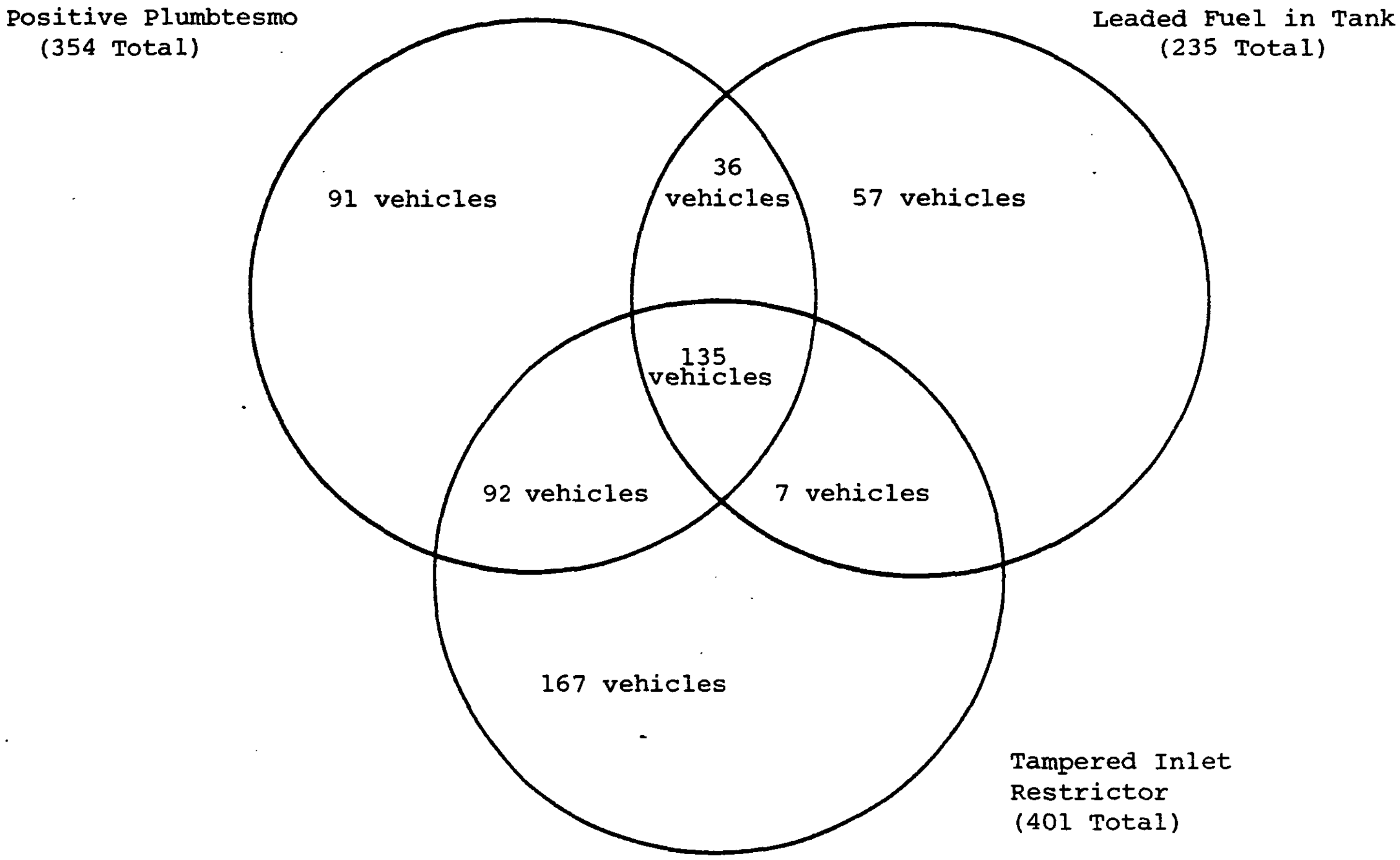


Figure 12. Overlap of fuel switching indicators among unleaded vehicles - 1984 Survey.

