**TECHNICAL NOTE**

# SMOG CHECK STATION PERFORMANCE ANALYSIS
## Based On Roadside Test Results

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**June 27, 2000**

## 1.0 INTRODUCTION AND SUMMARY

The most important elements of an inspection/maintenance (I/M) program are the identification and effective repair of vehicles with tampered, defective or worn-out emission control systems. In order for an I/M program to achieve maximum benefits, all stations must perform accurate and complete emission tests before and after repairs. The performance of individual stations is a critical issue that must be addressed in a comprehensive evaluation of an I/M program.

With support from Eastern Research Group (ERG), de la Torre Klausmeier Consulting (dKC) assessed the performance of different categories of inspection stations in California. The analysis uses data collected from roadside tests performed between February 1997 and October 1999. These data were collected by the California Bureau of Automotive Repair (BAR). With assistance from the California Highway Patrol, BAR pulls in-use vehicles over and performs an Acceleration Simulation Mode (ASM) test, as well as a limited functional and visual inspection when time permits. Inspections are conducted by state inspectors, and therefore provide an independent measure of the emission readings and the condition of vehicular smog equipment for California's vehicle fleet. Data from these tests help us assess the effectiveness of different types of inspection stations in California's I/M program, referred to as the Enhanced Smog Check Program.

This analysis looks at the differences in reductions achieved for vehicles that are certified at Test-Only and Test-and-Repair stations. In addition, reductions achieved at good performing vs. poor performing Test-and-Repair stations are analyzed. A key feature of the Enhanced Smog Check Program is the hybrid network, which uses two types of licensed inspection stations: Test-Only and Test-and-Repair. Test-Only stations can only perform inspections; they cannot repair vehicles. In California's hybrid network, vehicles with the highest probability of failure are directed to Test-Only stations in the state's enhanced program areas. About 50% of the vehicles tested at Test-Only are directed[1]; the rest come on their own accord.

The analysis is limited to vehicles receiving BAR-97 ASM tests in enhanced program areas before or after the roadside test. The analysis concentrates on the difference between Test-Only and Test-and-Repair stations, since it was easiest to classify Smog Check stations using this breakdown. The Test-and-Repair stations are further classified into different groups according to reported Smog Check statistics, in a preliminary attempt at separating high performing stations from low performing stations.

The following are some of the measures that can be used to compare the performance Smog Check stations:

- Observed emission reductions.
- Reported failure rates for vehicles that have high emissions in roadside tests prior to their Smog Checks.
- Roadside emission rates for vehicles that passed Smog Checks prior to roadside tests.

[1] 43.3% of the vehicles tested at Test-Only facilities are directed high emitters; 6.2% are selected and directed as part of a random sample.

- Percentages of high emitting vehicles after Smog Check.

This report assesses the performance of Smog Check stations using these and other metrics.

## Major Findings

Following are the major findings of the analysis of station performance:

- Much greater exhaust emission reductions were observed for vehicles certified at Test-Only facilities than Test-and-Repair facilities. The total sample inspected at Test-Only stations as well as the sample of vehicles failing the test showed greater reductions than the Test-and-Repair sample.

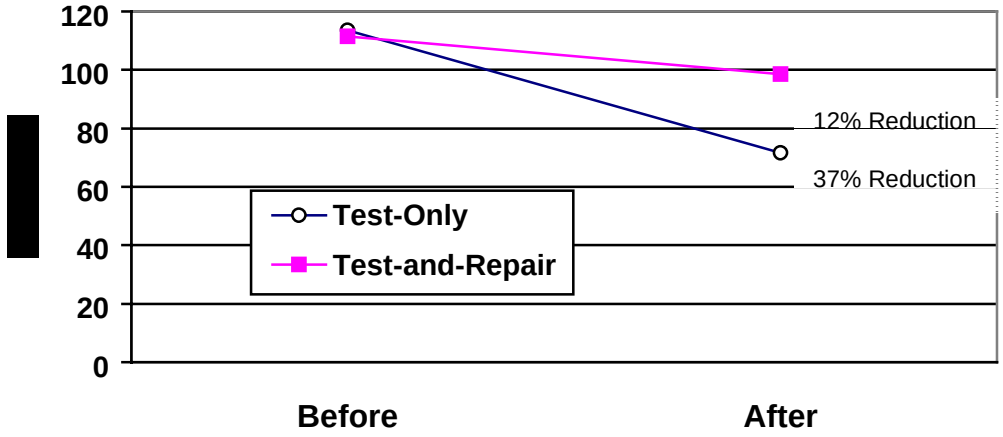
  Figure 1 shows emissions before and after repair by station type. This figure shows data on 1980 to 1986 vehicles. Vehicles within this group are not significantly impacted by BAR's policy of directing high emitters to Test-Only stations. As shown, vehicles certified at Test-Only stations have much lower after Smog Check emission levels, while their before Smog Check levels were almost identical to the Test-and-Repair category.

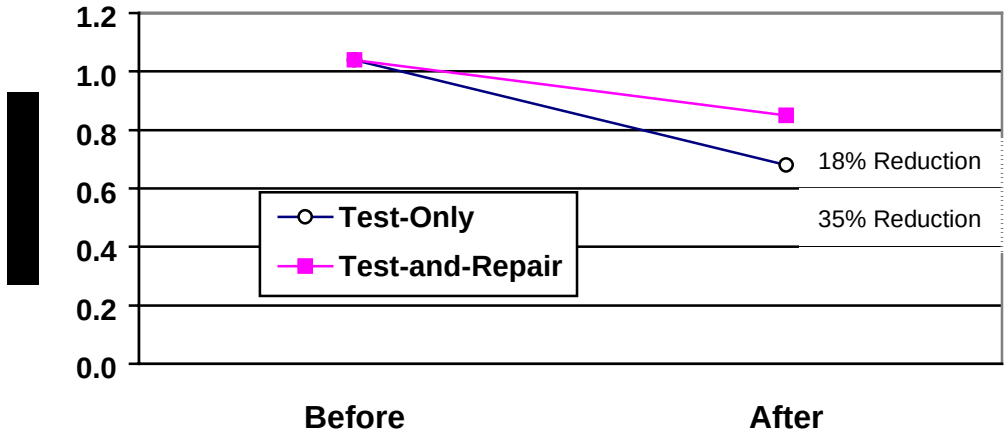
***Recommendation –*** *BAR should increase the percentage of high emitters directed to Test-Only facilities. Currently, BAR directs 15% of the vehicles with the highest probability of failure to Test-Only facilities. The SIP emission reductions are based on the assumption that 40% of the vehicles with the highest probability of failure are directed to Test-Only stations.*

- By analyzing Smog Check data, BAR has been able to develop performance standards for Test-and-Repair stations. The most promising performance standard is one that ranks stations according to their reported failure rates. Vehicles that were certified in stations that ranked in the top 25% of Test-and-Repair stations (based on reported failure rates) had similar after Smog Check emission levels and showed similar emission reductions to those certified by Test-Only facilities. This standard could be used as a requirement for Gross Polluter Certification (GPC) stations. About 19% of the vehicles in Enhanced areas were certified in the top 25% of Test-and-Repair stations. (About 20% were certified at Test-Only stations.) Currently, about 4% of the fleet is being certified at GPC stations.

  It takes a lot of time and money for BAR to "catch" poor performing stations and take legal action. Furthermore, having a large variation in station performance allows motorists that want to avoid repairs to seek out poor performing stations. The top 25% of the Test-and-Repair stations were observed to reduce ASM 2525 HC emissions by 44% while no reductions were observed for the bottom 25% (Figure 2). Inspections by the top 25% of the Test-and-Repair stations certainly must be much more cost-effective than inspections by the bottom 25%. It might be much more effective for BAR to set performance standards based on program statistics that stations have to meet. If BAR were to establish performance standards that resulted in all Test-and-Repair stations having the same performance as Test-Only stations, Smog Check benefits would increase by more than 50%. Establishing these performance standards would lower the cost per ton of pollutant removed.

**FIGURE 1**
**Comparison of Emission Levels**
**Before and After Smog Check by Station Type**
**ASM 2525 for 1980-1986 Vehicles**



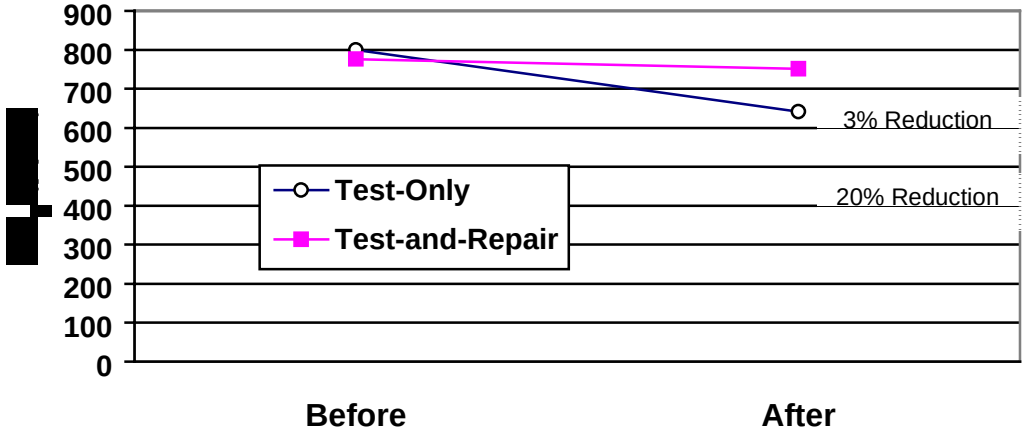
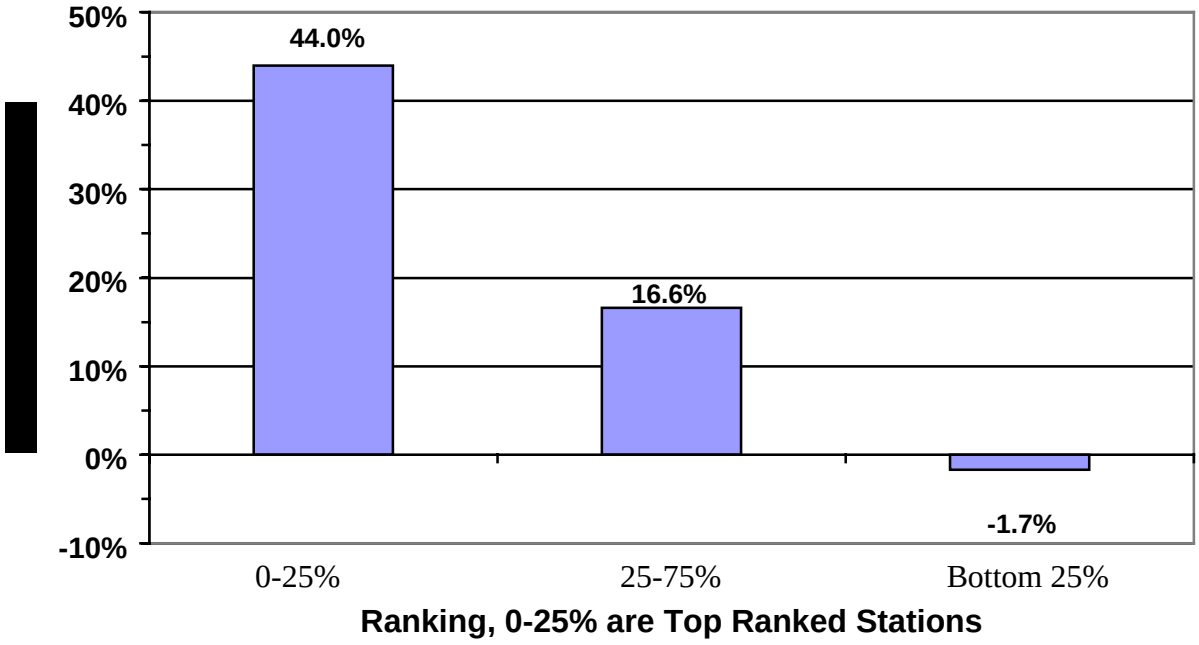



**FIGURE 2**
**Comparison of Observed HC Emission Reductions for Test-and-Repair Stations (1980 to 1991 Model Year Vehicles)**




*This figure compares observed reductions in HC 2525 emissions for the groups of ranked Test-and-Repair stations. The highest ranked groups had the greatest HC emission reductions. The top 25% had observed reductions of 44% compared to no reductions for the bottom 25%.*

***Recommendation –*** *As an alternative to increasing the percentage of vehicles directed to Test-Only stations, BAR could establish performance parameters for Test-and-Repair stations to ensure they achieve the same performance as Test-Only stations. Currently the top 25% of the Test-and-Repair stations based on their reported failure rates have equivalent performance to Test-Only stations. Additional triggers are needed to better weed-out the good Test-and-Repair and Test-Only stations from the bad and increase the percentage high performing stations.*

- Gas cap fail rates were reduced by 65% by the Smog Check program. Furthermore, the reductions were the same for Test-Only and Test-and-Repair stations.

