EPA-AA-TEB-81-24

# Emission Characteristics of 1979 and 1980 California Passenger Cars Equipped with Three-Way Catalysts

by

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August 1981

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Abstract

This report presents exhaust emissions data gathered on in-use vehicles equipped with three-way catalyst systems. The test vehicles were 1979 and 1980 passenger cars of various makes and models. Each of the 116 vehicles tested was certified to California standards. The purpose of the program was to gather information on current systems in customer use for projections on the ability of the three-way system to meet emission standards of the future.

The results indicated that vehicles equipped with these systems are capable of achieving low exhaust emission levels although high levels do occur due to defects, deterioration or tampering with the emission control equipment.

## Introduction

As exhaust emission and fuel economy standards for new motor vehicles have become more stringent, vehicle manufacturers have developed new technologies in order to meet these requirements. For the 1981 model year (1980 in California), the exhaust emission standards are such that most engines need more extensive controls in order to comply with the regulations. A summary of recent emission standards is displayed in Table 1. The emission control concept which most of these new vehicles employ is the three-way catalyst. This system was first brought to the marketplace by Volvo in 1977. The term "three-way" describes the ability of the converter to minimize all three regulated pollutants. The oxidation portion of the catalyst is similar to earlier models in that it contains platinum and palladium which promotes the conversion of HC, CO, and oxygen into carbon dioxide and water. The reduction portion of the catalyst contains rhodium which reduces the oxides of nitrogen into nitrogen and oxygen. In most cases, a conventional EGR valve is also used for preliminary control of NOx.

Some three-way systems employ a single converter which holds a homogeneous mixture of the catalytic materials which are deposited on a pelleted or monolithic substrate. This allows the oxidation and reduction processes to proceed simultaneously throughout the converter. Another technique employs the use of an oxidation catalyst downstream of the three-way catalyst. This system is called the three-way plus oxidation catalyst system. In this system, supplemental air is introduced ahead of the additional catalyst. It allows even more complete control of HC and CO emissions.

This latter technique is used in either the "dual catalyst" or "dual bed" configuration. The dual catalyst system utilizes two separate containers, whereas the dual bed type has the catalytic material in separate portions of the same container.

Although vehicle manufacturers have chosen a number of physically different configurations for the hardware, there are two basic ways to control these three-way systems: either "open loop" or "closed loop". Given the current and future exhaust emission standards, the closed loop system represents the state-of-the art and is considered to be the most effective for sizeable emission reductions without a loss of fuel economy. The term "closed loop" refers to the feedback mechanism between the output (exhaust) and the input (air-fuel mixture). This term will be used to denote all systems which employ this mechanism although most closed loop systems do operate on an open loop basis under certain operating modes, such as warm-up or heavy load.

The primary reason for the use of a closed loop system is that the overall effectiveness of the three-way catalyst is greatest when the air-fuel mixture is close to ideal. "Stoichiometric" is the chemical term used to describe the situation where all the combining elements are in the proper proportions. For a typical gasoline, the ratio of air to fuel is 14.7 to 1, by weight. Given the various limitations of a conventional carburetor (e.g., fixed jet size) it is difficult to maintain this mixture throughout the complete range of vehicle operating conditions. Thus, carburetors with the ability to precisely adjust the air-fuel mixture were developed. Such adjustments are currently accomplished by modulating the flow of fuel in response to a signal from an electronic control unit. This device processes a number of inputs such as temperatures and/or pressures but receives its primary signal from an oxygen sensor located in the path of the exhaust gases. This sensor produces an electrical output based on the concentration of oxygen in the exhaust stream. Too much oxygen means a lean mixture and the carburetor is directed to meter more fuel. Too little oxygen (rich mixture) is followed by a signal to reduce fuel flow. This sampling operation usually occurs many times a second.

The typical open loop system is virtually identical to earlier control systems. The only difference is the use of a three-way rather than only an oxidation catalyst. This technique is less expensive because it does not require the advanced electronics of the closed loop system.

Although passenger cars equipped with three-way catalyst systems represent only a small portion of the vehicles currently in use, the 1981-1985 model years will be responsible for approximately 60% of the passenger car miles-traveled by mid-1985 (Reference 1). This program was initiated to obtain data from the latest three-way catalyst vehicles. The results are being used:

1. For assessments and projections of air quality.

2. To provide information to assist in development of Inspection/ Maintenance programs.

3. To supplement data that examines the emission characterstics of three-way catalysts versus conventional control systems.

4. To identify weaknesses and potential failure areas in future emission control systems so that the effectiveness of the regulatory process can be enhanced.

Program Design

Test Locations - Although there are currently several three-way catalyst systems available for sale in the 49 states, most manufacturers had chosen California as the location to concentrate their initial sales. The Los Angeles area was selected as the primary test site due to its great density of automobiles and the fact that an independent testing laboratory in that area was already under contract to EPA.

Automotive Environmental Systems, Inc. (AESi), of Westminster, California conducted the testing. In two previous EPA programs, AESi had tested 450 three-way catalyst vehicles and were familiar with the procurement and testing procedures.

Test Vehicle Selection - Vehicles on which little or no data had been gathered in earlier three-way test programs were sought for testing. These have been grouped by manufacturer and engine size and are displayed in Table 2. Where possible, owners of candidate vehicles were identified on registration listings and contacted by direct mail. Solicitations through various media, such as newspaper advertising, were also permitted. Although media solicitation is not purely random, it was necessary due to the time lag between the purchase of a new automobile and its appearance on a registration list.

The test vehicles were drawn from the general public in the greater Los Angeles area. Since typical in use vehicles were sought, the contractors were instructed to avoid vehicles which had been abused, extensively modified or otherwise not considered to be representative of the population. Each owner completed a questionnaire containing questions related to the usage and maintenance of his vehicle. Although the final test fleet demonstrates a broad range of available systems, there was no attempt at sales-weighting.