## TABLE 17

## Fuel Switching Rates among Unleaded Vehicles by Site and Indicator - 1984 Survey

| Survey Location | Leaded Fuel in Tank(%) | Tampered Inlet Restrictor(%) | Positive Plumbtesmo (%) | >1 Positive Indicators (%) |
|---|---|---|---|---|
| **Non-I/M Areas** | | | | |
| Bakersfield, CA | 3 | 11 | 8 | 14 |
| Dallas, TX | 11 | 12 | 15 | 18 |
| Birmingham, AL | 17 | 19 | 21 | 25 |
| Cincinnati, OH | 7 | 8 | 7 | 12 |
| Tampa, FL | 15 | 17 | 16 | 23 |
| El Paso, TX | 13 | 17 | 16 | 23 |
| **I/M Only Areas** | | | | |
| Reno, NV | 17 | 15 | 17 | 22 |
| Washington, DC | 2 | 9 | 2 | 10 |
| New Jersey | 2 | 5 | 6 | 8 |
| New York, NY | 14 | 2 | 5 | 13 |
| Milwaukee, WI | 1 | 5 | 3 | 7 |
| **I/M + ATP Areas** | | | | |
| Boston, MA | 4 | 5 | 2 | 9 |
| St. Louis, MO | 7 | 7 | 6 | 10 |
| Portland, OR | 2 | 4 | 4 | 7 |
| ALL NON-I/M SITES | 11 | 14 | 14 | 19 |
| ALL I/M ONLY SITES | 5 | 6 | 5 | 10 |
| ALL I/M+ATP SITES | 4 | 6 | 4 | 8 |
| ALL SITES | 7 | 10 | 8 | 14 |

could not be obtained from all unleaded vehicles surveyed, the incidence of leaded fuel in the tank may be higher than the overall misfueling rate for some survey sites (e.g., New York). Non-I/M sites had the highest fuel switching rate (19%), followed by I/M-only and I/M + ATP areas. The prevalence of each fuel switching indicator in non-I/M areas was at least twice that found in I/M-only areas.

Tables 18 and 19 compare the fuel switching rates from the 1984 survey with previous surveys. Table 18 shows that although the overall fuel switching rate has not changed appreciably, the rate for non-I/M areas has been increasing steadily. Table 19 shows that inlet restrictor tampering has increased steadily, while the prevalence of the other two fuel switching indicators has remained unchanged.

Table 20 presents the combined tampering and fuel switching rates for the 1984 survey. The percentage of vehicles that were tampered or fuel switched was 24%, only 2% higher than the tampering rate alone. The overlap in the fuel switching and tampering rates results mainly from the inlet restrictor tampering rates being used to calculate both values.

## TABLE 18

### Fuel Switching Prevalence among Unleaded Vehicles in I/M and non-I/M Areas

| Survey Year | Fuel Switching Rate (%) non-I/M | I/M only | I/M + ATP | Overall |
|---|---|---|---|---|
| 1978 | 4* | NS | NS | 4* |
| 1979 | 12* | 3* | NS | 9* |
| 1981** | 16 | NS | NS | 16 |
| 1982 | 15 | 7 | 2* | 11 |
| 1983 | 17 | 12 | 5 | 14 |
| 1984 | 19 | 10 | 8 | 14 |

*Plumbtesmo test not used.
**1981 survey was of limited scope, covering only two sites and 399 vehicles.
NS: None surveyed

---

## TABLE 19

### Fuel Switching Rates among Unleaded Vehicles by Indicator and Survey Year

| Survey Year | Leaded Fuel in Tank(%) | Tampered Inlet Restrictor(%) | Positive Plumbtesmo(%) | >1 Positive Indicators(%) |
|---|---|---|---|---|
| 1978 | 4 | 3 | * | 4 |
| 1979 | 10 | 4 | * | 9 |
| 1981 | 7 | 6 | 8 | 16 |
| 1982 | 6 | 6 | 7 | 11 |
| 1983 | 7 | 7 | 10 | 14 |
| 1984 | 8 | 10 | 9 | 14 |

* No Plumbtesmo test

## TABLE 20

## Combined Tampering and Fuel Switching Rates - 1984 Survey

| Survey Location | Catalyst-equipped vehicles with catalysts removed or fuel switched (%) | Unleaded vehicles either tampered or fuel switched (%) |
|---|---|---|
| | Non-I/M Areas | |
| Bakersfield, CA | 19 | 34 |
| Dallas, TX | 22 | 31 |
| Birmingham, AL | 28 | 35 |
| Cincinnati, OH | 16 | 31 |
| Tampa, FL | 26 | 42 |
| El Paso, TX | 27 | 34 |
| | I/M-only Areas | |
| Reno, NV | 25 | 35 |
| Washington, DC | 13 | 25 |
| New Jersey | 9 | 18 |
| New York, NY | 16 | 25 |
| Milwaukee, WI | 8 | 12 |
| | I/M + ATP Areas | |
| Boston, MA | 9 | 17 |
| St. Louis, MO | 12 | 17 |
| Portland, OR | 7 | 10 |
| ALL NON-I/M SITES | 23 | 34 |
| ALL I/M-ONLY SITES | 12 | 20 |
| ALL I/M + ATP SITES | 9 | 13 |
| ALL SITES | 16 | 24 |

### 3. Fuel Switching by Vehicle Type

As was reported previously, the fuel switching rates for trucks was considerably higher than for passenger cars - 19% vs. 13% (Table 1). The filler neck restrictor tampering rates were also higher for trucks than for passenger cars (Table 1).