***Recommendation –*** *Smog Check stations should continue to perform gas cap pressure tests, as it provides substantial HC emission reductions.*

## Report Organization

The following section discusses the observed exhaust emission reductions by station type. Reasons for differences between the Test-Only and Test-and-Repair results are explored in Section 3. The performance of Test-and-Repair stations that are ranked according to the ratio of reported vs. expected failure rates is discussed in Section 4. The observed reductions in the incidence of gas cap failures by station type are presented in Section 5. Section 6 presents estimated fleet emission reductions in tons per day for Test-Only and Test-and-Repair inspection networks. Appendix A presents details on the methodology used to create and analyze the roadside data set.

## 2.0 OBSERVED EMISSION REDUCTIONS BY STATION TYPE

The performance of Test-Only versus Test-and-Repair stations can be compared in terms of the observed emission reductions. Percent reductions based on roadside emission levels before and after the station Smog Check inspection can be calculated for both station types.

### 2.1 Observed Impact of the Smog Check Program on ASM Fail Rates During Roadside Tests

The simplest measure of the impact of the Smog Check Program is how it affects the roadside failure rate. The "roadside failure rate" was calculated using emissions readings obtained during the roadside inspection and BAR's Phase 3 cutpoints. Theoretically, the roadside failure rate should be much lower for vehicles that have already passed Smog Check tests performed at licensed stations than before. Table 1 shows the average failure rate by station type before and after certification in the Smog Check Program. As shown, the Test-Only stations have lower failure rates after Smog Check certification than the Test-and-Repair stations.

**TABLE 1**
**Impact of Smog Check on Roadside Failure Rates**

| Station Type | Model Year Group | Before Smog Check | After Smog Check | Difference (%) |
|---|---|---|---|---|
| Test-and-Repair | 1974-1979 | 50.59% | 40.00% | 20.93% |
| | 1980-1986 | 44.15% | 38.24% | 13.39% |
| | 1987-1991 | 21.92% | 16.58% | 24.36% |
| Test-Only | 1974-1979 | 44.44% | 34.78% | 21.74% |
| | 1980-1986 | 47.53% | 31.35% | 34.03% |
| | 1987-1991 | 24.50% | 15.81% | 35.46% |

*This table compares failure rates for the two-mode ASM test using BAR's Phase 3 cutpoints. ASM failure rates in roadside tests conducted after Smog Check certification were lower for the Test-Only sample than the Test-and-Repair sample.*

### 2.2 Fleet Emission Reductions

Table 2 presents average roadside emissions using an ASM test procedure for vehicles before and after they had an Enhanced Smog Check. ASM 5015 and ASM 2525 emissions of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen ($NO_x$) are shown. The *before Smog Check* sample includes all vehicles that had not received an ASM Smog Check prior to their roadside test. The *after Smog Check* sample includes all vehicles that received an ASM Smog Check and were certified prior to their roadside test; it includes vehicles that passed their initial test, or those that failed their initial test and passed after repairs. As shown, the percent reduction observed for Test-Only stations is more than twice as high as the percent reduction observed for Test-and-Repair stations, for all model year groups. Showing results by model year group eliminates much of the bias due to Test-Only stations inspecting targeted high emitting vehicles, since vehicle age is a key parameter in the High Emitter Profile model (the model used to identify likely high emitters).

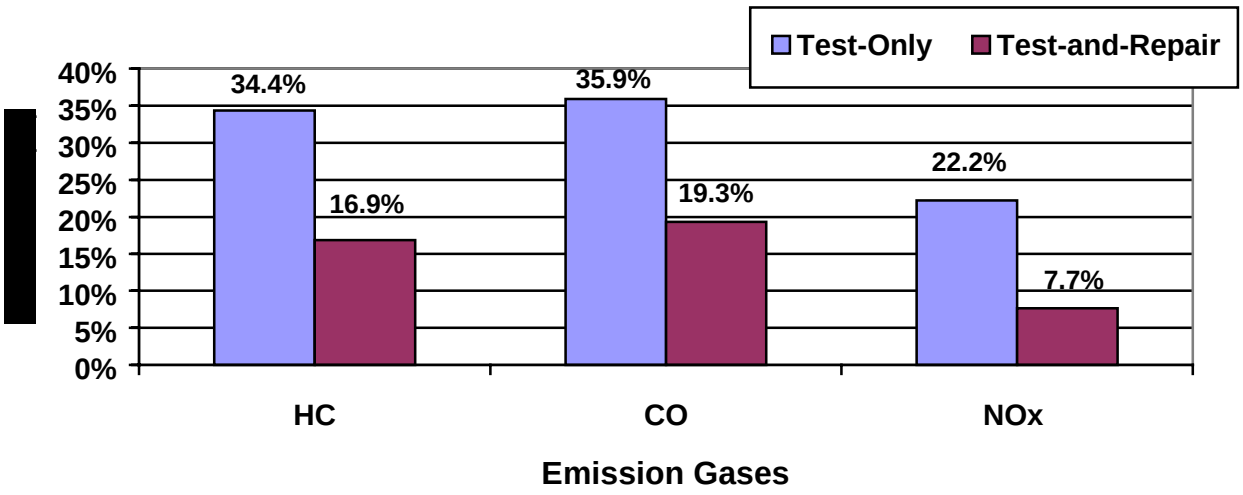
**TABLE 2**
**Average Emission Levels Before and After Smog Check by Station Type**

| Sequence | Station Type | Model Year Group | N | HC 5015 (ppm) | HC 2525 (ppm) | CO 5015 (%) | CO 2525 (%) | NO 5015 (ppm) | NO 2525 (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| Before Smog Check | Test-Only | 1974-1979 | 108 | 214.46 | 211.08 | 1.21 | 1.11 | 887.82 | 809.84 |
| | | 1980-1986 | 869 | 132.64 | 113.53 | 1.11 | 1.04 | 895.55 | 799.96 |
| | | 1987-1991 | 302 | 60.37 | 52.05 | 0.45 | 0.43 | 566.63 | 505.16 |
| | | **ALL*** | **1,279** | **107.42** | **95.51** | **0.80** | **0.75** | **734.00** | **657.24** |
| | Test-and-Repair | 1974-1979 | 340 | 293.48 | 278.23 | 1.43 | 1.39 | 1,058.53 | 941.99 |
| | | 1980-1986 | 1,649 | 127.44 | 111.53 | 1.06 | 1.04 | 852.50 | 776.37 |
| | | 1987-1991 | 1,788 | 65.61 | 55.18 | 0.42 | 0.41 | 543.29 | 483.89 |
| | | **ALL*** | **3,777** | **117.68** | **104.53** | **0.79** | **0.78** | **726.87** | **653.94** |
| Sequence | Station Type | Model Year Group | N | HC 5015 (ppm) | HC 2525 (ppm) | CO 5015 (%) | CO 2525 (%) | NO 5015 (ppm) | NO 2525 (ppm) |
| After Smog Check | Test-Only | 1974-1979 | 50 | 124.22 | 116.78 | 0.80 | 0.73 | 909.26 | 796.24 |
| | | 1980-1986 | 386 | 83.52 | 71.52 | 0.71 | 0.68 | 746.45 | 641.25 |
| | | 1987-1991 | 216 | 52.58 | 42.07 | 0.28 | 0.26 | 389.62 | 335.91 |
| | | **ALL*** | **652** | **73.42** | **62.71** | **0.51** | **0.48** | **592.26** | **511.23** |
| | Test-and-Repair | 1974-1979 | 193 | 198.78 | 187.26 | 1.14 | 1.21 | 1,053.32 | 893.74 |
| | | 1980-1986 | 981 | 110.13 | 98.49 | 0.89 | 0.85 | 833.44 | 750.98 |
| | | 1987-1991 | 1,618 | 63.92 | 52.35 | 0.32 | 0.30 | 462.98 | 413.83 |
| | | **ALL*** | **2,792** | **98.47** | **86.88** | **0.64** | **0.63** | **679.61** | **603.93** |
| Sequence | Station Type | Model Year Group | | HC 5015 (ppm) | HC 2525 (ppm) | CO 5015 (%) | CO 2525 (%) | NO 5015 (ppm) | NO 2525 (ppm) |
| Percent Reduction | Test-Only | 1974-1979 | | 42.08% | 44.68% | 33.88% | 34.23% | -2.41% | 1.68% |
| | | 1980-1986 | | 37.03% | 37.00% | 36.04% | 34.62% | 16.65% | 19.84% |
| | | 1987-1991 | | 12.90% | 19.17% | 37.78% | 39.53% | 31.24% | 33.50% |
| | | **ALL** | | **31.65%** | **34.35%** | **36.11%** | **35.92%** | **19.31%** | **22.21%** |
| | Test-and-Repair | 1974-1979 | | 32.27% | 32.70% | 20.28% | 12.95% | 0.49% | 5.12% |
| | | 1980-1986 | | 13.58% | 11.69% | 16.04% | 18.27% | 2.24% | 3.27% |
| | | 1987-1991 | | 2.58% | 5.13% | 23.81% | 26.83% | 14.78% | 14.48% |
| | | **ALL** | | **16.32%** | **16.88%** | **18.99%** | **19.31%** | **6.50%** | **7.65%** |

* Value for "ALL" vehicles determined by weighting the model year group average emissions by Vehicle Fraction for the average roadside test date (July 1998).

Figure 3 shows the calculated percent reduction in ASM 2525 emissions by station type. This figure shows results for 1974 to 1991 vehicles, weighted by their travel fraction. This figure graphically illustrates the greater emission reductions achieved from vehicles certified at Test-Only stations versus Test-and-Repair stations. ASM 5015 emissions show the same trends.

**FIGURE 3**
**Observed Emission Reductions**
**Percent Reduction in ASM 2525 Rates by Station Type**




*This figure compares the observed emission reductions for vehicles tested at Test-Only stations with Test-and-Repair facilities. Results are expressed in terms of percent reduction in ASM 2525 emissions. The sample of vehicles certified at Test-Only stations show much greater emission reductions than the sample certified at Test-and-Repair stations. This data is also shown in TABLE 2.*

## 2.3 Observed Emission Reduction for Failed Vehicles by Station Type

Emission reductions for failed vehicles were calculated by comparing roadside emission levels for vehicles that failed subsequent station Smog Check tests with roadside emission levels for vehicles that were tested after they were failed and repaired. Table 3 presents before and after roadside emission levels for the group of vehicles that failed the ASM test at an official Smog Check station. Results, again, are broken down by Test-Only and Test-and-Repair stations. Overall, the emission reductions observed for vehicles tested at Test-Only stations were about twice as high as those tested at Test-and-Repair stations.