Testing - Testing began in January, 1980 and was completed in August, 1980. Each vehicle received the Federal Test Procedure (FTP), a Highway Fuel Economy Test (HFET) and four short cycle tests (bagged idle, 50 mph cruise, four speed idle, and loaded two mode). Twenty-five vehicles also received evaporative emission tests. The vehicles were tested in "as-received" condition to gather data representative of the in-use vehicle population. An underhood inspection of emission-related components was also conducted to evaluate the degree of any maladjustments, disablements, defects or deterioration. No candidate vehicle was rejected due to any condition which would make it unsafe to operate on the dynamometer. Fuel inspections performed on the test vehicles did not reveal the presence of any leaded gasoline.

## Results

There are several ways to evaluate the exhaust emission results of these three-way systems. One is in terms of absolute levels. Another is conformance to applicable standards. Fuel economy was examined in a similar manner.

Table 3 presents the average exhaust emission levels, fuel economy, and percent meeting standards for each of the engine families. The emission levels of each group of vehicles were compared to the California Standards under which they were certified. In comparing the HC emission levels to the standards, a Methane Content Correction Factor (MCCF) was applied. California regulations recognize methane as a hydrocarbon which does not contribute to the formation of smog. Thus, they permit methane to be excluded from the total hydrocarbons. Three-way catalyst vehicles have been assigned a MCCF of .89. Some manufacturers have applied for and received other values appropriate for their vehicles. The measured value of the total HC is multiplied by the MCCF to obtain the value which is compared to the .41 gm/mi standard. As the FTP results show, the average emission levels of most vehicle classes in the test fleet are reasonably close to the standards to which they were certified. As shown in some engine families, one or two high emitters greatly increases the overall average.

Shown in Figure 1 are graphical presentations of test results on each category of vehicles. Within the figures are bar charts comparing FTP results to applicable standards and pie charts for describing pass/fail outcomes. For recent 49-state vehicles tested in as-received condition, the modes of failure have tended toward either CO in conjunction with HC or NOx alone. Failures to meet the standards on the basis of HC level alone have been minimal. Thus, the California HC standard of .41 gm/mi appears to be the limiting factor in the ability of these models to meet their standards. In terms of emission levels as well as percent meeting standards, the AMC, Audi, VW and GM 151 engines exhibited the best overall performance. However, each of these groups contained three or fewer vehicles. In the GM 305 category (15 vehicles), it is interesting to note the high average percent of standard for HC and CO in conjunction with the high pass rate (80%). In contrast, the Ford 351 group (11 vehicles) had a low pass rate (55%), but the average percent of standards for each of the three pollutants were under 100%. Such results indicate that this group contained many borderline failures. Figure 2 displays the pass/fail pie chart for the entire fleet. Included in Figure 2 is a pie chart comparison of three-way catalyst systems versus three-way plus oxidation catalyst vehicles. As shown, the HC failure rate is the major difference between the two catalyst categories. The three-way plus oxidation catalyst category shows a total of 26% of its sample failing at least HC while the three-way category showed a total 9% HC failure rate. Table 4 presents the average emission levels of these two types of systems.

The technique used to analyze the air quality impact of high emitters was to calculate their proportional contribution to the total emissions of the fleet. This can be seen in Figure 3 which displays the emission levels of all the 1980 model year vehicles ranked in ascending order.

Underhood Inspection - Every vehicle received an inspection of emission related components and adjustments. Each system (e.g., induction, carburetor, etc.) was examined for defects, maladjustments, disablements, inadequate maintenance or misbuilds. Failures were defined by any abnormalities in the component's physical condition and/or measured values outside of prescribed tolerances. Shown in Table 5 is a summary of the emission results for the test vehicles based on the outcome of the underhood inspection. These results show that vehicles which are in proper operating order generally produce the lowest emission levels. The higher emission levels attained by vehicles with malfunctions are consistent with those reported in earlier research on three-way catalyst systems (Reference 2, 3). Reviewing the results show 60% of the vehicles were in proper operating condition. This is much better than the 31% of the 1975 and 1976 vehicles evaluated in the year they were new (Reference 4). An examination of the individual modes of failure revealed that the fuel system was the largest area of malperformance (19 vehicles). This was followed by the three-way catalyst control system (12 vehicles), choke system (11 vehicles), and ignition system (6 vehicles). Three vehicles had some EGR and Evaporative system malperformance. Each of the thirty vehicles with malperformance in the fuel, three-way or choke system failed at least one standard. Seven of the vehicles with three-way system malperformance failed both HC and CO. An examination of individual modes of failure reveals that obvious tampering, such as removal of limiter caps and idle mixture maladjustment, is greatly reduced. This may be attributed to tamper-resistant features which have been incorporated recently and are present on many of the vehicles tested. Examples of these are sealed idle mixture adjustment and rivets replacing screws to prevent choke adjustments. The problems which are now predominant are either more minor, e.g. idle speed, or are malfunctions within the three-way system. Results of the underhood inspection on individual vehicles may be found in the appropriate report (Reference 5).

Fuel Economy - The values for the measured fuel economy for each engine family are listed in Table 3. Table 6 provides a comparison of these values to those in the EPA Gas Mileage Guide. Also listed are the fuel economy figures perceived by the owner. Both the measured values and those perceived by the owner have been normalized as percentages of values published in the applicable Guide. Since the HFET numbers are no longer published in the Guide, these were obtained independently from EPA records. Some of the entries are based on small samples because of the subdivision of the vehicle categories by body style and transmission or because the owners did not feel they could make a proper estimate. This table indicates that these production vehicles did not attain the fuel economy values achieved by the prototypes and preproduction vehicles during the certification process. Overall, the owner's perceived city estimate was 9% below the Guide value but was relatively close to actual FTP test results. The average highway fuel economy as perceived by the owner was 18% short of the Guide value while the HFET results indicated only a 7% shortfall.

