Eastern Research Group, Inc.

Evaluation of the Texas Inspection and Maintenance Programs in the Dallas/Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas

FINAL REPORT

Prepared for:

Texas Commission on Environmental Quality

Prepared by:

Eastern Research Group, Inc.

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Prepared for:

Texas Commission on Environmental Quality
P. O. Box 13087
Austin, TX 78711-3087

Prepared by:

Timothy H. DeFries
Thomas J. Petroski
Meredith F. Weatherby
Boonsiri Limsakul
Michael A. Sabisch
Scott W. Fincher
Cynthia F. Palacios
Sandeep Kishan
Eastern Research Group, Inc.
5608 Parkcrest Drive, Suite 100
Austin, Texas 78731

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Executive Summary

This report documents the evaluation of the Texas I/M program for the 2004 and 2005 biennial period. Eastern Research Group performed this evaluation for the Texas Commission on Environmental Quality. We performed the evaluation using the vehicle information database (VID) data from May 1, 2003 through December 31, 2005 and remote sensing device (RSD) data from April 2004 through December 2005.

The evaluation generally follows the U.S. EPA draft guidance on using in-program data for the evaluation of I/M program performance [Reference 1][1] and U.S. EPA guidance on the use of remote sensing for the evaluation of I/M program performance [Reference 2]. The evaluation used analyses of VID data and RSD data to evaluate the four basic I/M processes:

- Coverage,
- Inspection,
- Repair, and
- Enforcement.

These four I/M program processes must be working reasonably well for any I/M program to be effective. However, the proper operation of I/M program processes does not guarantee an effective I/M program. Accordingly, it is necessary to measure the results of an I/M program. Therefore, in addition, the evaluation uses the VID data and the RSD data measure the results of the I/M program via:

- the Annual I/M Benefit, and
- the Total I/M Benefit.

The overall findings of this evaluation for the above six qualities are presented below in the body of this executive summary. Overall, the results for the Texas I/M program look good. Nevertheless, in the course of performing this evaluation, we found several areas where improvements could be made both for improving the I/M program and for making the next biennial evaluation easier to perform and more reflective of program performance. Sixteen specific recommendations are presented in the last section of this executive summary.

[1] Citations for references are given in Section 9.

Comparison of the Evaluation with Other I/M Programs – Since this is the first evaluation of its type for the Texas I/M program, the results presented here cannot be compared with earlier evaluations. This evaluation does serve as the baseline for future biennial evaluations of the Texas I/M program. Where appropriate and possible we have provided some comparisons with other I/M programs. But in general, we have not been able to compare the results of this Texas evaluation with similar evaluations of other jurisdictions. The guidance from EPA on I/M program evaluation is more along the lines of suggested approaches rather than required specific calculational methods. Also, since the guidelines are relatively new, different jurisdictions with different types of I/M programs will have different evaluation approaches – even within the same guidance. In spite of these limitations for comparisons with other I/M programs, we believe that the results of this evaluation can be used to judge the quality of the Texas I/M program and to identify the improvements that should be considered.

Coverage

The results of two analyses of coverage using out-of-program data revealed a consistent, high rate of participation in the I/M program:

Parking Lot Survey[2] – The parking lot survey found that in the DFW and HGB areas greater than 95% of the I/M-program-eligible vehicles had current safety/emissions stickers and that greater than 92% of the vehicles had current safety/emissions stickers and had received the proper type of inspection – either OBDII, ASM, or TSI.

Participation Rates[3] – In the second analysis for coverage, we estimated program participation by determining the fraction of vehicles seen on the road during RSD that had recent records in the VID. This analysis found that in the DFW and HGB areas greater than 96% of I/M-program-eligible vehicles had been to I/M inspections within no greater than 15 months of the date that they were observed on the road during RSD.

[2] See Section 3.1 for details.
[3] See Section 3.2 for details.

Inspection

Appropriateness of Major VID Fields[4] – The vehicle information database (VID) is used to document the I/M program inspection process. The analysis in this activity checked the major fields in the VID using a series of basic data checks to demonstrate the accuracy and completeness of the data in the VID. We produced frequency distributions of almost all database variables to examine field values for in-range values, out-of-range values, and missing values. The following summarizes the major findings of this analysis:

- Frequency distributions of ASM, HC, CO, and NO and TSI HC and CO were the typical positively skewed distributions typically seen in a fleet of modern vehicles. Very few out-of-range emission values were found.

- Stoichiometric combustion of gasoline should produce an exhaust CO_2 concentration of approximately 15.6%. Fuel concentrations less than this value can occur because of dilution of exhaust gas by air leakage, engine misfires, and air pumps. However, fuel concentrations greater than 15.6% should not occur except because of the measurement error of the CO_2 channel of the analyzers. If the analyzers are operating correctly, this measurement error should be approximately ±0.36% CO_2. Thus, we would not expect to see any CO_2 measurements with concentrations greater than about 16.0%. Our analysis of the VID data indicated that 0.9% of the ASM CO_2 measurements and 0.5% of the TSI CO_2 measurements had concentrations greater than 16%. This suggests that a large number of inspection results (about 85,000) were made with CO_2 measurements that had large measurement errors. These may have been produced by analyzers with CO_2 channels that were out of calibration. While CO_2 is not a regulated pollutant, its value affects the reported values for HC, CO, and NO because CO_2 is used to calculate the dilution correction factor that is applied to the raw HC, CO, and NO measurements to determine whether a vehicle passes or fails the cutpoint value.

- Our analysis of the validity of vehicle identification numbers (VIN) in the VID indicated that 2% of the VINs had either illegal check digits or a check digit that did not agree with the check digit calculation. These results indicate that these VINs were not correct. Further analysis revealed that the inspection history of individual vehicles (as determined by the same plate for different VID entries) contained VINs that were sometimes correct and sometimes slightly incorrect as shown by the check digit calculation. We suspect that VIN errors are caused by transcription errors by I/M inspectors. Errors in VINs, even when it occurs in only 2% of the VINs in the VID, makes determining the inspection history of a given vehicle difficult to put together. Errors in VINs also make matching RSD measurements with VID records unreliable. Transcription errors in VINs and plates were the single biggest obstacle in this Texas I/M program evaluation study.

[4] See Section 4.1 for details.

However, VIN and plate transcription errors are common in I/M programs across the United States. Nevertheless, we recommend that Texas develop a system to ensure proper transcriptions of VINs and license plates.

- Seven abnormalities were found for VID variables. These are currently being investigated by TCEQ.

Inspection Statistics[5] – Analysis of the VID data indicated that during the evaluation period over 15 million ASM, TSI, and OBDII tests were performed on almost 8 million vehicles. Approximately 67% of the tests were OBDII tests, about 30% were ASM emissions tests, and about 3% were TSI tests. The DFW and HGB areas had comparable test fail rates. About 4.5% of the OBDII tests were fails, about 11% of the ASM tests were fails, and about 6% of the TSI tests were fails. OBDII tests are performed on 1996 and newer model year vehicles. ASM tests are performed on 1995 model year and older vehicles, and TSI tests are performed on 1995 and older model year vehicles where ASM tests cannot be performed such as on all-wheel-drive vehicles.

Repeat I/M Failure Patterns[6] – We examined the VID data to determine the relative frequencies of the I/M pass/fail patterns during each vehicle's inspection cycle.

- Approximately 99.3% of the test sequences were found to be made up of a verified initial test, or an initial test that could reasonably be assumed to be a true initial test, and a final test that was certified. Of these test sequences, approximately 94% were initial passes, approximately 5% were initial fails followed by a final certified pass, and approximately 0.27% were two initial fails followed by a final certified pass. The remaining 0.73% of the sequences that received final certifications had longer sequences.

- We could not verify that the final test of the remaining approximately 0.7% of the sequences was certified. We believe that some of these tests probably were not certified. However, some of these sequences could have had final certified tests that were performed after December 31, 2005, the end of the evaluation period. Also, isolated inspection records that could not be properly grouped with the other inspection records for the same vehicle (because of VIN and/or plate transcription errors) were likely present in this small sequence category. We believe this incompleted I/M sequence rate of 0.7% is a quite good result. It indicates that almost all vehicles that begin I/M participation complete their cycle. We have seen higher incompletion rates in other jurisdictions.

Emissions Analyzer Data Quality[7] – The VID data was analyzed to determine the quality of the emissions measurements made by the emissions analyzers. Specific analyses were

[5] See Section 4.2 for details.
[6] See Section 4.3 for details.

made using instrument calibrations to check for drift, individual inspection results to check for the stoichiometrically correct measured concentrations of CO, CO_2, and O_2, gas audit results for analyzer accuracy, and comparison of instrument calibrations with inspection results to check for proper lock-out of emissions equipment. The following provides a summary of the results:

- The drift of the emissions analyzers was measured by comparing the pre-calibration measurements of calibration gas with the post-calibration values. With the exception of the zero gas for hydrocarbon, the analysis showed that more than 90% of the pre-calibrations fell within the tolerance of the analyzer after the analyzer had been given an opportunity to drift for the 72 hours between calibrations. This tells us that results for more than 90% of the I/M inspections performed just before the calibration can be expected to be within the instrument tolerance except for very low values of hydrocarbon.

- The ES analyzers failed to calibrate the O_2 channel 97% of the time by recording oxygen values of less than 3% O_2 on air.

- A small percentage of the calibration gas bottle values that were entered in the VID were out of range of the spec values for bottled gas. We recommend that the software be modified to reject any calibration gas bottle values that are out of range of the bottle gas value specification.

- Dilution correction factors based on CO/CO_2 compared with dilution correction factors based on O_2 for all inspections in the evaluation period indicated that 88% of the two-speed idles and 90% of the ASMs produced measured CO, CO_2, and O_2 values that were consistent with the expected stoichiometric relationship for gasoline combustion. The remaining 10 to 12% of the dilution correction factor comparisons did not agree. These were primarily a consequence of exhaust gas O_2 concentration values recorded near 20.7% O_2 for the tailpipe exhaust which is inconsistent with the expected exhaust gas O_2 concentration from gasoline combustion. These inconsistent results were obtained primarily for analyzer manufacturer codes JB and SE.

- The Texas SIP requires that each analyzer be audited at least twice per year. The VID data indicates that 98% of the analyzers in the state were audited at least twice per year and many of them were audited many more times than that. The results of the audits indicated that the vast majority of the audit readings fell within the audit tolerance. Analyzers from one manufacturer were erroneously recording audit results as missing instead of failed. This problem was found to be in the analyzer software and was corrected early in 2004. The analysis indicated that since that time the audit results from this manufacturer were handled properly. Finally, 93% of instruments that failed gas audits had been repaired and were back online within one week of initially failing the audit.

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[7] See Section 4.4 for details.

- Calibration records, analyzer gas audit records, and vehicle inspection records were used to determine whether analyzer and dynamometer calibrations were taking place as required and whether uncalibrated analyzers and dynamometers were locked out until passing a calibration. Comparison of ASM and TSI test records with analyzer gas calibration, leak check, and dynamometer coast-down check records seems to indicate that for the majority of analyzers, 72-hour lockouts are independently enforced for each of these three calibrations/checks (i.e., the analyzer/dynamometer system must pass all three tests every 72 hours or it will be locked out). However, between 0.2% and 1.3 % of all ASM and TSI tests appear to have been performed on analyzer/dynamometer systems that had not successfully passed all three calibrations / checks within the last 72 hours. Additional analysis suggests that this could be occurring for several reasons:

For some analyzers, ***passing any one of these three tests*** (leak check, gas calibration, or dynamometer coast-down check) may reset the 72-hour clock for all three of these tests on some analyzers, allowing them to continue testing when they should be locked out.

For a smaller subset of analyzers, merely receiving one of the tests (but not passing any) may be sufficient to "reset the clock" for all three requirements. This was seen in approximately 0.12% of total ASM and TSI vehicle inspections over the period of evaluation.

A smaller subset of analyzers appears to not enforce 72-hour lockouts for gas calibrations, dynamometer coast-down checks, or leak tests. This was seen in approximately 0.02% of total ASM and TSI vehicle inspections over the period of evaluation.

VID Emissions Checks for Evidence of Station Fraud[8] – The vendor that operates the VID for TCEQ provides quarterly reports of 26 triggers, which are station and inspector statistics using data collected in the VID, that are thought to be indicators of fraudulent activity. For this analysis, we examined the 11 quarterly trigger reports for the evaluation period. We found that almost all of the stations and almost half of the inspectors in the Texas I/M program received at least one trigger in each quarterly report during the evaluation period. We saw no noticeable trend in the fraction of stations and inspectors that received triggers during the evaluation period that would indicate an improving or worsening trend in the level of trigger statistics. Because the methods to calculate triggers are kept secret by the VID vendor, it is not possible to evaluate or critique their correlation with any other measures of fraudulent activity. Accordingly, we must question whether the calculation of triggers and the production of trigger lists serve any useful purpose. This is especially the case given the large fractions of stations and inspectors that receive triggers routinely. It seems that the triggers are not distinguishing acceptable from

[8] See Section 4.5 for details.

unacceptable inspection performance. The DPS does not use any trigger information to direct their efforts of overt and covert auditing of stations.

OBDII Inspection Analyzer Communication Performance[9] – Overall OBDII communication rates between vehicle's computers and program analyzers appeared reasonably high (greater than 98% for all vehicle model years, including vehicles with damaged, missing, or inaccessible diagnostic link connectors).

VID Handling of OBDII Codes[10] – With a few exceptions, OBDII inspection logic used in Texas for light-duty gasoline-powered vehicles appeared generally sound and in agreement with EPA policies. The exceptions include:

- Analysis of "readiness" status indicates two unset monitors are permitted for all model year vehicles (reduction to only one unset monitor allowed for 2001 and newer model year vehicles is not enforced). We recommend TCEQ continue with its current plan of revising the analyzer functionality in order to allow only one unset readiness monitor for 2001 and newer model year vehicles, according to EPA OBDII program guidance requirements.

- A number of vehicles with three or more unset readiness monitors still received a readiness result of "pass" (5,704 model year 1996-2000 vehicle tests and 1,403 model year 2001 and newer vehicle tests). We recommend the analyzer software be updated to enforce readiness limits for all vehicles.

Evidence for OBDII Test Fraud[11] **–** Data analysis suggests OBDII test fraud (by way of clean scanning) occurs between 1% and 9% of all OBDII tests (including initial tests). Extracting the initial tests from the dataset increases this range to 7% up to 27%. TCEQ is using criteria similar to that used in this analysis to identify and prevent OBDII test fraud. We recommend that TCEQ begin looking at software methods that would be able to automatically notify inspectors and stations during an OBD inspection (or shortly thereafter) when an OBD result looks suspicious. We believe that such a flagging approach with immediate feedback will be beneficial and cost-effective in the long term.

[9] See Section 4.6 for details.
[10] See Section 4.7 for details.
[11] See Section 4.8 for details.

Repair

Number and Types of Repairs[12] – Analysis of the VID data indicates that over 550,000 I/M program induced repairs were made to vehicles during the evaluation period. The I/M program requires reporting the types of repairs in five categories: fuel system, ignition electrical system, emissions system, engine mechanical, and miscellaneous. The fractions of total repairs in these five categories were 17%, 14%, 43%, 2%, and 25%, respectively. The Department of Public Safety collects separate repair information from stations that volunteer to be designated Recognized Emission Repair Facilities. The repairs reported from RERF stations have much more detailed descriptions than the five categories used in the VID. However, because the RERF program is voluntary only about 38,000 repairs were reported to DPS. A third source of repair information is the LIRAP program. Texas created the LIRAP program to financially assist low income individuals with repairing or retiring vehicles that fail emissions testing. During the evaluation period, 9,649 of the repairs made at RERFs were performed under the LIRAP program.

Emissions Changes Associated with Repairs[13] – We analyzed the Texas VID data obtained during the evaluation period to determine the change in emissions of repaired vehicles before repair and after repair. The apparent emissions concentration changes at this one point in time for each vehicle for ASM HC, CO, and NO were approximately decreases of 66%, 80%, and 64%, respectively, on 448,440 repaired vehicles. Because the final passing ASM test for almost all of these vehicles would have been fast-pass ASM tests, the after-repair emissions concentrations are biased high. Therefore, the true decrease in emissions concentrations would actually have been larger then these values. However, because repair and emissions degradation sets in immediately after certification and continues throughout the year until the next-cycle ASM inspection, the net emissions benefit of the repair over the one year annual cycle will be much smaller than these percent reductions imply. The size of the overall Annual I/M Benefit is better measured by remote sensing data, which is independent of the I/M program.

We compared the average emissions before and after repairs with the same quantities obtained in the British Columbia I/M program between 1995 and 1999. At that time, the British Columbia I/M program used the ASM2525 test as their primary tailpipe emissions test. The emissions reductions of the Texas I/M program were very close to the emissions reductions of the British Columbia I/M program for ASM HC and CO and the Texas I/M program percent reductions for NO were twice as large as those for the British Columbia program. We also

[12] See Section 5.1 for details.
[13] See Section 5.2 for details.

compared the effect of repairs on tailpipe emissions at the I/M inspections as a function of calendar year and vehicle model year group. The same relative trends between the Texas and British Columbia I/M program emissions reductions were seen.

Finally, we compared the effects of repairs on average emissions for different categories of repairs. The British Columbia repair data is notable because of its completeness and generally high quality, which are the qualities that led us to choose the British Columbia emissions and repair data to compare with the Texas data. Because of past poor performance of Texas inspectors at recording specific repairs made to vehicles, Texas chose to use five broad categories in the VID to record repairs performed on vehicles. This makes the evaluation of emissions reductions with respect to repairs and comparison with the British Columbia data problematic. We recommend that Texas consider developing an improved system that contains more detail to document the repairs that are performed on vehicles. One system to consider is providing inspectors with a list of the most emissions-influential repairs for the technology of the vehicle that the inspector is working on. This approach would make the choices easier for the inspector while acquiring the most important data for the VID. The most emissions-influential repairs for different technologies can simply be taken from our 2004 analysis of the British Columbia repair and emissions data [Reference 3].

OBDII Repair Effectiveness[14] – Analysis indicates approximately 83% of OBDII tests that initially receive a fail (for illuminated MIL with stored DTCs) eventually receive a certificate. However, when evaluating repairs by failure category (evaporative emissions control system, O_2 Sensor, EGR System, air injection system and catalytic converter), unset readiness monitors were seen to potentially "hide" malfunctions in 4% to 35% of "repaired" vehicles. We recommend TCEQ investigate implementing an analyzer software change that would require certain monitors to have a "set" readiness status on an OBDII retest, based on the initial failure category. For example, the evaporative system monitor would need to be set to "ready" for a successful retest of an initial evaporative emission control system failure (DTC(s) within the range of P0440 - P0455). Enforcing monitor-specific readiness on certain retests would help confirm effective repairs had been made for these specific system failures.

Average Repair Costs[15] – The Texas VID contains information on repair costs that were induced by the I/M program. Our analysis of these repair costs data indicate that Texas motorists spent at least $60 million during this evaluation period to repair their vehicles so that they would be in compliance with the I/M program. Repair costs are hand entered into the VID by

[14] See Sections 5.3 and 5.4 for details.
[15] See Section 5.5 for details.

inspectors. Accordingly, these values can have errors. Approximately 1/3 of the repair costs in the Texas VID were recorded as zero and if we edited the repair costs by removing costs reported as zero and costs reported that were greater than $2,000 per repair, the mean and median repair costs were $171 and $125. The mean and median repair costs on the unedited data were $142 and $70. Additional analysis showed that mean repair costs for 1981 through 1999 model year vehicles were between $140 and $180. Repair costs for newer model year vehicles were lower than these mean values. The mean repair costs for the same model year ranges seen in the Arizona I/M program were also in this same cost range. The mean and median repair costs for repairs performed by the Recognized Emission Repair Facilities were $499 and $516. In addition, the average repair costs were constant from 1981 to 1999 model years just as the repair costs for all repair stations were. We do not believe the difference in repair costs between all repair stations and the RERF stations are inconsistent. We expect that the repair costs for RERF stations will be higher than average repair stations since these stations voluntarily participate in the RERF program and, therefore, are more likely to make repairs that are more technically challenging and, therefore, more expensive.

Enforcement

Registration Denial Analysis[16] – Historical registration information was not available in the registration database excerpt provided for this analysis. Consequently, we were unable to effectively quantify the extent of registration denial or fully measure the rate of compliance of the regulated fleet for the registration denial rule. We recommend TCEQ and TxDOT investigate modifying the registration database to allow collection of cumulative information (i.e., each transaction in the registration database would create a new record). Registration records beyond a number of years, for example three years, could be eliminated or archived. Collection of historical registration information would allow a more thorough evaluation of the effectiveness of the registration denial program.

Overt and Covert I/M Station and Equipment Audits[17] – Texas operates on-going overt and covert auditing programs to maintain surveillance over its decentralized program. In the region of evaluation, approximately 2,930 stations were in operation in 2004, and 3,210 decentralized stations were in operation in 2005. Records from legal enforcement activities conducted by Texas DPS Troopers were not available for this evaluation.

Overt auditors are responsible for managing 60 to 80 decentralized stations, and are required to perform one overt audit per station per month. The overall average ratio of overt audits to stations was 10.8 overt audits per station in 2004 and 11.2 overt audits per station in 2005. Analysis of audit records indicated approximately 60 overt auditors conducted audits for some period of time during 2004, and 67 overt auditors conducted audits for some period of time in 2005. Although the percentage of time each of these employees spent conducting overt audits during each year was not evaluated, the program reportedly employed approximately 47 overt auditors in the region of evaluation as of August 2006.

Covert audits are conducted to identify stations that may be engaged in non-compliant or fraudulent activity, and each covert auditor is responsible for performing one covert audit per each analyzer at a station per year. The overall average ratio of covert audits to stations was 1.2 covert audits per station in 2004 and 0.95 covert audits per station in 2005. Analysis of audit records indicated approximately 15 covert auditors conducted audits for some period of time during 2004, and 16 covert auditors conducted audits for some period of time in 2005. Although the percentage of time each of these employees spent conducting covert audits during each year

[16] See Section 6.1 for details.
[17] See Section 6.2 for details.

was not evaluated, the program reportedly employed approximately 10 covert auditors in the region of evaluation as of August 2006.

Twenty-six covert audit vehicles were in use in 2004, and twenty-seven were in use in 2005 (most vehicles were used both years). Fourteen of the covert vehicles in use were pre-1996 (pre-OBDII), and 17 were 1996 or newer. Tampers are generally induced on covert vehicles, and pre-audit and post-audit emission measurements are conducted on covert vehicles to evaluate the accuracy of emission results measured at emissions inspection stations.

In addition to legal enforcement imposed by DPS Troopers, lockouts and violation notices resulting in various penalties may be issued against non-compliant stations. Lockouts imposed may be cleared remotely through the VID application, but some lockouts that have been issued do require a DPS re-visit.

Annual I/M Benefit

The Annual I/M Benefit of an I/M program can be measured by the decrease in emissions for the I/M fleet at the time of vehicle repairs. The Annual I/M Benefit was measured separately in two ways using VID data and using RSD data.

Annual I/M Benefits as Measured by the VID Data[18] – Using the initial and final emissions concentrations of annual inspection sequences as recorded in VID data, which is in-program data, we calculated the change in emissions concentrations at the time of inspection. About 89% of the I/M sequences were produced by vehicles that simply initially pass. Of course, the emissions reductions from these I/M events were zero. Additionally, about 10% of the I/M sequences were produced by vehicles that initially failed, were repaired, and finally passed. These sequences were associated with emissions reductions at the I/M inspection of 64 to 86%. When all sequences were considered together using the VID data, the apparent changes in emissions concentrations at the inspection event were: ASM HC decreased 18 to 24%, ASM CO decreased 34 to 41%, ASM NO decreased 16 to 19%.

Annual I/M Benefits as Measured by the RSD Data[19] **–** The analysis of RSD data, which is out-of-program data, provides a quite different view of the Annual I/M Benefit of the I/M program. The average RSD emissions from 30 to 90 days before I/M inspections were compared to the average RSD emissions from 1 to 90 days after the I/M inspections. About 94% of the RSDed vehicles had I/M sequences produced by passing their initial inspections. The emissions of these vehicles <u>increased</u> by 4 to 7% from the period before the I/M inspection to the period after the inspection. We attribute this small increase to the general long term emissions deterioration of these relatively low-emitting vehicles. About 5% of the RSDed vehicles had I/M sequences produced by failing their initial inspections, getting repaired, and passing their final inspections. These sequences were associated with RSD emissions reductions from before to after the I/M inspection of 3 to 14%. When all sequences were considered together, the increases in the initially passing vehicles overwhelmed the decreases in the vehicles that failed initially and were repaired. Specifically, the overall apparent changes in RSD emissions concentrations going from before to after I/M inspection were: RSD HC increased 6%, RSD CO increased 2%, RSD NO increased 2%.

Keep in mind that the effect of the I/M program on emissions is not simply the drop in emissions during the inspection/maintenance activities because during the rest of the annual

[18] See Section 7.1 for details.
[19] See Section 7.2 for details.

period emissions increase. Overall, the RSD data indicates that initially passing vehicles (95% of the fleet) go through the I/M program, and their emissions increase each year. Finally, when their emissions have increased over the years to a high enough level, the cutpoint is tripped and repairs are done. During all of those previous years the emissions of the initially passing vehicles have been allowed to increase unchecked. More-stringent cutpoints should help reduce the number of vehicles that are allowed to go through the I/M program unchecked as their emissions characteristics go from excellent to questionable. However, more-stringent cutpoints would also cause an increase in the number of vehicles failed when the vehicles have no problem that can be identified. For the future, OBDII has the potential to catch vehicles with malfunctioning emission control systems before their emissions move from excellent to questionable because OBDII is designed to sense when an emission control system is not operating properly.

Total I/M Benefit[20]

The Total I/M Benefit is the difference in fleet emissions between the I/M fleet under consideration and a hypothetical fleet with the same vehicle characteristics and operating conditions but whose vehicles have never been in any I/M program.

An attempt to measure the Total I/M Benefit was made using RSD data and a modification of the EPA Reference Method. A direct application of the EPA Reference Method could not be made since no RSD measurements had been taken in Texas in any major metropolitan areas that do not have an I/M program. Therefore, we attempted to use the out-of-I/M-area registered vehicles that drive in the I/M area as a surrogate reference fleet. This approach was not successful. We believe that the distances that out-of-area vehicles had to drive to get to the I/M areas "filtered" vehicles so that primarily well-running (and therefore, low-emitting) vehicles from outer regions drove into the I/M program areas. So, the Total I/M Benefit could not be measured for this evaluation period using the RSD data. However, we believe that it could be measured if RSD data were taken in Texas in a non-IM area. We suggest San Antonio. Then, in the next evaluation that non-I/M-area RSD data could be used as reference data to measure the Total I/M Benefit of the HGB and DFW I/m areas.

[20] See Section 8.1 for details.

Recommendations

As a result of performing this biennial evaluation of the Texas I/M program, we have developed a list of recommendations that we think Texas should implement. The purpose of most of these recommendations is to improve the program but some also are intended to improve future biennial I/M program evaluations. For each recommendation, we have provided an importance rating of High **(★★★)**, Medium **(★★)**, or Low **(★)**. We provide these ratings to assist TCEQ in prioritizing efforts to improve the I/M program.

OBD Recommendations

We expect that the future of vehicle testing at I/M inspection stations in Texas is OBD testing, as it replaces TSI and ASM tailpipe emissions testing. Already 70% of the inspections in Texas are OBD with only 30% actual tailpipe emissions testing. Because of this trend, any OBD problems seen in this evaluation need to be addressed immediately – even if they are relatively minor right now.

Recommendation 1 (★★): Enforce readiness limits for all OBD vehicles. EPA guidance recommends 1996 through 2000 model year vehicles be allowed to have up to two unset readiness monitors and still receive an OBDII test, but only one unset readiness monitor be allowed for 2001 and newer vehicles. Analysis of "readiness" status for this program indicates two unset readiness monitors are permitted for all model year 1996 and newer vehicles. Discussion with TCEQ personnel revealed plans are underway to modify analyzer functionality to conform to EPA guidance. We recommend TCEQ continue with its current plan of revising the analyzer functionality to allow only one unset readiness monitor for 2001 and newer vehicles to conform with EPA OBDII program guidance requirements.