### 4. Fuel Switching and Vehicle Age

Table 21 correlates vehicle age and model year with fuel switching rates for the 1978-1984 surveys. This method of analysis is identical to the one used earlier to compare tampering rates across model years and vehicle ages. Analyzing Table 21 diagonally shows that the rate of fuel switching increased with vehicle age in every survey taken. The fuel switching rate reached a maximum of 20-30% when the vehicles were six or seven years old. A similar though less pronounced pattern can be seen when the data is analyzed within model years (horizontally) or within vehicle age groups (vertically).

### 5. Catalyst Tampering and Fuel Switching

Consumers and mechanics remove catalytic converters for a number of reasons, but much of their motivation is related to fuel switching. The vehicle owner may remove the catalytic converter either prior to misfueling, or after some misfueling if the vehicle's driveability has been adversely affected by a catalyst damaged from the repeated misfueling. The data from

## TABLE 21

### Percentage of Fuel Switching (and Sample Size) among Unleaded Vehicles by Model Year and Vehicle Age at Time of Survey

| | Year of Vehicle Life | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model Year | First | Second | Third | Fourth | Fifth | Sixth | Seventh | Eighth | Ninth | Tenth |
| 1984 | 3(462) | | | | | | | | | |
| 1983 | 5(182) | 4(471) | | | | | | | | |
| 1982 | 5(250) | 6(226) | 6(465) | | | | | | | |
| 1981 | 9(57) | 7(444) | 9(205) | 8(457) | | | | | | |
| 1980 | | 11(62) | 8(447) | 8(210) | 11(487) | | | | | |
| 1979 | 6(328) | | 16(55) | 12(432) | 19(269) | 18(455) | | | | |
| 1978 | 2(296) | 8(451) | | 18(74) | 12(377) | 15(221) | 24(486) | | | |
| 1977 | | 3(438) | 9(428) | | 18(60) | 13(283) | 23(176) | 27(357) | | |
| 1976 | | | 6(388) | 15(316) | | 37(49) | 14(249) | 21(147) | 24(314) | |
| 1975 | | | | 6(255) | 14(213) | | 30(20) | 17(146) | 24(82) | 26(174) |

this survey cannot be used to distinguish between these two situations, but can be used to examine the extent to which these types of abuse occur in conjunction.

Of the catalyst-equipped vehicles surveyed, 16% were either catalyst tampered or fuel switched (Table 20). The rates in non-I/M, I/M-only, and I/M + ATP areas were 23%, 12%, and 9%, respectively.

Figure 13 depicts the degree of overlap between catalyst removal and fuel switching. Vehicles with catalyst tampering exclusive of fuel switching were relatively uncommon -- only one-third of the catalyst tampered vehicles were not fuel switched. Fuel switching, however, is not always accompanied by catalyst removal. Over two-thirds of the fuel switched vehicles still have their catalysts.

## 6. Gasoline Lead Concentrations

Of the vehicles identified by any of the three indicators as misfueled, 37% had only trace amounts of lead (less than 0.05 gpg) in their gasoline when inspected. These vehicles, then, were identified as fuel switched by a tampered filler restrictor and/or a positive Plumbtesmo test. Figure 14 presents the distribution of lead concentrations of 0.05 gpg or more in misfueled vehicles. This figure shows that 39% of the misfueled vehicles have a gasoline lead concentration in excess of 1.0 gpg. Since the average lead concentration