Evaporative Emissions - Table 7 displays the average evaporative emission results by engine family. The 1980 California standard was 2 gm/test. Twenty-five vehicles were given the evaporative test in this program. Two engine families failed the evaporative test while eight passed. Overall, the average emission level was 96% of the standard.

## Conclusions

Based on the findings of this program, several conclusions can be made concerning three-way catalyst control systems:

1. The three-way catalyst systems can be effective in controlling emissions to levels below those of their predecessors.

2. Maladjustments, disablements, and defects are still present in similar proportions to those in earlier systems although there appears to be a shift away from problems due to tampering.

3. Because of the great degree of control, emission levels from vehicles equipped with three-way systems appear to be more sensitive to malfunctions.

4. There was no significant difference in the average emission levels between the three-way and the three-way plus ox-cat systems.

## References

1. J. T. White, G. T. Jones, and D. J. Niemczak, "Exhaust Emissions From In-Use Passenger Cars Equipped With Three-Way Catalysts", SAE Paper 800823, June 1980.

2. Charles M. Urban and Robert J. Garbe, "Exhaust Emissions from Malfunctioning Three-Way Catalyst-Equipped Automobiles", SAE Paper 800511, February 1980.

3. Thomas Cackette, Philip Lorang, and David Hughes, "The Need for Inspection and Maintenance for Current and Future Motor Vehicles", SAE Paper 790782, August 1979.

4. J. T. White, "An Evaluation of Restorative Maintenance on Exhaust Emissions From In-Use Automobiles", SAE Paper 780082, February 1978.

5. Alan D. Jones, "Testing of New Technology Three-Way Catalyst Equipped Vehicles in Los Angeles", Report for Task 1, Contract No. 68-03-2881, August, 1980.

Table 1 - Exhaust Emission Standards for Passenger Cars (grams/mile)

| | Federal | | | | California | | |
|---|---|---|---|---|---|---|---|
| Model Year | HC | CO | NOx | | HC | CO | NOx |
| 1975 | 1.5 | 15 | 3.1 | | 0.9 | 9.0 | 2.0 |
| 1976 | 1.5 | 15 | 3.1 | | 0.9 | 9.0 | 2.0 |
| 1977 | 1.5 | 15 | 2.0 | | 0.41 | 9.0 | 1.5 |
| 1978 | 1.5 | 15 | 2.0 | | 0.41 | 9.0 | 1.5 |
| 1979 | 1.5 | 15 | 2.0 | | 0.41 | 9.0 | 1.5 |
| 1980 | 0.41 | 7.0 | 2.0 | | 0.41(c) | 9.0 | 1.0(d) |
| 1981 | 0.41 | 3.4(a) | 1.0(b) | A | 0.41(c) | 3.4 | 1.0(d) |
| | | | | B | 0.41(c) | 7.0 | 0.7 |

(a) Waiver up to 7.0 gm/mi possible.

(b) Waiver up to 1.5 gm/mi possible for diesel or innovative technology.

(c) .39 gm/mi standard for hydrocarbons other than methane if methane is actually measured.

(d) 1.5 gm/mi allowed with 100,000 mile durability.

Note: For the 1981 model year, manufacturers may choose options A or B separately for their gasoline and diesel product lines in California. The option chosen in 1981 must be retained for the 1982 model year.

Table 2

Description of Vehicle Categories

| MFR. | Model Year | Engine Family | CID | Cyl. | Fuel System* | Models | Type of Control: Closed Loop | Open Loop | Catalyst Configuration: 3-Way | 3-Way + Ox Cat. | AIR INJ | EGR | No. Tested |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chrysler | 79 | 9CD-225-1-WP | 225 | 6 | 2V | Volare, Aspen | X | | X | | X | X | 4 |
| Chrysler | 80 | 0CB-318-4-AUP | 318 | 8 | 4V | Cordoba, Mirada | X | | | X | X | X | 5 |
| Chrysler | 80 | 0CB-225-1-ARP | 225 | 6 | 1V | LeBaron, Volare | X | | | X | X | X | 3 |
| Chrysler | 80 | 0CB-105-2-CLP | 105 | 4 | 2V | Omni, Horizon | X | | | X | X | X | 5 |
| Ford | 80 | 5.8 WAXC | 351 | 8 | VV | Ford, Lincoln Mercury | X | | | X | X | X | 11 |
| Ford | 80 | 3.3 GQ | 200 | 6 | 1V | Mustang, Fairmont | | X | | X | X | X | 10 |
| Ford | 80 | 2.3 AX | 140 | 4 | 2V | Mustang | X | | | X | X | X | 1 |
| GM | 80 | 06T4RCZ | 368 | 8 | 4V | DeVille, Fleetwood | X | | | X | X | X | 10 |
| GM | 80 | 06J0RCZ | 350 | 8 | EFI | SeVille, Eldorado | X | | | X | X | X | 13 |
| GM | 80 | 01Y4MCRZ | 305 | 8 | 4V | Pontiac, Olds, Chevrolet, Buick | X | | X | | X | X | 15 |
| GM | 80 | 04E2MCRZ | 231 | 6 | 2V | Chevrolet, Buick Oldsmobile | X | | X | | X | X | 14 |
| GM | 80 | 04E4UCD | 231 | 6 | 4V | Monte Carlo | X | | | X | X | X | 2 |
| GM | 80 | 02X2NC | 151 | 4 | 2V | Starfire | X | | X | | | X | 1 |
| GM | 80 | 01W2PC | 98 | 4 | 2V | Chevette | X | | X | | X | X | 11 |
| AMC | 80 | CP-5N1 | 258 | 6 | 2V | Concord | X | | X | | X | X | 2 |
| Audi | 80 | 5000 CL | 131 | 5 | MFI | Audi-5000 | X | | X | | | | 1 |
| Audi | 80 | 4000 CL | 97 | 4 | MFI | Audi-4000 | X | | X | | | | 1 |
| Datsun | 80 | L24/28C | 168 | 6 | MFI | 280Z | X | | X | | | | 3 |
| Datsun | 80 | L24/28C | 146 | 6 | MFI | 810 | X | | X | | | | 1 |
| Volkswagen | 80 | 37CL | 97 | 4 | MFI | Rabbit, Scirocco | X | | X | | | | 3 |
| | | | | | | | | | | | | | 116 |