Recommendation 2 (★★): Investigate requiring a "set" status for certain monitors to prevent hiding malfunctions. Our analysis found that in 4% to 35% of instances when a vehicle received an initial fail for a certain monitored component, the retest OBD result, which follows a repair, could be hidden by an "unset" readiness status for that monitor. This opens up the possibility that malfunctioning emissions control components could remain unrepaired even though the follow-up OBD test received a "pass." We recommend TCEQ investigate implementing a software change that would require certain monitors to have a "set" readiness status on an OBDII retest that follows certain types of initial failures.

Recommendation 3 (★★): Develop software methods to detect OBD fraud at the time of the inspection. Based on our analysis of OBD data, we estimate that "clean-scanning,"

a type of OBD fraud, may be occurring in between 1% and 9% of OBD inspections. We believe that since we were able to use OBD data in this biennial evaluation to detect potential clean-scanning, and since TCEQ is using these strategies to identify fraud, it should be possible to develop VID software that could notify the inspector and station of a suspicious OBD result as soon as it occurs. This "warning" approach, if applied tactfully, would serve to help reduce test fraud and maintain OBD inspection quality in an automated, timely, and cost-effective manner.

ASM and TSI Recommendations

Even though OBD testing will eventually replace tailpipe emissions testing in Texas, tailpipe testing will probably be used on the 1995 and older vehicles for some time. Therefore, efforts need to continue to provide quality tailpipe tests and accurate VID records of them.

Recommendation 4 (★): Reject calibration bottle concentration values that are outside the specified range. Our analysis of analyzer gas calibration data indicated that about 0.1% of the bottle gas label concentrations were outside of the acceptable tolerances. This is not a large problem; however, not enforcing tolerances on bottle gas label concentrations may leave open a possibility for fraud. We recommend that the software be modified to reject any calibration gas bottle values that are out of range of the bottle gas label concentration specifications. Thus, the software would not allow a calibration to proceed unless reasonable bottle gas values were entered.

Recommendation 5 (★): Fix, replace, and/or "de-classify" triggers. Triggers are statistics calculated by the VID vendor using inspection records in the VID. The calculational method for each trigger is kept secret by the vendor. The purpose of triggers is to identify unusual behavior by individual inspectors or stations that may be associated with fraud. Our analysis indicates that almost all stations and almost half of the inspectors receive at least one trigger each calendar quarter. Perhaps as a consequence, the DPS does not use the trigger reports to target stations for auditing. This high level of triggering indicates to us that triggers do not serve as a useful means of identifying suspicious inspectors and stations. We believe that if triggers are to be useful, they need to be made more discriminating or replaced and need to be declassified so that they can be critiqued.

RSD Recommendations

In the past, initial measurements of tailpipe emissions at the annual I/M inspection could be used to track fleet emissions. But now, tailpipe emissions measurements are being replaced by OBD testing, which does not provide emissions levels. That leaves RSD as the only major source

of data to monitor the emissions of the fleet in the future. Because of this trend, any RSD problems seen in this evaluation need to be addressed immediately – even if they are relatively minor right now.

Recommendation 6 (★★★): Collect RSD data in San Antonio. The Total I/M Benefit is the difference in emissions between the I/M fleet and a hypothetical never-seen-I/M fleet that has the same vehicle and operation characteristics. The Total I/M Benefit could not be measured for this evaluation period because no RSD data exists for a Texas metropolitan area similar to HGB or DFW. Currently, Texas collects RSD data only in I/M areas. If Texas wants to calculate the Total I/M Benefit for future biennial evaluations using the EPA Reference Method, Texas will need to acquire a large amount of RSD measurements in a non-I/M area that is similar to HGB and DFW. We suggest San Antonio.

Recommendation 7 (★★): Perform regular evaluations of RSD measurements. As in most jurisdictions that routinely collect RSD data, Texas archives the data for future use but it does not regularly examine the data. During this biennial evaluation, which made extensive use of the archived RSD data, we identified problems with the data that could have been avoided. For the future we recommend that RSD data be regularly examined (perhaps every six months) using a cursory analysis to ensure that the important aspects of the RSD data are being realized. The following remaining five RSD recommendations reflect the important RSD data needs that we discovered in this biennial evaluation.

Recommendation 8 (★★★): Continue to not round negative RSD measurements to zero. During the early part of this evaluation period, negative RSD concentration measurements were rounded up to zero before archiving. This incorrect practice introduces a positive bias in the emissions concentrations of the cleanest vehicles and thereby ruins the entire dataset. For this evaluation, DPS went back to the pre-archived data and re-acquired the raw RSD concentration values to ensure that negative values were not rounded. For the future, DPS requires that no RSD measurements be rounded to zero. This practice must continue.

Recommendation 9 (★★★): Require a site slope for every RSD measurement. The slope or grade of the road is required for every RSD measurement. The slope is used with vehicle speed and acceleration to calculate the Vehicle Specific Power, which is a measure of engine load, for the RSD measurement. Only RSD measurements taken on vehicles operating within a certain VSP range are acceptable. Therefore, if either the slope, speed, or acceleration is missing, the RSD measurement is useless. It seems that the RSD vendor is diligent about getting the RSD,

license plate, speed, and acceleration, but frequently forgets to include the road grade, which is the easiest to obtain, in the dataset.

Recommendation 10 (★): Encourage RSD measurement vendors to improve license plate character recognition software. The license plate of the vehicles that are RSDed are required to match RSD readings with the registration and then the VID records to perform any sort of analysis. RSD vendors use video cameras to obtain digital images of license plates, which are then post-processed using character recognition software. However, the software has a way to go, and RSD operators frequently use banks of people with video displays to read plate images and manually enter results into a computer file. The current limitation on RSD accuracy and RSD cost may well be with the license plate reading rather than with the measurement of tailpipe emissions concentrations. Texas needs to keep up the pressure on RSD vendors to find or develop better license plate character recognition software.

Recommendation 11 (★★): Increase the fraction of RSD records with known county of registration. Our examination of the RSD data indicated that most of the RSD records had the assigned county of registration at the time of the RSD measurement as "Unknown." This makes the RSD value less useful because without a county of registration in the RSD dataset we cannot determine if the vehicle was registered in an I/M area. We do not know why these records have unknown counties of registration. Perhaps they are caused by erroneous license plate readings (see Recommendation 13) that do not exist. Given that the registration database is not historical (see Recommendation 16), it is not possible to post-process to find the county of registration.

Recommendation 12 (★): Enter the state and the license plate in RSD datasets for out-of-state RSDed vehicles. In the RSD data, out-of-state license plates are commonly designated as OS, but the state or the license number is not recorded. In our analyses using the RSD data, we observed that a large fraction of the vehicles that were RSDed in I/M areas were out-of-state vehicles. This observation raises emissions source and enforcement issues. The state information for out-of-state vehicles would allow the RSD data to be designated as from vehicles from I/M or non-I/M jurisdictions. The state and plate information for out-of-state vehicles would allow vehicles that are permanently driving in the I/M area while registered in another state to be identified.

Vehicle Tracking Recommendations

Whether vehicles are inspected/measured by TSI, ASM, OBD, or RSD, these sources of data on individual vehicles can be used effectively only if vehicles are identified and tracked

accurately in all of the information sources. A major part of the effort in this biennial evaluation was spent trying to properly identify VID and registration data for individual vehicles. Because transcription errors of VINs and plates were common in these databases, in the end we could provide only approximately correct vehicle histories that were needed for the analyses. The following two recommendations are the most important recommendations coming from this biennial evaluation.

Recommendation 13 (★★★): Develop a system to ensure error-free VINs and plates in the VID and in the registration database. Almost 2% of the VINs in the VID had some sort of transcription error. We do not know the percent of plates in the VID that were incorrect, but we saw many of them by looking at VID records for the same VIN. We also saw VIN errors in the registration database. We did not see errors in the plates in the registration database. All of these combined errors make looking up vehicle VID histories and matching RSD measurements (which have their own plate transcription errors) with registration records and VID histories, activities that we had to do repeatedly in this project, quite difficult. We believe that VIN transcription errors need to be totally eliminated from the registration database and from the VID. VIN transcription errors will occur at every point where VINs are entered. Therefore, the most effective time to eliminate the errors is to prevent them from ever occurring by using software at every point of original entry. Prevention should be possible since all 1981+ VINs have a check digit. Once the VINs are error-free, keeping the plates error-free will be possible.

Recommendation 14 (★★★): Develop an historical vehicle registration database. We recommend the registration database be modified to allow collection and querying historical information on individual vehicles. Each registration transaction would create a new record in the registration database. This would create a database that would contain the registration history of each vehicle. An historical registration database for the registration denial effort, determination of I/M participation, and linking RSD records to I/M records and county of registration on the date of the RSD measurement.

Repair Tracking Recommendations

Whether malfunctioning vehicle emission control systems are detected by TSI, ASM, or OBD, Texas needs to record the repairs that are made to vehicles. The repairs, not the inspections, keep vehicle emission control systems operating properly and, in turn, maintain low vehicle emissions.

Recommendation 15 (★★): Use a more detailed, but short, list of repairs for I/M inspectors to choose from. The VID gives inspectors five general repair categories to use to report I/M-induced repairs. These categories are too broad to be useful. We recommend that Texas develop an improved system for reporting I/M-induced vehicle repairs that contains more detail. The system we favor provides inspectors with a list of the 5 to 10 most emissions-influential repairs for the technology of the vehicle that the inspector is working on. These repair types have already been determined by an analysis of British Columbia I/M program repair and ASM emissions data. Information on the myriad of other repairs that might have been performed is not needed because other repairs have minor influences on emissions. This approach makes a convenient, short list of repairs for inspectors while getting the valuable repair information that is most important to the I/M program.

Recommendations for the Next Biennial Evaluation

One final recommendation should be passed on to those who perform the next biennial I/M program evaluation for Texas.

Recommendation 16 (★★★): Include VID data 6 months before and after the evaluation period. For the next two-year evaluation (2006-2007), use VID data records from 6 months before to 6 months after the evaluation period. When the 2-year evaluation period is "snipped out" of the historical VID, the I/M cycles at the beginning and at the end of the period are incomplete. This makes the status of the first and last inspections uncertain. These 6-month periods of additional records would not be evaluated but can be used to more clearly identify which inspections were the vehicle's first and last inspections for each I/M cycle.

1.0 Introduction

EPA requires that states with I/M programs submit an evaluation of their programs every two years to their EPA Regional office. TCEQ conducted the most recent biennial evaluation in 2000. Since that time, EPA has issued new guidance for I/M program evaluations, and the Texas I/M programs have changed. In accordance with both of those changes, TCEQ, working with ERG, has chosen a set of evaluation elements that will comprehensively, yet simply, document the performance of the Texas I/M programs for the most recent two years.

This evaluation of the Dallas/Fort Worth (DFW) and Houston-Galveston-Brazoria (HGB) programs will follow EPA guidance. EPA guidance specifies that I/M programs should provide specific information to demonstrate I/M processes and I/M results. The four general I/M processes are Coverage, Inspection, Repair, and Enforcement. The two important measures of I/M results are the Annual I/M Benefit and the Total I/M Benefit. Analyses of in-program data and out-of-program data will be used to evaluate Texas' I/M program with respect to these six attributes.

This evaluation will not be a research effort, but instead, an effort to benchmark where the Texas I/M programs in Dallas/Fort Worth and Houston-Galveston-Brazoria currently are. The elements of the evaluation are intended to be simple, easily repeated criteria that measure I/M program processes and results. The same criteria can then be calculated for future evaluations so that progress in the I/M program can be tracked over a series of two-year evaluations. Accordingly, the types of evaluations used in this first evaluation will be a template for future evaluations.

1.1 Evaluation Analysis Approach

The Clean Air Act requires that states evaluate their I/M programs every two years. The so-called Sierra Method was used to evaluate the previous version of the Texas I/M program in 2000 [Reference 4]. However, since that time, EPA has issued new guidance on I/M program evaluation [References 1 and 2]. In addition, Texas completed a major change to its I/M program on May 1, 2003. Accordingly, we chose the period from May 1, 2003 through December 31, 2005 as the period for this evaluation.

EPA acknowledges that the guidance documents are somewhat vague in their description of what specifically must be done by states to meet the I/M program evaluation requirements. However, the documents are not vague in defining the areas that need to be covered by the evaluation. They can be summarized by six attributes:

- Process-based measure: Coverage,
- Process-based measure: Inspection,
- Process-based measure: Repair,
- Process-based measure: (Enforcement)
- Results-based measure: Annual I/M Benefit, and
- Results-based measure: Total I/M Benefit

as applied to these types of performance:

- Tailpipe emissions,
- Evaporative emissions, and
- (OBD performance).

The two items in parentheses in the above lists (Enforcement and OBD performance) were not actually discussed in the guidance documents; however, we recognize them, and we believe that EPA would also recognize them, as key elements of an I/M program evaluation. Accordingly, the analyses described in this document are designed to address the areas of investigation in the above lists.

The problem TCEQ faced was to decide what analyses to do to meet the 2-year evaluation requirement. We encouraged TCEQ to make an evaluation of its I/M program by using analyses that provided the most useful information at reasonable cost but without placing much importance on how the (unknown) results of the analyses might make the I/M program appear. Rather than perform only analyses that are expected to make the program look good, we believe it is more beneficial to Texas in the long term for TCEQ to measure those aspects that TCEQ believes are important to a successful I/M program. Then, the next time the evaluation is performed, improvements in those measures will reflect real improvements in the I/M program that TCEQ has identified, worked toward, and achieved. We provided the following guidance to help TCEQ make these decisions:

- Support each of the above six attributes of evaluation with analyses. None should be left unsupported.
- Try to select analyses that measure aspects that are fundamental and important to I/M. Doing this will help make the next 2-year evaluation easier to define even if the Texas I/M program were to change.
- View this evaluation as a baseline evaluation against which future evaluations will be compared.

1.2 Structure of the Report

To familiarize the reader with the Texas I/M program, the body of the report begins in Section 2 with a brief history and description of the Texas I/M program. Then, the report follows the six attributes of evaluation. Analyses of Coverage, Inspection, Repair, Enforcement, the Annual I/M Benefit, and the Total I/M Benefit are presented in Sections 3, 4, 5, 6, 7, and 8. Within each section, we used individual analysis activities to support each of the six attributes. Some analysis ideas were taken directly from the two guidance documents. Other ideas for analysis were developed specifically for this report based on our knowledge of the Texas I/M program.

Section 3 investigates Coverage first by examining a recent parking lot survey of windshield registration and inspection stickers. The study was performed by the Texas Transportation Institute for the Department of Public Safety (DPS). A second measure of Coverage was obtained by comparing vehicle license plates read during RSD measurements with the vehicles seen in the I/M program Vehicle Information Database (VID).

Section 4 investigates Inspection in various ways using the VID data for the evaluation period. VID data fields were checked for appropriate ranges. The various types of inspections and failure patterns were counted. The emissions analyzer calibration and audit results were checked. The measured concentrations of CO, CO_2, and O_2 obtained during individual emissions inspections were checked for consistency with combustion chemistry stoichiometry. We investigated OBDII communication performance and VID handling of OBDII inspection data. Finally, we looked for evidence of fraud by examining trends in “trigger” data and by looking for “clean-scanning” in OBDII data.

In Section 5 we look at VID data and DPS’ Recognized Emission Repair Facility data to determine the level, cost, and emissions and OBDII effects of repairs caused by the I/M program.

Enforcement is examined in Section 6 by reviewing the Registration Denial program and the covert and overt I/M station and equipment audit program.

In Section 7 we use VID data and DPS’ RSD data to estimate the Annual I/M Benefit, which is the size of the downward jog in emissions caused by I/M inspections. In Section 8 we used the RSD data to attempt to measure the Total I/M Benefit, which is the emissions difference between the existing Texas I/M fleet and a hypothetical Texas fleet that has never participated in an I/M program.

2.0 Background of the Texas I/M Program

2.1 History of the Texas I/M Program[21]

The purpose of the motor vehicle inspection and maintenance (I/M) program in Texas is to reduce mobile source emissions of hydrocarbons (HC), some of which can react with oxides of nitrogen (NOx) to form ground level ozone. Ground level ozone is a lung irritant that particularly affects children, the elderly, and others with decreased lung capacity. Exposure to elevated levels has been shown to result in acute respiratory affects, and to aggravate asthma. Ground level ozone is the main ingredient in urban smog, and can also damage trees, crops, and other vegetation. Although no area of the state has exceeded the National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO), the I/M program will also reduce motor vehicle emissions CO. Exposure to elevated levels of CO can aggravate angina and other aspects of coronary heart disease, and can decrease exercise tolerance in persons with cardiovascular problems.

Emissions testing in Texas started in Harris County on July 1, 1984 with the implementation of a tailpipe exhaust test for lead. The test also included an anti-tampering component, which involved an enhanced visual inspection for the presence of required emissions components. The anti-tampering component of the test was expanded to include El Paso County on January 1, 1986, and Dallas and Tarrant Counties were added on January 1, 1987.

Testing of tailpipe emissions of HC and CO began on January 1, 1987 in El Paso County, using a BAR-84 low speed idle, four-gas analyzer. Tailpipe testing of HC and CO expanded to include Dallas and Tarrant Counties on April 1, 1990. These programs were administered by the Texas Department of Public Safety (DPS).

Texas legislation passed in 1993 required that emissions testing be centralized and use a loaded-mode IM240 test instead of the idle test. Therefore, administration of the I/M program was shifted to the Texas Commission of Environmental Quality (TCEQ), formerly the Texas Natural Resource Conservation Commission (TNRCC), on January 1, 1995. However, the new centralized program was terminated by the legislature in February of 1995, and the DPS resumed low-idle emissions testing in Dallas, Tarrant, El Paso, Denton, Collin, and Harris Counties on July 1, 1995. As instructed by the legislature, the TCEQ, working with the DPS, developed a new decentralized I/M program, which was announced in November 1995 as the Motorist's Choice Program.

[21] This section was written by C.F. Palacios.

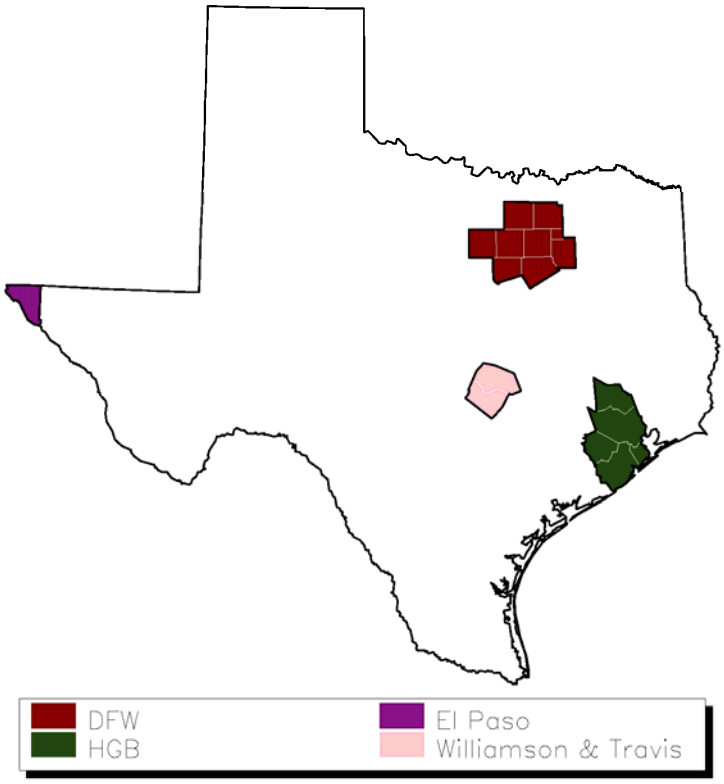
Also in November of 1995, EPA finalized its I/M Flexibility Amendments, which would allow states to design I/M programs to meet different levels of I/M performance standards (basic, low-enhanced, and high-enhanced). A less-stringent I/M program that is more responsive to motorist's concerns may be used if it will allow that area to make reasonable progress in improving air quality. Texas decided to implement an I/M program that would meet or exceed the low-enhanced I/M performance standards, which include an annual centralized or decentralized two-speed idle (TSI) test and a visual inspection of emissions control devices. Additional credit may be given for acceleration simulation (ASM) testing, on-board diagnostic (OBD) testing, remote sensing (RSD), and technician training and certification.

On October 1, 1996 in Dallas and Tarrant Counties, and January 1, 1997 in Harris and El Paso Counties, the full Motorist's Choice Program was implemented, including a TSI test, a gas cap leak check, enhanced hardware and software, Recognized Repair Facilities, and real-time communication with a vehicle inspection database (VID).

On May 1, 2002 in Dallas, Denton, Collin, Tarrant, and Harris Counties, and May 1, 2003 in Brazoria, Ellis, Fort Bend, Galveston, Johnson, Kaufman, Montgomery, Parker, and Rockwall Counties, emissions testing changed to OBD for 1996 and newer vehicles, and ASM for pre-1996 vehicles. Other counties in the I/M program continue with TSI testing. The map in Figure 2-1 shows the locations of the ASM/OBD counties, the TSI counties, and the non-I/M counties in Texas. Dallas, Denton, Collin, Parker, Rockwall, Johnson, Ellis, Kaufman, and Tarrant Counties comprise the Dallas/Fort Worth (DFW) I/M area, while Brazoria, Fort Bend, Galveston, Harris, and Montgomery make up the Houston/Galveston/Brazoria (HGB) I/M area.

On January 1, 2007, El Paso County will change to OBD testing for 1996 and newer vehicles, while continuing with TSI tests for pre-1996 vehicles.

Figure 2-1. Map of Texas I/M Program Areas



2.2 Description of the Current I/M Program[22]

As described above, Texas' current I/M program in the DFW and HGB areas consists of OBD testing for 1996 and newer vehicles and ASM testing for pre-1996 vehicles. Other counties included in the I/M program use a TSI inspection, but the focus of this evaluation is the DFW and HGB areas. Further details of the I/M program are described below.

Program administration - The EPA's 40 Code of Federal Regulations (CFR) Part 51 requires states to implement a vehicle inspection and maintenance program in nonattainment areas. Texas' Health and Safety Code, 382.202 - 382.208, and Texas Transportation Code, Chapters 502 and 548, give the authority and responsibility for implementing the I/M program to the TCEQ and the DPS. To fund the program, the TCEQ and the DPS receive a portion of the fee for each safety and emissions certificate issued. Currently, of the $2.50 fee TCEQ receives $0.50 and DPS receives $2.00.

The primary I/M Program responsibilities of the TCEQ relate to the planning of the program, and evaluation of its results, including SIP amendments, rulemaking, program development, data collection and analysis, performance monitoring and evaluation, registration denial, and consumer and technical assistance. The primary I/M Program responsibilities of the DPS relate to the implementation of the program: overt and covert auditing of inspection stations, technician and consumer assistance, enforcement, waiver oversight, and remote sensing.

Fleet Coverage and Inspection Frequency - In the DFW and HGB areas, motor vehicles between two and 24 years old are required to receive annual I/M inspections. All gasoline-powered vehicles (including dual-fuel vehicles capable of operating on gasoline) that are registered and primarily operated in the areas, or required to be registered in the areas, are required to participate in the program. The requirements apply to both owned and leased vehicles. Vehicles exempt from the program include those less than two or more than 24 years old, motorcycles, diesel vehicles, military tactical vehicles, and vehicles registered with the Texas Department of Transportation (TxDOT) as antiques. Vehicles registered in the DFW or HGB areas but operated in an attainment area of Texas are not required to be tested. Registration information for vehicles required to participate in the I/M Program is provided to the TCEQ by TxDOT, and is used to identify non-compliant vehicles (non-compliance will be discussed further below).

[22] This section was written by C.F. Palacios.

Vehicles registered in a non-I/M county and then sold into an I/M county must provide proof of passing an I/M inspection within 90 days prior to being registered in the I/M county. This test-on-resale does not apply to vehicles exempt from the I/M program as described above, and does not apply to 1996 and newer vehicles with less than 50,000 miles on the odometer.

Each eligible vehicle is required to receive an I/M inspection every year. If the inspection is failed, the motorist must have the vehicle repaired and return for a re-inspection. If the re-inspection takes place at the same facility that performed the initial failed inspection, and if less than 15 days elapsed between inspections, no additional inspection fee is charged for the retest. The vehicle must continue to receive repairs and return for retest until the vehicle passes the inspection or waiver requirements are met (waivers will be discussed further below).

I/M Inspection Components - The annual I/M inspection includes three components: an emissions test, a gas cap integrity test, and a visual inspection of emissions system components (intended to detect missing or tampered components). In the DFW and HGB areas, the emissions test for 1996 and newer vehicles uses a vehicle's On-Board Diagnostic (OBD) computer system to detect any problems that might lead to elevated emissions. Components checked by the OBD include emissions control equipment, the fuel metering system, and the ignition system.

For vehicles older than 1996, the primary emissions test is an Acceleration Simulated Mode (ASM) test. The vehicle's tires are placed on a dynamometer, which applies a resistance as the vehicle is accelerated, and is intended to simulate the tailpipe emissions of actual driving conditions. The test includes two phases: the 50/15 mode, using 50% of the vehicle's available horsepower to accelerate at 15 mph, and the 25/25 mode, using 25% of the vehicle's available horsepower to accelerate at 25 mph. Tailpipe emissions are measured throughout the test. Vehicles with very low or very high emissions may not be required to complete the entire test, based on fast pass/fast fail algorithms.

Some vehicles cannot be tested on the ASM dynamometer, including all-wheel drive vehicles, and vehicles with gross vehicle weight ratings greater than 8500 lbs. These vehicles receive the two-speed idle (TSI) test, where tailpipe emissions are measured while the vehicle idles, first at a low engine speed and then at a high engine speed.

Motorist Compliance - The primary tools used to enforce motorist compliance with the I/M Program are re-registration denial and windshield sticker enforcement. Windshield stickers indicate to law-enforcement officers the county of registration for the vehicle, and the county of I/M inspection. Re-registration denial is determined by comparing vehicle inspection database

(VID) with the registration database. This comparison can identify vehicles that have an unresolved failure (no record of a passing an inspection or receiving a waiver) within the last twelve months. Owners of vehicles found to be out of compliance with the program requirements are first notified, receive citations and fines if the vehicle is driven while out of compliance, and denied re-registration if the non-compliance continues. A 96% compliance rate is targeted.

Another tool used to oversee motorist compliance with the I/M Program is on-road testing. A remote sensing device (RSD) is used to measure the tailpipe HC, CO, NO, speed, acceleration (from which vehicle engine load may be estimated), and the license plate of a vehicle passing by. The tailpipe emissions measurements are used to identify vehicles that are most likely to fail an emissions inspection (probable high emitters). The license plate can be matched to registration information for the vehicle.

DPS primarily uses remote sensing to identify probable high-emitting vehicles that are registered and operated within the HGB and DFW areas but are not reporting for periodic I/M inspections, and to identify probable high-emitting vehicles that are registered in the surrounding counties and commuting into the I/M area. Owners of these vehicles are sent a letter notifying them that the vehicle is a probable high emitter and must report for an I/M inspection, be tested, and obtain repairs as needed. Failure to comply will result in a citation (up to $1000 per offense); non-compliance beyond 30 days will result in re-registration denial until the vehicle is brought into compliance.

Waivers - A vehicle that does not meet emissions standards may receive a waiver of I/M Program requirements if other specified conditions are met. A waiver lasts for only one test cycle (one year), but a vehicle may receive a new waiver each year if waiver requirements are met each year.

A Low-Mileage Vehicle Waiver may be issued if the vehicle failed an initial inspection and a retest, $100 or more was spent on relevant repairs, the DPS can determine that the vehicle was driven 5,000 miles or less since the prior annual inspection, and it is projected that the vehicle will be driven 5,000 miles or less before the next annual inspection.

An Individual Vehicle Waiver may be issued if a vehicle fails an initial inspection and a retest, and the DPS determines that the motorist has taken all appropriate measures to attempt to bring the vehicle into compliance, that further measures would be economically unfeasible during the current inspection cycle, and that a waiver would result in minimal impact on air

quality. In the DFW and HGB areas, the maximum reasonable repair expenditure prior to obtaining a waiver is $600.