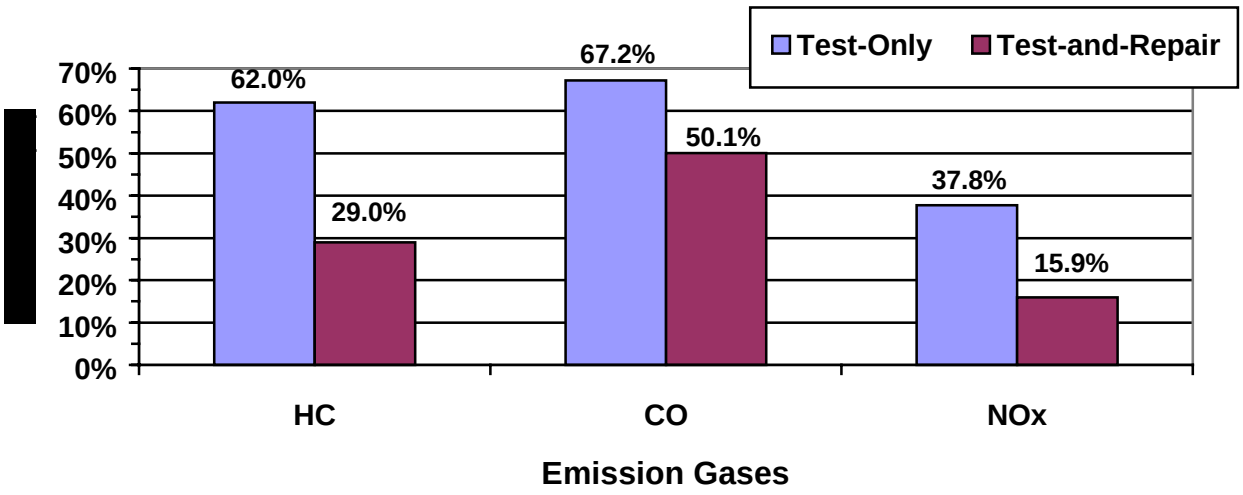
Figure 4 shows calculated percent reductions in ASM 2525 emissions for failed vehicles for the two station types, again, illustrating the greater emission reductions for vehicles certified at Test-Only stations. ASM 5015 emissions show the same trends. The greater reductions for vehicles retested at Test-Only stations can not be explained by the fact that they inspect targeted high emitters, since this analysis is only concerned with reported emission test failures.

**TABLE 3**
**Emission Reduction for Failed Vehicles by Station Type**

| Sequence | Station Type | Model Year Group | N | HC 5015 (ppm) | HC 2525 (ppm) | CO 5015 (%) | CO 2525 (%) | NO 5015 (ppm) | NO 2525 (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| Before Smog Check | Test-Only | 1974-1986 | 325 | 241.74 | 222.98 | 2.01 | 1.94 | 1,109.50 | 1006.38 |
| | | 1987-1991 | 46 | 130.26 | 129.89 | 1.28 | 1.30 | 1,113.05 | 987.38 |
| | | **ALL*** | **371** | **227.92** | **211.44** | **1.92** | **1.86** | **1,109.94** | **1004.02** |
| | Test-and-Repair | 1974-1986 | 350 | 187.06 | 182.57 | 1.90 | 1.94 | 1,058.43 | 940.55 |
| | | 1987-1991 | 168 | 131.11 | 116.70 | 1.06 | 0.98 | 1,078.61 | 970.88 |
| | | **ALL*** | **518** | **168.91** | **161.21** | **1.63** | **1.63** | **1064.97** | **950.39** |
| Sequence | Station Type | Model Year Group | N | HC 5015 (ppm) | HC 2525 (ppm) | CO 5015 (%) | CO 2525 (%) | NO 5015 (ppm) | NO 2525 (ppm) |
| After Smog Check | Test-Only | 1974-1986 | 69 | 96.55 | 86.84 | 0.71 | 0.70 | 797.13 | 657.99 |
| | | 1987-1991 | 24 | 87.10 | 61.78 | 0.54 | 0.35 | 530.60 | 529.64 |
| | | **ALL*** | **93** | **94.11** | **80.37** | **0.67** | **0.61** | **728.35** | **624.87** |
| | Test-and-Repair | 1974-1986 | 121 | 149.68 | 136.77 | 1.16 | 1.09 | 970.87 | 875.76 |
| | | 1987-1991 | 85 | 93.89 | 82.73 | 0.35 | 0.42 | 840.48 | 689.96 |
| | | **ALL*** | **206** | **126.66** | **114.47** | **0.83** | **0.81** | **917.07** | **799.09** |
| Sequence | Station Type | Model Year Group | | HC 5015 (ppm) | HC 2525 (ppm) | CO 5015 (%) | CO 2525 (%) | NO 5015 (ppm) | NO 2525 (ppm) |
| Percent Reduction | Test-Only | 1974-1986 | | 60.06% | 61.05% | 64.68% | 63.92% | 28.15% | 34.62% |
| | | 1987-1991 | | 33.13% | 52.44% | 57.81% | 73.08% | 52.33% | 46.36% |
| | | **ALL** | | **58.71%** | **61.99%** | **65.30%** | **67.23%** | **34.38%** | **37.76%** |
| | Test-and-Repair | 1974-1986 | | 19.98% | 25.09% | 38.95% | 43.81% | 8.27% | 6.89% |
| | | 1987-1991 | | 28.39% | 29.11% | 66.98% | 57.14% | 22.08% | 28.93% |
| | | **ALL** | | **25.02%** | **28.99%** | **49.26%** | **50.05%** | **13.89%** | **15.92%** |

* Value for "ALL" vehicles determined by weighting the model year group average emissions by the sample size (N).

**FIGURE 4**
**Observed Emission Reductions**
**Percent Reduction in ASM 2525 from Repairs to Failed Vehicles**
**Test-Only vs. Test-and-Repair**




*This figure compares the observed emission reductions for vehicles that failed and were retested at Test-Only facilities vs. Test-and-Repair facilities. Results are expressed in terms of percent reduction in ASM 2525 emission rates. The sample of vehicles tested at Test-Only stations after failing the initial test show much greater emission reductions than the sample tested at Test-and-Repair stations after failing the initial test. This data is also shown in TABLE 3.*

## 2.4 Observed Impact of the Smog Check Program on Percentages of Super Emitters

The primary goal of an I/M program is to identify and force the repair of high emitting vehicles. Of primary interest is how the program impacts the percentage of super emitting vehicles – vehicles that emit at rates an order of magnitude greater than their certification standards. Theoretically, few vehicles should be super emitters after they have been certified in the Smog Check program. Using data from BAR's roadside test program, dKC estimated the impact of the Smog Check program on the percentages of the fleet that are classified as super emitters. Trends by station type – Test-Only vs. Test-and-Repair – were investigated.

dKC limited the analysis to 1980 to 1991 passenger cars that were tested in BAR's roadside test program (5644 observations). dKC used projected FTP emission rates in g/mi. as the basis for determining if a vehicle was classified as a super emitter. These projections were made by applying ERG's FTP conversion factors to the two-mode ASM results in the roadside dataset. For this analysis, super emitters are defined as vehicles that exceed new vehicle certification standards by the following multiples:

- HC – 9 times (> 3.69 g/mi.)
- CO – 10 times (>70.0 g/mi.)
- NOx – 4 times (>2.8 g/mi.)

Trends were evaluated by each pollutant and by all pollutants, i.e., classified as a super emitter for any of the pollutants.

Table 4 presents a breakdown of the percentages of super emitters before and after Smog Check by station type and model year group. As shown, much greater reductions in the incidence of super emitters were observed for vehicles certified at Test-Only stations than Test-and-Repair stations. In addition, after Smog Check, there were much lower percentages of super emitting vehicles among the sample that was certified at Test-Only stations. For example, 10.8% of the 1980 to 1986 vehicles certified at Test-and-Repair stations were HC super emitters, while 5.0% of the 1980 to 1986 vehicles certified at Test-Only stations were HC super emitters.

**TABLE 4**
**Percent of Super Emitters Before and After Smog Check Certification**
**By Station Type and Model Year Group**

| Model Year Group | Station Type | Pollutant | Super Emitters (%) Before Smog Check | Super Emitters (%) After Smog Check | Reduction in Super Emitters (%) |
|---|---|---|---|---|---|
| 1980-86 | Test-and-Repair | HC | 13.07% | 10.83% | 17.19% |
| | | CO | 9.35% | 6.98% | 25.35% |
| | | $NO_x$ | 13.07% | 13.11% | -0.24% |
| | | Any Pollutant | 25.28% | 23.08% | 8.72% |
| | **Test-Only** | **HC** | **13.76%** | **5.03%** | **63.41%** |
| | | **CO** | **9.63%** | **3.36%** | **65.15%** |
| | | **$NO_x$** | **13.34%** | **10.40%** | **22.03%** |
| | | **Any Pollutant** | **26.69%** | **15.10%** | **43.41%** |
| 1987-91 | Test-and-Repair | HC | 1.93% | 2.31% | -19.50% |
| | | CO | 1.21% | 0.98% | 19.11% |
| | | $NO_x$ | 4.92% | 3.47% | 29.47% |
| | | Any Pollutant | 6.93% | 5.87% | 15.34% |
| | **Test-Only** | **HC** | **2.52%** | **1.27%** | **49.79%** |
| | | **CO** | **2.52%** | **0.63%** | **74.89%** |
| | | **$NO_x$** | **4.62%** | **0.63%** | **86.31%** |
| | | **Any Pollutant** | **7.98%** | **1.90%** | **76.22%** |

## 3.0 INVESTIGATION INTO DIFFERENCES BETWEEN TEST-ONLY AND TEST-AND-REPAIR INSPECTION PERFORMANCE

The following factors may help explain why Test-Only stations achieve better performance than Test-and-Repair stations:

- Test-Only stations fail more vehicles that have high emissions.
- Better repairs are performed if the vehicle's certification test is performed at a different station than the station that repaired the vehicle.
- Test-Only stations perform more accurate and complete reinspections, and may not incorrectly certify as many high emitting vehicles as Test-and-Repair facilities.

The accuracy of Test-Only vs. Test-and-Repair stations in failing high emitting vehicles can be addressed by analyzing data on the following:

- Vehicles that undergo Smog Checks after they exceed Smog Check standards in roadside tests.
- Vehicles that are tested in the roadside inspection program after they pass their initial Smog Checks.