*Code for Fuel System: 1V - 1 barrel carburetor, 2V - 2 barrel carburetor, 4V - 4-barrel carburetor
VV - variable venturi carburetor, EFI - electronic fuel injection, MFI - mechanical fuel injection

Table 3

Average FTP Results by Vehicle Category

| Mfg. | Model Year | Engine Family | CID | N | Avg. Odom | FTP Results (gm/mi): THC* | NMHC* | CO | NOx | FTP MPG | HFET MPG | % meeting standards |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GM | 80 | 06T4RCZ | 368 | 10 | 8200 | .39 | .33 | 3.63 | .92 | 13.3 | 19.6 | 60 |
| GM | 80 | 06J0RCZ | 350 | 13 | 6700 | .41 | .35 | 4.02 | .78 | 12.8 | 20.4 | 69 |
| GM | 80 | 01Y4MRCZ | 305 | 15 | 5700 | .83 | .74 | 25.40 | .58 | 13.8 | 19.5 | 80 |
| | minus | high emitters | | 13 | 6000 | .25 | .22 | 4.00 | .62 | 14.1 | 19.9 | 92 |
| GM | 80 | 04E2MCRZ | 231 | 14 | 4200 | .30 | .27 | 6.30 | .74 | 17.6 | 24.1 | 79 |
| GM | 80 | 04E4UCD | 231 | 2 | 4200 | .53 | .46 | 4.88 | .74 | 15.6 | 20.8 | 50 |
| GM | 80 | 02X2NC | 151 | 1 | 3800 | .22 | .20 | 7.78 | .66 | 18.8 | 25.9 | 100 |
| GM | 80 | 01W2PC | 98 | 11 | 3000 | .22 | .20 | 5.10 | .60 | 22.2 | 28.4 | 73 |
| Ford | 80 | 5.8 WAXC | 351 | 11 | 5100 | .42 | .35 | 6.10 | .63 | 14.3 | 23.8 | 55 |
| Ford | 80 | 3.3 GQ | 200 | 10 | 4300 | .39 | .33 | 4.99 | .81 | 18.3 | 24.3 | 70 |
| | minus | high emitter | | 9 | 4600 | .33 | .28 | 2.82 | .84 | 18.4 | 24.4 | 78 |
| Ford | 80 | 2.3 AX | 140 | 1 | 6000 | .52 | .38 | 6.24 | 1.14 | 19.9 | 28.5 | 0 |
| Chrysler | 80 | 0CB-318-4-AUP | 318 | 5 | 5900 | .42 | .37 | 6.86 | .84 | 15.3 | 23.6 | 60 |
| | minus | high emitter | | 4 | 4600 | .24 | .21 | 4.42 | .79 | 15.1 | 23.4 | 75 |
| Chrysler | 79 | 9CD-225-1-WP | 225 | 4 | 5600 | .61 | .54 | 11.20 | .99 | 14.6 | 19.1 | 0 |
| | minus | high emitter | | 3 | 6000 | .53 | .47 | 7.05 | 1.18 | 15.1 | 20.1 | 0 |
| Chrysler | 80 | 0CB-225-1-ARP | 225 | 3 | 5400 | .58 | .52 | 10.90 | .83 | 16.0 | 20.0 | 67 |
| | minus | high emitter | | 2 | 4500 | .36 | .32 | 4.56 | 1.06 | 17.3 | 21.7 | 100 |
| Chrysler | 80 | 0CB-105-2-CLP | 105 | 5 | 6100 | .35 | .31 | 5.75 | .63 | 21.8 | 31.6 | 80 |
| AMC | 80 | CP-5N1 | 258 | 2 | 3000 | .32 | .28 | 6.41 | .74 | 15.7 | 23.0 | 100 |
| Audi | 80 | 5000 CL | 131 | 1 | 9800 | .16 | .14 | 1.34 | .79 | 17.4 | 24.3 | 100 |
| Audi | 80 | 4000 CL | 97 | 1 | 8300 | .10 | .08 | 1.25 | .36 | 22.7 | 32.8 | 100 |
| Volkswagen | 80 | 37CL | 97 | 3 | 5400 | .20 | .18 | 2.19 | .41 | 23.4 | 36.9 | 100 |
| Datsun | 80 | L24/28C | 146 | 3 | 4900 | .24 | .21 | 2.25 | .41 | 20.7 | 26.2 | 100 |
| Datsun | 80 | L24/28C | 168 | 1 | 10200 | .26 | .23 | 2.97 | 1.11 | 18.4 | 29.7 | 0 |
| | All 1980 vehicles | | | 112 | 5300 | .41 | .36 | 7.87 | .70 | 16.0 | 23.2 | 72 |
| | Minus high emitters | | | 107 | 5200 | .32 | .27 | 4.56 | .71 | 16.1 | 23.4 | 75 |
| | California Standards | | | | | .41 | .39 | 9.0 | 1.0 | | | |
| | All 1979 vehicles | | | 4 | 5600 | .61 | .54 | 11.26 | .99 | 14.6 | 19.1 | 0 |
| | Minus high emitter | | | 3 | 6000 | .53 | .50 | 7.05 | 1.18 | 15.2 | 21.0 | 0 |
| | California Standards | | | | | .41 | - | 9.0 | 1.5 | | | |