A low-income time extension for repairs is also available for motorists who are not able to afford adequate repairs to bring a failing vehicle into compliance. The time extension is available for only one year; at the next inspection cycle, the vehicle must be brought into compliance.

Inspection Stations - The Texas I/M Program uses a decentralized network of test only (TO) and test and repair (T&R) inspection stations. Test only stations may perform other services (such as oil changes, self-serve gasoline) in addition to emissions inspections, but do not perform emissions related repairs. Test and repair stations perform emissions testing and can also make indicated repairs to the vehicles. EPA has determined that the effectiveness of this type of network is comparable to that of a centralized test-only network.

An inspection station must employ at least one full-time certified inspector to perform emissions inspections. To become certified, a potential inspector must complete numerous requirements, including a DPS training session, passing a written or verbal examination, and a demonstration of proficiency in operating the inspection equipment at the station of employment.

To ensure that emissions inspections are being performed properly, the DPS conducts overt and covert performance audits, records audits, and equipment audits. In addition to scheduled audits, the DPS may perform random audits based on tips or complaints from customers.

The DPS conducts at least two overt audits of each inspection lane or analyzer per year. The overt audit includes observation of the inspectors performing tests, verification of proper calibrations, and verification of adequate documentation procedures. The DPS also conducts at least one covert audit per full time equivalent employee, per year. During a covert audit, a vehicle that has been modified to fail the emissions inspection is presented for testing, and the auditor observes whether proper procedures are followed. A covert audit also includes remote visual observation of the station, also to verify proper inspector performance. The DPS maintains an adequate number of covert audit vehicles and auditors to prevent recognition at the stations.

Records audits involve a monthly screening of vehicle inspection station and inspector records, including an evaluation of document security, record keeping practices, and

certifications. The intent of the audit is to identify data discrepancies or patterns that might indicate potential fraud or incompetence.

Equipment audits are intended to ensure that all inspection equipment is working properly and is fully calibrated. The audit includes gas audits to check the calibration of the analyzers, confirmation that the station's gas audit bottles are properly labeled and within specifications, a general equipment check for tampering, a leak check, and a gas cap pressure test equipment check.

If station or inspector misconduct is identified, a wide range of enforcement procedures may be taken, depending on the severity of the offense. Penalties may include revocation of a facility or inspector's license, suspension from performing inspections for six months up to three years, fines up to $10,000, or jail time for up to 10 years.

Results and Evaluation - A wide variety of inspection-related data is collected in the Vehicle Inspection Database (VID), maintained by the TCEQ. A detailed inspection record is kept for each test performed, including information about where the inspection was performed; vehicle information such as VIN, license plate, fuel type, and emissions system components; and inspection results, including emissions levels and any flags identifying testing abnormalities. In addition to the inspection records, the VID includes information about each inspection station and its equipment, each certified inspector, analyzer calibrations, audits, and other data relevant to monitoring and analyzing the performance of the I/M program.

The VID is the primary source of information for I/M Program analysis. VID records are used to generate yearly reports to EPA, including a test data report, with basic statistics describing the number of inspections performed and pass/fail rates; quality assurance and quality control reports, with statistics about station audits performed; and a compliance report, with statistics related to the rate at which the covered fleet participated in the I/M Program. A biennial report is required to be made to EPA every two years describing any program changes, any problems with the program that have been identified and steps that are being taken to correct them, and future plans for the program.

EPA's MOBILE 6.2 model is used to produce emissions factors, by program area, to determine whether the Texas I/M Program will meet emissions reductions goals for EPA low-enhanced performance standard. The model's outputs are grams per mile emission reductions for HC, CO, and NOx. Changes to design of the I/M Program (such as changes to the model year range of vehicle required to receive inspections or the test type administered) are modeled

to determine their potential effect on emissions reductions. Program results, such as the compliance rate and the waiver rate, may also be modeled.

3.0 Coverage

One of the four major process-based I/M evaluation elements is the level of fleet coverage, or the vehicle compliance rate, achieved by the program. In this section, coverage is evaluated using two different sources of out-of-program data. In Section 3.1, we describe the results of a parking lot survey [suggested by Section 4.1.5 of Reference 1] that provides an estimate of fleet compliance with the I/M program. Section 3.2 reports of the evaluation of fleet coverage by estimating the fraction of vehicles observed on the road during remote sensing that have I/M program VID records.

3.1 Parking Lot Survey[23]

The parking lot survey of registration and I/M inspection stickers was conducted by the Texas Transportation Institute (TTI) for the DPS in 2004 [Reference 5]. In that study, a small sample of vehicles in the fleet was observed in parking lots or stopped at intersections. For each vehicle observed, information about the license plate, registration sticker status, and I/M sticker status was recorded. By comparing the date of the expiration of the I/M sticker with the current date and with the type of county of registration (I/M or non-I/M) for each vehicle, the level of compliance with the I/M program was then compared to the level of compliance with the registration requirement. No statistically significant difference was found between the I/M sticker status and registration sticker status, for the Dallas or Houston metropolitan areas.

In the following sub-sections, the TTI/DPS parking lot survey methodology will be described, their findings will be summarized, and our recommendations for future out-of-program estimates of fleet coverage will be presented.

Description of Parking Lot Survey

The TTI conducted the parking lot survey in the summer of 2004. Fifteen I/M counties were covered: Dallas, Denton, Collin, Tarrant, Ellis, Johnson, Kaufman, Parker, and Rockwell (the Dallas metropolitan area); Brazoria, Fort Bend, Galveston, Harris, and Montgomery (the Houston metropolitan area); and El Paso. To obtain a reasonably varied sample, sampling was divided among weekdays (80%) and weekends (20%), and parking lots (75%) and intersections (25%). Also, each county was divided into three, four, or five sections for sampling, based on population density from U.S. Census data. Target sample size for each county was based on an

[23] This section responds to the Work Plan's Task 3 Element 5A: Estimate Compliance Rate from Parking Lot Surverys of Registration and I/M Stickers and was written by C.F. Palacios.

assumed compliance rate of 95%, with a goal of 12,675 vehicles for each of the three largest counties (Harris, Dallas, Tarrant), and 3,175 vehicles for each of the other 12 counties.

To collect the survey data, observers visited parking lots and intersections where vehicles were stopped at a signal. The observers recorded information from windshield registration and safety/emissions stickers and from the front and back license plates of vehicles. Sample size quotas were not set for individual observation sites; observers were instructed to collect data from any parking lot or parking area where multiple vehicles were located and observations could be made with minimal interference to the public. Motorcycles, 18-wheelers, and non-motorized vehicles (trailers) were excluded from the survey. All observations were made during daylight hours. The information that was recorded for each vehicle included:

- License plates: comparison of front and back plates for presence and agreement, state or country of license, and license plate number if registration sticker was missing;
- Registration certificate: placement, status (current, expired, or missing), county, and indication of emissions test requirement; and
- Inspection certificate: type, status (current, expired, or missing), and validity (i.e., the type of emissions test indicated on the registration sticker versus the type of emissions test on the emissions sticker).

Summary of Results

The TTI tabulated statistics for all of the survey information in the above list. Results were given individually by county, and then for the three consolidated metropolitan areas: El Paso, the Houston area, and the Dallas/Ft. Worth area. The primary results are listed below in Table 3-1. Vehicles licensed outside the state of Texas are excluded from the table. The first column of the table shows the percentage of vehicles observed that had valid Texas license plates, where both the front and back plates were present, both were the same, both were properly placed, and neither was obscured. The second column shows the percentage of vehicles with current (as opposed to expired or missing) registration stickers, and the third column gives similar information for the safety/emissions sticker. The fourth column shows the percentage of vehicles with both registration and safety/emissions stickers that were current. Finally, the fifth column presents the percentage of vehicles with valid emissions stickers, which is the percentage of vehicles where the registration sticker indicated that the vehicle was required to participate in the I/M program and what type of inspection it should receive (OBD, ASM, or TSI), and the emissions/safety sticker indicated that the vehicle had in fact received that type of emissions

inspection. This last column for percentage of vehicles with valid emissions certificates gives the best estimate of fleet coverage by the I/M program.

Table 3-1. Summary of Parking Lot Survey Findings, by Metropolitan Area, for Texas Vehicles

Area	Valid Front and Back License Plate	Current Registration	Current Inspection	Current Registration & Inspection	Valid Emissions
Houston area	92.7%	94.5%	95.8%	90.4%	92.1%
Dallas area	94.0%	94.0%	95.1%	91.3%	93.1%
El Paso	88.9%	92.2%	93.1%	88.7%	94.9%

After tabulating the number of missing, expired, and current registration and emissions/safety stickers for each county, and for each consolidated metropolitan area, the TTI then performed a statistical analysis to determine whether there was a significant difference between the percentage of vehicles with valid registration stickers and the percentage of vehicles with valid safety/emissions stickers. No statistically significant difference was found for either the Dallas or Houston metropolitan areas.

Recommendations for Future Surveys

The objective of the TTI study was to compare the percentage of vehicles with valid registration stickers to the percentage of vehicles with valid safety/emissions inspection stickers. The percentage of vehicles observed with current registration and emissions/safety inspection stickers was also tabulated. However, these do not provide a complete picture of the compliance rate for the fleet. Obviously, the vehicles observed with expired or missing registration or inspection stickers are out of compliance with the program. However, out-of program data from a parking lot survey could be used for additional measures of I/M non-compliance. For example, vehicles with current registration and current valid safety inspections might still be non-compliant if they are registered and inspected in a non-I/M area but operated primarily in an I/M area. In this case, use parking lot survey results to compare county of registration with county of observation would add depth to an out-of-program estimate of the fleet compliance rate. Results such as these are only obtainable through out-of-program data.

3.2 Participation Rates[24]

We estimated the participation rate of vehicles subject to I/M in the DFW area and in the HGB area through a comparison of RSD data and VID data. RSD is a sample of vehicles that were driven on the road. If these vehicles were eligible for I/M, they should have been participating in the I/M program. We looked in the VID to determine the fraction of vehicles that are participating in the I/M program of those that are seen on the road during RSD and are eligible for I/M.

We first created a dataset of I/M-eligible and I/M-county registered vehicles seen on the road with RSD at least once. This dataset does not include out of state vehicles nor non-I/M county Texas vehicles. This dataset does consist of all I/M eligible model years. That is, vehicles younger than 2 years and older than 24 years at the time of the RSD are excluded from the analysis. Table 3-2 shows the counts of unique RSDed vehicles registered in the DFW and HGB program areas. RSD measurements were collected from April 2004 through December 2005, which is approximately the last half of the evaluation period.

[24] This section responds to a part of the Work Plan's Task 3 Element 1A: Inspection Statistics and was written by T.J. Petroski.

Table 3-2. Count of Unique I/M-Eligible RSDed Vehicles Registered in I/M Program Areas

Registered at time of RSD	Unique RSDed Vehicles
DFW	1,093,876
HGB	947,748
Total	2,041,624

Next, we determined the number of unique I/M tested vehicles that received certifications in each of the I/M Program Areas. Table 3-3 shows the counts for the DFW and HGB program areas.

Table 3-3. Count of Unique I/M-Tested Vehicles in I/M Program Areas

I/M Area where Test Performed	Unique I/M-Tested Vehicles
DFW	4,197,006
HGB	3,586,575
Total	7,783,581

The I/M tests were then matched to RSD measurements by GroupID, which is our best estimate of the correct VIN. (See Appendix A for a discussion of GroupIDs.) If an I/M test occurred any time between May 1, 2003 and December 31, 2005 and was found to link up with an RSD measurement taken any time between April 2004 and December 2005, this was a matched pair. Of the 1,093,876 RSD measurements in DFW, there were 1,064,339 pairs of matched I/M-test and RSD measurements or 97.30% participation rate. Of the 947,748 RSD measurements in DFW, there 922,028 pairs of matched I/M-test and RSD measurements or 97.29% participation rate.

A further refinement to the participation rate was to look at a distribution of time differences between the matched pairs of RSD to certifying I/M tests. For these calculations we considered I/M tests both before and after RSD measurement events. If the time difference is more than a year, then that vehicle may no longer be participating in the I/M program. However, if the time difference is between 12-15 months, these vehicles may actually be participating in the I/M program. They may have returned late for their I/M test or they may have needed several repairs to satisfy I/M requirements. The final test can occur a few months after the initial I/M test. Table 3-4 shows the distribution of time differences between matching pairs in each I/M program area.

Table 3-4. Time Between RSD and I/M Test

I/M Program Area	Time difference between RSD and I/M Test	Count	Percent
DFW	<12 months	1,041,660	97.87
	12 -15 months	11,301	1.06
	> 15 months	11,378	1.07
	Total	1,064,339	100.00
HGB	<12 months	900,689	97.69
	12 -15 months	10,226	1.11
	> 15 months	11,113	1.21
	Total	922,028	100.00

4.0 Inspection

4.1 Check Major VID Fields for Appropriateness[25]

The goal of this check was to analyze the ranges and values produced in the major variables that make up the VID. This is a process-based measure for inspection. This analysis is an indication of the ability of the VID database system to accurately record the activities of the I/M program. When VID variables have values that are out of range or are missing for an unexplained reason, this suggests that I/M program activities are not being properly monitored. [Section 4.2.1.5 of Reference 1]

Since the in-program data is the primary basis of the I/M program evaluation, a series of basic data checks were used to demonstrate the accuracy and completeness of the data in the database.

1) The beginning and ending dates of the data under consideration include:

   - IM Test Records: May 1, 2003 – December 31, 2005.
   - RSD Measurements: April 2004 – December 31, 2005.

2) A frequency distribution was conducted of almost all database variables to demonstrate the accuracy and completeness of data entry. These frequency distributions included just filtered data, so many missing values and nonsensical values were removed during the filtering process. See Table A-2 in Appendix A for an explanation of the filters. Throughout this report, additional details about the accuracy and completeness of individual fields are noted.

The following is a list of some findings after checking the various VID fields:

- We found an inconsistency in the way the final inspection results are recorded in the VID for vehicles that initially passed the emissions test but failed the overall inspection. This situation occurred about for about a quarter-million vehicles out of the millions of vehicles tested in the evaluation period. We saw three roughly equally occurring scenarios. In each scenario the initial inspection record in the VID had emissions concentrations, a passing emissions result, and a failing overall result. The differences among the three scenarios occurred in how the final inspection was recorded in the VID. For Scenario 1, the final inspection record had emissions concentrations equal to zero, a blank emissions pass/fail result, and a passing overall result. For Scenario 2, the final inspection record had emissions concentrations identical to the concentrations in the initial emissions test, a passing emissions result, and a passing overall result. For

[25] This section responds to the Work Plan's Task 3 Element 1C: Check Major VID Fields for Appropriateness and was written by T.J. Petroski.

Scenario 3, the final inspection record had emissions concentrations different from the concentrations in the initial emissions test (which indicates that another emissions test was performed at the time of the final inspection), a passing emissions result, and a passing overall result.

- 85% of the ASM tests had missing Dilution Pass/Fail Flags while for TSI tests only 0.03% had missing Dilution Pass/Fail Flags. Also Dilution Limit was set to 0 on 33% of the ASM tests while virtually none of the TSI tests had the Dilution Limit set to 0.

- Duration of tail pipe test times are missing on 33% of ASM tests and on 29% of TSI tests.

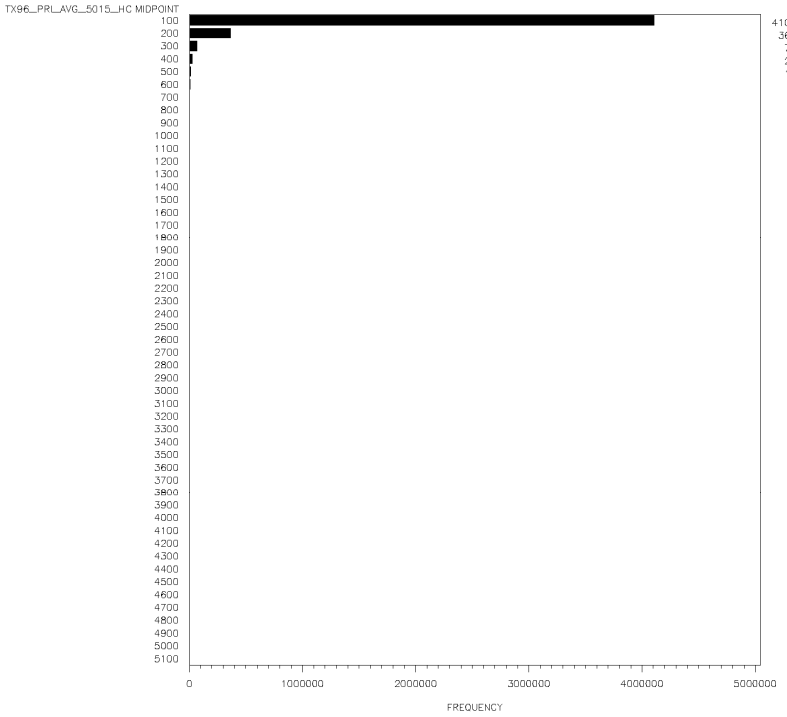
- The GAS_CAP_PF_FL and GAS_CAP_PF_FL1 fields appear to be the same quantity, but the values do not always agree.

- RPM Pass/Fail Flag is missing for all ASM tests.

- RPM bypass is used on 17% of the TSI tests.

3) A distribution of the emissions measurements is a special case of the above. Ideally, no observations with missing values should be present. Figures 4-1 through 4-10 show the distributions of the emissions measurements for HC, CO, and NO for ASM tests and HC and CO for TSI tests in both program areas. The distributions are all positively skewed (that is, most observations are at low emissions concentrations), and there is no evidence of large numbers of very high concentration values. The shapes of the distributions look typical for a fleet of modern in-use vehicles. Overall, the figures indicate that no gross errors are being made in measuring and recording tailpipe emissions. Also, all observations should have a CO_2 concentration between about 6% and 16%, since a combustion process must be present. Table 4-1 shows the distribution of CO_2 measurements that fall within range.

Figure 4-1. Distribution of ASM HC5015 Concentrations for All Filtered I/M Tests



MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
100	4107347	4107347	89.11	89.11
200	366229	4473576	7.95	97.05
300	70361	4543937	1.53	98.58
400	27031	4570968	0.59	99.17
500	11850	4582818	0.26	99.42
600	6056	4588874	0.13	99.55
700	3599	4592473	0.08	99.63
800	2439	4594912	0.05	99.68
900	1638	4596550	0.04	99.72
1000	1285	4597835	0.03	99.75
1100	1015	4598850	0.02	99.77
1200	851	4599701	0.02	99.79
1300	691	4600392	0.01	99.80
1400	605	4600997	0.01	99.82
1500	612	4601609	0.01	99.83
1600	535	4602144	0.01	99.84
1700	460	4602604	0.01	99.85
1800	397	4603001	0.00	99.86
1900	396	4603397	0.00	99.87
2000	371	4603768	0.00	99.88
2100	352	4604120	0.00	99.88
2200	315	4604435	0.00	99.89
2300	322	4604757	0.00	99.90
2400	323	4605080	0.00	99.91
2500	285	4605365	0.00	99.91
2600	250	4605615	0.00	99.92
2700	240	4605855	0.00	99.92
2800	184	4606039	0.00	99.93
2900	191	4606230	0.00	99.93
3000	127	4606357	0.00	99.93
3100	148	4606505	0.00	99.94
3200	152	4606657	0.00	99.94
3300	115	4606772	0.00	99.94
3400	98	4606870	0.00	99.94
3500	105	4606975	0.00	99.95
3600	118	4607093	0.00	99.95
3700	119	4607212	0.00	99.95
3800	89	4607301	0.00	99.95
3900	95	4607396	0.00	99.96
4000	111	4607507	0.00	99.96
4100	107	4607614	0.00	99.96
4200	103	4607717	0.00	99.96
4300	99	4607816	0.00	99.96
4400	101	4607917	0.00	99.97
4500	100	4608017	0.00	99.97
4600	125	4608142	0.00	99.97
4700	91	4608233	0.00	99.97
4800	108	4608341	0.00	99.98
4900	105	4608446	0.00	99.98
5000	84	4608530	0.00	99.98
5100	903	4609433	0.02	100.00

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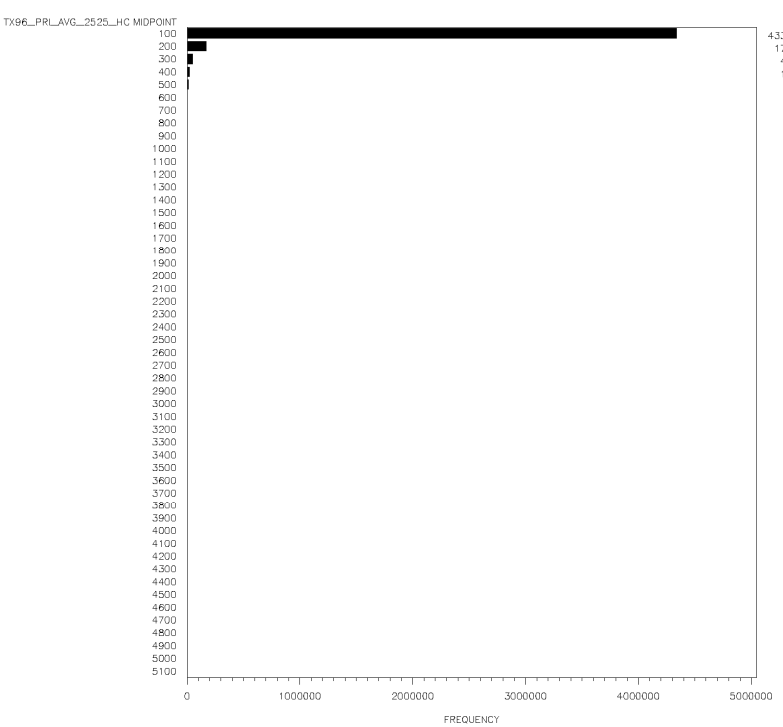
Figure 4-2. Distribution of ASM HC2525 Concentrations for All Filtered I/M Tests



MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
100	4337650	4337650	94.10	94.10
200	171266	4508916	3.72	97.82
300	48019	4556935	1.04	98.86
400	19002	4575937	0.41	99.27
500	9462	4585399	0.21	99.48
600	5451	4590850	0.12	99.60
700	3331	4594181	0.07	99.67
800	2195	4596376	0.05	99.72
900	1675	4598051	0.04	99.75
1000	1182	4599233	0.03	99.78
1100	1020	4600253	0.02	99.80
1200	818	4601071	0.02	99.82
1300	705	4601776	0.02	99.83
1400	611	4602387	0.01	99.85
1500	565	4602952	0.01	99.86
1600	525	4603477	0.01	99.87
1700	405	4603882	0.00	99.88
1800	370	4604252	0.00	99.89
1900	341	4604593	0.00	99.89
2000	313	4604906	0.00	99.90
2100	278	4605184	0.00	99.91
2200	292	4605476	0.00	99.91
2300	261	4605737	0.00	99.92
2400	228	4605965	0.00	99.92
2500	209	4606174	0.00	99.93
2600	200	4606374	0.00	99.93
2700	203	4606577	0.00	99.94
2800	189	4606766	0.00	99.94
2900	122	4606888	0.00	99.94
3000	121	4607009	0.00	99.95
3100	108	4607117	0.00	99.95
3200	114	4607231	0.00	99.95
3300	106	4607337	0.00	99.95
3400	94	4607431	0.00	99.96
3500	99	4607530	0.00	99.96
3600	111	4607641	0.00	99.96
3700	100	4607741	0.00	99.96
3800	86	4607827	0.00	99.97
3900	74	4607901	0.00	99.97
4000	90	4607991	0.00	99.97
4100	86	4608077	0.00	99.97
4200	86	4608163	0.00	99.97
4300	79	4608242	0.00	99.97
4400	84	4608326	0.00	99.98
4500	66	4608392	0.00	99.98
4600	74	4608466	0.00	99.98
4700	91	4608557	0.00	99.98
4800	83	4608640	0.00	99.98
4900	78	4608718	0.00	99.98
5000	61	4608779	0.00	99.99
5100	654	4609433	0.01	100.00

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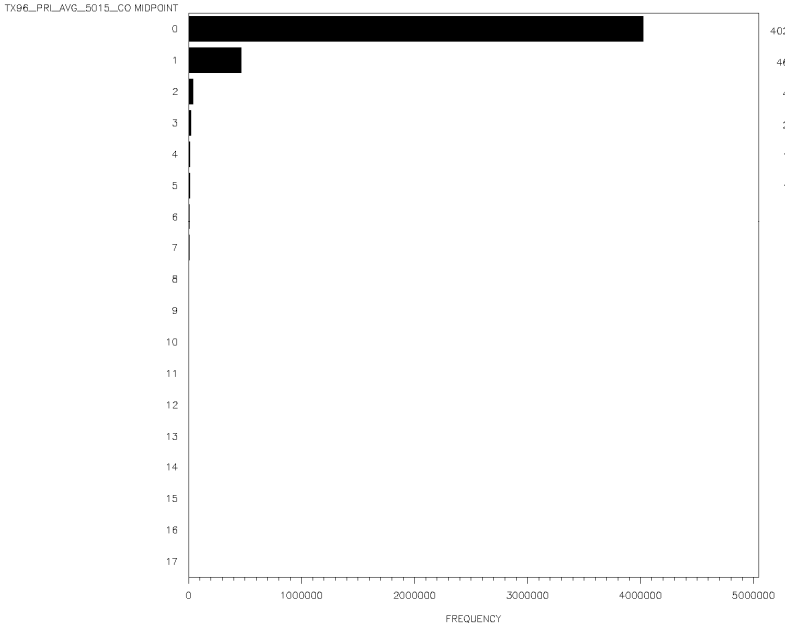
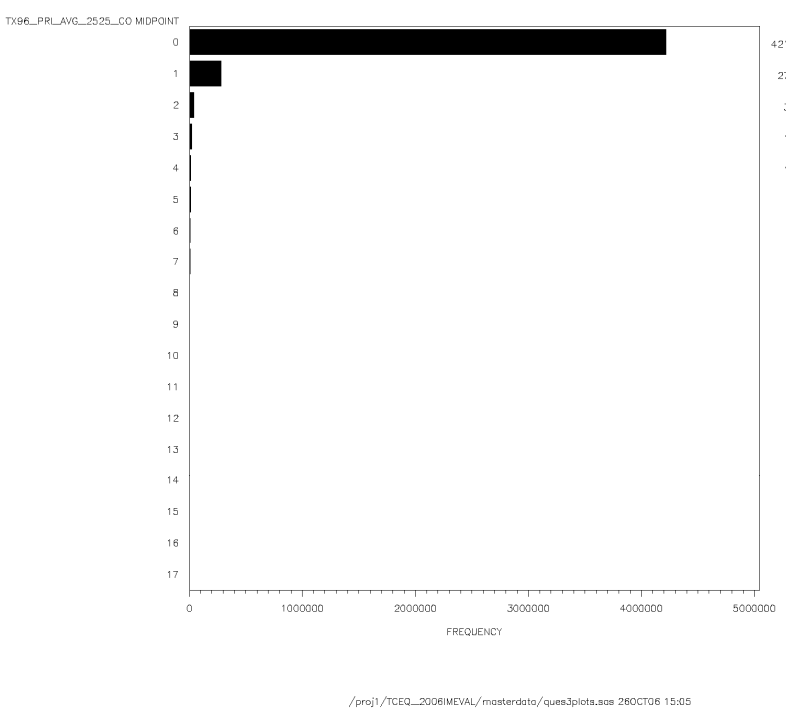
Figure 4-3. Distribution of ASM CO5015 Concentrations for All Filtered I/M Tests