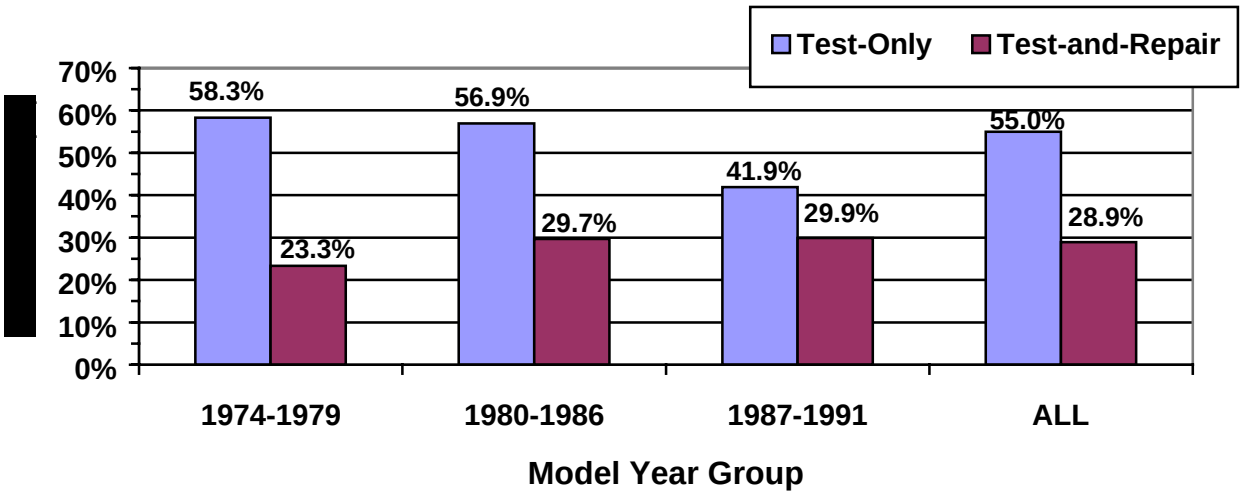
The performance of Test-Only vs. Test-and-Repair stations in certifying that failed vehicles comply with Smog Check standards can be assessed by analyzing data on vehicles that are tested in the roadside test program after they fail their initial Smog Checks and then pass.

### 3.1 Analysis of Smog Check Station Results on Vehicles That Exceed ASM Standards in Roadside Tests

Results of roadside tests that were performed before vehicles are given their Smog Check can help us assess the accuracy of the initial smog inspections. Of primary interest are the Smog Check results on vehicles that exceeded ASM standards during the roadside tests. Although some of these vehicles will be repaired prior to inspection, one would expect that most of the vehicles would still be in a high emissions state when they were inspected. Consequently, they should fail their initial Smog Check. The exception would be for $NO_x$ since Smog Check standards for station inspections are significantly less stringent than roadside standards.

Figure 5 compares the failure rate (tailpipe failure rate only) for the Smog Check that was performed after the roadside test on vehicles that exceeded Smog Check standards during the roadside test. These results differ from the results shown on Table 1 in that here we are comparing reported failure rates for vehicles that exceeded Smog Check standards on prior roadside tests, while Table 1 shows the differences in roadside failure rates before and after Smog Check Certification. As shown, the failure rate was about twice as high for the Test-Only stations versus the Test-and-Repair stations.

**FIGURE 5**
**Comparison of Failure Rates**
**Failed Roadside Test before Smog Check**



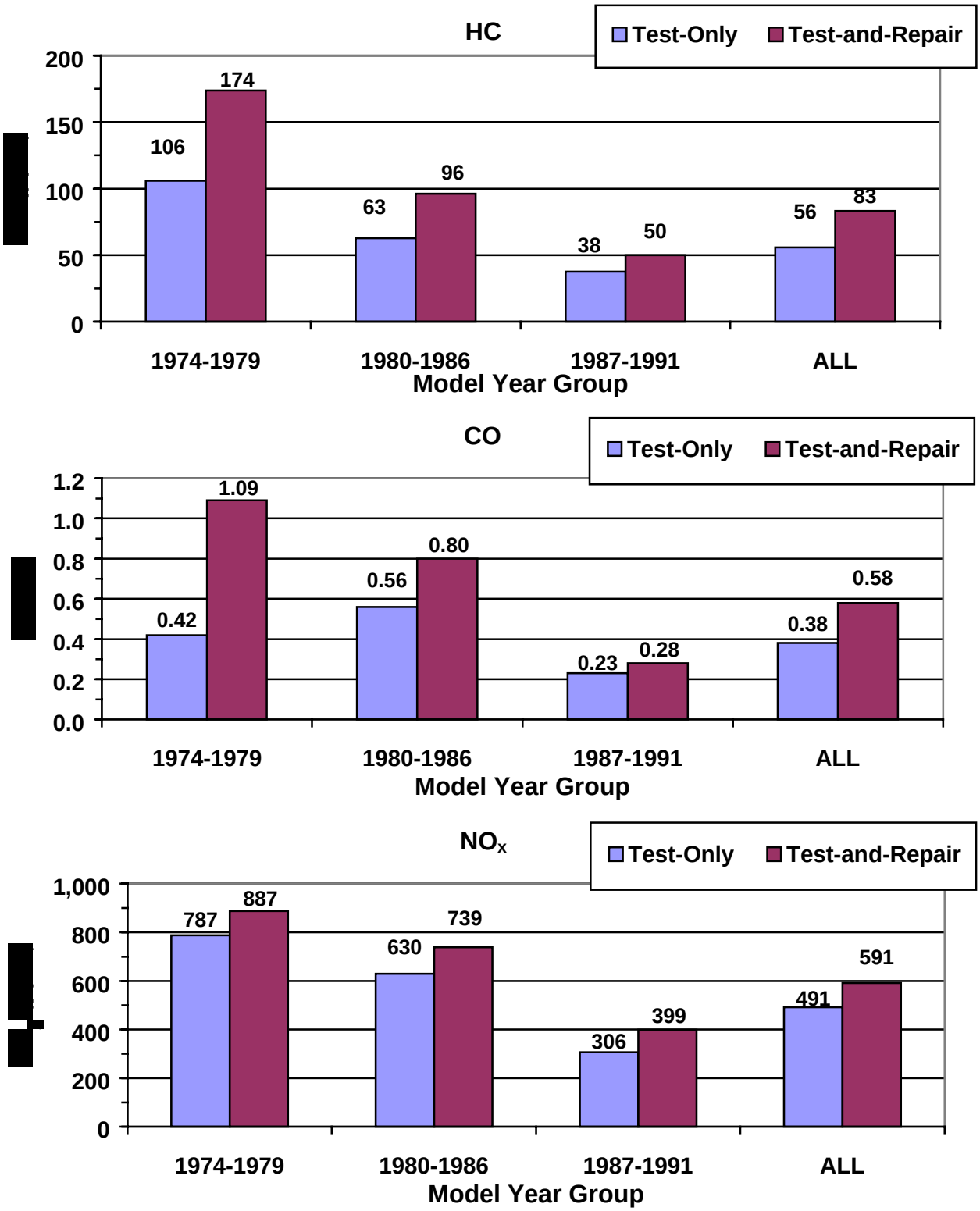

*This figure shows the emissions failure rate that was reported by Smog Check stations on vehicles that exceeded Smog Check standards in roadside tests that were conducted prior to the Smog Check. The higher failure rate reported by Test-Only stations might indicated that they perform more reliable and accurate inspections than Test-and-Repair stations.*

## 3.2 Analysis of Roadside Test Results on Vehicles After They Passed Their Initial Smog Check

The results of roadside tests that were conducted after vehicles were certified in the Smog Check program again reveals much about the performance of different types of stations. Vehicles may have been improperly certified if they have high emissions during subsequent roadside tests.

Ideally, a vehicle that passes its initial test should have low emission rates when inspected at a subsequent roadside test. Figure 6 summarizes roadside emission trends for vehicles that passed initial tests in different types of stations, broken down by model year group. Results are expressed in terms of ASM 2525 emissions. ASM 5015 emissions show the same trends. As shown, vehicles certified at Test-Only stations had lower emissions in the roadside tests that followed than those certified at Test-and-Repair stations. This indicates that Test-and-Repair stations may be improperly certifying some of the vehicles, possibly through improper test procedures or clean piping.

**FIGURE 6**
**Roadside ASM 2525 Emissions for Vehicles that Pass Their Initial Station Smog Check**



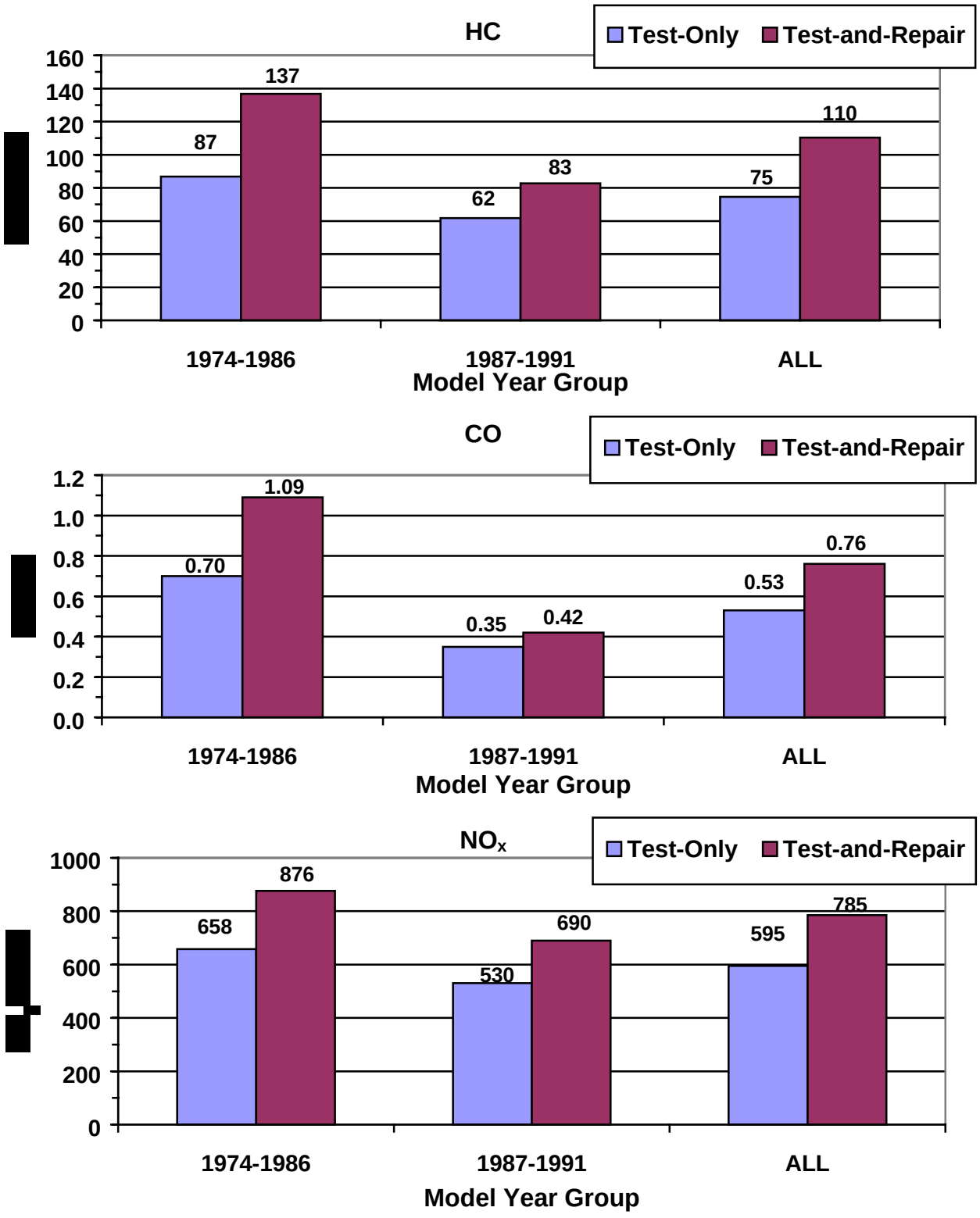

*This figure shows average Roadside ASM 2525 emissions by pollutant for vehicles that pass their initial Smog Check. Lower emissions are observed for vehicles tested at Test-Only stations.*

## 3.3 Analysis of Roadside Test Results on Vehicles that Passed Smog Check After Previously Failing

The matched dataset indicated if a vehicle that passed its Smog Check had previously failed a Smog Check in the prior six-month period. These are the vehicles that are presumed to have been repaired. BAR identified these vehicles by analyzing data from the Vehicle Information Database (VID) to determine if previously there was a failing record. Vehicles that are improperly certified or that received inadequate repairs are likely to have higher emissions on subsequent roadside tests.