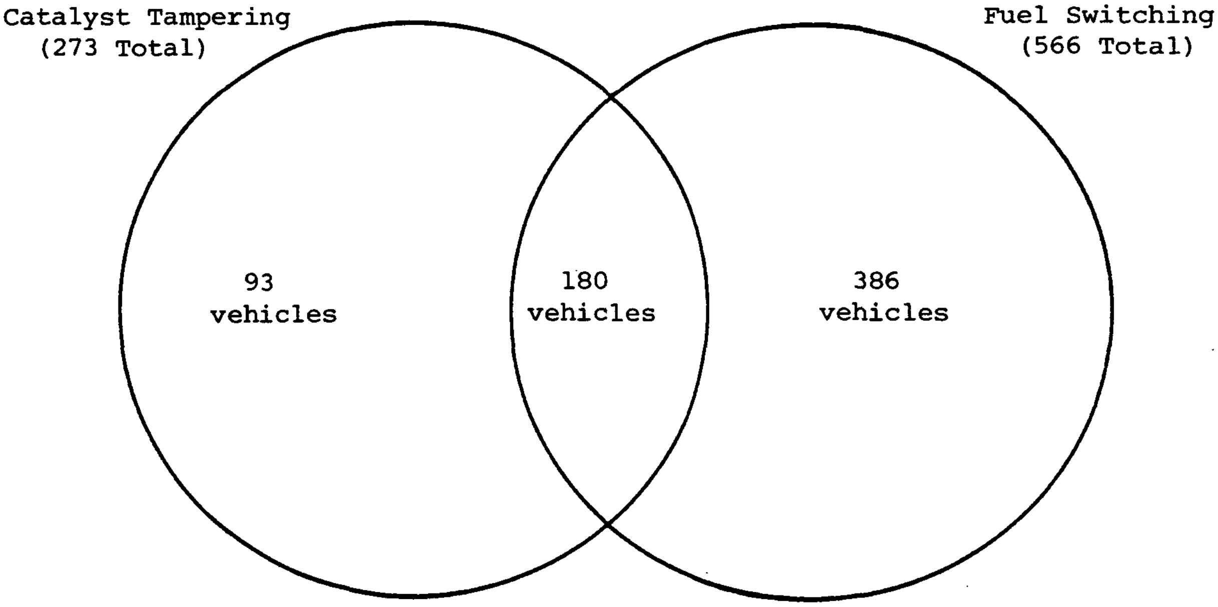


Figure 13. Overlap of catalyst tampering and fuel switching among catalyst-equipped vehicles - 1984 Survey.