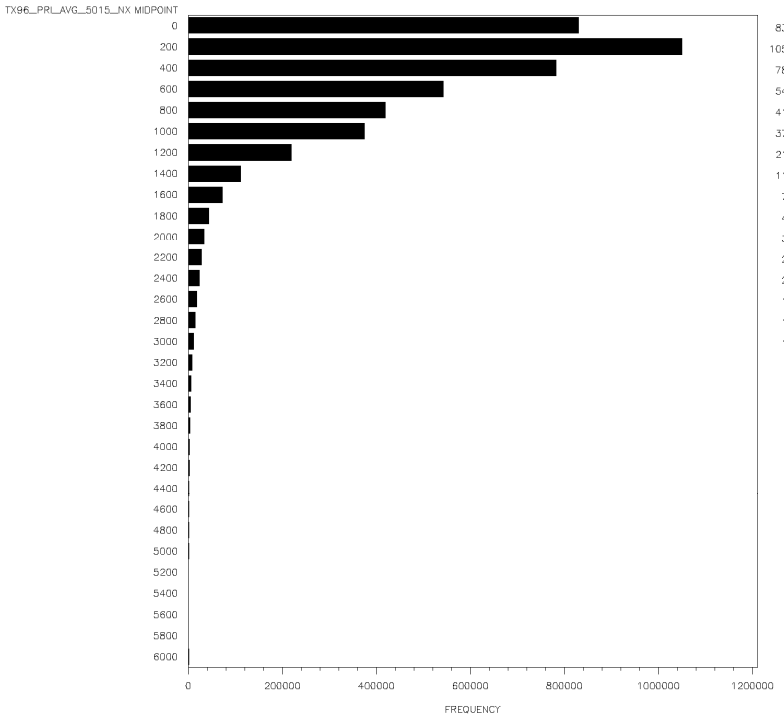
	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	4023659	4023659	87.29	87.29
1	465042	4488701	10.09	97.38
2	40384	4529085	0.88	98.26
3	20720	4549805	0.45	98.71
4	14249	4564054	0.31	99.02
5	10279	4574333	0.22	99.24
6	8119	4582452	0.18	99.41
7	6459	4588911	0.14	99.55
8	5217	4594128	0.11	99.67
9	4072	4598200	0.09	99.76
10	5308	4603508	0.12	99.87
11	3186	4606694	0.07	99.94
12	1391	4608085	0.03	99.97
13	772	4608857	0.02	99.99
14	379	4609236	0.00	100.00
15	129	4609365	0.00	100.00
16	22	4609387	0.00	100.00
17	46	4609433	0.00	100.00

Figure 4-4. Distribution of ASM CO2525 Concentrations for All Filtered I/M Tests



	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	4215928	4215928	91.46	91.46
1	277881	4493809	6.03	97.49
2	38621	4532430	0.84	98.33
3	19457	4551887	0.42	98.75
4	12975	4564862	0.28	99.03
5	9705	4574567	0.21	99.24
6	7719	4582286	0.17	99.41
7	6258	4588544	0.14	99.55
8	5166	4593710	0.11	99.66
9	4096	4597806	0.09	99.75
10	5242	4603048	0.11	99.86
11	3382	4606430	0.07	99.93
12	1426	4607856	0.03	99.97
13	859	4608715	0.02	99.98
14	472	4609187	0.01	99.99
15	159	4609346	0.00	100.00
16	27	4609373	0.00	100.00
17	60	4609433	0.00	100.00

Figure 4-5. Distribution of ASM NX5015 Concentrations for All Filtered I/M Tests



MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	830647	830647	18.02	18.02
200	1050137	1880784	22.78	40.80
400	782570	2663354	16.98	57.78
600	542603	3205957	11.77	69.55
800	418982	3624939	9.09	78.64
1000	374660	3999599	8.13	86.77
1200	218593	4218192	4.74	91.51
1400	111612	4329804	2.42	93.93
1600	72095	4401899	1.56	95.50
1800	44251	4446150	0.96	96.46
2000	33702	4479852	0.73	97.19
2200	27568	4507420	0.60	97.79
2400	23210	4530630	0.50	98.29
2600	18343	4548973	0.40	98.69
2800	14651	4563624	0.32	99.01
3000	11137	4574761	0.24	99.25
3200	8699	4583460	0.19	99.44
3400	6442	4589902	0.14	99.58
3600	4915	4594817	0.11	99.68
3800	3484	4598301	0.08	99.76
4000	2651	4600952	0.06	99.82
4200	2089	4603041	0.05	99.86
4400	1519	4604560	0.03	99.89
4600	1156	4605716	0.03	99.92
4800	849	4606565	0.02	99.94
5000	650	4607215	0.01	99.95
5200	464	4607679	0.01	99.96
5400	384	4608063	0.01	99.97
5600	296	4608359	0.01	99.98
5800	225	4608584	0.00	99.98
6000	849	4609433	0.02	100.00

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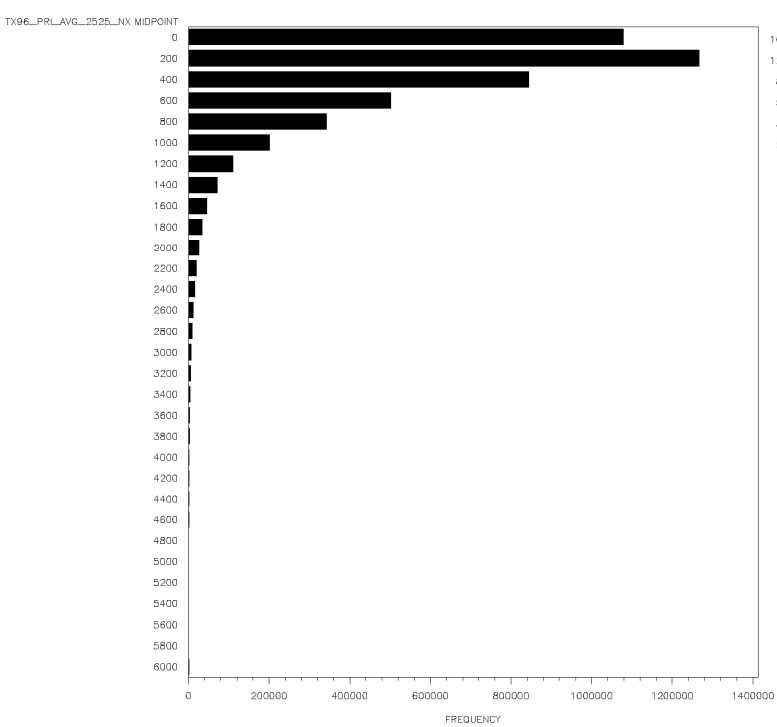
Figure 4-6. Distribution of ASM NX2525 Concentrations for All Filtered I/M Tests



MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	1078287	1078287	23.39	23.39
200	1267003	2345290	27.49	50.88
400	843311	3188601	18.30	69.18
600	502698	3691299	10.91	80.08
800	342431	4033730	7.43	87.51
1000	201549	4235279	4.37	91.88
1200	110331	4345610	2.39	94.28
1400	71140	4416750	1.54	95.82
1600	45544	4462294	0.99	96.81
1800	33608	4495902	0.73	97.54
2000	25701	4521603	0.56	98.10
2200	20145	4541808	0.44	98.53
2400	15910	4557718	0.35	98.88
2600	12118	4569836	0.26	99.14
2800	9271	4579107	0.20	99.34
3000	7054	4586161	0.15	99.50
3200	5589	4591750	0.12	99.62
3400	4061	4595811	0.09	99.70
3600	3226	4599037	0.07	99.77
3800	2470	4601507	0.05	99.83
4000	1832	4603339	0.04	99.87
4200	1483	4604822	0.03	99.90
4400	985	4605807	0.02	99.92
4600	822	4606629	0.02	99.94
4800	626	4607255	0.01	99.95
5000	469	4607724	0.01	99.96
5200	350	4608074	0.01	99.97
5400	270	4608344	0.01	99.98
5600	226	4608570	0.00	99.98
5800	149	4608719	0.00	99.98
6000	714	4609433	0.02	100.00

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Figure 4-7. Distribution of TSI HC Curb Idle Concentrations for All Filtered I/M Tests

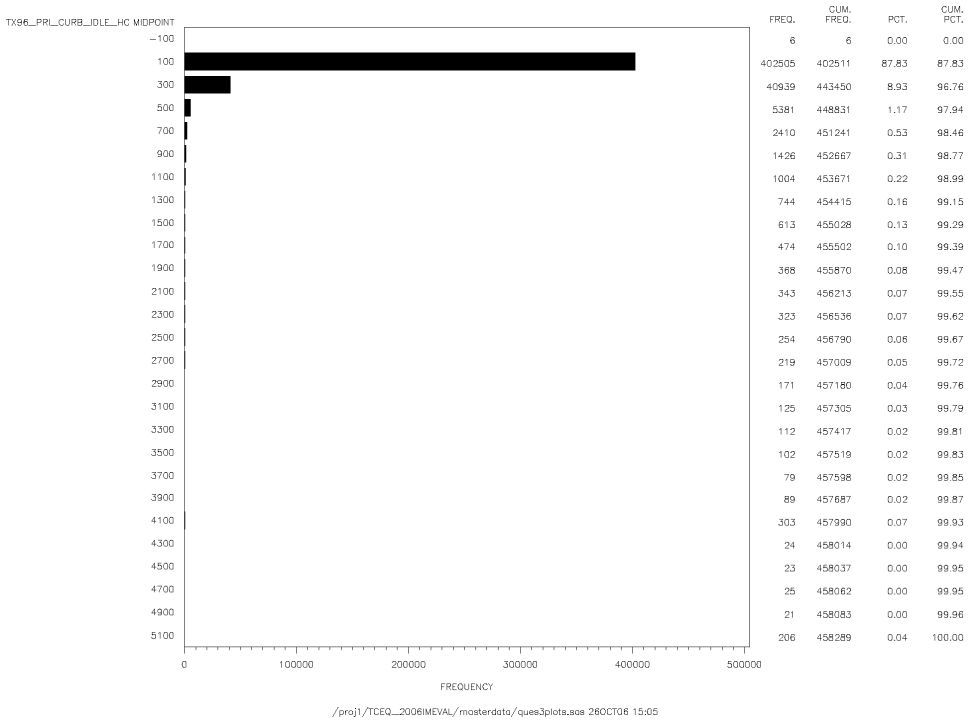

Figure 4-8. Distribution of TSI HC High Speed Concentrations for All Filtered I/M Tests

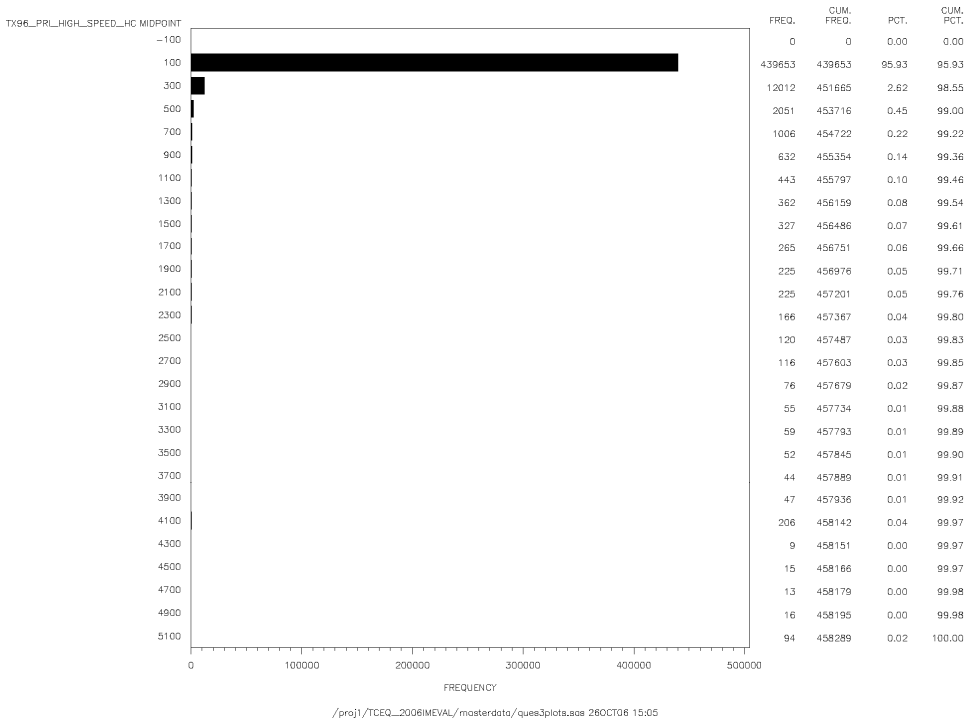

Figure 4-9. Distribution of TSI CO Curb Idle Concentrations for All Filtered I/M Tests

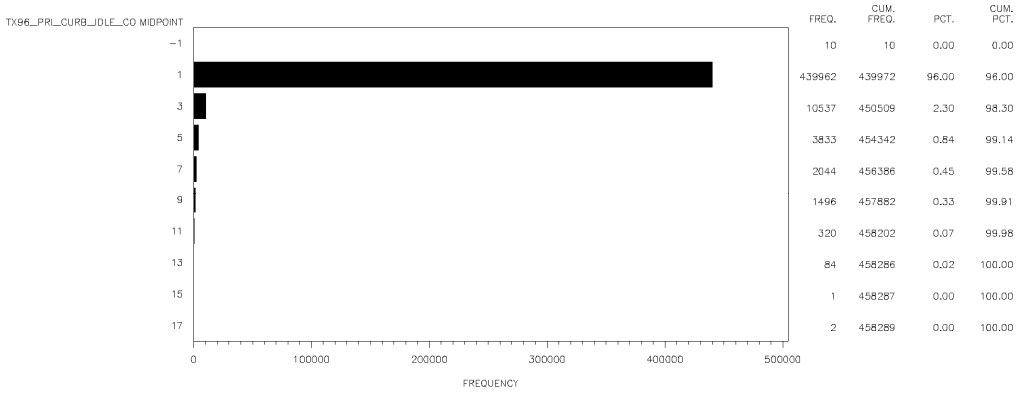

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Figure 4-10. Distribution of TSI CO High Speed Concentrations for All Filtered I/M Tests

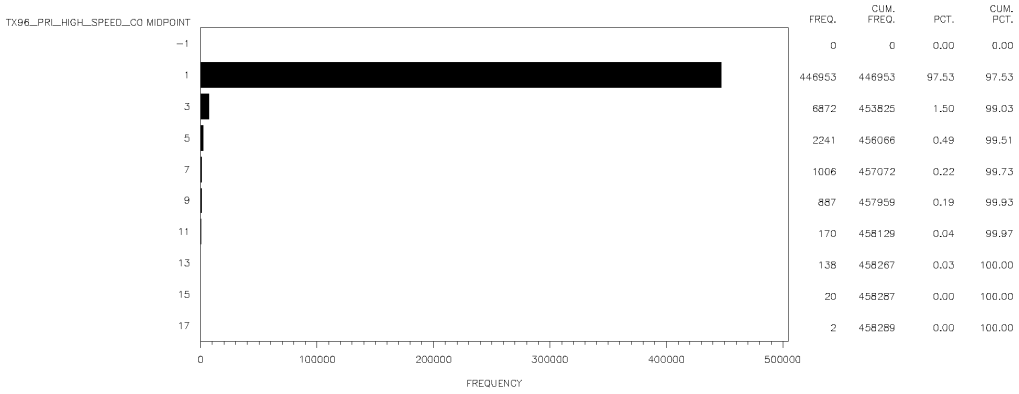

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Table 4-1. Distribution of Measured CO_2 Concentrations

Emission Test Type	Test Mode	Frequency	Fraction of CO_2 Readings		
			$CO_2 < 6\%$	$6\% < CO_2 < 16\%$	$CO_2 > 16\%$
ASM	5015	4,609,433	0.0039	0.9878	0.0083
	2525	4,609,433	0.0038	0.9872	0.0090
TSI	Curb Idle	458,289	0.0077	0.9872	0.0051
	Fast Idle	458,289	0.0077	0.9866	0.0057

4) The fraction of observations with both the license plate and the VIN missing was determined. 99.75% of the observations have neither VIN nor Plate missing. 0.25% of the observations have VIN present, but a missing Plate. These are the only two combinations present.

5) The validity of each 17-digit VIN was checked. Following the simplest method, the check digit in 17-digit (1981+) VINs was checked. Table 4-2 shows the counts of the various Check Digit results. There are also 48,507 unique VINs that have fewer than 17 digits; however, since these older VINs do not have check digits, we did not examine them.

The frequency distribution of the VIN characters for the BADCKs showed about the same number of counts for all illegal check digit characters – except for B, S, and Z. These three illegal check digit characters, which are easily confused with 8, 5, and 2, had elevated counts relative to the other illegal check digit characters. We conclude that the illegal check digit characters may be caused by VIN transcription errors. Similarly, illegal VIN characters I, O, and Q are easily confused with legal VIN characters 1 and 0. So, this is another case where VIN transcription errors may be the cause.

The table shows that a large number of the 17-digit VINs that did not have BADCKs or CHARs had check digits that did not agree with the calculated check digit. Again, this must be caused by VIN transcription errors at some point in the VIN entry process. Altogether, almost 2% of the VINs had some sort of transcription error. These errors make looking up vehicle VID histories and matching RSD measurements with registration records and VID histories, activities that we had to do repeatedly in this project, prone to errors. We believe that VIN transcription errors need to be totally eliminated from the DPS registration database and from the VID. The most effective point of eliminating the errors is to prevent them from ever occurring by using software at the point of original entry.

Table 4-2. Distribution of Check Digit Codes on Unique 17-Digit VINs in the I/M Test Records

Check Digit Code	Description of Code	Frequency	Percent
BADCK	Illegal Check Digit (should be 0 to 9 or X)	14,549	0.19
CHAR	Either I, O, or Q is in the VIN string	127	0.00
ERROR	Check Digit does not agree with check digit calculation	130,495	1.70
OK	Check Digit agrees with check digit calculation	7,528,916	98.11
Total		7,674,087	100.00

6) Each license plate should usually be associated with only a single VIN. In Table 4-3 below, 98.37% of the plates have a single VIN. Beyond this, we start to see some suspect plates. For example, 1.5% of the plates have two VINs. However, this may not be a problem because in some situations, such as for dealer plates and for vanity plates, plates can be legitimately moved to another vehicle.

Table 4-3. Number of VINs per Plate

VIN Count	Frequency	Percent
1	7,359,299	98.39
2	114,088	1.53
3	2,831	0.04
4	780	0.01
5	493	0.01
>5	2,505	0.02
Total	7,479,996	100.00

4.2 Inspection Statistics: Number of Vehicles Inspected by Inspection Type[26]

The goal of this element was to estimate the I/M participation rate of I/M eligible vehicles in each I/M program area. This is a process-based measure for coverage. We used the VID to make a simple count of various types of inspections performed (TSI, ASM, OBD) and the number of vehicles that received these inspections. This is an indication of the extent to which the Texas I/M program fleet was receiving the attention of the I/M program. Counts include only emissions inspections.

Inspection Statistics

Table 4-4 shows the number of ASM, OBDII, and TSI tests in each I/M program area performed during the evaluation period (May 1, 2003 to December 31, 2005).

Table 4-4. Emissions Tests per I/M Program Areas

I/M Program Area	Emission Test Type	Counts	Percent
DFW	ASM	2,512,205	30.3
	OBDII	5,549,917	66.9
	TSI	229,827	2.8
	Total	8,291,949	100.0
HGB	ASM	2,097,228	29.3
	OBDII	4,820,057	67.5
	TSI	228,462	3.2
	Total	7,145,747	100.0

Table 4-5 shows the number of vehicles receiving at least one I/M test during the evaluation period.

Table 4-5. Number of Vehicles Receiving at least One Emissions Test

I/M Program Area	Emission Test Type	Counts	Percent
DFW	ASM	1,322,873	30.6
	OBDII	2,829,260	65.5
	TSI	164,393	3.8
	Total	4,136,516	100.0
HGB	ASM	1,105,838	29.4
	OBDII	2,430,597	65.7
	TSI	165,404	4.5
	Total	3,701,839	100.0

[26] This section responds to part of the Work Plan's Task 3 Element 1A: Inspection Statistics – Number of Vehicles Inspected by Inspection Type and was written by T.J. Petroski.

Table 4-6 shows the number of passes and fails and the fail fraction along with the number of emissions tests (including ASM, OBDII, and TSI) performed in each I/M Program Area.

Table 4-6. Emission Test Pass/Fail Counts

I/M Program Area	Emission Test Type	Pass/Fail Status	Counts	Fail Fraction
DFW	ASM	Fail	268,144	0.107
		Pass	2,240,336	
	OBDII	Fail	226,591	0.041
		Pass	5,317,486	
	TSI	Fail	14,199	0.062
		Pass	215,170	
HGB	ASM	Fail	243,656	0.116
		Pass	1,848,105	
	OBDII	Fail	232,218	0.048
		Pass	4,581,578	
	TSI	Fail	13,266	0.058
		Pass	214,477	

We also looked at the emission test types within I/M cycles to determine whether emission test types changed mid-cycle. For about 99.75% of the I/M cycles the same emissions test type was performed throughout the duration of the cycle.

Figures 4-11 and 4-12 show the distributions of numbers of vehicles by model year for each emission test type for the DFW and HGB I/M Program Areas, respectively. There is a noticeable transition between the 1995 and 1996 model year vehicles. This sudden change occurs because OBD II tests are conducted on 1996 and newer model year vehicles while ASM tests are conducted on 1995 and older model vehicles. TSI tests are performed on vehicles such as those with all-wheel drive that cannot be tested on a dynamometer. The figures show that the VID contains a small number of apparent OBDII inspections on pre-1996 vehicles, which do not have OBDII capability. We do not know the reason for these observations, but whatever the reason, the trend is very minor in this large VID dataset.

Figure 4-11. Count of Emission Test Types by Model Year for DFW

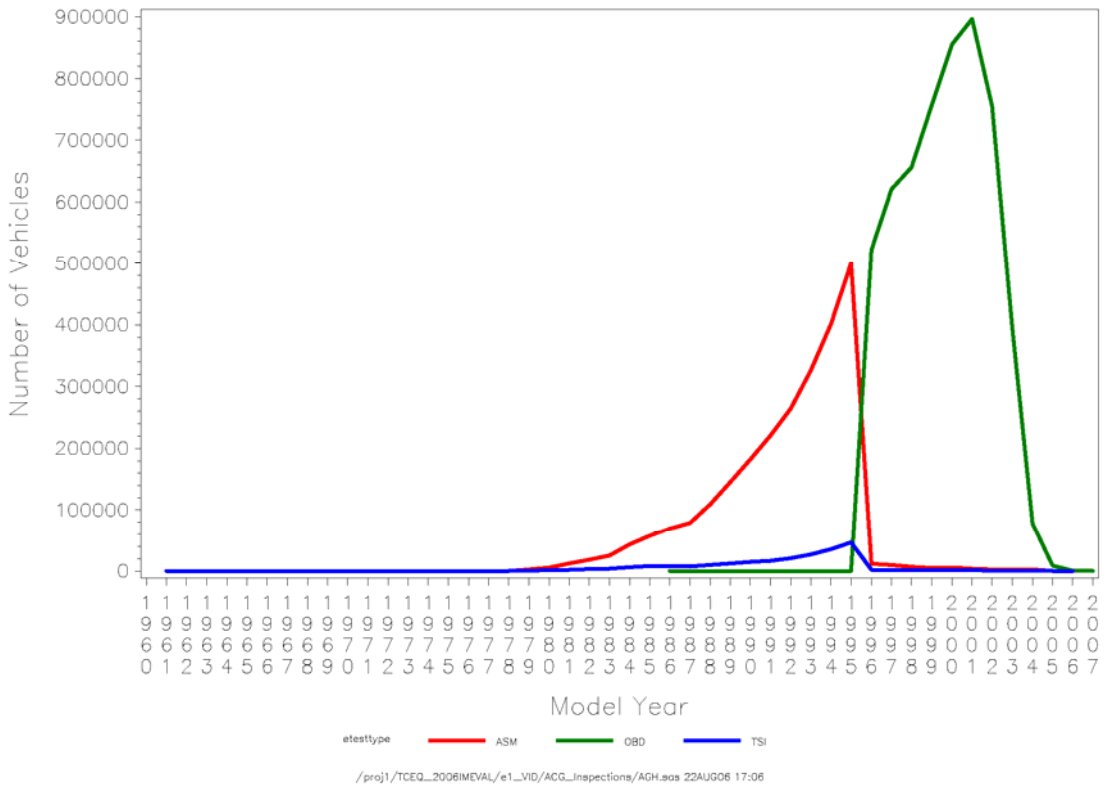
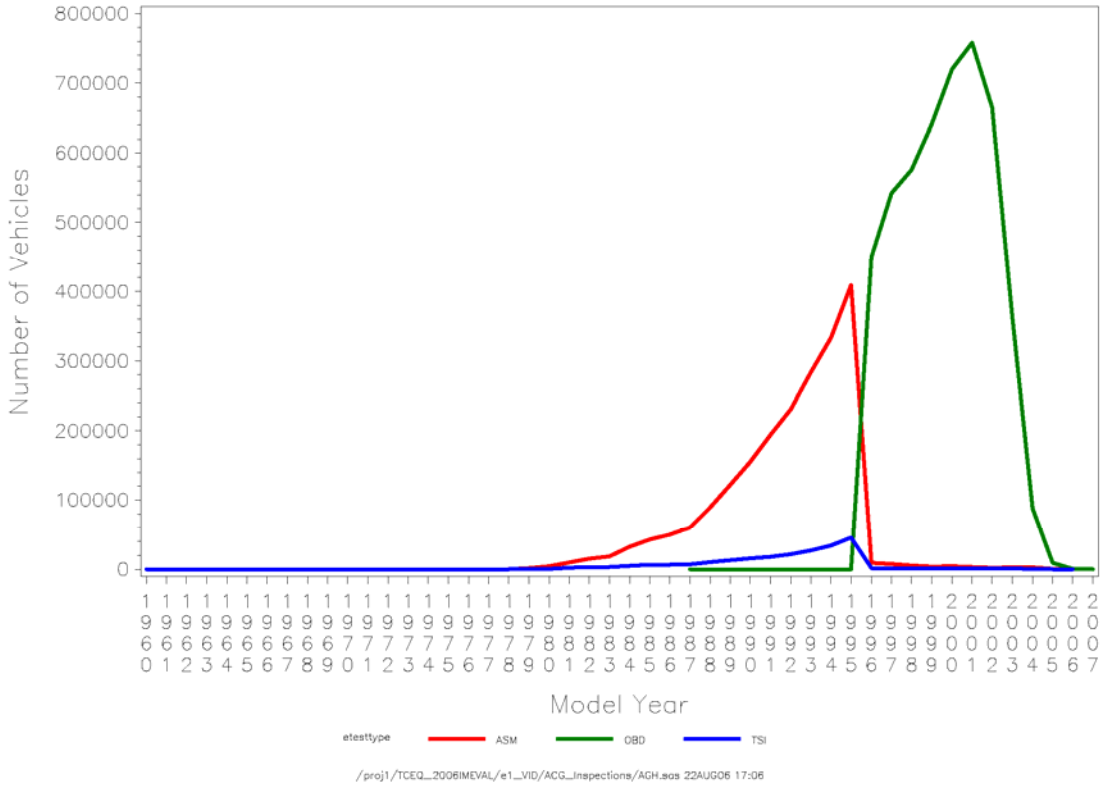


Figure 4-12. Count of Emission Test Types by Model Year for HGB



Figures 4-13 and 4-14 show the number of vehicles tested by month and by year for the DFW and HGB I/M program areas, respectively. The number of tests conducted each month is not the same from month to month, in both I/M areas for all years. There tends to be a peak in April and a low in November. In both Figures 4-13 and 4-14 the counts of vehicles tested begins in May 2003, which is the beginning of the evaluation period. The figures show a gradually increasing trend in number of inspections for 2003, 2004, and 2005 as the fleet grows.