*California regulations permit methane to be excluded from the total hydrocarbons (THC) before comparison to the standards. In most cases the column for non-methane hydrocarbons (NMHC) reflects the .89 correction factor assigned to these three-way catalyst systems. However, for the 06T4RCZ, 06J0RCZ and 04EUCD engine families, the factor was .86. For the 5.8 WAXC, 3.3 GQ, and 2.3 AX engine families, the factors were .85, .84 and .74 respectively.

Table 4

Average Emission Levels of 3 Way + Oxidation Catalyst Versus 3 Way Catalyst Vehicles

| Catalyst Type | N | Avg. Odom | FTP Results (gm/mi) THC | NMHC | CO | NOx | FTP MPG | HFET MPG | % meeting standards |
|---|---|---|---|---|---|---|---|---|---|
| 3 way + ox cat | 60 | 5500 | .44 | .38 | 5.93 | .81 | 16.4 | 23.6 | 63 |
| Minus high emitters | 57 | 5800 | .39 | .34 | 4.71 | .83 | 16.5 | 23.8 | 67 |
| 3 way catalyst | 56 | 5600 | .32 | .28 | 6.94 | .64 | 18.6 | 26.1 | 75 |
| Minus high emitters | 53 | 5500 | .25 | .22 | 4.38 | .66 | 18.7 | 26.3 | 79 |

Table 5: Emission Levels versus Results of Underhood Inspection

| System Inspection 3 Way | Other | N | Avg. Odom. | FTP Results (gm/mi) HC | CO | NOx | FTP (MPG) | HFET (MPG) |
|---|---|---|---|---|---|---|---|---|
| Pass | Pass | 67 | 4766 | .30 | 4.2 | .65 | 17.1 | 24.3 |
| Fail | Pass | 4 | 7012 | .48 | 7.7 | .55 | 15.2 | 24.1 |
| Pass | Fail | 36 | 6335 | .37 | 5.7 | .87 | 16.3 | 22.9 |
| Fail | Fail | 5 | 6158 | 2.37 | 73.4 | .63 | 14.6 | 20.9 |
| All Systems | Pass | 67 | 4766 | .30 | 4.2 | .65 | 17.1 | 24.3 |
| Any System | Fail | 45 | 6376 | .60 | 13.4 | .81 | 16.0 | 22.8 |
| Overall | | 112 | 5413 | .42 | 7.9 | .72 | 16.7 | 23.8 |

Table 6

Comparisons of Fuel Economy Estimates and Results as a Percentage of Guide Values

| Model Year | Mfr. | Engine Family | CID | N | City (FTP) Owner Perceived | City (FTP) Test Results | N | Highway (HFET) Owner Perceived | Highway (HFET) Test Results | Type of Catalyst |
|---|---|---|---|---|---|---|---|---|---|---|
| 80 | GM | 06T4RC | 368 | 7 | 90% | 95% | 7 | 86% | 94% | 3 way + oxidation catalyst |
| 80 | GM | 06J0RCZ | 350 | 11 | 95 | 91 | 10 | 78 | 88 | 3 way + oxidation catalyst |
| 80 | GM | 01Y4MCRZ | 305 | 10 | 92 | 97 | 9 | 92 | 99 | 3 way catalyst |
| 80 | GM | 04E2MCRZ | 231 | 9 | 87 | 92 | 9 | 83 | 92 | 3 way catalyst |
| 80 | GM | 04E4UCD | 231 | 2 | 94 | 87 | 2 | 88 | 83 | 3 way + oxidation catalyst |
| 80 | GM | 01W2PC | 98 | 7 | 84 | 88 | 7 | 83 | 89 | 3 way catalyst |
| 80 | Ford | 5.8 WAXC | 351 | 9 | 84 | 91 | 9 | 68 | 93 | 3 way + oxidation catalyst |
| 80 | Ford | 3.3 GQ | 200 | 2 | 97 | 104 | 2 | 82 | 98 | 3 way + oxidation catalyst |
| 80 | Ford | 2.3 AX | 140 | 1 | 95 | 95 | 1 | 72 | 89 | 3 way + oxidation catalyst |
| 80 | Chrysler | 0CB-318-4-AUP | 318 | 2 | 93 | 90 | 1 | 75 | 96 | 3 way + oxidation catalyst |
| 80 | Chrysler | 0CB-225-1-ARP | 225 | 1 | 100 | 111 | 1 | 86 | 102 | 3 way + oxidation catalyst |
| 79 | Chrysler | 9CD-225-1-WP | 225 | 3 | 106 | 95 | 3 | 98 | 96 | 3 way catalyst |
| 80 | Chrysler | 0CB-105-2-CLP | 105 | 4 | 92 | 94 | 4 | 82 | 95 | 3 way + oxidation catalyst |
| 80 | AMC | CP-5N1 | 258 | 1 | 100 | 98 | 1 | 83 | 97 | 3 way catalyst |
| 80 | Datsun | L24/28C | 146/168 | 4 | 93 | 96 | 4 | 96 | 98 | 3 way catalyst |
| 80 | VW | 37 CL | 97 | 2 | 92% | 87% | 2 | 82% | 90% | 3 way catalyst |
| Totals and weighted averages (all vehicles) | | | | 75 | 91% | 93% | 72 | 82% | 93% | |
| Totals and weighted averages (3 way catalyst vehicles) | | | | 36 | 90% | 93% | 35 | 88% | 94% | |
| Totals and weighted averages (3 way + oxidation catalyst vehicles) | | | | 39 | 91% | 93% | 37 | 78% | 92% | |