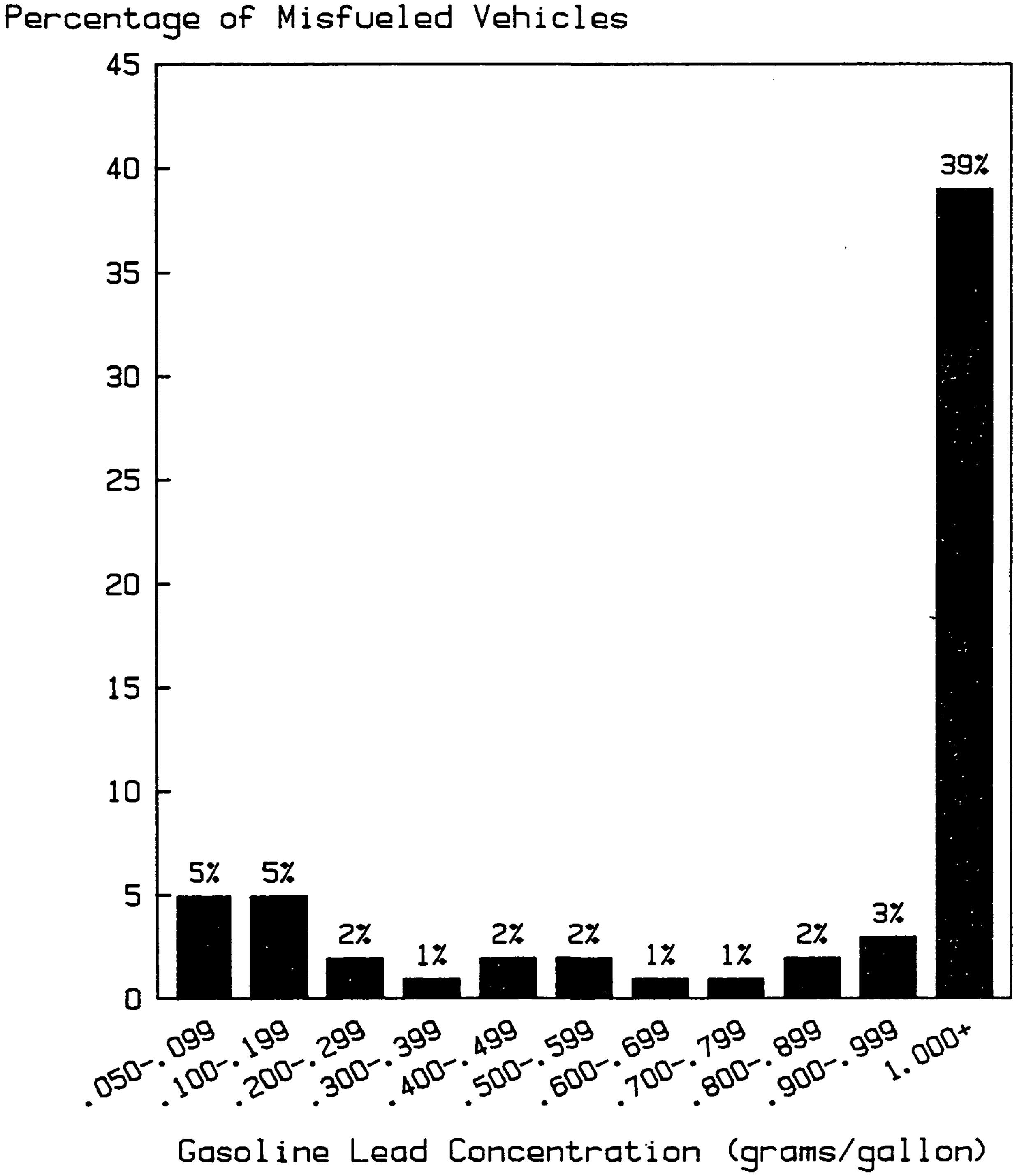


Figure 14. Lead concentrations in fuel sampled from misfueled vehicles.

in leaded gasoline at the refinery is 1.1 gpg, the results suggest that about 39% of the misfueled vehicles are habitually misfueled, as the leaded gasoline in their tanks showed no evidence of having been diluted by subsequent tankfuls of unleaded gas.

## APPENDIX A

## RELEVANT PORTIONS OF THE CLEAN AIR ACT

Section 203(a)(3): The following acts and the causing thereof are prohibited --

(A) for any person to remove or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title prior to its sale and delivery to the ultimate purchaser, or for any manufacturer or dealer knowingly to remove or render inoperative any such device or element of design after such sale and delivery to the ultimate purchaser; or

(B) for any person engaged in the business of repairing, servicing, selling, leasing, or trading motor vehicles or motor vehicle engines, or who operates a fleet of motor vehicles, knowingly to remove or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title following its sale and delivery to the ultimate purchaser.

# APPENDIX B

## SURVEY AND DATA RECORDING PROCEDURES

### 1. Explanation of Survey Forms

The forms on the following pages were used for recording the survey data in the field. The forms were forced choice to ensure coding consistency, and were designed to facilitate direct data entry. The following codes were used to record data for the major system components on the data sheets:

0 - Not originally equipped
1 - Functioning properly
2 - Electrical disconnect
3 - Vacuum disconnect
4 - Mechanical disconnect
5 - Incorrectly routed hose
6 - Non-stock equipment
7 - Missing item
8 - Misadjusted item
9 - Malfunctioning
P - Stock equipment
A - Add on equipment

Additional codes were used for those components which could not be classified into the above categories. A brief description of each data entry follows.

SURVEY - FORM A (Rear)

☐☐☐☐ ID NUMBER
1 4

☐☐☐☐ MAKE
5 8

☐☐☐☐ MODEL
9 12

☐ VEHICLE TYPE (1-Car, 2-Truck)
13

☐☐ LICENSE PLATE (State)
14 15

☐☐☐☐ HC, PPM
16 19

☐☐☐.☐ CO, %
20 23

☐ PLUMBTESMO (Positive, Negative)
24

☐☐☐ ODOMETER READING, Thousand
25 27

☐ DASH LABEL (0, 1, 7)
28

3/84

☐ TANK CAP (1, 7, 9)
29

☐ TANK LABEL (0, 1, 7)
30

☐ FUEL INLET RESTRICTOR (0, 1, 4, 7)
31

☐ CAT (0, 1, 7, 9)
32

☐ EXHAUST SYSTEM (P-stock, N-non)
33

☐ EXHAUST INTEGRITY (1, 9)
34

☐ FUEL SAMPLE (Y, N)

0 - Not Original Equipped
1 - Functioning Properly
2 - Electrical Disconnect
3 - Vacuum Disconnect
4 - Mechanical Disconnect
5 - Incorrectly Routed Hose
6 - Non-Stock
7 - Missing Item
8 - Misadjusted Item
9 - Malfunctioning

## NATIONAL SURVEY - FORM B (Underhood)

1 ☐☐☐☐ 4 ID NUMBER

5 ☐ EGR VALVE (0, 1, 3, 7, 9)

6 ☐ EGR SENSOR (0, 1, 3, 5, 7, 9) (CTO-Transducers-Other)