Figure 4-13. Emission Test by Month Year for DFW

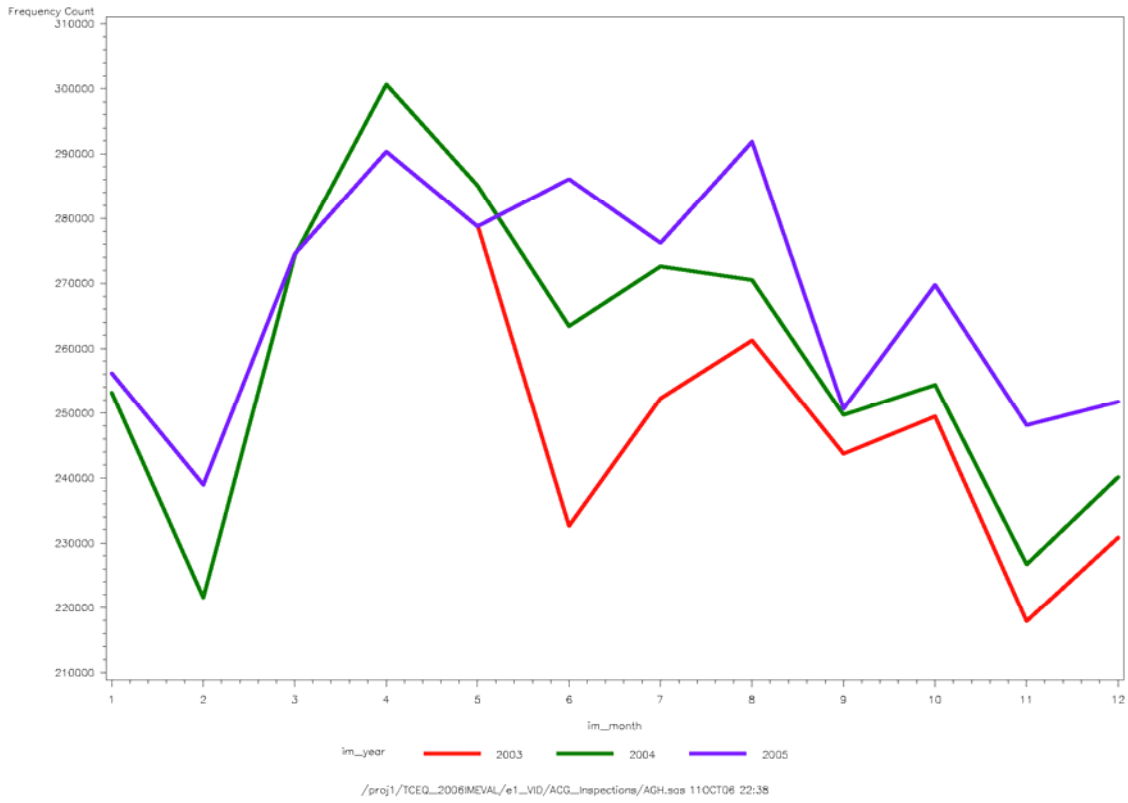
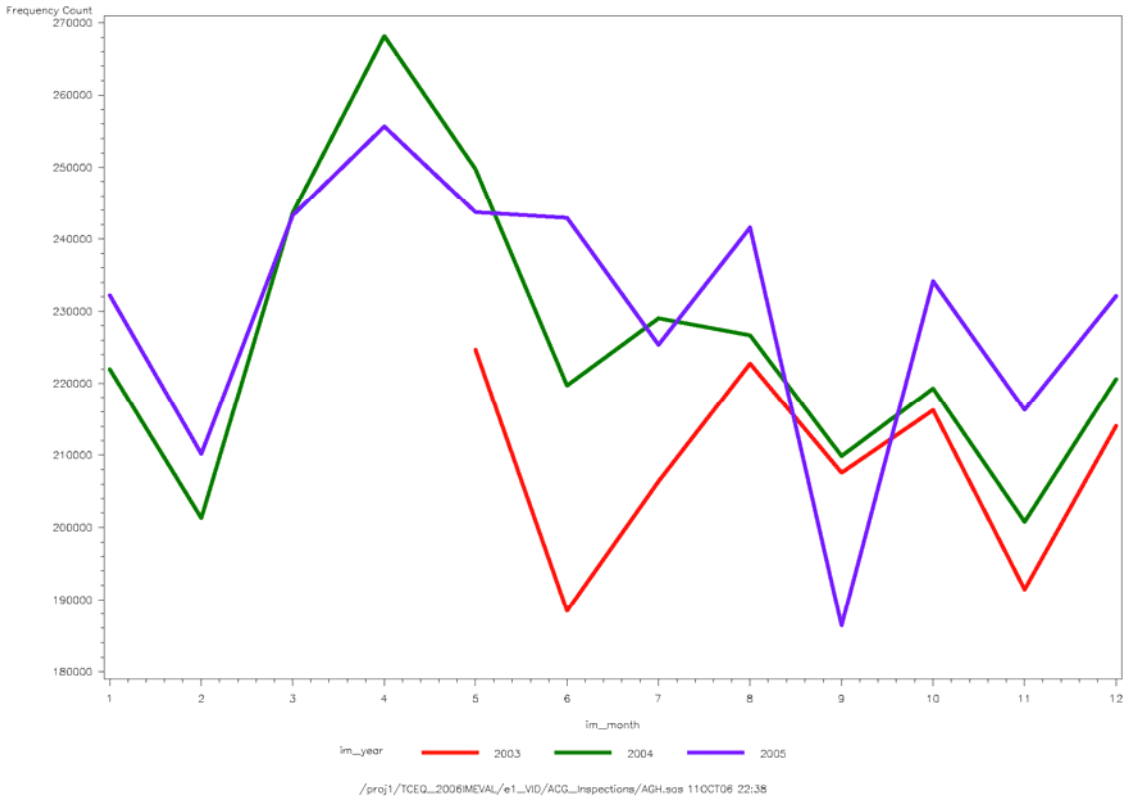


Figure 4-14. Emission Test by Month Year for HGB



4.3 Repeat I/M Failure Patterns[27]

We examined the Texas VID to determine the patterns of repeated I/M failures. This is part of the demonstration of the extent and properties of repairs that the I/M program causes to occur. This is a process-based measure for repair.

The dataset for this analysis was created by snipping out a piece of the historical VID from May 2003 to December 2005. This snipping also snips the I/M inspection histories of some individual vehicles. To distinguish and handle partial and complete individual vehicle histories, we developed four I/M cycle categories as defined in Appendix A:

1) Initial test (first time GroupID is encountered) occurred during the first three months of the dataset, but unsure whether it is a true initial test (i.e., the true initial test may have occurred prior to May 1, 2003) AND the Final test is a Certified[28] test.

2) Initial test (first time GroupID is encountered) occurred during the first three months of the dataset, but unsure whether it is a true Initial test AND the Final test is NOT a Certified test.

3) Initial test (either definition applies) occurs after the first three months of the dataset and assumed to be a true Initial test AND the Final test is a Certified test.

4) Initial test (either definition applies) occurs after the first three months of the dataset and assumed to be a true Initial test AND the Final test is NOT a Certified test.

Every vehicle that participates in the I/M program produces a brief history when it is inspected, repaired, and retested. Ideally, we want vehicles to be tested and pass if they are in proper working condition and if they are not, we would expect them to be failed, repaired once, tested, and passed immediately. If all vehicles in the inspected fleet had only one of these two possibilities, we could conclude that the accuracy of the I/M measurements and the efficacy of the repairs made to Texas vehicles were top notch. The actual test-repair sequences of real I/M programs were determined by an analysis of the VID data and, in general, produced many more possibilities besides the ideal two scenarios. For example, a sequence that is fail, fail, fail, pass can indicate that either the motorist is "shopping around" for a passing result or that the repairs done to the vehicle were inadequate, or that the emissions test was inaccurate.

[27] This section responds to the Work Plan's Task 3 Element 1G: Repeat I/M Failure Patterns and was written by T.J. Petroski.

[28] In this report we use the term Certified test to designate an I/M inspection in which the vehicle was issued a certificate, that is, a windshield sticker, for having completed and met the I/M program inspection requirements.

Each vehicle was tested at an I/M station on one or more occasions. The VID does contain a variable that gives the type of test (Initial or Retest) and a variable that gives the result of the emissions test (Pass or Fail). The type of test variable has special rules for designating whether a test is an Initial or a Re-test. For the purposes of determining failure patterns, we did not consider whether the test was designated by the VID as an initial or retest. In the I/M sequences that we built, we considered the first test after the last certifying test as an initial test, and any test after the initial up to an including the certifying test is a retest. We designated failures with an “F” and passes with a “P”.

For each unique GroupID (=VIN, see Appendix A), the designators were concatenated in chronological order to create a sequence that describes the failure pattern that each vehicle experienced during a I/M testing cycle. For example, for a vehicle that initially failed and then passed on a re-test, the test sequence would be “FP”. The frequency distribution of the resulting test sequences for completed I/M cycles (I/M Cycle Category = 3) is shown in Tables 4-7 and 4-8 for DFW and HGB, respectively.

Table 4-7. Frequency Distribution of Test Sequences for DFW for I/M Cycle Category = 3

Test Sequence	Vehicle Frequency	% of Vehicles
P	6,422,903	94.505
FP	340,752	5.014
FFP	16,900	0.249
PP	13,101	0.193
FFFP	940	0.014
F	490	0.007
PFP	480	0.007
FF	340	0.005
FPP	177	0.003
PPP	72	0.001
FFF	71	0.001
FFFFP	60	0.001
13 Other Test Sequences	69	0.001
Total	6,796,355	100.000

Table 4-8. Frequency Distribution of Test Sequences for HGB for I/M Cycle Category = 3

Test Sequence	Vehicle Frequency	% of Vehicles
P	5,488,458	93.887
FP	326,248	5.581
FFP	16,855	0.288
PP	11,762	0.201
FFFP	939	0.016
PFP	426	0.007
F	394	0.007
FF	233	0.004
FPP	174	0.003
FFF	97	0.002
FFFFP	72	0.001
PPP	65	0.001
17 Other Test Sequences	88	0.001
Total	6,682,225	100.000

In Table 4-7, the distribution shows that the top five most frequently found sequences accounted for 99.97% of the vehicles tested in DFW. In Table 4-8, the distribution shows that the top five most frequently found sequences accounted for 99.97% of the vehicles tested in HGB. Some of these sequences raise questions. Why are approximately 0.20% of the vehicles

tested a second time after they pass initial in both I/M program areas? One explanation is that a vehicle goes to one station and passes its emissions test, but fails its safety test. Rather than returning to the same station, the vehicle goes to another station, but needs to be completely tested again even though it failed just the safety portion at its previous test. Analysis of the PP sequences shows that 75% of them take less than 90 days to complete indicating either these vehicles are returning to the same station more than 15 days later to get retested or are getting retested at another inspection station. Another 10% of the PP sequences are separated by about a year indicating that these sequences should be split into two P sequences, but the first passing test was not certified.

Approximately, 13 and 17 less common sequences accounted for the remaining 0.03% of the tested fleets in DFW and HGB. Many of these remaining sequences seem to be unlikely, and these sequences account for only 157 vehicles of the more than 13 million in the dataset. We suspect that these sequences represent database data entry problems instead of real situations. While better inspection database systems could reduce the occurrence of these unlikely test sequences, the problem is very minor.

Tables 4-7 and 4-8 showed the results for the third I/M cycle category separated into the HGB and DFW fleets. Tables 4-9 through 4-11 show the first, second, and fourth I/M cycle categories for the combined fleet.

The test sequences for the first I/M cycle category in Table 4-9 look very similar to the sequences in Tables 4-7 and 4-8. Many of these cycles are probably complete and certified cycles with the true initial tests occurring in the dataset, but uncertainty remains without examining the VID data prior to May 1, 2003. The test sequences for the second and fourth I/M Cycle Categories in Tables 4-10 and 4-11 consist of many more sequences that end in a Fail as expected since these are not certified cycles. Approximately 89% of the sequences are either a single Fail or Fail-Fail. The 9 to 10% of single uncertified passes may be due to grouping errors (See Group ID in Appendix A).

Table 4-9. Frequency Distribution of Test Sequences for I/M Cycle Category=1

Test Sequence	Vehicle Frequency	% of Vehicles
P	1,593,941	91.90
FP	122,851	7.08
FFP	9,978	0.58
PP	5,508	0.32
FFFP	728	0.04
FF	534	0.03
PFP	312	0.02
F	191	0.01
FFF	118	0.01
FPP	112	0.01
13 Other Test Sequences	162	0.01
Total	1,734,435	100.00

Table 4-10. Frequency Distribution of Test Sequences for I/M Cycle Category=2

Test Sequence	Vehicle Frequency	% of Vehicles
F	13,244	82.50
P	1,479	9.21
FF	1,122	6.99
FFF	113	0.70
FP	32	0.20
PF	33	0.21
FFFF	11	0.07
PP	8	0.05
FFP	3	0.02
3 Other Test Sequences	8	0.05
Total	16,053	100.00

Table 4-11. Frequency Distribution of Test Sequences for I/M Cycle Category=4

Test Sequence	Vehicle Frequency	% of Vehicles
F	80,887	83.38
P	10,580	10.91
FF	4,731	4.88
FFF	359	0.37
PF	183	0.19
FP	158	0.16
FFFF	33	0.03
PP	52	0.05
FFP	8	0.01
FPF	9	0.01
PFF	7	0.01
3 Other Test Sequences	8	0.01
Total	97,015	100.00

4.4 Emissions Analyzer Data Quality[29]

The goal was to demonstrate the accuracy of the emissions inspection methods. This is a process-based measure for inspection. The following four I/M analyzer checks were made using Texas VID data:

- Drift,
- Dilution Correction Factors,
- Gas Audits, and
- Lockouts.

4.4.1 Analyzer Drift

Texas I/M program emissions analyzers are calibrated every 72 hours. The calibration is done using the analyzer to measure a bottled calibration gas mixture with a concentration that is known within a specified precision. Before a calibration is performed, a pre-calibration measurement on the calibration gas is made and recorded in the VID for HC, CO, NO, O_2, and CO_2 gases. The difference between the pre-calibration analyzer reading and the labeled concentration of the gas mixture is a direct measure of instrument drift. If the analyzer has not drifted since the last calibration, its readings for the calibration gas will be close to the bottle label value, and little calibration adjustment will be necessary. This fact can be used to develop an indicator of analyzer calibration stability. Analyzers that consistently drift little from calibration to calibration can be expected to produce more accurate measures of vehicle emissions than those that drift greatly. If the difference between the bottle label value and the pre-calibration analyzer reading is very large, then we presume that some of the emissions measurements made during the previous 72 hours were more inaccurate than necessary.

Calibration Procedures and Specifications

In each 3-day calibration, the analyzer first records pre-calibration readings for HC, CO, CO_2, and NO for zero, low-span, and mid-span bottle gases, and for O_2 with ambient air. The analyzer is then calibrated on the mid-span gases to within 1% of the bottle gas values. Next, the analyzer is tested on the low-span gases, and must fall within 2% of the bottle gas value. If the analyzer cannot be brought within specifications during the calibration, the instrument is

[29] This section responds to the Work Plan's Task 3 Element 1B: Evaluate VID Analyzer Data for Quality and was written by C.F. Palacios.

automatically prohibited from performing any portion of an I/M test until it is successfully adjusted.

Table 4-12 shows the specified bottle gas values for the low-span and mid-span portions of the calibration. The bottled gases are permitted a 5% blend tolerance, which is also shown in the table. Finally, the table shows the specified accuracy of the analyzer for I/M inspections for each pollutant and gas level. These tolerances for I/M inspections are less stringent than the 1% mid-span and 2% low-span tolerances that are used for calibrations. The I/M inspection tolerances are applicable to this analysis of pre-calibration readings since we are concerned here with whether analyzer drift affected I/M inspection results just prior to calibration. As an example from the table, the low-span HC bottle gas concentration is specified to be 200 ppm, but may range between 190 and 210 ppm. If a bottle gas labeled to contain 195 ppm HC were used for a calibration, the analyzer would be required to read between 189 and 201 ppm in order to meet the specification.

Table 4-12. Calibration Span Gas Values and Tolerances

Gas	Specified Bottle Gas Concentration	Bottle Gas Blend Tolerance	Analyzer Tolerance for I/M Inspections
Zero Gas			
HC (ppm)	<1	Not applicable for zero gases	±4
CO (%)	<0.01		±0.02
NOx (ppm)	<1		±25
CO_2 (%)	<4.0		±0.3
O2 (%)	20.7		±1.04
Low-Span Bottle Gas			
HC (ppm)	200	±10	±6
CO (%)	0.5	±0.025	±0.02
NOx (ppm)	300	±15	±25
CO_2 (%)	6.0	±0.3	±0.3
Mid-Span Bottle Gas			
HC (ppm)	3200	±160	±160
CO (%)	8.0	±0.4	±0.24
NOx (ppm)	3000	±150	±120
CO_2 (%)	12.0	±0.6	±0.36

The actual concentrations of the bottle gases used in each calibration are recorded in the VID. More than 99.9% of calibration records include bottle gas label concentrations within the tolerances listed in Table 4-12. However, the remaining small fraction of records includes some surprisingly high and low bottle gas values, such as 62 records with zero percent or ppm for each of the low-span and mid-span concentrations. It is possible that the bottle gas concentration was entered incorrectly into the VID or that the outlying values represent real bottle gas mixtures that

were occasionally used. In either case, the calibration results are called into question when the analyzer reading is compared to out-of-specification bottle gas label values. To eliminate this issue in future calibration records, ERG recommends that TCEQ restrict the inspector-entered bottle gas values to a range that corresponds to the specifications. Thus, the VID software would not allow a calibration to proceed unless reasonable bottle gas values were entered.

Results

792,749 span test calibration records from the VID between May 2003 and December 2005 were available for this analysis. 677 records with missing station ID or analyzer ID information were deleted, leaving 792,072 records in the dataset.

The calibration dataset included records for the entire state, rather than just the Dallas/Fort Worth and Houston/Galveston/Brazoria areas of interest. It was found that calibration records from analyzers located outside the DFW or HGB (i.e., in areas using only TSI inspections rather than ASM inspections) contained only missing information for all NO results, or only zero values for all NO results, for all calibrations by that analyzer. These 77,846 out-of-area records were deleted, leaving 714,226 records in the dataset.

Finally, an additional 23,348 records where the pre-calibration reading for each gas and level was zero were deleted, leaving 690,878 records in the dataset. Although these records contain no span gas calibration readings, each does include a pass or fail result for the span gas calibration. Some of these records do contain dynamometer calibration information, and some contain a pass or fail result for the leak check, so they might just be records for calibration events that did not include a span gas calibration. However, if that is the case, the VID software should not allow a pass/fail result to be recorded for the span gas audit.

Figures 4-15 through 4-28 each show the distribution of the difference between the analyzer reading and the labeled value of the bottle gas, for one gas type/concentration level combination. For the zero level readings, the difference between zero and the recorded concentration is shown. The calibration records for O_2 have been divided into two separate groups for Figures 4-19 and 4-20. The pre-calibration value of O_2 is supposed to be 20.7%, for the O_2 content of ambient air. It was found that analyzers with manufacturer codes of SE, JB, and WW measured near 20.7% O_2 in more than 99% of calibrations, while analyzers with the manufacturer code ES measured less than 3% O_2 in more than 97% of calibrations. It may be that ES analyzers are designed to measure O_2 from bottle gas (perhaps the CO/HC bottle that contains zero O_2) during calibrations, instead of ambient air as specified. Since the tolerance for the analyzer is tighter at 0% O_2 than at 20.7% O_2, the two sets of readings are plotted separately.

All of the distributions show a clear peak at zero, indicating that many analyzers drift very little between 3-day calibrations. For many of the figures, almost the entire range of readings falls within the tolerance for that gas type/concentration level.

Figure 4-15. Distribution of Difference Between Zero and HC Pre-Calibration Reading

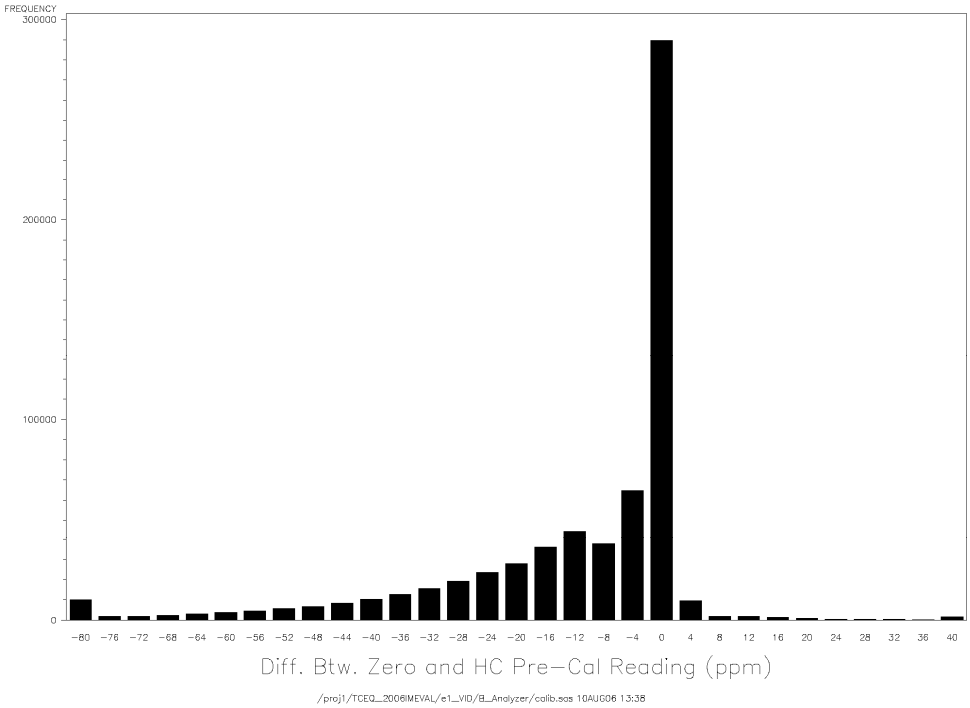


Figure 4-16. Distribution of Difference Between Zero and CO Pre-Calibration Reading

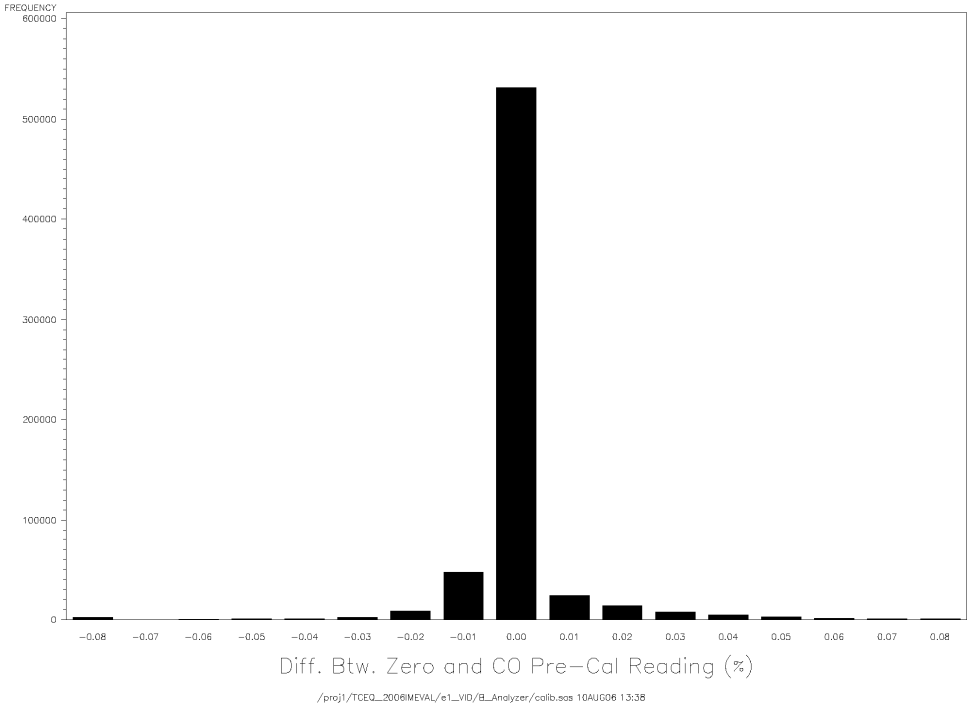


Figure 4-17. Distribution of Difference Between Zero and NX Pre-Calibration Reading

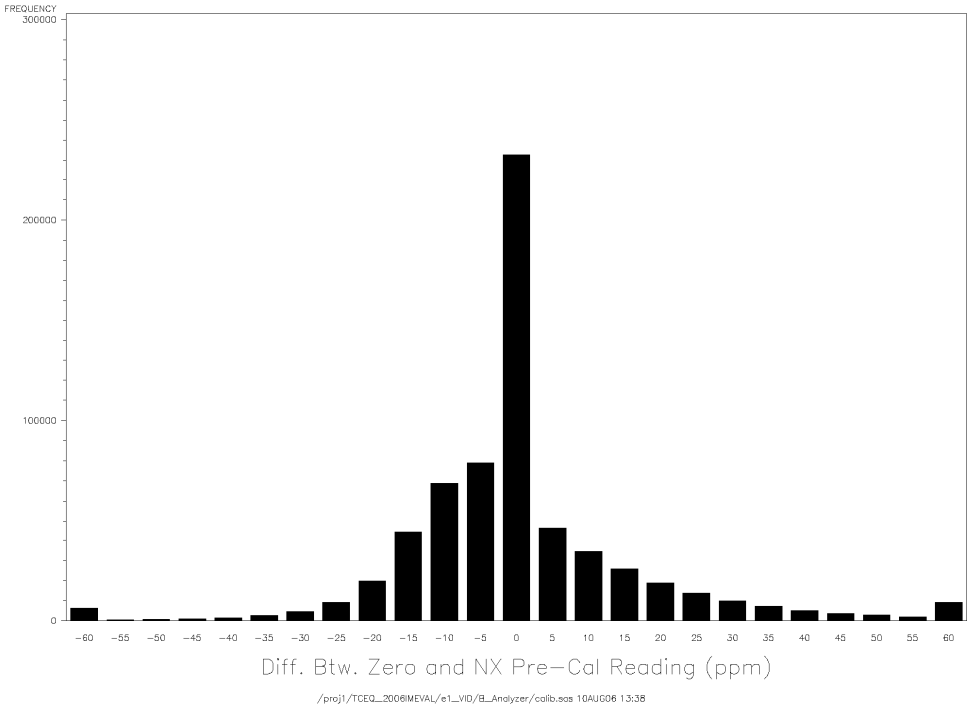


Figure 4-18. Distribution of Difference Between Zero and CO_2 Pre-Calibration Reading

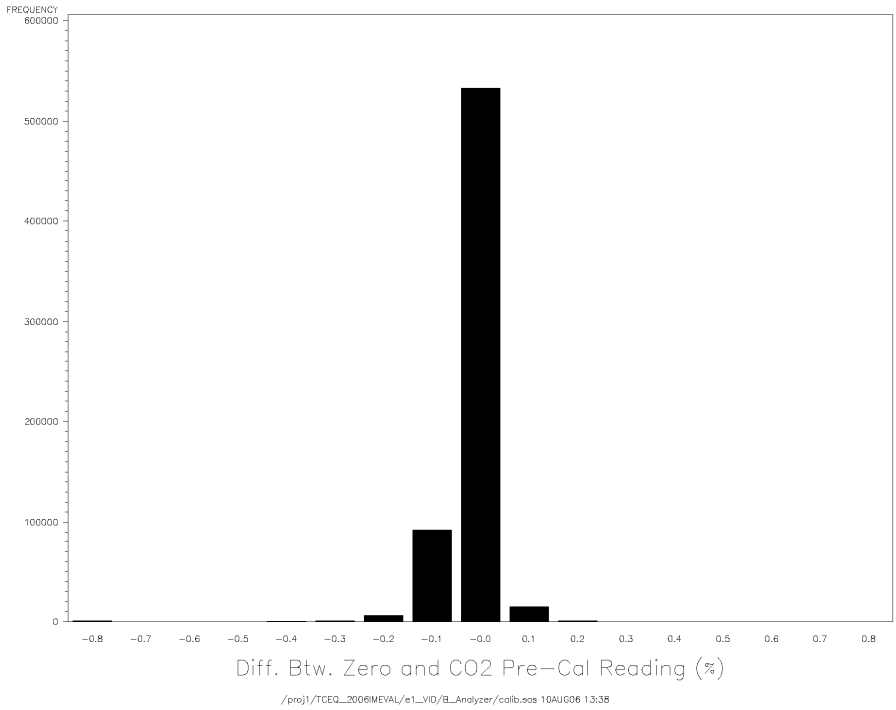


Figure 4-19. Distribution of Difference Between Zero and O_2 Pre-Calibration Reading