Figure 7 summarizes the emission trends for vehicles that pass their station Smog Check after failing an initial Smog Check at the station. Results are expressed in terms of ASM 2525 emissions. ASM 5015 emissions show the same trends. Vehicles that passed their retests (presumably after repairs) at Test-Only stations had significantly lower HC, CO, and NO emissions than those that passed their retest at Test-and-Repair stations. These results indicate that repairs may be more complete if a vehicle is retested at a Test-Only station. They also could indicate that Test-and-Repair stations might be more likely to falsely pass a vehicle, either through clean piping or improper test procedures.

**FIGURE 7**
**Roadside ASM 2525 Emissions for Vehicles that Pass Their Station Smog Check After Failing Their Initial Station Smog Check**




*This figure shows average ASM 2525 emissions results by pollutant for vehicles that pass after failing their initial Smog Check. Lower emissions are observed for vehicles tested at Test-Only stations, implying that they received more complete repairs.*

## 4.0 RANKING THE PERFORMANCE OF INDIVIDUAL STATIONS

In order for an I/M program to achieve maximum benefits, all stations must perform accurate and complete emission tests before and after repairs. Based on the analysis presented in sections 2 and 3, vehicles certified at Test-Only facilities show much greater exhaust emission reductions and lower after Smog Check emission levels than vehicles certified at Test-and-Repair facilities. dKC and ERG investigated the performance of the different types of Test-and-Repair stations with the goal of identifying characteristics of high performing stations – stations that appear to have similar performance to Test-Only stations. These characteristics could then be incorporated into performance standards for Test-and-Repair stations.

Possible performance standards were calculated using data stored in BAR's Vehicle Information Database (VID), a database containing all Smog Check results. The standards were evaluated using data collected from roadside tests performed between February 1997 and October 1999.

### 4.1 Emission Reductions by Station Type

Before we discuss possible performance standards, emission reductions for different types of stations will be reviewed. Within the Test-and-Repair category, there are three types of stations:

- Gross Polluter Certification (GPC)
- Gold Shield Registered (GSR)
- Regular Test-and-Repair (REG)

We evaluated the performance of the above stations using two basic parameters:

- Observed emission reductions based on roadside tests before and after Smog Check.

- Observed roadside emission levels after Smog Check.

We concentrated on hydrocarbon (HC) emissions during the ASM 2525 cycle. Emission standards for oxides of nitrogen ($NO_x$) were not in place for much of the roadside test period, so observed $NO_x$ emissions are not as valid as observed HC emissions for program evaluation.

Table 5 compares HC emissions before and after Smog Check for vehicles certified by different station types. Results for Test-Only stations are shown for comparison purposes. Vehicles certified by GPC stations appear to have greater emission reductions and lower after Smog Check emission levels than vehicles certified by GSR or regular Test-and-Repair stations, but the sample sizes for the GPC group is small. Vehicles certified at Test-Only stations appear to have greater emission reductions than all the Test-and-Repair groups.

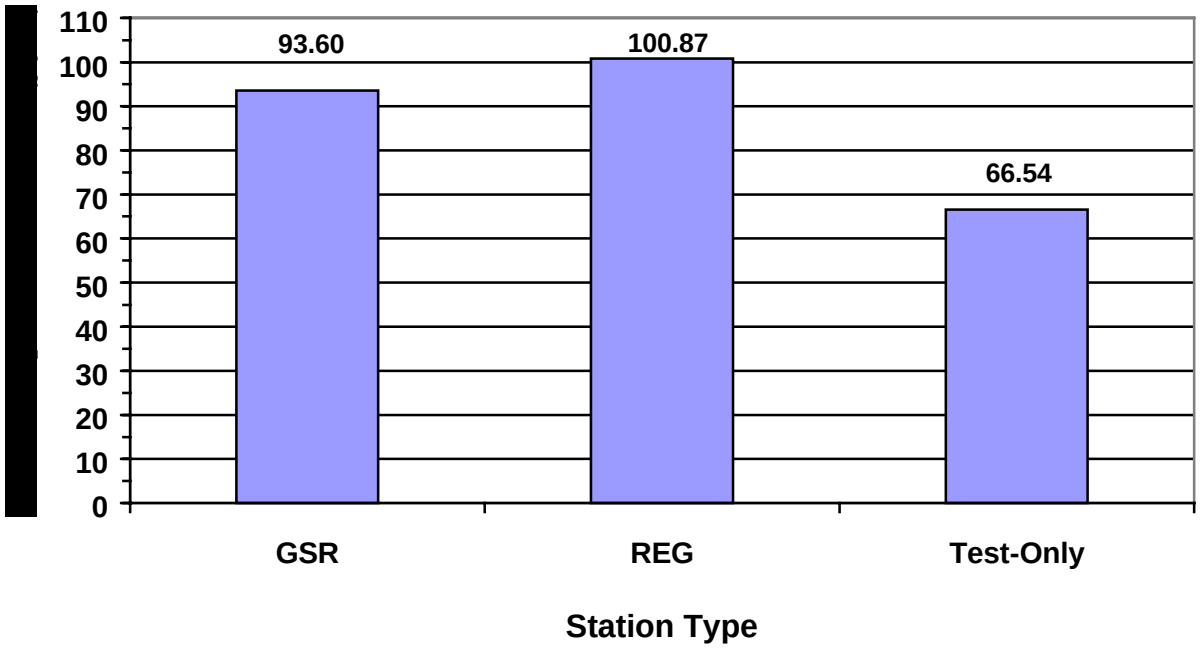
Figure 8 compares after repair HC emissions levels by station type for the 1980 to 1986 vehicles. Vehicles within the 1980 to 1986 group are not significantly impacted by BAR's policy of directing high emitters to Test-Only stations. These vehicles are as a group high emitting and thus it does not matter that a few are directed to Test-Only stations. For the purpose of evaluation, it can be assumed that all station types are inspecting 1980 to 1986 vehicles with similar emissions. After Smog Check HC emission levels for vehicles certified by GSR and regular Test-and-Repair stations were much greater than the levels for Test-Only certification. There were insufficient data to include GPC stations by model year group in the comparison.

**TABLE 5**
**Roadside HC 2525 Emissions and Percent Reductions by Test-and-Repair Station Type and Model Year**

| Station Type | Model Year Group | Parameter | Before Smog Check | After Smog Check | Reduction (%) |
|---|---|---|---|---|---|
| **GPC** | ALL[2] | Average HC 2525 | 63.70 | 44.30 | 30.45% |
| | | Count | 189 | 148 | |
| **GSR** | 1974-1979 | Average HC 2525 | 251.94 | 201.79 | 19.91% |
| | | Count | 88 | 67 | |
| | 1980-1986 | Average HC 2525 | 98.19 | 93.60 | 4.67% |
| | | Count | 500 | 288 | |
| | 1987-1991 | Average HC 2525 | 56.91 | 50.68 | 10.94% |
| | | Count | 596 | 524 | |
| | ALL | Average HC 2525 | 88.84 | 76.26 | 14.15% |
| | | Count | 1184 | 879 | |
| **Regular (REG)** | 1974-1979 | Average HC 2525 | 289.68 | 194.21 | 32.96% |
| | | Count | 241 | 112 | |
| | 1980-1986 | Average HC 2525 | 121.01 | 100.87 | 16.65% |
| | | Count | 1062 | 631 | |
| | 1987-1991 | Average HC 2525 | 56.07 | 53.74 | 4.16% |
| | | Count | 1099 | 994 | |
| | ALL | Average HC 2525 | 108.22 | 79.92 | 26.15% |
| | | Count | 2402 | 1737 | |
| **Test-Only (TO)** | 1974-1979 | Average HC 2525 | 211.08 | 106.04 | 49.76% |
| | | Count | 108 | 46 | |
| | 1980-1986 | Average HC 2525 | 113.41 | 66.54 | 41.33% |
| | | Count | 870 | 371 | |
| | 1987-1991 | Average HC 2525 | 51.89 | 40.28 | 22.36% |
| | | Count | 303 | 215 | |
| | ALL | Average HC 2525 | 107.10 | 60.48 | 43.52% |
| | | Count | 1281 | 632 | |

[2] Insufficient data for a breakdown by model year.

**FIGURE 8**
**Comparison of After Smog Check HC 2525 Emissions**
**1980 to 1986 Vehicles**




*This figure compares after Smog Check HC emissions during the ASM 2525 test for Test-Only stations with different types of Test-and-Repair stations. Vehicles certified at GSR and Regular Test-and-Repair stations have much higher after Smog Check levels to those certified at Test-Only stations.*

## 4.2 Ranking Test-and-Repair Stations Based on Reported Failure Rates

dKC and ERG investigated ways to rank the different Test-and-Repair stations. Our goal was to determine if ranking parameters could be developed that identify Test-and-Repair stations with similar performance to Test-Only stations. This section presents station rankings based on observed vs. expected failure rates for each station in the Enhanced program area. ERG ranked the stations using the procedure presented below.

The ERG rankings are based on the actual failure rate at a station compared with the expected failure rate. Data from BAR's VID were used to calculate expected and reported failure rates. The expected failure rate at a station is based on the average failure probability of the set of vehicles that were tested at the station. The difference between the actual and expected failure rate is used to develop the final rankings. The standard error of the expected failure rate is also considered in determining these rankings. The difference between the actual and expected failure rates is divided by the standard error of the expected failure rate to determine how the station's actual failure rate compares to the expected failure rate. The following equation is used to calculate the number of standard deviations between the actual and expected failure probabilities.

$$N_{\sigma} = \frac{\left(F_p - FR\right)}{Std\ Err}$$

$F_p$ = Average expected Fail Rate at Station
FR = Actual Fail Rate at Station
Std Err = Standard Error of the Expected Fail Rate at Station

$N_{\sigma}$ is used to rank the station from the lowest value to the highest. Stations at the top of the list report failure rates that exceed the expected failure rates. Their $N_{\sigma}$ values are negative. Stations at the bottom of the list report failure rates that are much lower than expected failure rates. Their $N_{\sigma}$ values are positive.

The fleet was broken down into 4 categories from top to bottom ranks based on $N_{\sigma}$:

- 0 to 25% of all stations -- The highest ranked stations.
- 25 to 50% of all stations
- 50 to 75% of all stations
- 75 to 100% of all stations -- The lowest ranked stations.

Table 6 shows a breakdown in the percentages of Test-and-Repair and Test-Only stations by rank, along with the percent of vehicles inspected by these stations, based on 1999 VID data.

**TABLE 6**
**Percent of Stations by Rank**

| $N_\sigma$ Ranking | Test-Only | | Test-and-Repair | |
|---|---|---|---|---|
| | Percent of Stations | Percent of Vehicles Inspected | Percent of Stations | Percent of Vehicles Inspected |
| 0-25% (Best) | 59.9% | 12.8% | 21.2% | 19.3% |
| 25-50% | 21.5% | 3.6% | 25.4% | 17.3% |
| 50-75% | 12.3% | 2.5% | 26.4% | 18.1% |
| 75-100% (Worst) | 6.3% | 1.4% | 27.0% | 25.0% |
| All | 100.0% | 20.2% | 100.0% | 79.8% |

Table 7 compares HC emissions before and after Smog Check for vehicles certified by different ranks of Test-and-Repair stations. Stations with too few observations to generate statistically valid $N_\sigma$ were put in the unranked category. As shown, after Smog Check HC emission levels for the top 25% of the Test-and-Repair stations are much lower than the bottom 25%, even though average emissions before Smog Check for the top 25% group are significantly higher than average emissions for the bottom 25% group. Collectively, stations falling in the Top 75% based on $N_\sigma$ reduced HC emissions by 30%, while stations falling in the bottom 25% (the 75-100% group) showed no reductions in HC emissions.