7 ☐ 8 ☐ MODEL YEAR

9 ☐☐☐☐ 12 DISPLACEMENT (CID or liters)

13 ☐☐☐☐☐☐☐☐☐☐☐ 23 ENGINE FAMILY

24 ☐☐☐☐☐☐☐☐☐☐☐☐☐ 36 VIN*

37 ☐ CAT EQUIPPED (1-Yes; 2-No; 3-Can't Tell)

38 ☐ AIR CLEANER (P-Stock; 6-Non)

39 ☐ HEATED AIR INTAKE (0, 1, 3, 4, 6, 7, 9)

40 ☐ PCV (0, 1, 3, 4, 6, 7)

41 ☐ TURBO (0, P-Stock, 6-Non, A-Add on)

*If Engine Family Not Found
3/84

42 ☐ EVAP. (0, 1, 3, 4, 5, 7, 9)

43 ☐ AIR PUMP (0, 1, 4, 7, 9)

44 ☐ AIR PUMP BELT (0, 1, 7, 8)

45 ☐ P.A.I.R. (0, 1, 4, 7, 9)

46 ☐ INTAKE MANIFOLD (P, 6)

47 ☐ EXHAUST MANIFOLD (P, 6)

48 ☐ $O_2$ SENSOR (0, 1, 2, 4, 7)

49 ☐ DISTRIBUTOR (P, 6)

50 ☐ VACUUM SPARK RETARD (0, 1, 2, 3)

51 ☐ CARBURETOR TYPE (P, Sealed, Fuel Injection, 6)

52 ☐ CARBURETOR, NUMBER OF BARRELS (0, 1, 2, 4)

53 ☐ IDLE STOP SOLENOID (0, 1, 2, 7, 9)

54 ☐ LIMITER CAP (0, 1, 4, 7, 8-Sealed Plugs Removed)

0 - Not Original Equipped
1 - Functioning Properly
2 - Electrical Disconnect
3 - Vacuum Disconnect
4 - Mechanical Disconnect
5 - Incorrectly Routed Hose
6 - Non-Stock
7 - Missing Item
8 - Misadjusted Item
9 - Malfunctioning
P - Stock

<u>Form A - Rear</u>

| | |
|---|---|
| 1-4 | ID Number - Vehicles are numbered sequentially as they are inspected. This number is preceded by a site identifying letter. |
| 5-8 | Make |
| 9-12 | Model |
| 13 | Vehicle Type - coded as follows: 1 = car, 2 = truck |
| 14-15 | License Plate - State abbreviation |
| 16-19 | Exhaust gas HC concentration (in ppm) at curb idle. |
| 20-23 | Exhaust gas CO concentration (in percent) at curb idle. |
| 24 | Plumbtesmo - Plumbtesmo paper is used to check for the presence of lead in vehicle exhaust pipes. A positive indication is coded as 'P' and a negative as 'N'. |
| 25-27 | Odometer - mileage in thousands |
| 28 | Dash Label - displays the fuel required and is coded '0', '1', or '7'. |
| 29 | Tank Cap - seals the fuel tank during normal operating conditions and is coded '1', '7', or '9'. |
| 30 | Tank Label - displays required fuel and is coded '0', '1', or '7'. |

31 Filler Neck Inlet Restrictor (unleaded vehicles only) - The restrictor is designed to prevent the introduction of leaded fuel into a vehicle requiring unleaded fuel. It is coded '0', '1', '4' (widened), or '7'.

32 Catalytic Converter - oxidizes the HC and CO to water and $CO_2$ in the exhaust gas. Later model catalysts also reduce oxides of nitrogen. The converter is coded '0', '1', '7' (entire catalyst canister removed), or '9' (high temperature discoloration, usually light blue).

33 Exhaust System - if originally equipped a 'P' is coded. If non-stock an "N' is coded.

34 Exhaust System Integrity - the condition of the exhaust system is coded '1' (no obvious leaks) or '9' (leaks evident).