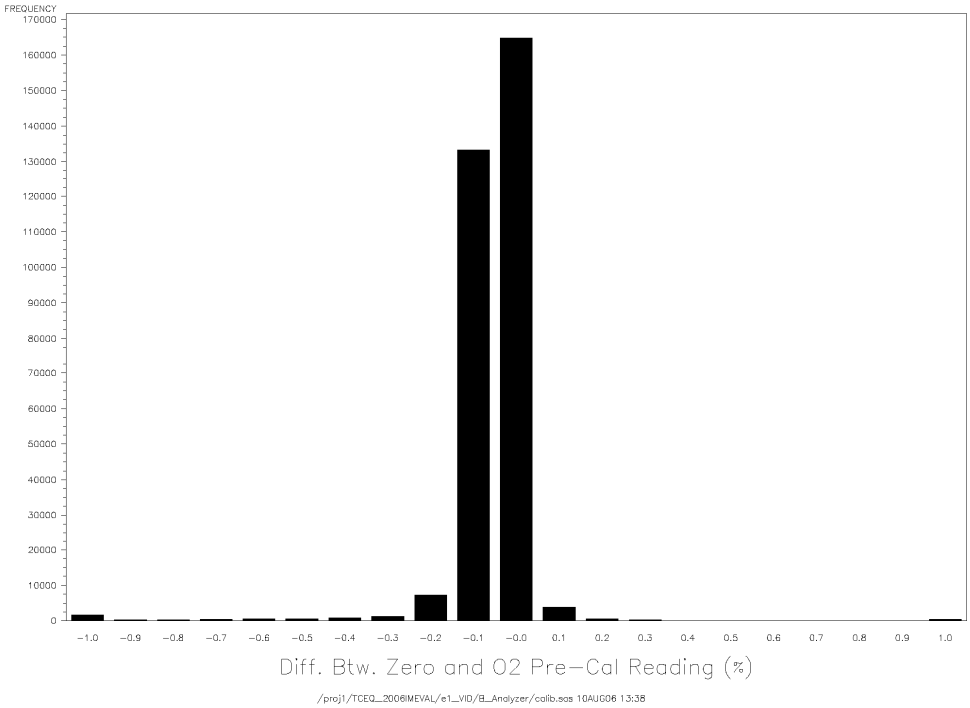


Figure 4-20. Distribution of Difference Between 20.7% and O_2 Pre-Calibration Reading

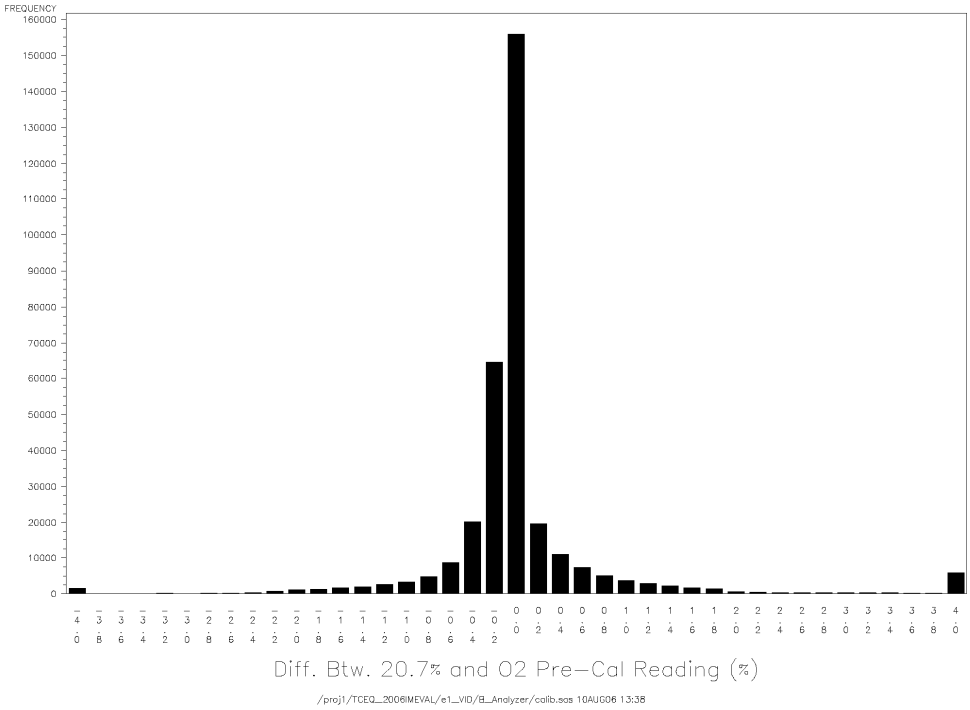


Figure 4-21. Distribution of Difference Between Low-Span Bottle and HC Pre-Calibration Reading

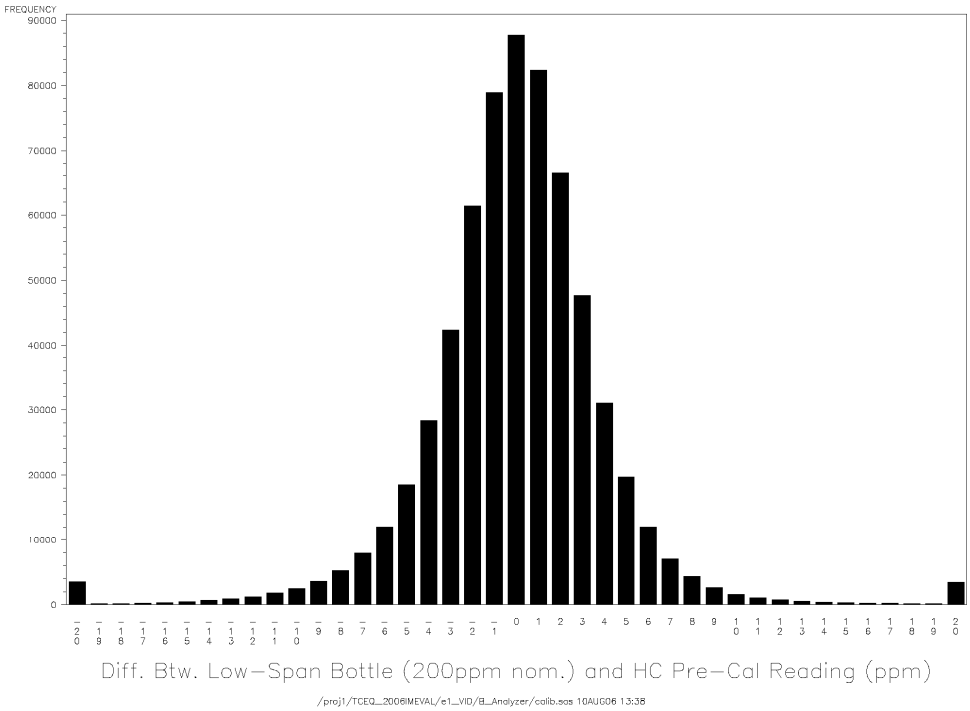


Figure 4-22. Distribution of Difference Between Low-Span Bottle and CO Pre-Calibration Reading

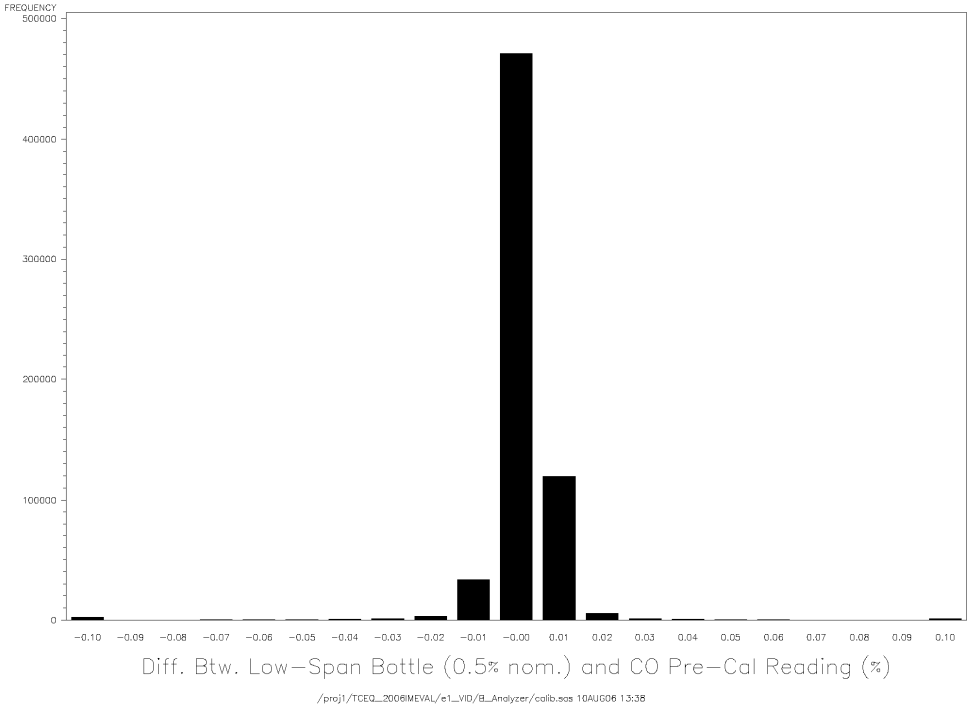


Figure 4-23. Distribution of Difference Between Low-Span Bottle and NX Pre-Calibration Reading

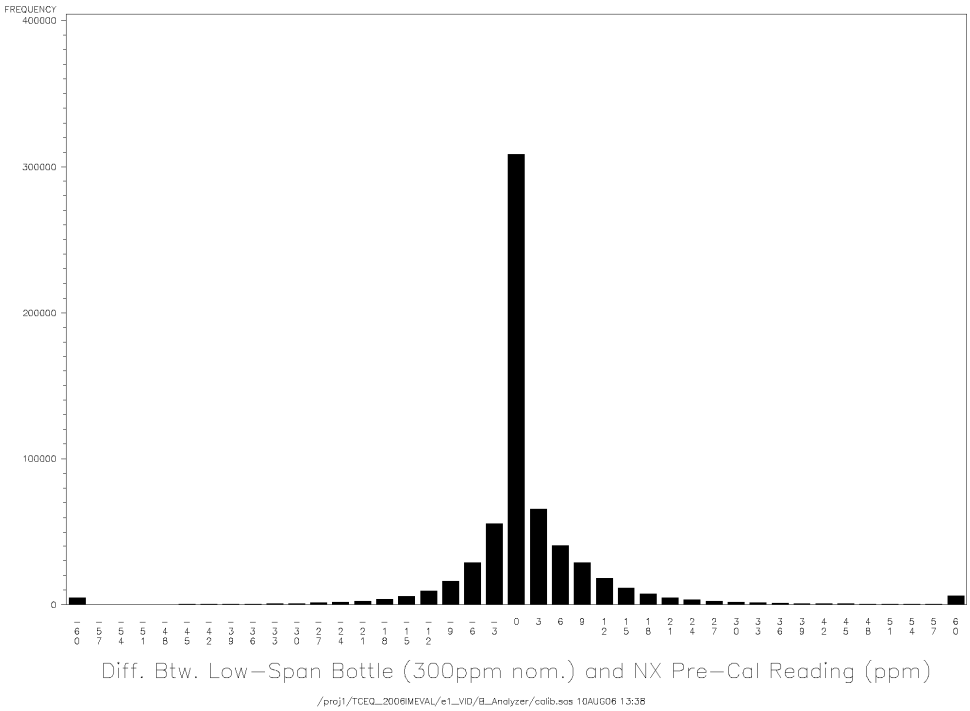


Figure 4-24. Distribution of Difference Between Low-Span Bottle and CO_2 Pre-Calibration Reading

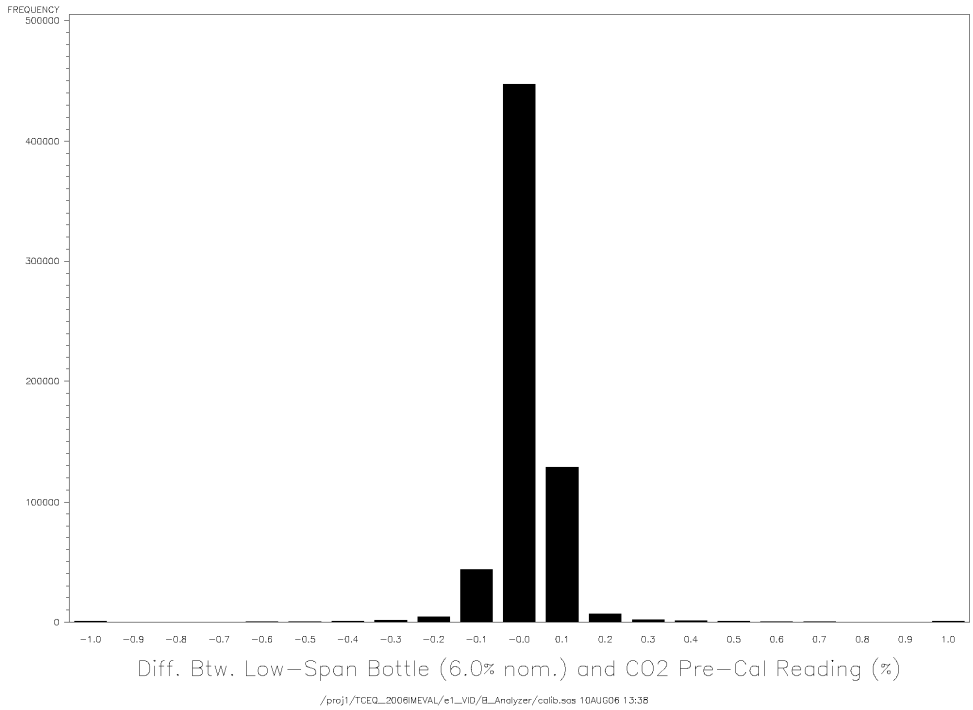


Figure 4-25. Distribution of Difference Between Mid-Span Bottle and HC Pre-Calibration Reading

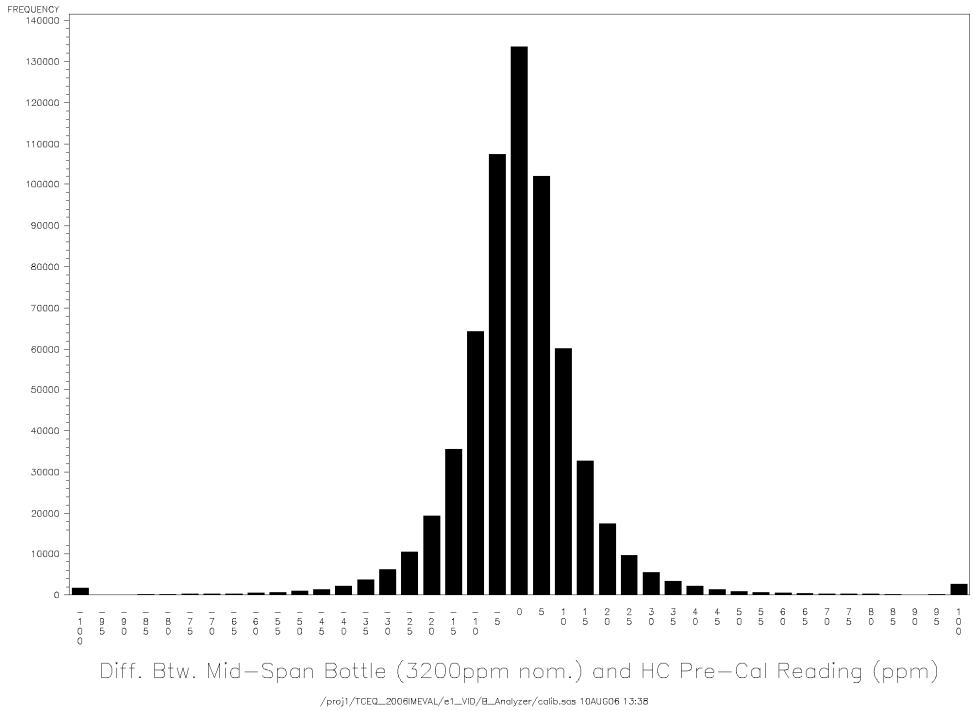


Figure 4-26. Distribution of Difference Between Mid-Span Bottle and CO Pre-Calibration Reading

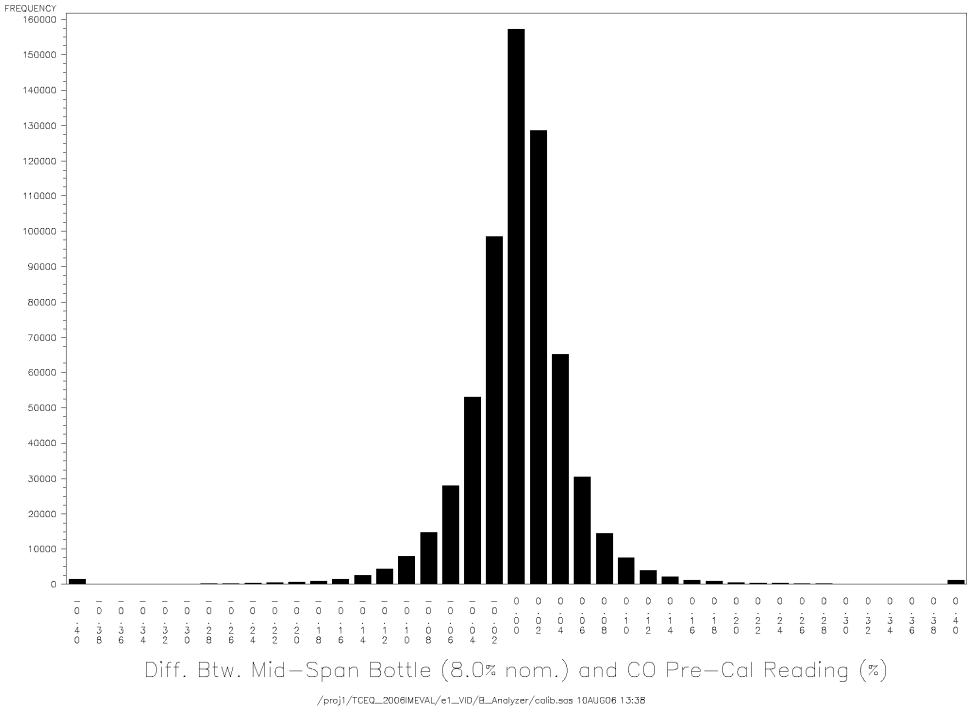


Figure 4-27. Distribution of Difference Between Mid-Span Bottle and NX Pre-Calibration Reading

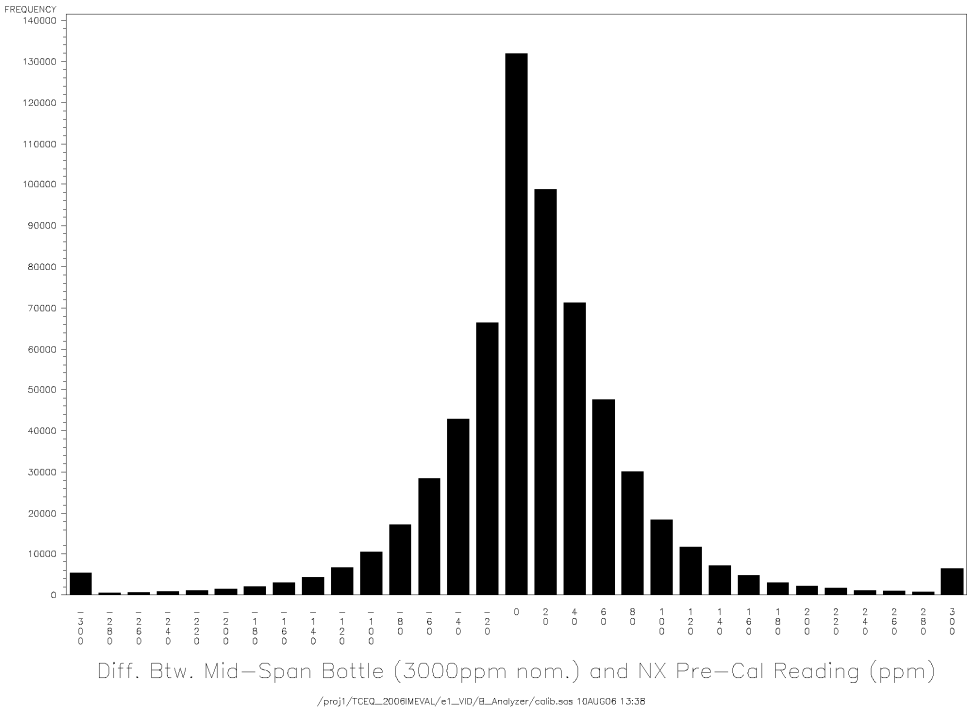


Figure 4-28. Distribution of Difference Between Mid-Span Bottle and CO_2 Pre-Calibration Reading

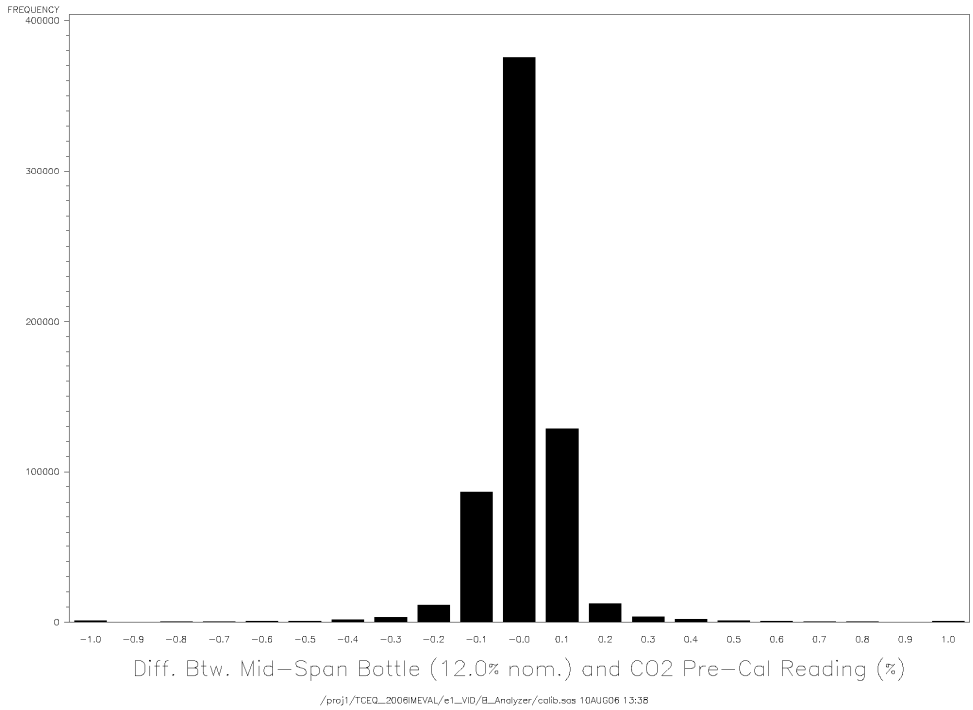


Table 4-13 shows the specified value and tolerance for each gas type/concentration level, the total number of pre-calibration records available at that level, the percent of records whose values fell within the tolerance bounds, and finally, the amount of difference from the specified value that would include 90% of calibration records (the 90th percentile).

Note that the total record counts vary by concentration level in Table 4-13. About 690,000 records were available at the zero level, but only 660,000 records at the low-span level. The reduction results from calibrations where the zero pre-calibration values were recorded, but not the low-spanvalues. For a similar reason, there are only 633,000 records available at the mid-span level. It is important to record the pre-calibration readings so that analyzer drift can be tracked, but it appears that not all portions of the pre-calibration data are recorded at every calibration event.

For almost all gas type/concentration level combinations, more than 85% of records fell within the tolerance of the analyzer. The exception is the zero level HC, where only 52% of records were within tolerance (the wide distribution can be seen in Figure 4-15 as well). This tells us that results for more than 85% of I/M inspections performed just before the calibration can be expected to be within instrument tolerance (except for very low values of HC).

Table 4-13. Number and Percent of Pre-Calibration Records Occurring Outside Analyzer Tolerance

Gas	Specification	Total Number of Pre-Cal Records	Within Tolerance		90th Percentile
			N	%	
Zero Gas					
HC (ppm)	0±4	690,878	363,132	52.6	37
CO (%)	0.00±0.02	690,878	665,438	96.3	0.01
NOx (ppm)	0±25	690,878	623,035	90.2	25
CO_2 (%)	0.0±0.3	690,878	688,751	99.7	0.1
O_2 (%)	0.0±0.1	317,350	302,873	95.4	0.1
O_2 (%)	20.7±1.04	373,528	323,555	86.6	1.5
Low-Span Gas					
HC (ppm)	200±6	660,358	604,660	91.6	6
CO (%)	0.50±0.02	660,417	640,728	97.0	0.01
NOx (ppm)	300±25	646,844	619,095	95.7	14
CO_2 (%)	6.0±0.3	660,433	650,327	98.5	0.1
Mid-Span Gas					
HC (ppm)	3200±160	633,644	630,637	99.5	22
CO (%)	8.00±0.24	633,702	628,645	99.2	0.07
NOx (ppm)	3000±150	632,935	576,601	91.1	113
CO_2 (%)	12.00±0.36	633,700	622,707	98.3	0.1

4.4.2 Analyzer Dilution Correction Factors

For every ASM emissions test, a dilution correction factor based on the measured CO and CO_2 concentration is calculated. Dilution correction factors (DCFs) can also be calculated based on the measured O_2 concentration. The dilution correction factors from these two separate sources of tailpipe emissions should be within agreement with a relatively small tolerance. With those emissions tests where the DCFs are not in substantial agreement, there is question about the accuracy of the emissions test. The analysis does not indicate which emission is in error but indicates that something is wrong with the CO, CO_2, or O_2 measurements. Unless all three of these pollutants are in agreement with respect to their corresponding dilution correction factors, the HC, CO, and NOx measurements reported by the instrument are in question. [Section 4.2.1.3 of Reference 1]

The measurement of exhaust emissions concentrations can be confounded by the dilution of the exhaust gas by non-optimal probe placement, leaking exhaust systems, cylinder misfires, and excess oxygen from air pumps. The Texas I/M program analyzers quantify the degree of dilution for each ASM or TSI inspection using measured CO and CO_2 concentrations to calculate a dilution correction factor (DCF). For this analysis, we recalculated the CO/CO_2 DCFs for the ASM and TSI inspections in the VID.

The CO/CO_2 DCFs are the official dilution correction factors; however, DCFs can also be calculated using the O_2 concentration measured at each emissions test. A comparison of CO/CO_2 DCFs with O_2 DCFs is just another way to check the emissions instruments. Therefore, we also calculated DCFs based on the measured O_2 concentration. The dilution corrections reported in the VID, the CO/CO_2 dilution corrections calculated by ERG, and the O_2 dilution corrections calculated by ERG should be within agreement with a relatively small tolerance. This analysis does not necessarily indicate which emission is in error but indicates that something is wrong with the CO, CO_2, or O_2 measurements. Unless all three of these pollutants are in agreement with respect to their corresponding dilution correction factors, the HC, CO, and NOx measurements reported by the instrument are in question.

Background

Assuming stoichiometric combustion of gasoline, an exhaust dilution correction factor can be estimated using a carbon mass-balance and the measurements of CO and CO_2. These constituents are measured in the non-dispersive infrared bench of the analyzer. The equations are based on the average composition of gasoline.

First, define the variable x:

$$x = \frac{CO_2}{CO_2 + CO}$$

where CO_2 and CO values are in percent.

Then the dilution factor, DCFCO/CO_2, is as follows:

$$DCF_{CO\,/\,CO2} = 100\frac{x/(4.64 + 1.88x)}{CO_2}$$

If a fuel other than gasoline were used, the 4.64 constant would be different. However, only gasoline-fueled vehicles will be considered in this analysis.