**TABLE 7**
**Emission Reductions by Failure Probability Ranking -- 0-25% is best**
**Test-and-Repair 1980 to 1991 Model Years**

| $N_\sigma$ group | Parameter | HC 2525 Emissions | | |
|---|---|---|---|---|
| | | Before Smog Check | After Smog Check | Reduction (%) |
| **Top 25% (0-25%) Best Stations** | **Average of HC 2525** | **98.41** | **55.10** | **44.01%** |
| | **Count** | **813** | **543** | |
| 25-75% | Average of HC 2525 | 71.35 | 59.48 | 16.64% |
| | Count | 1140 | 906 | |
| **Bottom 25% (75-100%) Worst Stations** | **Average of HC 2525** | **81.88** | **83.26** | **-1.68%** |
| | **Count** | **1092** | **825** | |
| Not ranked | Average of HC 2525 | 81.21 | 80.13 | 1.32% |
| | Count | 392 | 301 | |
| ALL | Average of HC 2525 | 82.22 | 68.59 | 16.58% |
| | Count | 3437 | 2575 | |

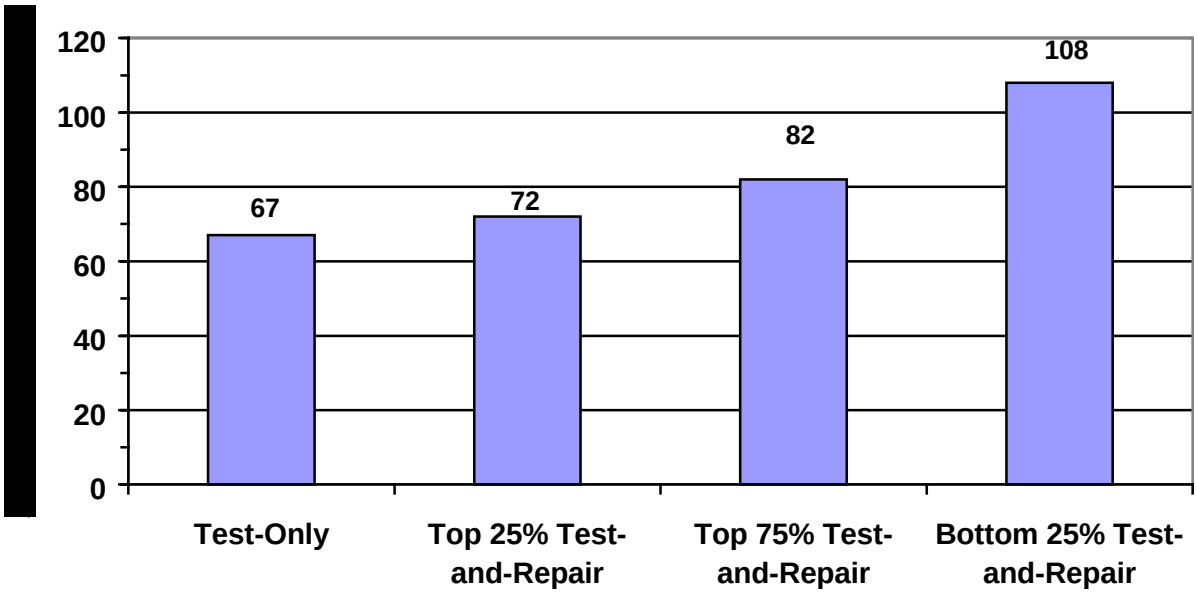
As shown on Table 7, HC emission reductions for vehicles certified by the top 25% of the Test-and-Repair stations are significantly greater than the other groups. Conversely, Vehicles certified by the bottom 25% of the Test-and-Repair stations show no HC emission reductions.

Figure 9 compares after Smog Check levels for ranked Test-and-Repair stations with Test-Only stations. As with the previous comparison of Test-Only vs. Test-and-Repair results shown on Figure 7, the dataset is limited to 1980 to 1986 model year vehicles to minimize concerns over sampling biases due to high emitters being directed to Test-Only facilities. After Smog Check HC emissions for the top 25% (0-25%) of Test-and-Repair stations averaged 72 ppm; after Smog Check HC emissions for the Test-Only stations averaged 67 ppm. Vehicles certified at the bottom 25% of the Test-and-Repair stations had much higher emissions after Smog Check, averaging 108 ppm HC. After Smog Check HC emissions for the top 75% of Test-and-Repair stations averaged 82 ppm.

Table 8 presents a breakdown of the percentages of super HC emitters before and after Smog Check for Test-and-Repair stations broken down by their ERG failure rate rank. Super emitters are defined in Section 2.4. As shown, a much greater reduction in the incidence of super emitters was observed for vehicles certified at the top 25% of Test-and-Repair stations (0-25%) than at the bottom 25% (75-100%). In addition, after Smog Check there were much lower percentages of super HC emitting vehicles among the sample that was certified at the top 25% of Test-and-Repair stations. For example, 7.6% of the 1980 to 1991 vehicles certified at the bottom 25% of Test-and-Repair stations were HC super emitters, while 3.9% of the 1980 to 1991 vehicles certified at the top 25% of Test-and-Repair stations were HC super emitters. The percent of super emitters after Smog Check for the top 25% of Test-and-Repair stations were similar to the percent for Test-Only stations.

To further validate the station rankings based on $N_\sigma$, we ranked different types of Test-and-Repair stations (GPC, GSR, and REG) and compared the observed emission reductions. Table 9 shows observed HC emissions before and after Smog Check by station type and rank. For all station types, the bottom 25% showed the highest emissions and lowest emission reductions. This further confirms that Test-and-Repair stations falling into to the bottom 25% perform inferior inspections. The top 25% consistently showed the greatest emission reductions. Furthermore, these reductions generally were similar to those observed for the Test-Only group.

**FIGURE 9**
**Comparison of After Smog Check HC 2525 Emissions for Ranked Test-Only Stations and Test-and-Repair Stations**
**(1980 to 1986 Vehicles)**




*This figure compares after Smog Check HC emissions during the ASM 2525 test for the ranked Test-and-Repair stations with Test-Only stations. The highest ranked stations, the top 25%, had HC emissions close to the Test-Only group, implying they achieved similar benefits.*

**TABLE 8**
**Percent of Super Emitters Before and After Smog Check Certification**
**1980 to 1991 Vehicles by Failure Rate Rank**

| Station Type | Fprob Rank | Parameter | Super Emitters (%) | | |
|---|---|---|---|---|---|
| | | | Before Smog Check | After Smog Check | Reduction (%) |
| Test-and-Repair | **0-25%** | **HC Super Emitter (%)** | **7.97%** | **3.95%** | **50.48%** |
| | | **Count** | **552** | **380** | |
| | 25-75% | HC Super Emitter (%) | 5.26% | 4.86% | 7.62% |
| | | Count | 799 | 659 | |
| | 75-100% | HC Super Emitter (%) | 9.39% | 7.58% | 19.21% |
| | | Count | 767 | 567 | |
| **Test-Only** | | **HC Super Emitter (%)** | **10.98%** | **3.73%** | **66.06%** |
| | | **Count** | **965** | **456** | |

**TABLE 9**
**Emission Reductions by Failure Rate Ranking and Station Type:**
**0-25% is best -- TEST-AND-REPAIR - 1980 to 1991 Model Years**

| Station Type | $N_\sigma$ group | Parameter | Before Smog Check | After Smog Check | Reduction (%) |
|---|---|---|---|---|---|
| GPC | 0-25% | Average of HC2525 | 53.62 | 43.07 | 19.67% |
| | | Count | 64 | 47 | |
| | 25-75% | Average of HC2525 | 52.23 | 43.95 | 15.87% |
| | | Count | 71 | 56 | |
| | 75-100% | Average of HC2525 | 26.9 | 64.6 | -140.15% |
| | | Count | 10 | 10 | |
| | Not ranked | Average of HC2525 | 61.14 | 36.67 | 40.03% |
| | | Count | 33 | 24 | |
| | ALL | Average of HC2525 | 52.96 | 43.88 | 17.15% |
| | | Count | 178 | 137 | |
| GSR | 0-25% | Average of HC2525 | 91.92 | 47.31 | 48.53% |
| | | Count | 218 | 162 | |
| | 25-75% | Average of HC2525 | 61.70 | 52.22 | 15.37% |
| | | Count | 395 | 292 | |
| | 75-100% | Average of HC2525 | 69.43 | 74.54 | -7.35% |
| | | Count | 369 | 280 | |
| | Not ranked | Average of HC2525 | 113.85 | 124.78 | -9.60% |
| | | Count | 114 | 78 | |
| | ALL | Average of HC2525 | 75.74 | 65.90 | 12.98% |
| | | Count | 1096 | 812 | |
| REG | 0-25% | Average of HC2525 | 106.47 | 60.56 | 43.12% |
| | | Count | 531 | 334 | |
| | 25-75% | Average of HC2525 | 79.02 | 64.83 | 17.95% |
| | | Count | 674 | 558 | |
| | 75-100% | Average of HC2525 | 89.09 | 88.17 | 1.03% |
| | | Count | 713 | 535 | |
| | Not ranked | Average of HC2525 | 69.23 | 68.13 | 1.59% |
| | | Count | 243 | 198 | |
| | ALL | Average of HC2525 | 87.98 | 72.04 | 18.12% |
| | | Count | 2161 | 1625 | |

Table 10 compares HC emissions before and after Smog Check for vehicles certified by different ranks of Test-Only stations. There are no significant differences in the after Smog emission levels for the top and bottom groups of Test-Only stations. This implies that most Test-Only stations have similar performance in assuring that vehicles comply with standards when they are certified to pass Smog Check requirements.

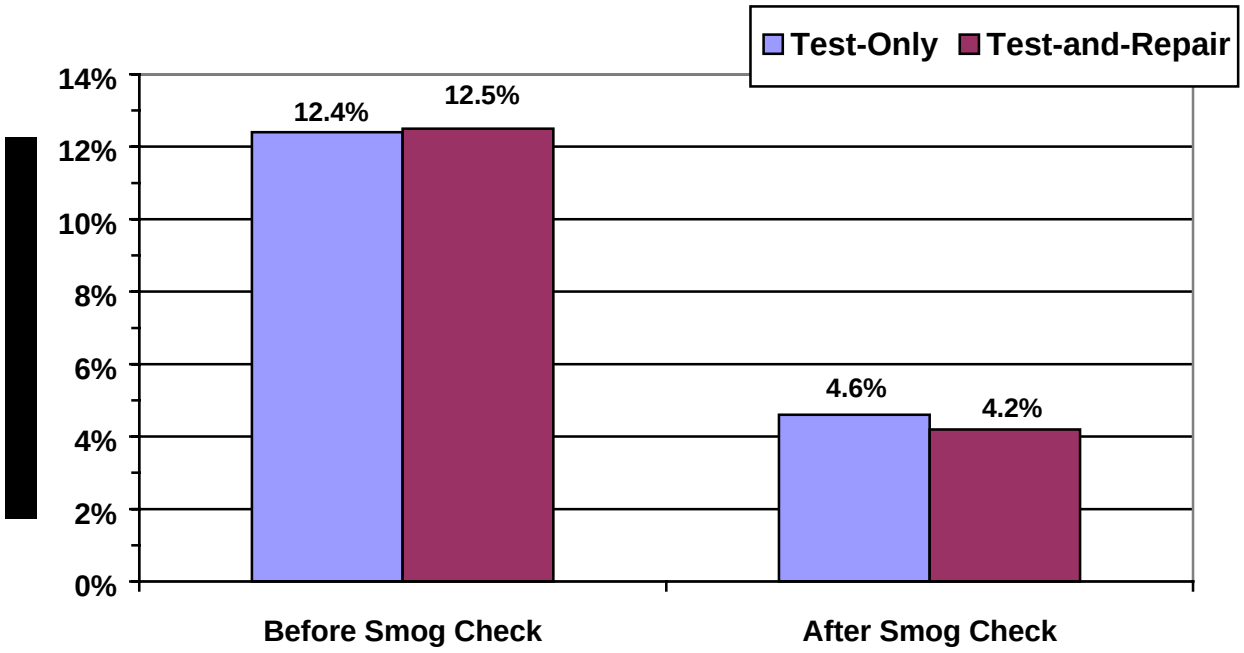
**TABLE 10**
**Emission Reductions by Failure Rate Ranking:**
**TEST-ONLY 1980 to 1991 Model Years**