**Table 7**

**1980 Model Year Vehicles**

**Evaporative Emissions Results by Engine Family**

**(1980 Evaporative Emission Standard = 2 gms/test)**

| Mfr. | N | Engine Family | CID | Average Odometer | Average Emissions (gm/test) | Percent Meeting Standards |
|---|---|---|---|---|---|---|
| GM | 2 | 06T4RCZ | 368 | 14400 | 3.30 | 0 |
| GM | 3 | 06J0RCZ | 350 | 9500 | .80 | 100 |
| GM | 3 | 01Y4MCRZ | 305 | 6700 | 1.37 | 100 |
| GM | 4 | 04E2MCRZ | 231 | 5600 | 1.96 | 75 |
| GM | 1 | 01W2PC | 98 | 7400 | 1.80 | 100 |
| Ford | 2 | 3.3GQ | 200 | 6200 | 1.60 | 50 |
| Chrysler | 3 | OCB-318-4-AUP | 318 | 4400 | 1.93 | 67 |
| Chrysler | 2 | OCB-225-1-ARP | 225 | 4200 | 5.71 | 0 |
| Chrysler | 4 | OCB-105-2-CLP | 105 | 6300 | 1.02 | 100 |
| Datsun | 1 | L24/28C | 168 | 10240 | .57 | 100 |
| Overall | 25 | | | 7066 | 1.91 | 72 |

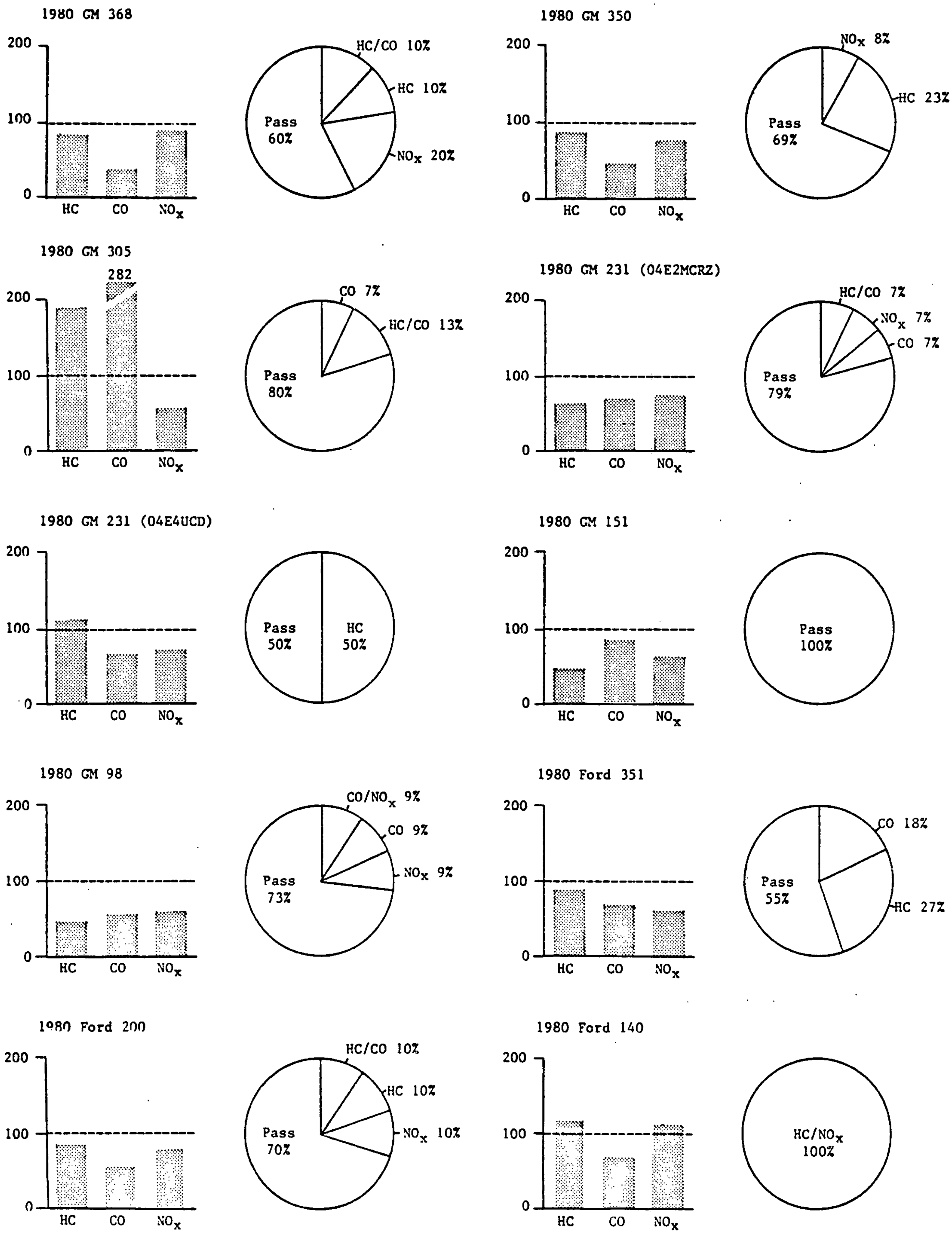


Fig. 1 - FTP test results as percent of standards and pass/fail outcomes for individual vehicle categories.