In addition, many emissions analyzers also measure exhaust gas oxygen concentration with an electrochemical cell. Assuming an ambient air oxygen concentration of 20.9%, the exhaust oxygen measurement can also be used to estimate dilution in the exhaust. A dilution correction factor based on the measured oxygen concentration O_2 is:

$$dcf_{O_2} = \frac{20.9}{20.9 - O_2}$$

This relationship assumes that the tailpipe oxygen concentration for stoichiometric combustion and no air in-leakage is 0.0% O_2. Field measurements indicate that new vehicles with no exhaust system leaks and operating at stoichiometric air/fuel ratio have 0.0% tailpipe oxygen concentrations.

If CO, CO_2, and O_2 are measured correctly, the independent DCFs (CO/CO_2 and O_2) for each vehicle inspection should agree well with each other. Previous studies have indicated that the difference between the two DCFs should be no larger than about ±0.14 [Reference 1].

Results

For this analysis, vehicle inspection records from the VID for vehicles tested in the Dallas/Fort Worth and the Houston/Galveston/Brazoria areas were used. Results for 5,760,671 inspections of gasoline-fueled vehicles that received either the ASM or the two-speed idle (TSI) test were available. 375,710 records were dropped due to flags that indicated the inspection had been aborted, timed out, or ended due to a dilution condition, leaving 5,384,961 records in the dataset for this analysis.

It was found that the VID variable indicating which inspection type was performed (ASM or TSI) was not always accurate. In a small number of cases, it indicated that an ASM inspection was performed, but the emissions concentration data in the record was for a TSI inspection, or vice-versa. Therefore the inspection type was determined by whether a record contained a non-zero, non-missing value for CO_2 for the ASM2525, ASM5015, low-idle TSI, or high-idle TSI. The presence of CO_2 indicates that combustion was taking place and being recorded. This resulted in a dataset with 4,907,483 records for the ASM 2525 test condition, 4,907,917 records for the ASM 5015 test condition, 476,108 records for the low-idle TSI inspection, and 475,188 records for the high-idle TSI inspection.

The CO/CO_2-basis DCF and the O_2-basis DCF were calculated for each inspection record, and then plotted against each other. Figure 4-29 shows a plot of the ASM2525 DCF based on CO/CO_2 versus the ASM2525 DCF based on O_2 for each ASM2525 test. Similar plots for ASM5015, low-idle TSI, and high-idle TSI results are shown in Figures 4-30, 4-31, and 4-32. In each plot, most of the points fall near the 1:1 line as expected, and the degree of scatter around the 1:1 line is relatively low. However, in addition to the points clustered on the 1:1 line, the four plots also a smaller horizontal ray ($DCFCO/CO_2 \approx 1$ while DCFO2 increases) and vertical ray ($DCFO2 \approx 1$ while $DCFCO/CO_2$ increases). This is especially noticeable in Figures 4-31 and 4-32, for the TSI records. Points at a distance from the 1:1 line may represent analyzer sensors for CO, CO_2, or O_2 that are broken or out of calibration, data entry errors, or other anomalies. Some of the reasons for these out-of-line points will be discussed in further detail in the sub-sections below.

Figure 4-29. Comparison of ASM2525 DCFCO/CO_2 and DCFO2

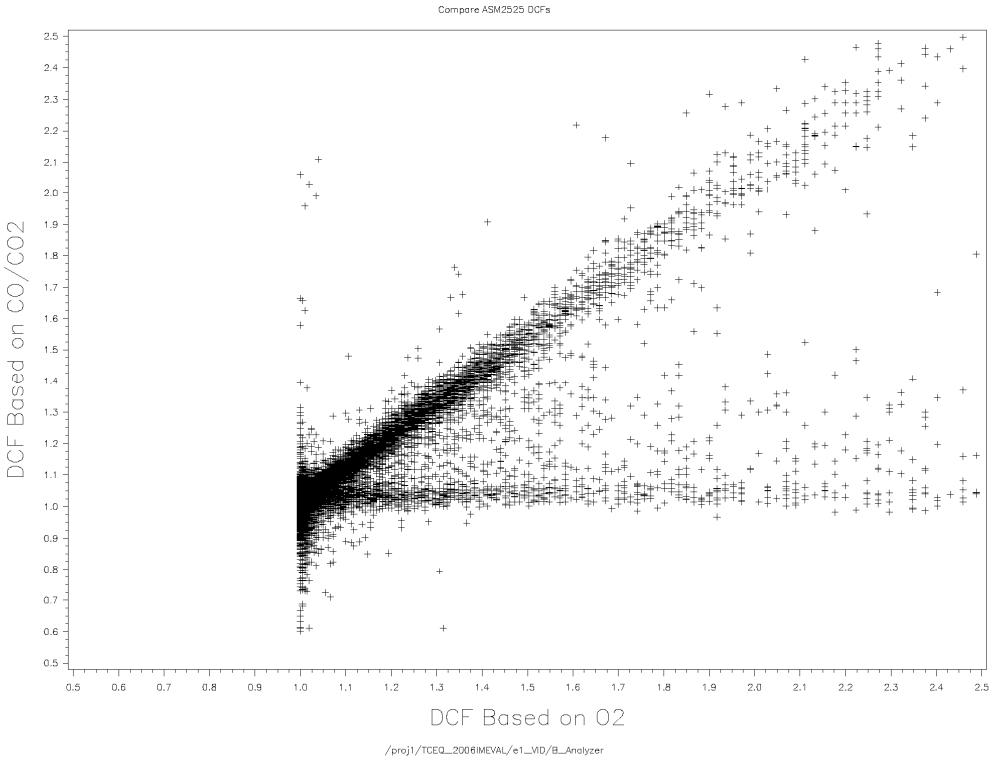


Figure 4-30. Comparison of ASM5015 DCFCO/CO_2 and DCFO2

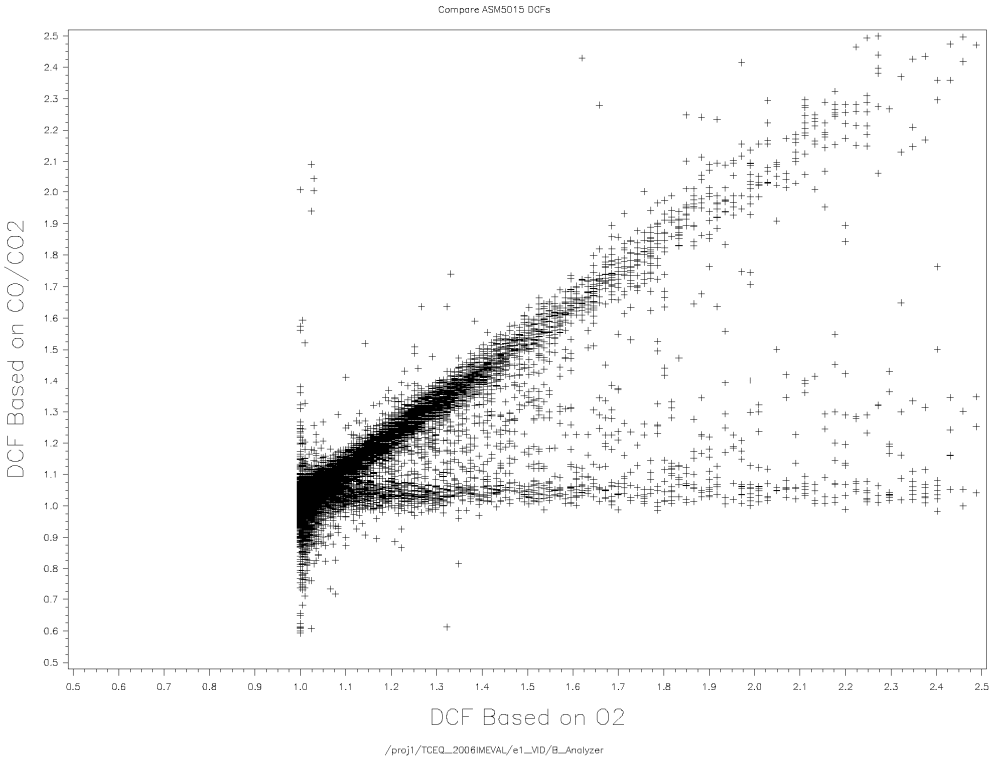


Figure 4-31. Comparison of Low-Speed Idle TSI DCFCO/CO_2 and DCFO2

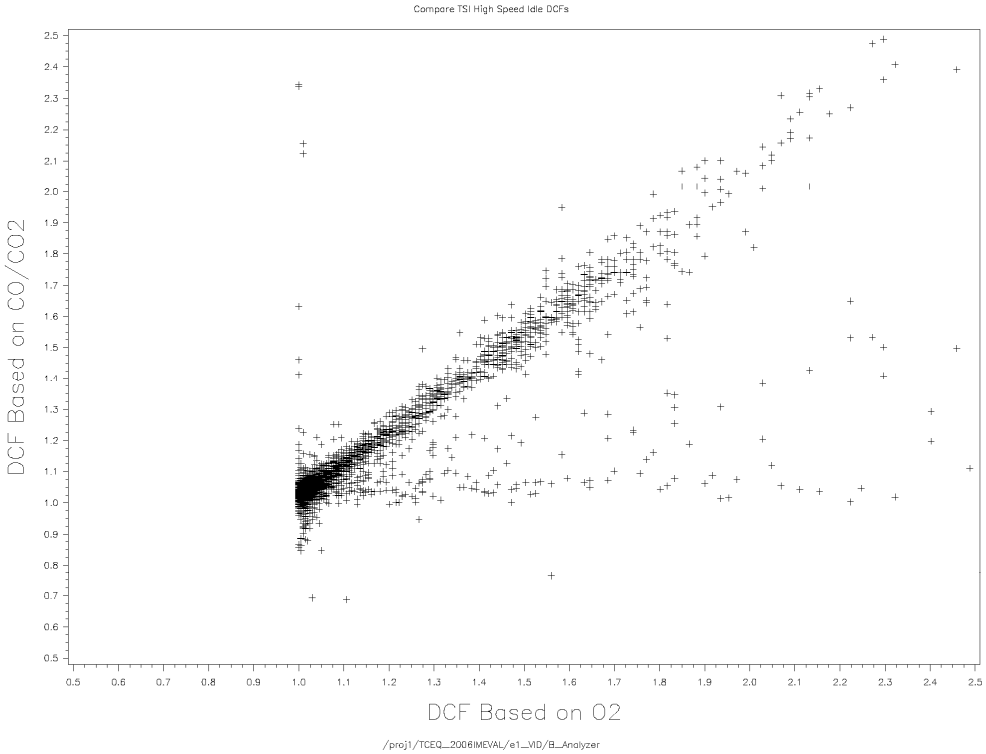
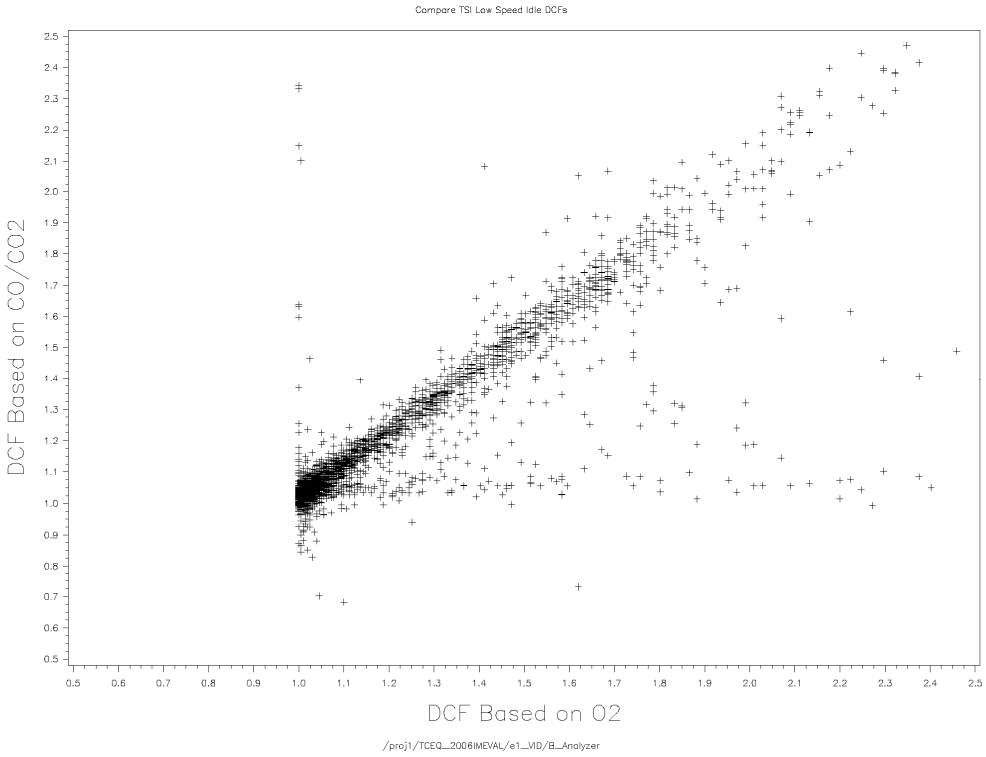


Figure 4-32. Comparison of High-Speed Idle TSI DCFCO/CO_2 and DCFO2



The information presented graphically in Figures 4-29 through 4-32 is quantified in Table 4-14. For each inspection record, the difference between the CO/CO_2-basis DCF and the O_2-basis DCF was calculated. The table shows the number and percentage of records that fall into six levels of DCF difference, for each type of inspection. As noted above, previous studies have found that this difference should be no more than about ±0.14. It can be seen from Table 4-14 that for the ASM inspection, more than 90% of records have a difference of less than 0.14. For the TSI inspection records, slightly less than 90% have a difference of less than 0.14.

Table 4-14. Distribution of Differences Between DCFCO/CO_2 and DCFO2

Test Type	<0.01	0.01-0.14	0.14-0.3	0.3-1.0	1-10	>10	Total
ASM2525	1,045,159 21.3%	3,497,309 71.3%	60,733 1.2%	51,160 1.0%	60,816 1.2%	192,306 3.9%	4,907,483 100%
ASM5015	1,147,305 23.4%	3,383,795 69.0%	63,989 1.3%	55,109 1.1%	83,293 1.7%	173,989 3.5%	4,907,480 100%
TSI Low	81,270 17.1%	338,252 71.1%	11,515 2.4%	7,611 1.6%	9,451 2.0%	28,009 5.9%	476,108 100%
TSI High	82,471 17.4%	339,772 71.5%	8,765 1.8%	7,074 1.5%	9,176 1.9%	27,930 5.9%	475,188 100%

The VID contains a DCF based on CO/CO2 for the ASM2525 and ASM5015 test cycles. The VID DCFCO/CO_2 was compared to the DCFCO/CO2 calculated by ERG. Results are shown in Table 4-15. It was expected that agreement would be extremely close, since the same two emissions concentrations (CO and CO_2) were used for the VID calculation and the ERG calculation. It can be seen from Table 4-15 that agreement was very good; more than 99% of records had a difference of less than 0.14.

Table 4-15. Distribution of Differences Between ERG DCFCO/CO_2 and VID DCFCO/CO_2

Test Type	<0.01	0.01-0.14	0.14-0.3	0.3-1.0	1-10	>10	Total
ASM2525	4543938 92.6%	335761 6.8%	14162 0.3%	8146 0.2%	3188 0.1%	2288 <0.1%	4907483 100%
ASM5015	4,489,952 91.5%	391,411 8.0%	12,709 0.3%	6,756 0.1%	4,089 <0.1%	2,563 <0.1%	4,907,480 100%

The VID record for each inspection contains an identification number for the analyzer used to perform the inspection. The first two characters of the analyzer identification number indicate the manufacturer of the analyzer. The distribution of differences between the DCFCO/CO_2 and the DCFO2 (both calculated by ERG, not from the VID) were compared by analyzer manufacturer, and some substantial differences were found, as shown in Table 4-16. The ES and WW analyzers both provide 95% of records with DCF differences of less than 0.14,

but the JB and SE analyzers have only 56% and 66% of differences that are less than 0.14. One of the reasons for these large differences was found to be related to problems with the O_2 sensor, which will be discussed in more detail below.

Table 4-16. Distribution of Differences Between DCFCO/CO_2 and DCFO2 by Analyzer Manufacturer, for ASM5051 Inspections

Analyzer Mfg. ID	<0.01	0.01-0.14	0.14-0.3	0.3-1.0	1-10	>10	Total
ES	695,942 27.1%	1,805,757 70.3%	20,447 0.8%	11,192 0.4%	13,959 0.5%	23,345 0.9%	2,570,642 100%
JB	2,933 5.1%	29,562 51.1%	676 1.2%	789 1.4%	6,753 11.7%	17,183 29.7%	57,896 100%
SE	36,224 5.7%	385,055 60.6%	13,587 2.1%	21,311 3.4%	49,221 7.8%	129,994 20.5%	635,392 100%
WW	412,206 25.1%	1,163,421 70.8%	29,279 1.8%	21,817 1.3%	13,360 0.8%	3,467 0.2%	1,643,550 100%

O_2 Emissions Concentration Anomalies

One factor that was found to cause problems with the DCF calculations was inaccuracy in the reported O_2 emissions concentrations. The tailpipe oxygen concentration for stoichiometric combustion and no air in-leakage would be 0.0% O_2, while the ambient air concentration of O_2 is assumed to be 20.9%. The percent of otherwise-valid inspection records that included O_2 concentrations greater than 20.5% is shown in Table 4-17, for each test condition. From the table, 3.3% of ASM and 5% of TSI records included suspicious O_2 concentrations, with tailpipe exhaust O_2 concentrations very close to or equal to ambient O_2 concentrations. These will cause the O_2-based DCF to have a very high (or undefined, at exactly 20.9% O_2) value.

Table 4-17. Number and Percent of Suspicious O_2 Concentrations by Test Mode

Test Type	O_2 >20.5%	O_2 <20.5%	Total
ASM2525	160,754 3.3%	4,746,750 96.7%	4,907,504 100%
ASM5015	162,114 3.3%	4,745,803 96.7%	4,907,917 100%
TSI Low	23,897 5.0%	452,263 95%	476,160 100%
TSI High	24,025 5.1%	451,215 94.9%	475,240 100%

It was also found that the rate of suspicious O_2 concentrations was much higher for two of the analyzer manufacturers than for the other two, as shown in Table 4-18. The ES and WW analyzers are responsible for 85% of inspection records, but only 15% of suspicious O_2

concentrations. It is possible that some differences among the analyzer types make it easier to avoid dilution using some analyzers than others.

Table 4-18. Number and Percent of Suspicious O_2 Concentrations (O_2 >20.5%), by Analyzer Manufacturer, for ASM5015

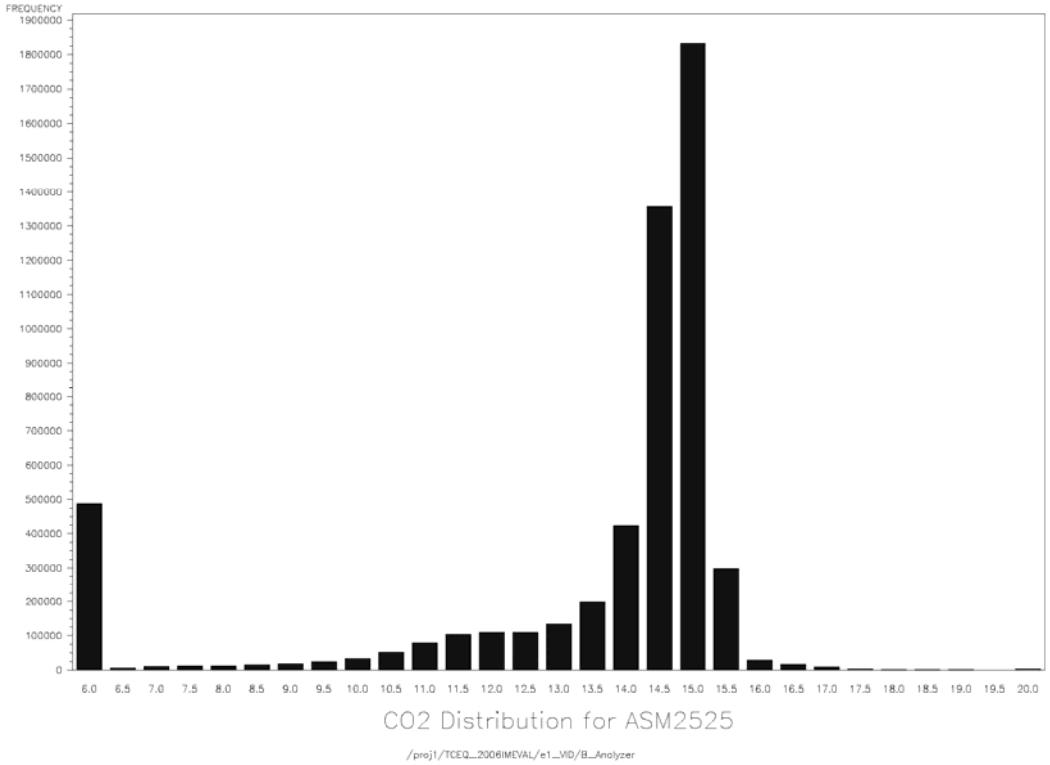
Analyzer Mfg. ID	O_2 >20.5%	O_2 <20.5%	Total
ES	19,351 0.7%	2,551,292 90.9%	2,807,392 100%
JB	16,092 24.6%	41,804 63.9%	65,393 100%
SE	122,159 16.7%	513,241 70.3%	729,638 100%
WW	4,512 0.3%	1,639,466 92.0%	1,782,528 100%

CO_2 Emissions Concentration Anomalies

Another factor that was found to cause problems with the DCF calculations was inaccuracy in the reported CO_2 emissions concentrations. The tailpipe carbon dioxide concentration for stoichiometric combustion and no air in-leakage would be 15.6% CO_2. CO_2 values lower than 15.6% can occur because of air in-leakage or because part of the carbon is as CO or HC. Any CO_2 values higher than 15.6% would be cause for suspicion.

The distribution of CO_2 values for the ASM2525 inspection is shown in Figure 4-33. It can be seen from the figure that the CO_2 values are concentrated around 15%, as expected. However, a small fraction of CO_2 values do exceed 16%, for 0.5% of ASM2525 inspection records. These records were investigated further.

Figure 4-33. Distribution of CO_2 Values for ASM 2525 Inspection



The rate of high CO_2 concentrations was found to vary slightly among the different analyzer manufacturers, as shown in Table 4-19, although the differences were not as pronounced as those found for the suspicious O_2 concentrations.

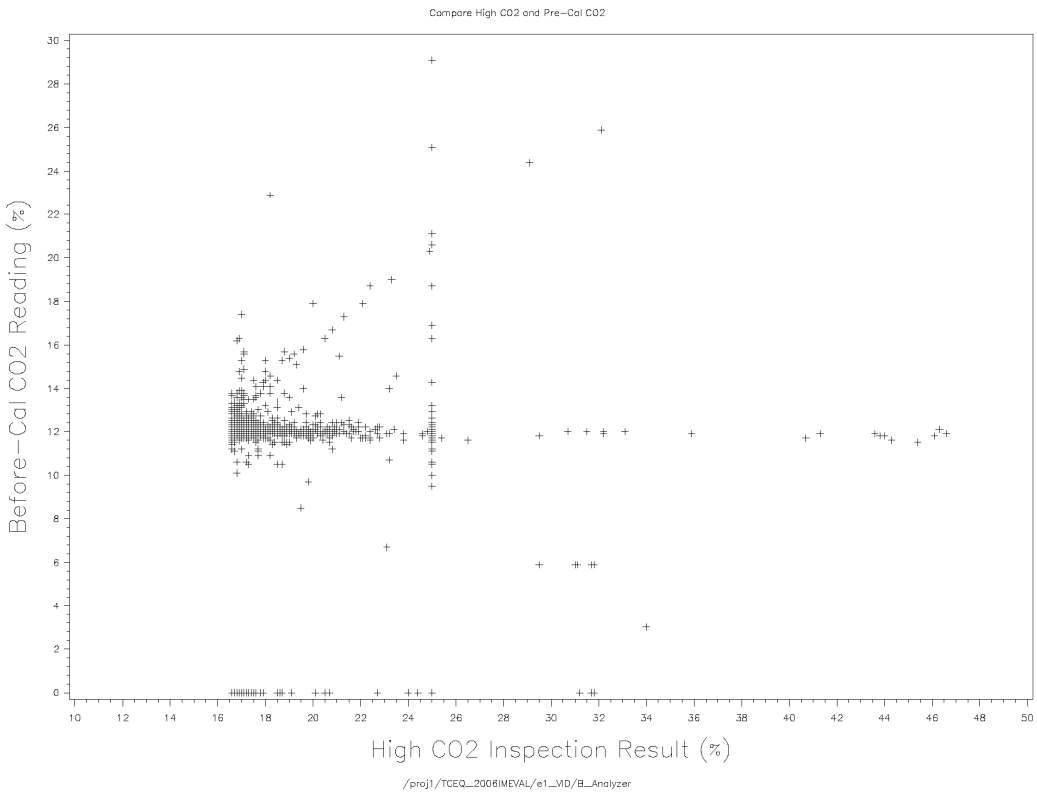
Table 4-19. Number and Percent of Suspicious CO2 Concentrations (CO2 >16.5%), by Analyzer Manufacturer, for ASM 2525

Analyzer Mfg. ID	CO_2 >16.5%	CO_2 <16.5%	Total
ES	23,057 0.8%	2,784,335 99.2%	2,807,392 100%
JB	15 0.0%	65,378 100.0%	65,393 100%
SE	457 0.1%	729,181 99.9%	729,638 100%
WW	6,039 0.3%	1,776,489 99.7%	1,782,528 100%

The high-CO_2 inspection records were matched to calibration records (described in Section 4.4.1) to find instances where the analyzer responsible for the high-CO_2 inspection record was calibrated within the following 24 hours. The mid-span pre-calibration CO_2 readings

were then inspected to determine whether the high-CO_2 records could be attributed to out-of-calibration analyzers. In Figure 4-34, the pre-calibration CO_2 readings are plotted against the high CO_2 readings found in the inspection record dataset. The plot does not show a correlation between increasingly high-CO_2 inspection results and increasingly high pre-calibration CO_2 levels (which should be close to 12% for the mid-span bottle gas), so analyzer drift does not seem to be responsible for the high CO_2 results.

Figure 4-34. High CO_2 Inspection Results Compared to CO_2 Pre-Calibration Reading



One consequence of recording a CO_2 concentration greater than 15.6% is that the CO/CO_2-basis dilution correction factor will be less than 1, indicating a "concentration" condition, rather than a dilution condition. Records with very high CO concentrations will also have a DCF of less than 1. In the VID, these DCFs are rounded up to 1; no DCFs of less than 1 are stored. However, just as a high DCF (greater than 1) can act as a flag for a problematic dilution condition, a low DCF (less than 1) can also provide a useful warning that inspection results may be suspect. The equation for the O_2-basis DCFs does not allow the O_2 DCF to fall below 1. However, low CO/CO_2-basis DCFs can be seen in Figures 4-29 through 4-32. For the ASM2525 inspection, 303 records (less than 0.01% of total inspection records) have

DCFCO/CO_2 between 0 and 0.55, and 48,686 records have DCFCO/CO_2 between 0.55 and 0.95 (0.9% of total inspection records).

Extra Vertical and Horizontal Rays

It was noted above that Figures 4-29 to 4-32, with the CO/CO_2-basis DCF plotted against the O_2-basis DCF, appear to contain three distinct "rays": the majority of points fall near the diagonal 1:1 line, but there is substantial set of points near a horizontal line at DCFCO/CO_2 =1, and a smaller set of points near a vertical at DCFO2=1. To investigate the reasons for the rays, the set of inspection records for the ASM 2525 test was subdivided into four categories: points falling along each of the diagonal, horizontal, and vertical rays, and other points that didn't fall neatly into any of the rays. The distributions of emissions concentrations for O_2, CO_2, and CO for records comprising the three rays were then compared, as shown in Figures 4-35 through 4-37.