35 Fuel Sample - indicates if inspector was able to take fuel sample for later lead analysis ('Y' or 'N').

## Form B - Format

1-4 ID Number - same as on Form A

Exhaust Gas Recirculation (EGR) System - directs a portion of the exhaust gases back into the cylinders to reduce $NO_x$ emissions in the exhaust gas. The standard EGR configuration consists of a vacuum line from the carburetor to a sensor (used to detect engine operating temperature to activate the EGR valve), and another vacuum line from the sensor to the EGR valve.

| | |
|---|---|
| 5 | EGR Control valve - coded '0', '1', '3', '7', or '9'. |
| 6 | EGR Sensor - coded '0', '1', '3', '5', '7', or '9'. |
| 7-8 | Vehicle Model year |
| 9-12 | Displacement - as recorded on the underhood emission label. |
| 13-23 | Engine Family - as recorded on the underhood emission label. |
| 24-36 | Non-serial number portion of VIN - as recorded on the driver's side of the dash under the windshield or the driver's door post. The VIN is recorded only if the engine family can not be determined. |
| 37 | Originally Catalyst Equipped - as recorded on the underhood emission label or the driver's door post. |
| 38 | Air Cleaner - is coded 'P' (stock) or '6'. |

39 Heated Air Intake - provides warm air to the carburetor during cold engine operation. The heated air intake is coded '0', '1', '3', '4', '6' (custom air cleaner), '7' (stovepipe hose), or '9' (vacuum override).

40 Positive Crankcase Ventilation (PCV) system - prevents crankcase emissions by purging the crankcase of blow-by gases which leak between the piston rings and the cylinder wall in the combustion chamber under high pressures. The PCV system is coded '0', '1', '3', '4' (fresh air hose), '6' (includes fuel economy devices), or '7'.

41 Turbocharger - coded '0', '6', 'P', or 'A'.

42 Evaporative Control System (ECS) - controls vapors from the fuel tank and carburetor. Some systems have two lines: from the fuel tank to the canister, and from the canister to the carburetor or air cleaner (for purging the canister). Other systems have a third line connected to the carburetor. The ECS is coded '0', '1', '3' (carburetor line), '4' (tank line), '5', '7', or '9' (air cleaner unsealed).

Air Injection System - extends the combustion process into the engine's exhaust system by injecting fresh air into the exhaust ports, lowering exhaust emissions while still maintaining proper vehicle performance. Two types of air injection systems are currently used. One type uses a belt-driven air pump to direct air through a control valve and into the exhaust manifold. The other type is a Pulse Air Injection Reaction (PAIR) system, which uses an aspirator located in the air cleaner to supply air to the exhaust manifold.

43 Air Pump System - for the purposes of this report, consists of the air pump and control valve and is coded '0' (if a PAIR or none), '1', '4' (excluding belt removal), '7', or '9'.

44 Air Pump Belt - is coded '0' (if PAIR), '1', '7', or '8' (loose belt).

45 PAIR - coded '0' (if air pump system or none), '1', '4', '7', or '9'.

46 Intake Manifold - coded 'P' or '6'.

47 Exhaust Manifold - coded 'P' or '6'.

48 Oxygen Sensor - Controls the air-fuel mixture going into the engine of vehicles equipped with three-way catalytic converters. The sensor is coded '0', '1', '2', '4' (unscrewed), or '7'.

49 Distributor - coded 'P' or '6'.

50 Vacuum Spark Retard - retards the spark during idle to delay ignition within the combustion chamber and increase exhaust temperature, prolonging the combustion process and reducing HC emissions. Vacuum spark retard is coded '0', '1', '2', or '3'.

51 Idle Stop Solenoid - provides an idle stop for maintaining idle speeds at higher rpm levels and prevents the throttle plate from fully closing during deceleration to minimize CO emissions. The idle stop solenoid is coded '0', '1', '2', '7', or '9'.

53 Limiter Caps - plastic caps on the idle mixture screws to limit carburetor adjustments. The limiter caps are coded '0', '1', '4' (tabs broken or bent), '7', or '8' (sealed plugs removed).

## 2. Classification Of Component Conditions

The table below was used to classify the various system components as 'tampered', 'arguably tampered', or 'malfunctioning' Only those codes which are applicable to a given component are listed. Codes for 'not originally equipped' and 'functioning properly' are not included in this table. Refer to Appendix B, Part 1 for an explanation of the codes.

| | Codes from form | | | | | | |
|---|---|---|---|---|---|---|---|
| Component/system | 2 | 3 | 4 | 5 | 6 | 7 | 9 |
| Dash Label | | | | | | A | |
| Tank Cap | | | | | | A | |
| Tank Label | | | | | | A | |
| Filler Neck Restrictor | | | T | | | T | |
| Catalytic Converter | | | | | | T | M |
| Oxygen Sensor | T | | T | | | T | |
| PCV System | | T | T | | T | T | |
| Idle Stop Solenoid | T | | | | | T | M |
| Heated Air Intake | | T | A | | T | A | M |
| Evaporative Control System | | T | T | T | | T | M |
| Aspirated Air Injection System | | | T | | | T | M |
| Air Pump Belt | | | | | | T | |