| $N_\sigma$ group | Parameter | Before Smog Check | After Smog Check | Reduction (%) |
|---|---|---|---|---|
| 0-25% | Average of HC 2525 | 118.85 | 65.41 | 44.97% |
| | Count | 870 | 392 | |
| 25-50% | Average of HC 2525 | 83.50 | 53.28 | 36.19% |
| | Count | 176 | 93 | |
| 50-75% | Average of HC 2525 | 65.01 | 50.96 | 21.61% |
| | Count | 141 | 85 | |
| 75-100% | Average of HC 2525 | 98.75 | 49.50 | 49.87% |
| | Count | 76 | 52 | |
| Not Ranked | Average of HC 2525 | 134.67 | 72.60 | 46.09% |
| | Count | 18 | 10 | |
| ALL | Average of HC 2525 | 107.10 | 60.48 | 43.52% |
| | Count | 1281 | 632 | |

## 5.0 IMPACT OF THE SMOG CHECK PROGRAM ON GAS CAP FAIL RATES

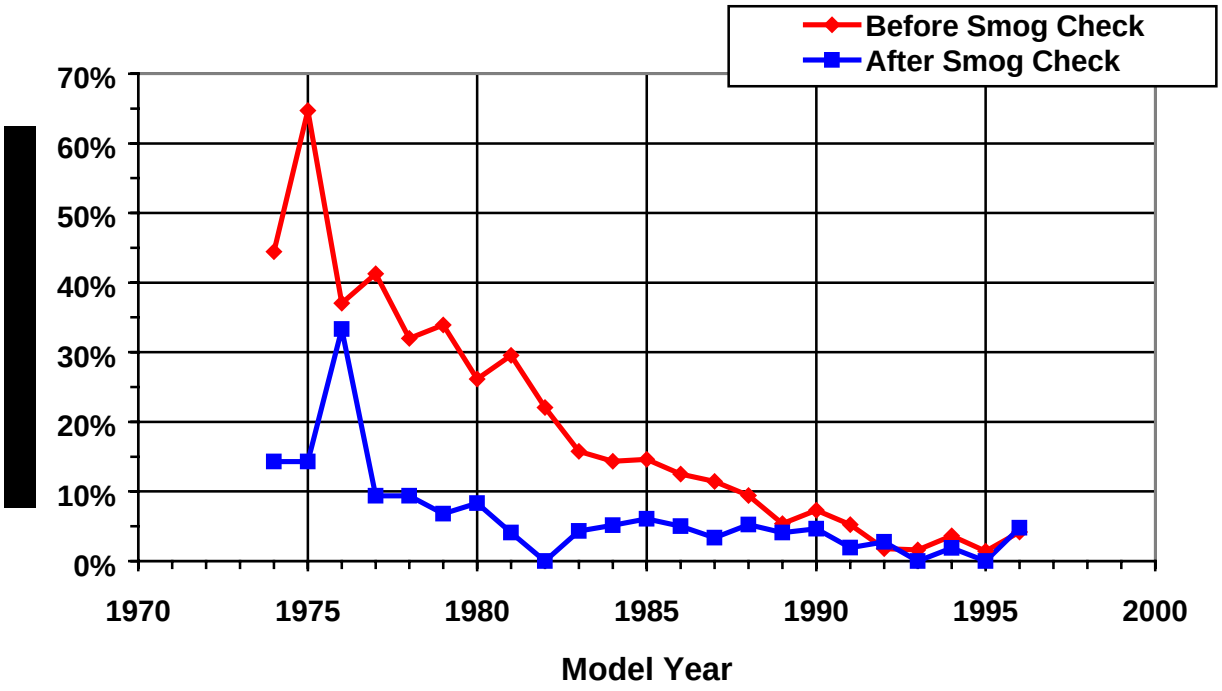
dKC investigated the impact of the Enhanced Smog Check Program on gas cap fail rates and found that the program significantly reduced the incidence of gas cap failures. The gas cap fail rate before Smog Check was 12.4%. The after Smog Check fail rate was 4.29% or 65.5% lower. The reductions were the same for Test-Only and Test-and-Repair stations (Figure 10). Furthermore, as shown on the Figure 11, the impact was very consistent by model year.

**FIGURE 10**
**Gas Cap Failure Rate (%)**




*This figure compares failure rates for the gas cap pressure test before and after Smog Check. After Smog Check failure rates are much lower than before Smog Check failure rates. There is no difference between Test-and-Repair and Test-Only stations in terms of the impact on gas cap failure rates.*

**FIGURE 11**
**Gas Cap Failure Rate (%)**




*This figure compares failure rates by vehicle model year for the gas cap pressure test before and after Smog Check. After Smog Check failure rates are much lower than before Smog Check failure rates for most of the model years.*

## 6.0 COMPARISON OF FLEET EMISSION REDUCTIONS FOR A TEST-ONLY VS. TEST-AND-REPAIR INSPECTION NETWORK

Using data from roadside emissions tests, ERG estimated fleet emission reductions for two scenarios:

- 100% Test-Only Inspection Network
- 100% Test-and-Repair Inspection Network

ERG first converted results of the ASM test into projected emissions during the Federal Test Procedure (FTP). ERG then calculated projected FTP emission levels in grams/mile before and after Smog Check. After Smog Check results were divided into vehicles that were certified at Test-Only and Test-and-Repair stations. Total tons per day benefits for the two scenarios were calculated by multiplying the difference in grams/mile emissions before and after Smog Check by estimates of daily vehicle miles traveled (VMT).

### 6.1 Fleet Average Predicted FTP Emissions

ASM results in concentrations were converted into predicted FTP rates (g/mi) using the latest conversion equations developed by Radian/ERG. These conversion equations are described in the Radian/Eastern Research Group (ERG) report titled, "Equations for Estimating California Fleet FTP Emissions from ASM Concentrations," dated January 13, 2000.

Once the predicted FTP emission rates were determined, the fleet average FTP emission rates were calculated using the following methodology:

1. Calculate the average predicted FTP emission rate by model-year for each pollutant (HC, CO and $NO_x$);

2. Multiply the average predicted FTP emission rate for each model-year and pollutant by the respective travel fraction for that model-year; and

3. Sum the products for each model-year by pollutant to determine the overall fleet average predicted FTP emission rate for each time period.

### 6.2 Predicted FTP Emission Rates Before and After Smog Check Inspection

ERG then calculated Before and After Smog Check emission levels for vehicles undergoing BAR97 ASM tests in the enhanced Smog Check program. California's VID records were matched with the roadside sample. Vehicles which had completed the BAR-97 ASM test requirement were selected for this analysis. Vehicles which had either passed the BAR-97 ASM test or had 90 days lapse since producing a BAR-97 ASM test failure were assumed to have completed the I/M requirements. This dataset contained vehicle model-years 1974 through 1995. This subset is representative of the After BAR-97 I/M fleet. To complete the analysis for model-

years that are not covered by the program, 1966 to 1973 model-year estimates and 1996 to 1999 model-year estimates from the roadside sample during the same time period have been added to the After I/M dataset.

Tables 11 through 13 show the results of this analysis. Table 11 shows the Before Smog Check emission levels; Table 12 shows After Smog Check emission levels for vehicles that were certified at Test-and-Repair stations; Table 13 shows After Smog Check emission levels for vehicles that were certified at Test-Only stations. The 1966 to 1973 model-year and 1996 to 1999 model-year estimates are shown in italics. The overall fleet estimates weighted by travel fraction are shown at the bottom of the table.

## 6.3 Estimated Reductions in Tons per Day

The weighted average exhaust emission rates in grams per mile were multiplied by estimated daily VMT to calculate tons per day exhaust emissions. We used the same VMT estimates that ARB used in its report *Evaluation of California's Enhanced Vehicle Inspection and Maintenance Program (Smog Check II), April 27, 2000.* For evaporative emissions reductions, we used ARB's estimate of 25 tons per day. Based on the gas cap test results discussed in Section 5, we used the same evaporative emission reductions for Test-Only and Test-and-Repair stations.

Emission reductions were calculated by subtracting the After Smog Check emission estimates for the two scenarios – Test-Only and Test-and-Repair – from Before Smog Check emission estimates. Table 14 summarizes the results of this analysis. ARB's current estimates for the program also are presented. As shown, total HC plus $NO_x$ estimates for the Test-Only scenario are about double the estimated reductions for the Test-and-Repair scenario. Switching to a 100% Test-Only scenario, or equivalent in terms of Test-and-Repair performance standards, is estimated to increase emission reductions for the current program by 80 tons per day.

**TABLE 14**
**Emission Reductions in Tons per Day – Test-Only vs. Test-and-Repair**

| Scenario | Emission Reductions – Tons per Day | | | |
|---|---|---|---|---|
| | HC Evaporative | HC Exhaust | $NO_x$ | Total HC+$NO_x$ |
| **Current Program** | **25** | **74** | **24** | **123** |
| **100% Test-and-Repair** | **25** | **53** | **19** | **97** |
| **100% Test-Only** | **25** | **125** | **53** | **203** |

**TABLE 11**
**Predicted FTP Emission Rates by Model-Year for Vehicles Tested on Roadside before a BAR97 ASM Smog Check Inspection**

| Model-year[a] | Number of vehicles | HC (g/mi) | CO (g/mi) | $NO_x$ (g/mi) |
|---|---|---|---|---|
| *1966* | *24* | *8.62* | *97.6* | *1.86* |
| *1967* | *20* | *10.77* | *109.0* | *2.34* |
| *1968* | *29* | *7.81* | *77.1* | *2.20* |
| *1969* | *17* | *9.62* | *96.9* | *3.16* |
| *1970* | *30* | *6.83* | *78.2* | *2.65* |
| *1971* | *22* | *6.08* | *77.9* | *2.66* |
| *1972* | *32* | *9.25* | *77.1* | *2.59* |
| *1973* | *62* | *8.18* | *79.1* | *2.43* |
| 1974 | 42 | 9.05 | 73.4 | 3.16 |
| 1975 | 28 | 5.08 | 73.6 | 2.61 |
| 1976 | 40 | 8.00 | 56.4 | 2.82 |
| 1977 | 89 | 6.74 | 55.9 | 2.65 |
| 1978 | 104 | 6.28 | 49.2 | 2.79 |
| 1979 | 122 | 4.59 | 47.6 | 2.57 |
| 1980 | 110 | 3.56 | 55.6 | 2.06 |
| 1981 | 121 | 3.93 | 53.5 | 2.07 |
| 1982 | 144 | 3.20 | 45.6 | 1.91 |
| 1983 | 208 | 2.98 | 37.5 | 2.27 |
| 1984 | 319 | 2.92 | 38.7 | 1.93 |
| 1985 | 460 | 2.38 | 27.8 | 1.80 |
| 1986 | 515 | 1.66 | 20.8 | 1.64 |
| 1987 | 456 | 1.48 | 19.1 | 1.52 |
| 1988 | 417 | 1.30 | 14.4 | 1.41 |
| 1989 | 518 | 0.90 | 10.5 | 1.13 |
| 1990 | 444 | 0.78 | 8.6 | 0.95 |
| 1991 | 448 | 0.62 | 7.3 | 0.84 |
| 1992 | 132 | 0.66 | 7.8 | 0.82 |
| 1993 | 139 | 0.42 | 5.2 | 0.57 |
| 1994 | 157 | 0.36 | 4.8 | 0.55 |
| 1995 | 237 | 0.33 | 4.3 | 0.49 |
| *1996* | *232* | *0.22* | *3.0* | *0.34* |
| *1997* | *61* | *0.20* | *2.3* | *0.30* |
| *1998* | *64* | *0.17* | *2.0* | *0.24* |
| *1999* | *11* | *0.12* | *1.6* | *0.17* |
| Weighted Average[b] : | 5,854 | 1.14 | 13.2 | 0.91 |

[a] The predicted FTP emissions are for the roadside sample tested after November 11, 1998.
[b] Weighted by May 1999 model-year travel fraction table.