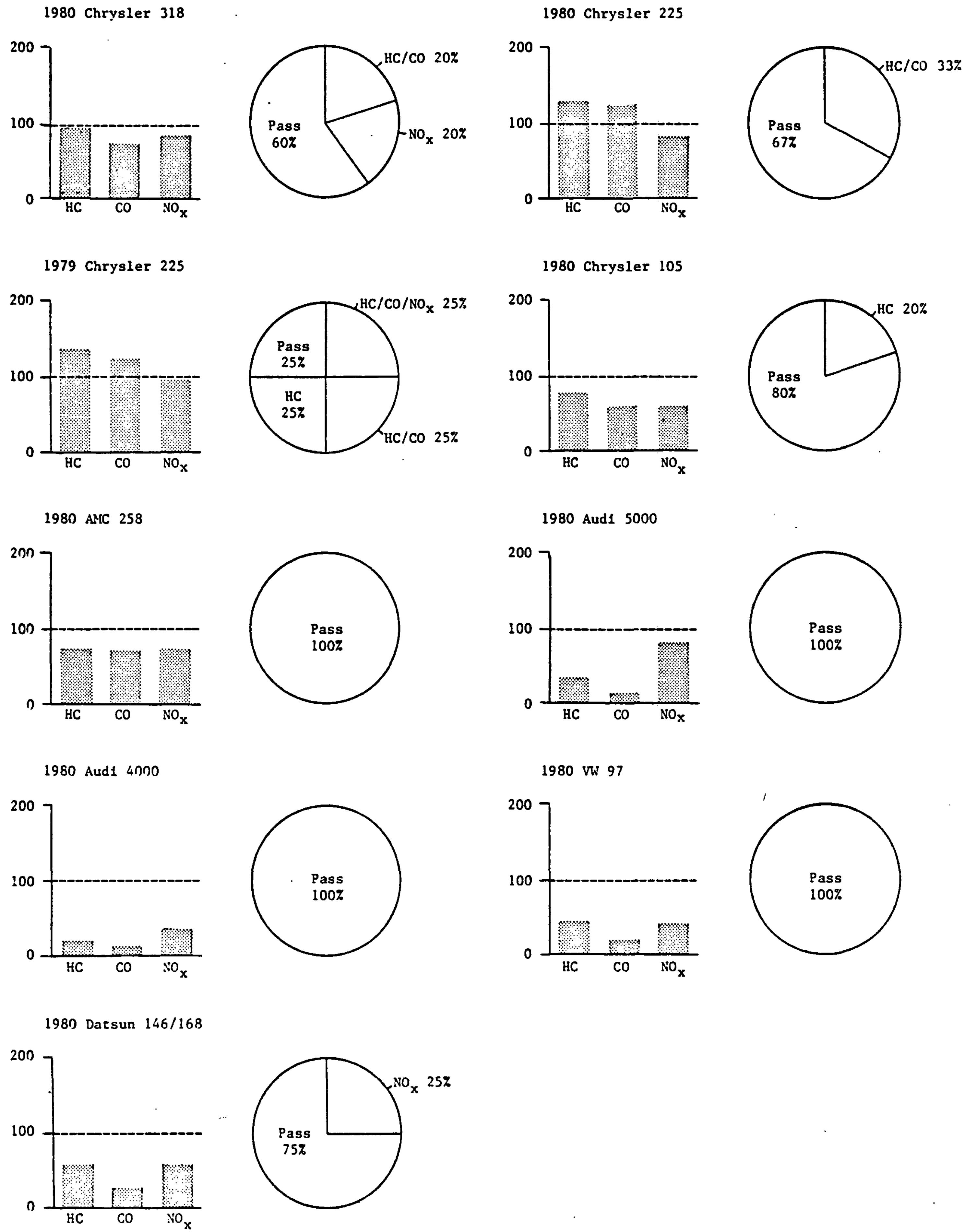
1980 Chrysler 318
200
100
0
HC
CO
$NO_x$
HC/CO 20%
$NO_x$ 20%
Pass 60%
1980 Chrysler 225
200
100
0
HC
CO
$NO_x$
HC/CO 33%
Pass 67%
1979 Chrysler 225
200
100
0
HC
CO
$NO_x$
HC/CO/$NO_x$ 25%
Pass 25%
HC 25%
HC/CO 25%
1980 Chrysler 105
200
100
0
HC
CO
$NO_x$
HC 20%
Pass 80%
1980 AMC 258
200
100
0
HC
CO
$NO_x$
Pass 100%
1980 Audi 5000
200
100
0
HC
CO
$NO_x$
Pass 100%
1980 Audi 4000
200
100
0
HC
CO
$NO_x$
Pass 100%
1980 VW 97
200
100
0
HC
CO
$NO_x$
Pass 100%
1980 Datsun 146/168
200
100
0
HC
CO
$NO_x$
$NO_x$ 25%
Pass 75%