T = tampered
A - arguably tampered
M = malfunctioning

| | Codes from form | | | | | | |
|---|---|---|---|---|---|---|---|
| Component/system | 2 | 3 | 4 | 5 | 6 | 7 | 9 |
| Air Pump System | | | T | | | T | M |
| EGR Control Valve | | T | | | | T | M |
| EGR Sensor | | T | | T | | T | |
| Vacuum Spark Retard | T | T | | | | | |

---

T = tampered
A - arguably tampered
M = malfunctioning

## 3. Fuel Sample Collection and Labeling Procedures

A fuel sample was taken from each vehicle requiring unleaded fuel. These samples were collected in four-ounce bottles with a hand-operated fuel pump. Once the sample was drawn, the fuel was replaced with an equivalent amount of unleaded fuel if the driver requested, and the pump was flushed with unleaded fuel.

Each bottle was identified with an adhesive label that had the vehicle identifying survey number on it. The vehicle identifying number was the first entry on the data forms described in Part 1 of Appendix B.

Prior to shipment from the field, a sample tag with the same identifying number was attached to each bottle. The bottles were packed, labeled, and shipped to NEIC Chemistry Branch according to the shipper's requirements and the NEIC Policy and Procedures Manual.

## 4. Plumbtesmo Application

1) Clean a portion of the inside of the tailpipe large enough for the test paper by wiping it out with a paper towel or cloth. This may be necessary to remove soot deposits which might mask the color change.

2) Moisten the Plumbtesmo paper with distilled water and immediately* press firmly against the surface to be tested for approximately thirty seconds. If the tailpipe is hot you may wish to clamp the test paper in the tailpipe using a clean clamp.

   *Note: The Plumbtesmo paper must be applied during the time that the paper is yellow for the reaction to take place. After approximately 15 seconds the yellow color disappears and the paper is no longer effective. Excess water also interferes with the reaction.

   Care must be taken to avoid contamination of the test paper. If a person has recently handled a test paper with a positive reaction, some lead or reactive chemical may have been transferred to their fingers. Subsequently handling a clean test paper may cause contamination.

3) After removing the test paper, determine whether a color change has occurred. Red or pink coloration indicates the presence of lead.

## 5. Field Quality Control/Assurance

Reference and calibration gases were used to ensure the accuracy of the emissions analyzer. Horiba gases certified by RTP were used as reference gases. Two cylinders of reference gas were used to validate the accuracy of the calibration gases before they were taken to the field on each survey.

Three calibration gases (Horiba) were used. These gases were a mixture of CO and HC in nitrogen and were used to check the instrument at least three times daily. These calibration gases were certified by the manufacturer and the RTP reference gases. Their approximate compositions were:

8% CO
1560 ppm HC (Hexane equivalent)

4% CO
827 ppm HC (Hexane equivalent)

1.6% CO
320 ppm HC (Hexane equivalent)

# APPENDIX C

## EMISSION CUTPOINTS FOR I/M AREAS

The table below lists the emission cutpoints used by the I/M areas covered in the 1984 tampering survey. The cutpoints for pre-1975 vehicles are not included, since these vehicles were not surveyed.

| Survey Site | Model Year | Emissions Cutpoints<br>CO (%) | HC (ppm) |
|---|---|---|---|
| Boston, MA | 1975-79 | 4.0 | 400 |
| | 1980 | 2.7 | 300 |
| | 1981+ | 1.2 | 220 |
| Milwaukee, WI | 1975-77 | 6.0 | 600 |
| | 1978-79 | 4.0 | 400 |
| | 1980 | 2.5 | 275 |
| | 1981+ | 1.2 | 220 |
| New Jersey | 1975-80 | 3.0 | 300 |
| | 1981+ | 1.2 | 220 |
| New York, NY | 1975-77 | 5.7 | 700 |
| | 1978 | 4.3 | 500 |
| | 1979 | 3.0 | 400 |
| | 1980 | 2.7 | 330 |
| | 1981+ | 1.2 | 220 |
| Portland, OR | 1975+ | 0.5* | 175* |
| Reno, NV | 1975+ | 3.0 | - |
| St. Louis, MO | 1975-79 | 6.0 | 600 |
| | 1980 | 3.0 | 300 |
| | 1981+ | 1.2 | 220 |
| Washington, DC | 1975-79 | 6.5 | 600 |
| | 1980+ | 1.5 | 300 |

*Cutpoints for Portland are established by make and model year. The listed cutpoints are applicable to most 1975 and newer vehicles.