## TABLE 12
## Predicted FTP Emission Rates by Model-Year for Vehicles Tested on Roadside After a *Test and Repair* BAR97 ASM Smog Check Inspection

| Model-Year[a] | Number of vehicles | HC (g/mi) | CO (g/mi) | $NO_x$ (g/mi) |
|---|---|---|---|---|
| *1966* | *24* | *8.62* | *97.6* | *1.86* |
| *1967* | *20* | *10.77* | *109.0* | *2.34* |
| *1968* | *29* | *7.81* | *77.1* | *2.20* |
| *1969* | *17* | *9.62* | *96.9* | *3.16* |
| *1970* | *30* | *6.83* | *78.2* | *2.65* |
| *1971* | *22* | *6.08* | *77.9* | *2.66* |
| *1972* | *32* | *9.25* | *77.1* | *2.59* |
| *1973* | *62* | *8.18* | *79.1* | *2.43* |
| 1974 | 13 | 7.02 | 52.9 | 3.09 |
| 1975 | 14 | 5.13 | 49.3 | 2.89 |
| 1976 | 15 | 4.51 | 67.3 | 2.71 |
| 1977 | 38 | 6.26 | 58.5 | 2.51 |
| 1978 | 36 | 4.41 | 50.7 | 2.83 |
| 1979 | 51 | 4.69 | 49.7 | 2.24 |
| 1980 | 46 | 4.53 | 55.5 | 2.06 |
| 1981 | 41 | 2.57 | 37.1 | 2.07 |
| 1982 | 58 | 4.38 | 42.2 | 1.86 |
| 1983 | 84 | 2.07 | 27.2 | 2.00 |
| 1984 | 136 | 2.20 | 30.0 | 1.83 |
| 1985 | 220 | 2.01 | 26.8 | 1.82 |
| 1986 | 286 | 1.39 | 17.6 | 1.59 |
| 1987 | 297 | 1.53 | 17.8 | 1.51 |
| 1988 | 290 | 1.07 | 12.6 | 1.25 |
| 1989 | 324 | 0.94 | 10.0 | 1.13 |
| 1990 | 299 | 0.73 | 8.6 | 0.97 |
| 1991 | 300 | 0.55 | 6.3 | 0.76 |
| 1992 | 63 | 0.54 | 6.7 | 0.76 |
| 1993 | 59 | 0.38 | 4.8 | 0.51 |
| 1994 | 98 | 0.34 | 4.4 | 0.49 |
| 1995 | 47 | 0.28 | 3.4 | 0.43 |
| *1996* | *232* | *0.22* | *3.0* | *0.34* |
| *1997* | *61* | *0.20* | *2.3* | *0.30* |
| *1998* | *64* | *0.17* | *2.0* | *0.24* |
| *1999* | *11* | *0.12* | *1.6* | *0.17* |
| Weighted Average[b] : | 3,419 | 1.03 | 12.0 | 0.87 |

[a] 1966 through 1973 vehicles are not subject to the Smog Check Program and the first four model-years (1996 through 1999 vehicles) were not subject to biennial Smog Check inspection requirements. Therefore, the predicted FTP emissions from the roadside sample after November 11, 1998 were used for these model-years.

[b] Weighted by May 1999 model-year travel fraction table.

## TABLE 13
## Predicted FTP Emission Rates by Model-Year for Vehicles Tested on Roadside After a *Test Only* BAR97 ASM Smog Check Inspection

| Model-Year[a] | Number of vehicles | HC (g/mi) | CO (g/mi) | $NO_x$ (g/mi) |
|---|---|---|---|---|
| *1966* | *24* | *8.62* | *97.6* | *1.86* |
| *1967* | *20* | *10.77* | *109.0* | *2.34* |
| *1968* | *29* | *7.81* | *77.1* | *2.20* |
| *1969* | *17* | *9.62* | *96.9* | *3.16* |
| *1970* | *30* | *6.83* | *78.2* | *2.65* |
| *1971* | *22* | *6.08* | *77.9* | *2.66* |
| *1972* | *32* | *9.25* | *77.1* | *2.59* |
| *1973* | *62* | *8.18* | *79.1* | *2.43* |
| 1974 | 1 | 4.25 | 49.3 | 4.29 |
| 1975 | 1 | 5.61 | 86.8 | 1.29 |
| 1976 | 3 | 4.48 | 95.5 | 1.59 |
| 1977 | 14 | 2.64 | 33.1 | 2.81 |
| 1978 | 12 | 2.32 | 30.3 | 1.88 |
| 1979 | 17 | 4.16 | 37.1 | 2.45 |
| 1980 | 14 | 2.73 | 43.7 | 1.29 |
| 1981 | 24 | 2.73 | 44.1 | 2.29 |
| 1982 | 40 | 2.25 | 28.3 | 1.85 |
| 1983 | 47 | 1.97 | 27.6 | 1.88 |
| 1984 | 80 | 1.61 | 19.5 | 1.86 |
| 1985 | 85 | 1.65 | 21.2 | 1.43 |
| 1986 | 80 | 1.28 | 15.0 | 1.57 |
| 1987 | 66 | 1.14 | 14.8 | 1.21 |
| 1988 | 53 | 0.99 | 11.2 | 0.98 |
| 1989 | 40 | 0.80 | 8.5 | 1.10 |
| 1990 | 22 | 0.59 | 6.7 | 0.87 |
| 1991 | 26 | 0.47 | 5.1 | 0.70 |
| 1992 | 6 | 0.72 | 7.4 | 0.87 |
| 1993 | 4 | 0.36 | 4.0 | 0.58 |
| 1994 | 6 | 0.41 | 5.0 | 0.33 |
| 1995 | 4 | 0.20 | 2.4 | 0.23 |
| *1996* | *232* | *0.22* | *3.0* | *0.34* |
| *1997* | *61* | *0.20* | *2.3* | *0.30* |
| *1998* | *64* | *0.17* | *2.0* | *0.24* |
| *1999* | *11* | *0.12* | *1.6* | *0.17* |
| Weighted Average[b] : | 1,249 | 0.88 | 10.5 | 0.80 |

[a] 1966 through 1973 vehicles are not subject to the Smog Check Program and the first four model-years (1996 through 1999 vehicles) were not subject to biennial Smog Check inspection requirements. Therefore, the predicted FTP emissions from the roadside sample after November 11, 1998 were used for these model-years.

[b] Weighted by May 1999 model-year travel fraction table.

# APPENDIX A

# DATA ANALYSIS METHODOLOGY

This appendix describes the matched dataset and how it was analyzed.

## Description of Matched Dataset

The "matched dataset" was created by BAR and then transmitted to dKC and ERG for analysis. BAR matched 27,080 roadside emissions test records (collected from February 10, 1997 to October 29, 1999) with official Smog Check station inspections. Station inspection results are collected and stored in BAR's Vehicle Information Database (VID).

BAR found official Smog Check test records or "VID records" that matched license plates or vehicle identification numbers (VINs) for 22,643 of the 27,080 vehicles that receive roadside emission tests. For most vehicles there was only one VID record since the majority of vehicles pass the first time tested; other vehicles had multiple VID records. Some vehicles received both a pre-inspection test as well as an official test that displayed a passing result. Other vehicles failed initial tests and received one or more "retests" before finally passing.

Next, BAR identified the VID record closest to the roadside event based on the test dates regardless of the test result (pass or fail). For example, a particular vehicle failed an initial Smog Check test on September 21$^{st}$ and was retested on September 28$^{th}$ and 29$^{th}$ , before finally passing the station Smog Check test on September 30$^{th}$. Based on its roadside test date of October 27, 1999, the station test on September 30$^{th}$ was considered the official Smog Check test closest to the roadside event.

BAR then sorted the data into the following two groups. Data within these two groups were further sorted by the type of station (test-only or test-and-repair) that performed the official Smog Check test. A final subgroup was formed based on the station Smog Check test result. The vehicle either passed or failed the station Smog Check closest to the roadside test.

- BEFORE SMOG CHECK: Roadside emission test results for vehicles that had a roadside test *before* an official BAR-97 ASM Smog Check inspection performed at a licensed Smog Check station.

- AFTER SMOG CHECK: Roadside emission test results for vehicles that had a roadside test *after* an official BAR-97 ASM Smog Check inspection performed at a licensed Smog Check station. The vehicle described above was included in this group since its roadside test on October 27, 1999, was performed *after* its station inspection on September 30$^{th}$.

For the purpose of this evaluation, only data meeting the following criteria were analyzed:

1. Vehicles with model years 1974 to 1991. There were only a few 1992 and newer vehicles in the matched data set, particularly those that failed their Smog Check inspection.

2. Vehicles with less than one year (365 days) between the roadside test date and the station Smog Check test date. Whenever the sample size was sufficient, the analysis was duplicated for the subset of vehicles with less than six months (180 days) between the roadside test date and the station Smog Check test date.

3. Vehicles receiving BAR-97 ASM tests at Smog Check stations. This report focuses on matched test results for vehicles that received BAR97 ASM tests.

As a result of these edits, the final matched data set included 5,056 BEFORE SMOG CHECK records and 3,497 AFTER SMOG CHECK records.

Table A-1 summarizes the sample sizes for the different groups and subgroups of the matched dataset used in this analysis.

**TABLE A-1**
**Breakdown of Sample Sizes**

| Test Type | Station Type | Roadside Test Sequence | Smog Test Disposition | Model Year | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1974-1979 | 1980-1986 | 1987-1991 | All |
| BAR97 ASM | Test Only | Before Smog | All | 108 | 869 | 302 | 1,279 |
| | | | Failed | 36 | 289 | 46 | 371 |
| | | | Passed Initial | 72 | 580 | 256 | 908 |
| | | After Smog | All* | 52 | 398 | 222 | 672 |
| | | | Failed/Passed | 4 | 65 | 24 | 93 |
| | | | Passed Initial | 42 | 305 | 191 | 538 |
| | Test and Repair | Before Smog | All | 340 | 1,649 | 1,788 | 3,777 |
| | | | Failed | 54 | 296 | 168 | 518 |
| | | | Passed Initial | 286 | 1,353 | 1,620 | 3,259 |
| | | After Smog | All* | 195 | 994 | 1,636 | 2,825 |
| | | | Failed/Passed | 22 | 99 | 85 | 206 |
| | | | Passed Initial | 169 | 867 | 1,525 | 2,561 |

*All includes vehicles that never had a passing result before their roadside tests.