Fig. 1 - Cont'd

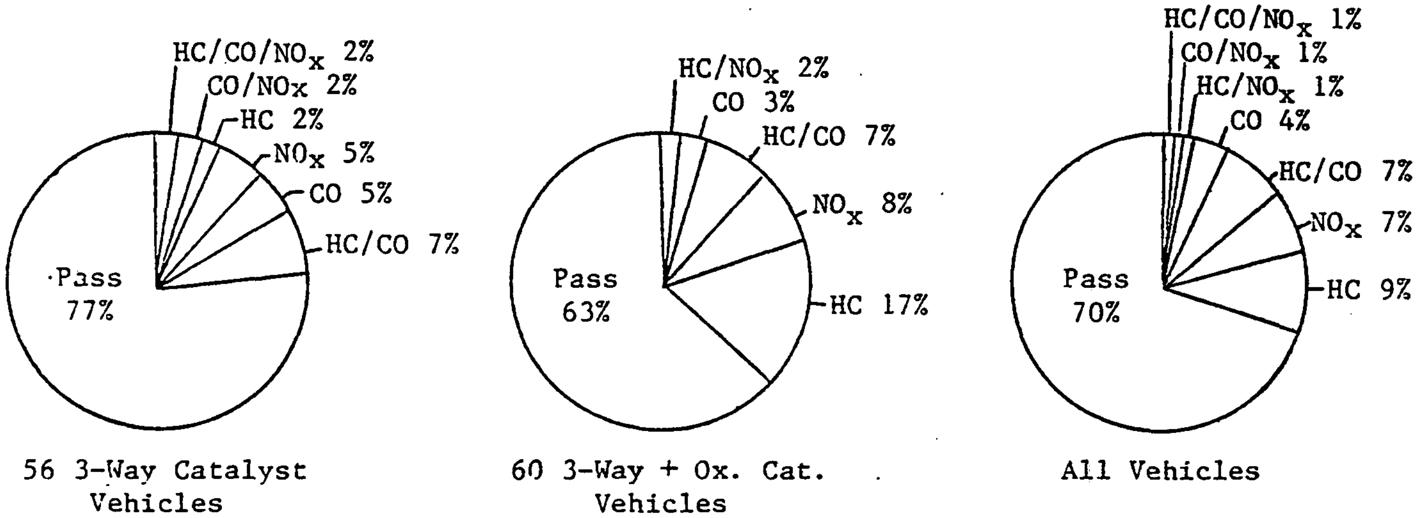


Fig. 2 - Pass/Fail outcomes from the FTP

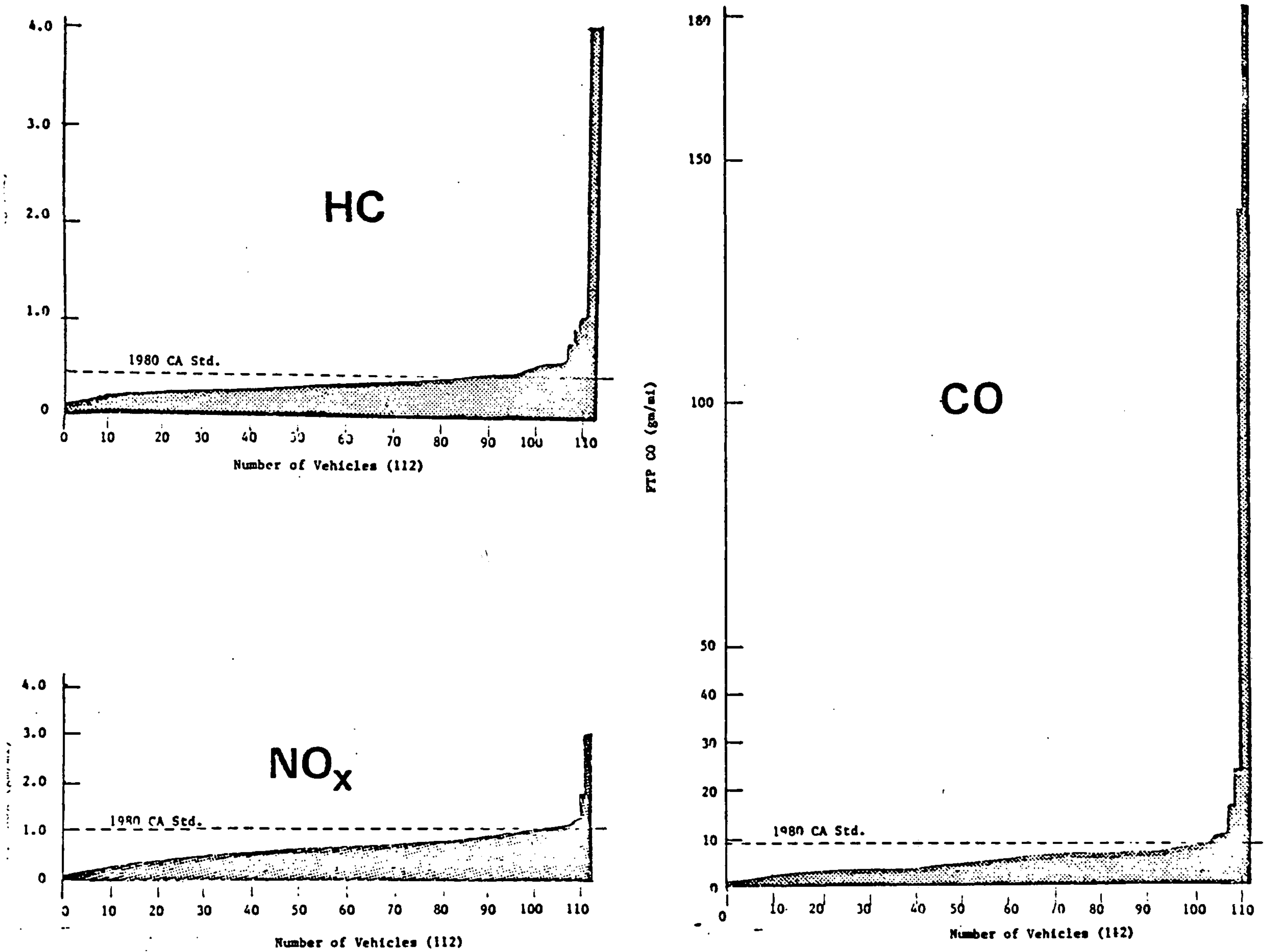


Fig. 3 - Emission Levels of all 1980 vehicles ranked in ascending order.