Figure 4-35 shows that the horizontal ray is comprised of inspection records with high O_2 concentrations. Almost all of the records with O_2 concentrations greater than 4% fall into that ray. (The horizontal ray results from records with high DCFO2 values and DCFCO/CO_2 values near 1.) A high O_2 concentration results in a high DCFO2 value, and would seem to indicate a dilution condition (air entering the exhaust stream to add O_2 to the sample), but the DCFCO/CO_2 values remain around 1 in the horizontal ray, indicating that the CO and CO_2 emissions are not being diluted. Figures 4-36 and 4-37 show that the distributions of CO_2 and CO concentration for the horizontal ray are very similar to the distributions for the diagonal ray.

The figures show the opposite result for the vertical ray (comprised of records with high DCFCO/CO_2 and DCFO2 near 1). Figure 4-35 shows that the O_2 concentration distribution for the vertical ray is similar to that of the diagonal ray. Figure 4-36 shows that the CO_2 concentration for records in the vertical ray was almost always between 6 and 10%, instead of the 15% seen for the diagonal ray. Figure 4-37 shows that the CO concentration for records in the vertical ray was higher than that of records in the diagonal ray.

Overall, what can be seen from Figures 4-35, 4-36, and 4-37 is that the records in each ray were systematically different from the records in each other ray.

Figure 4-35. Distribution of O_2 Concentrations, by "Ray"

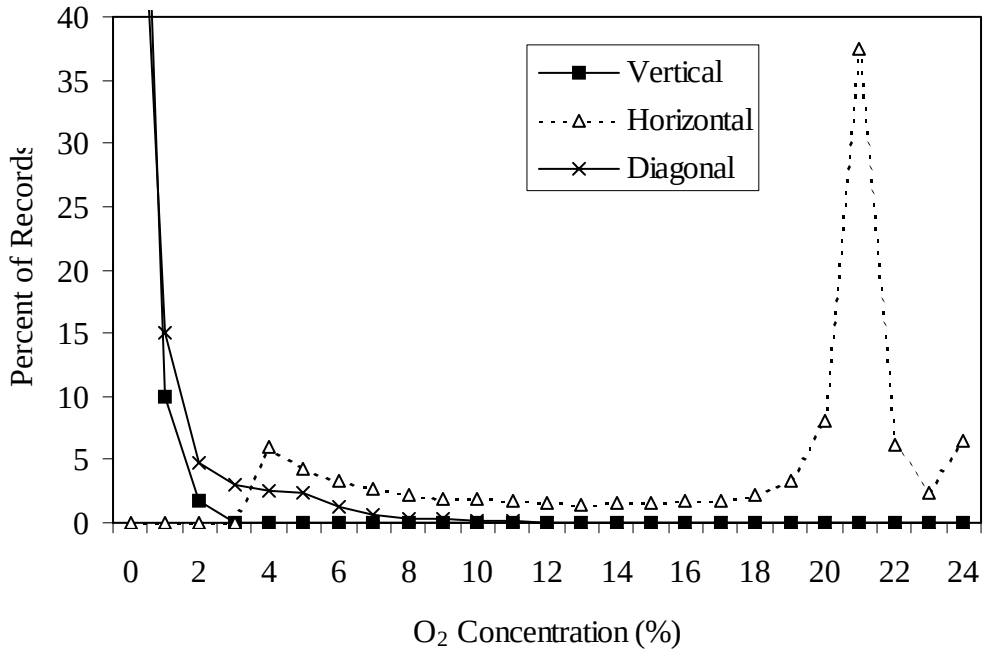


Figure 4-36. Distribution of CO_2 Concentrations, by "Ray"

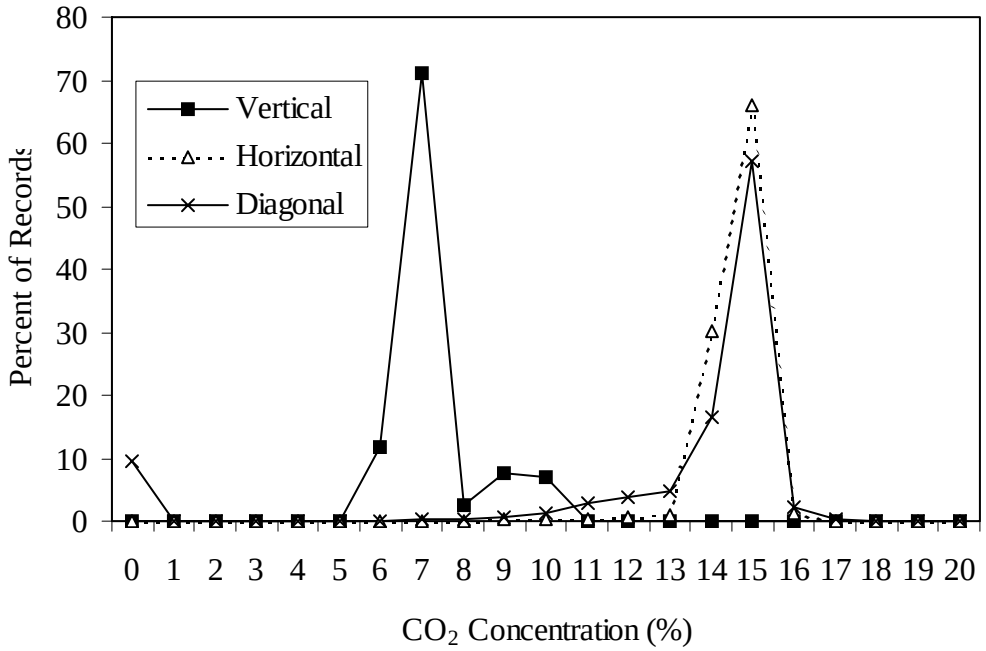
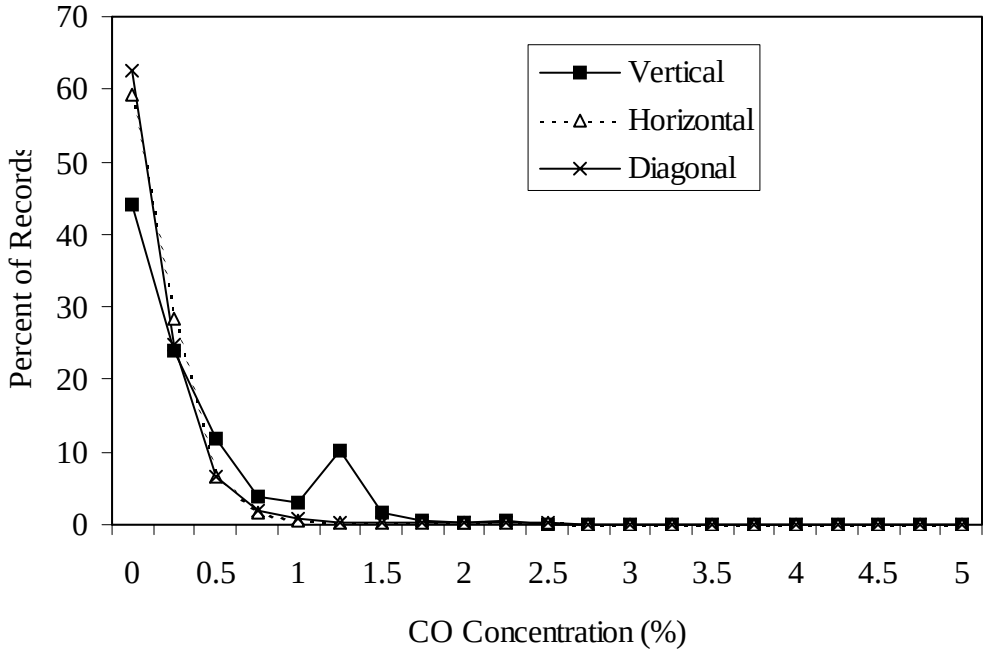


Figure 4-37. Distribution of CO Concentrations, by "Ray"



The distribution of records into each ray-group was tabulated by analyzer manufacturer, as shown in Table 4-20 below. As expected, the manufacturers represented by codes JB and SE contribute a large portion of the records for the horizontal ray. In Figure 4-35 it was seen that this ray includes most of the records with O_2 concentrations near 20.9% (ambient concentration), and in Table 4-18 it was seen that the JB and SE manufacturers contributed the majority of the records with the high O_2 concentrations. Table 4-20 also shows that the JB and SE analyzers were responsible for a greater proportion of the records in the "Other" column than were the ES and WW analyzers. The "Other" group includes all records that didn't fall neatly into one of the rays; these records represent scatter in the data, rather than a systematic problem as represented by the vertical and horizontal rays. It is more difficult to see trends among the analyzer manufacturers for the vertical ray, since there were many fewer records in that ray, but the SE analyzers do represent a somewhat higher rate of records in the vertical ray than the other analyzers.

Table 4-20. Number and Percent of Records in Each Ray by Analyzer Manufacturer, for ASM 2525

Analyzer Mfg. ID	Vertical	Horizontal	Diagonal	Other	Total
ES	222 <0.1%	32,968 1.2%	2,740,223 97.6%	33,979 1.2%	2,807,392 100%
JB	1 <0.1%	18,972 29.0%	39,977 61.1%	6,443 9.9%	65,393 100%
SE	790 0.1%	164,779 22.6%	518,644 71.1%	45,425 6.2%	729,638 100%
WW	38 <0.1%	28,496 1.6%	1,719,964 96.5%	34,030 1.9%	1,782,528 100%

4.4.3 Analyzer Gas Audits

One component of a station equipment audit is the gas analyzer audit. This audit uses bottle gases independent of the calibration gas bottles, and the gas is introduced at the tailpipe sampling probe rather than simply at the analyzer inlet (as in a 3-day analyzer calibration). This type of audit adds an additional level of certainty about instrument measurement accuracy, since it can identify problems with the probe and the line that goes from the probe to the I/M analyzer. If the analyzer fails the gas audit, it must be repaired (if necessary) and successfully re-calibrated before it may be used for additional I/M inspections involving tailpipe measurements.

Bottle gases containing blends of HC, CO, NOx, and CO_2 at zero, low span, and mid span concentration levels are used in a gas audit. The analyzer specification requires that the measured pollutant concentrations fall within 5.5% of the labeled bottle gas value for the low and mid span level gases, in order to pass the gas audit. The nominal bottle gas concentrations for the low and mid span gas audits are listed in Table 4-21 (these are the same as the nominal bottle gas values for low- and mid-span calibrations). Actual labeled bottle gas concentrations may vary up to 5% from the nominal values, so the labeled bottle gas values are recorded in the analyzer and transmitted to the VID for each audit.

Table 4-21. Bottle Gas Concentrations for Low and Mid Span Audits

Gas	Low Span Nominal Concentration	Mid Span Nominal Concentration
CO (%)	0.5	8.0
HC (ppm)	200	3200
CO_2 (%)	6.0	12.0
NOx (ppm)	300	3000

The Texas SIP requires that each analyzer be audited at least twice per year. For the two and a half year dataset that is used for this analysis, this should result in an average of 5 audits per analyzer. A frequency distribution of the number of audits per analyzer is shown in Table 4-22. As can be seen from the table, many of the 2,229 analyzers received many more than five audits; in fact, 31.4% of the analyzers received more than 10 audits. Many of the extra audits result from follow-up audits (re-audits) after an analyzer failed a portion of an initial audit: 42% of repeat audits happen within a week of the earlier audit.

Table 4-22. Number of Gas Audits per Analyzer Over a 2.5 Year Period

Number of Audits	Number of Analyzers	Percent of Analyzers
1	47	2.1
2	59	2.7
3	55	2.5
4	97	4.4
5	217	9.7
6	239	10.7
7	208	9.3
8	344	15.4
9	263	11.8
10 or more	700	31.4
Total	2229	100.0

The pass/fail results for the gas audit are based on whether or not the analyzer reads a pollutant concentration within 5.5% of the labeled bottle gas value:

Difference (%) = 100 x [(Reading – Bottle Value) / Bottle Value]

The distribution of percent differences between readings and bottle gas values is shown in Figures 4-38 through 4-45 for CO, HC, CO_2, and NOx, at the low- and mid-span levels. In almost all of the figures, the vast majority of readings fall between -4 and 4% of the labeled bottle gas values. The main exceptions were the low-span HC, with a somewhat wider spread, and the low- and mid-span NOx, which were both biased toward low readings.

Figure 4-38. Percent Difference Between Reading and Bottle Gas, Low-Span CO

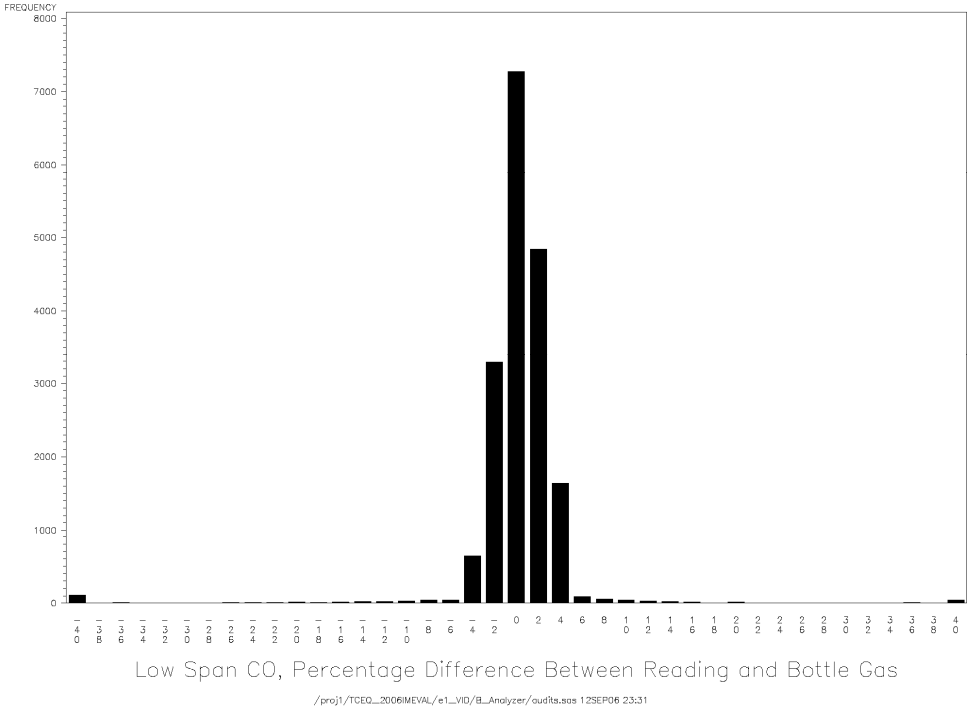


Figure 4-39. Percent Difference Between Reading and Bottle Gas, Low-Span HC

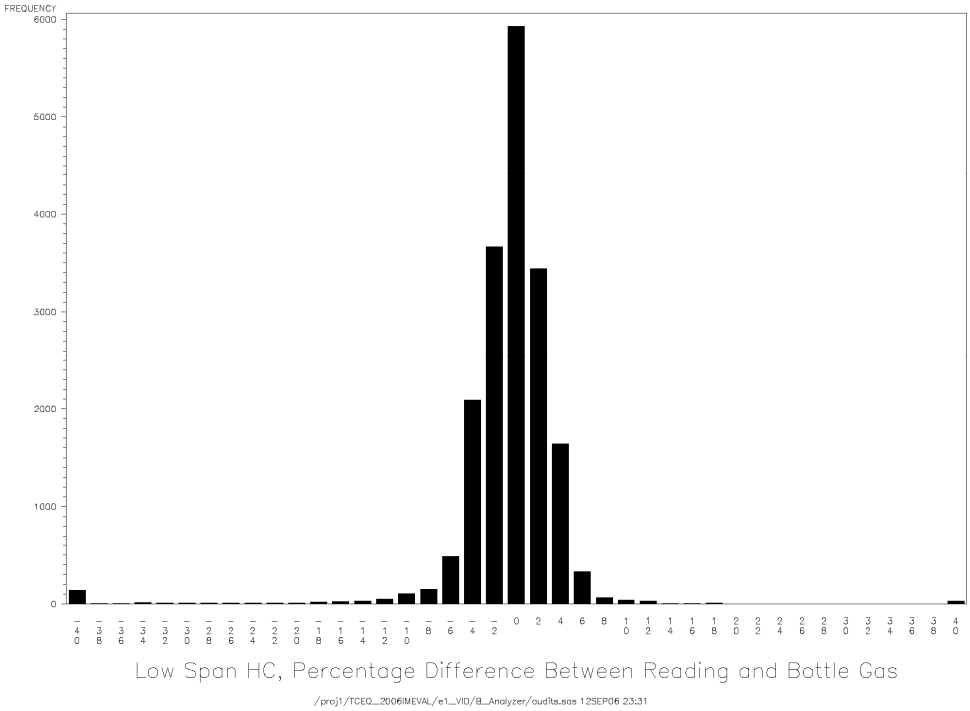


Figure 4-40. Percent Difference Between Reading and Bottle Gas, Low-Span CO_2

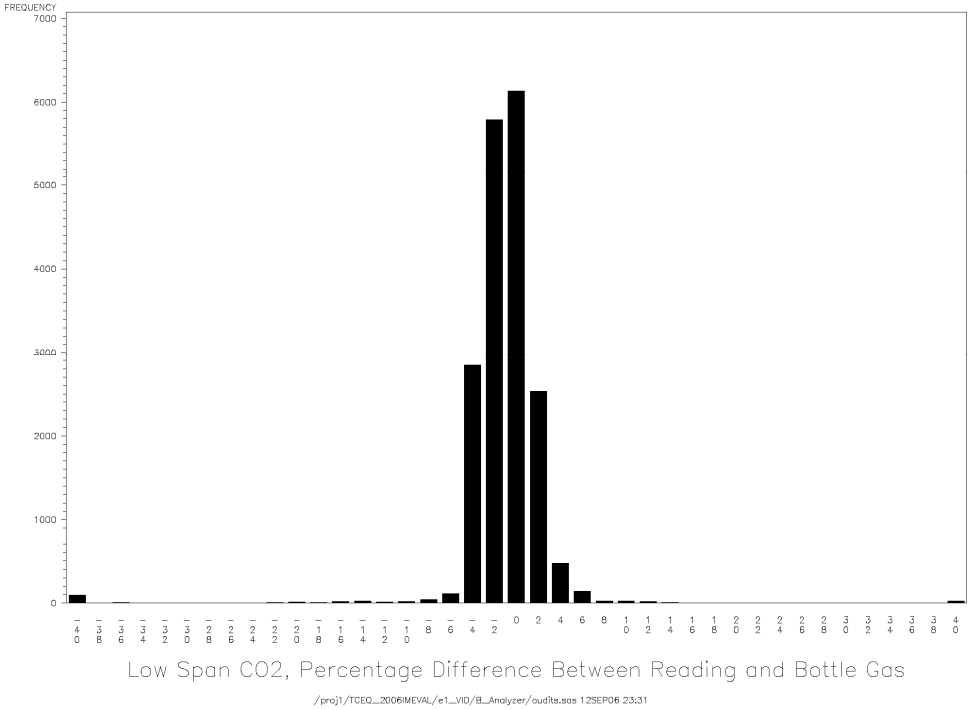


Figure 4-41. Percent Difference Between Reading and Bottle Gas, Low-Span NOx

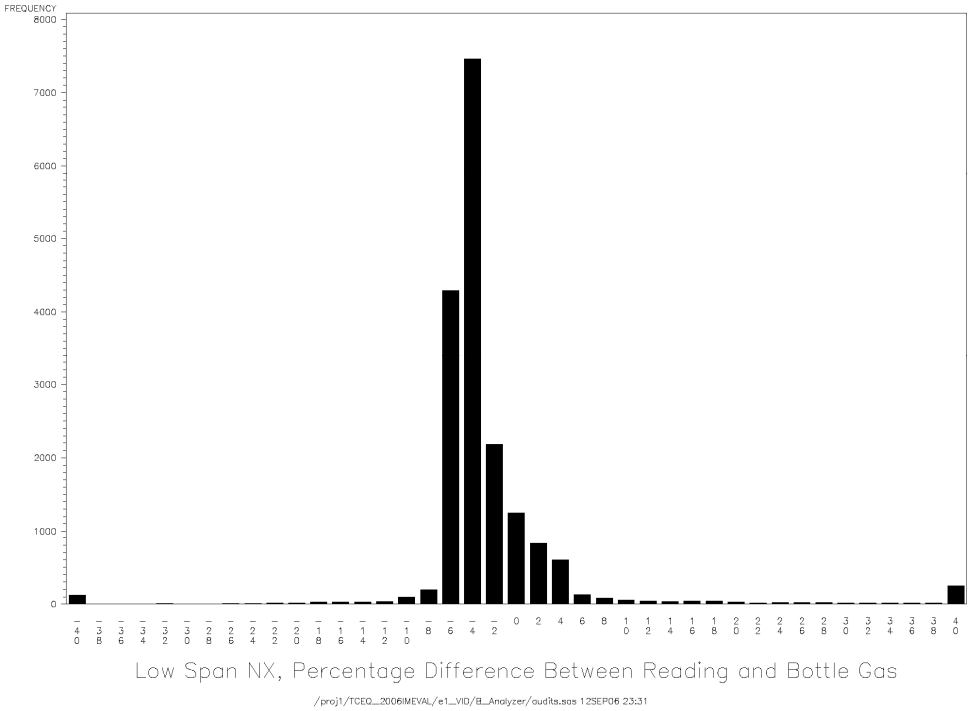


Figure 4-42. Percent Difference Between Reading and Bottle Gas, Mid-Span CO

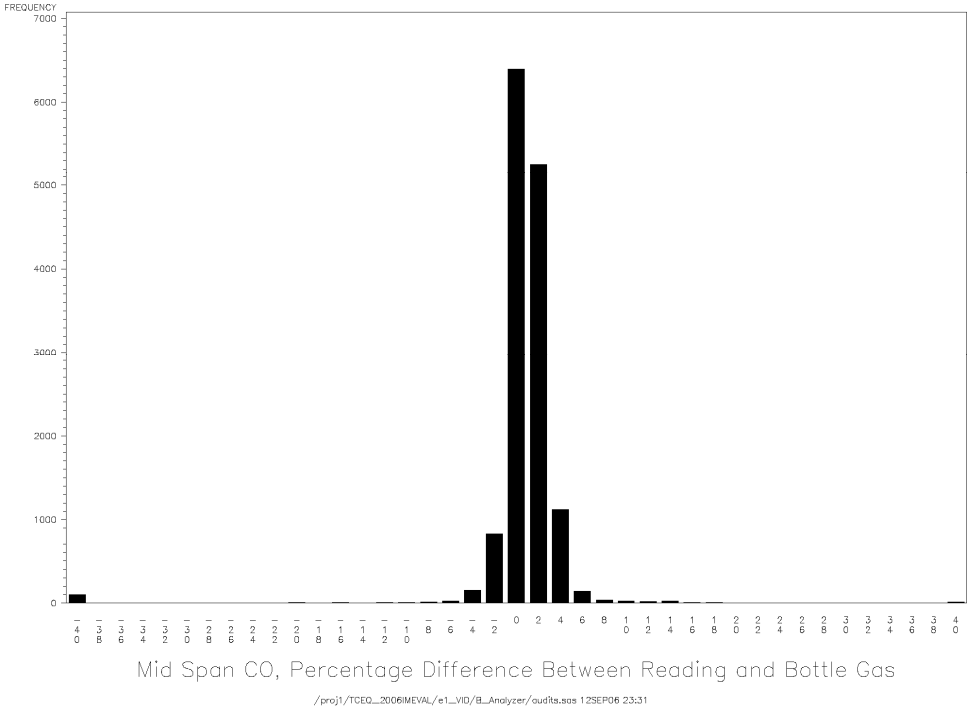


Figure 4-43. Percent Difference Between Reading and Bottle Gas, Mid-Span HC

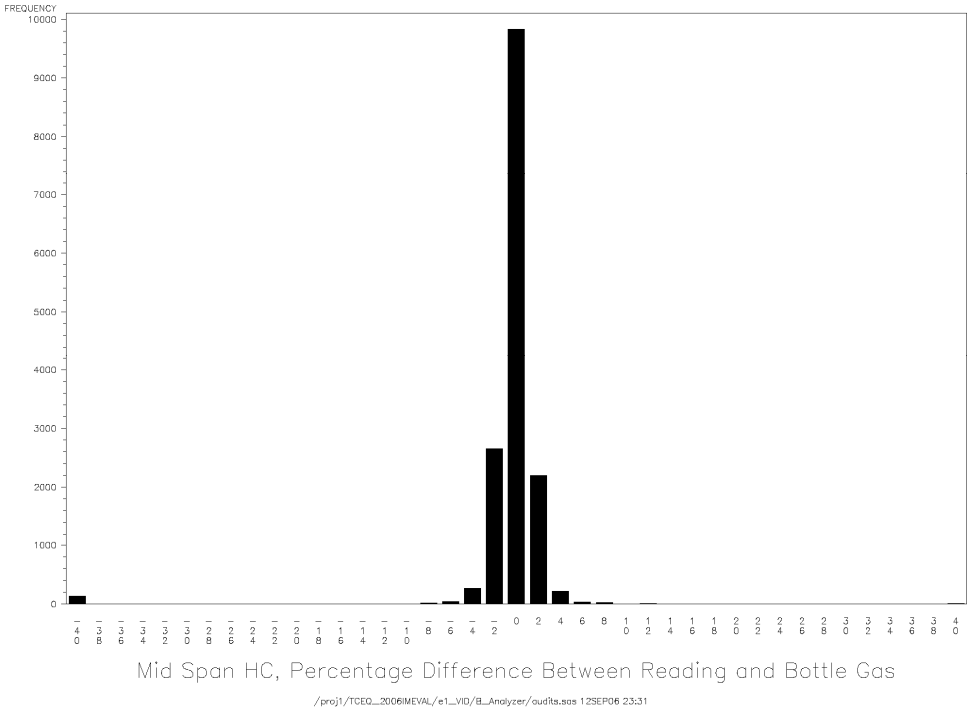


Figure 4-44. Percent Difference Between Reading and Bottle Gas, Mid-Span CO_2

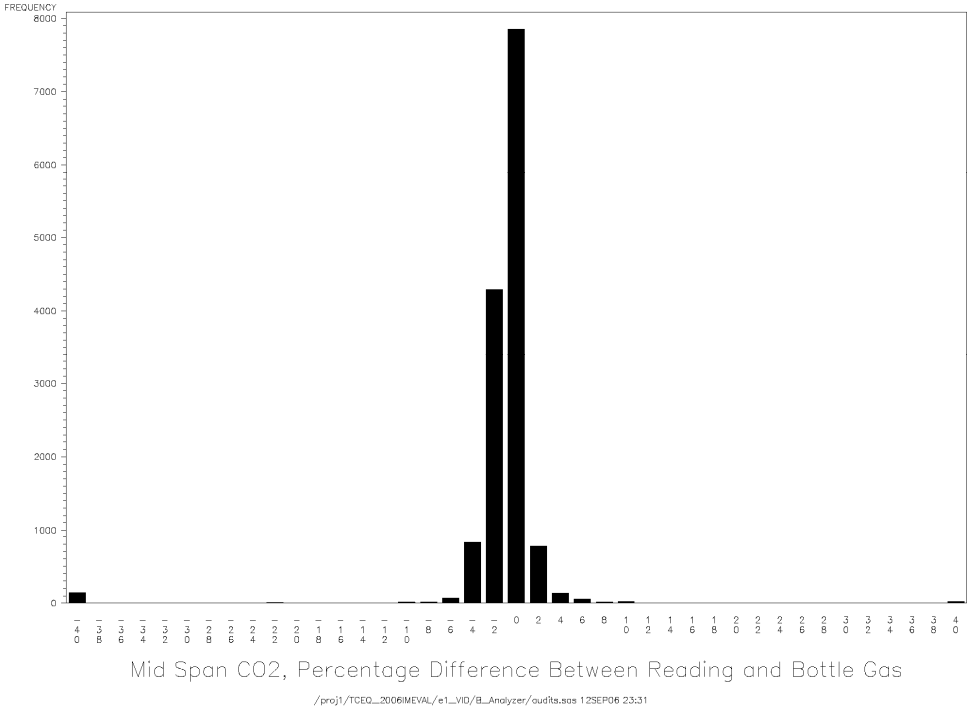


Figure 4-45. Percent Difference Between Reading and Bottle Gas, Mid-Span NOx

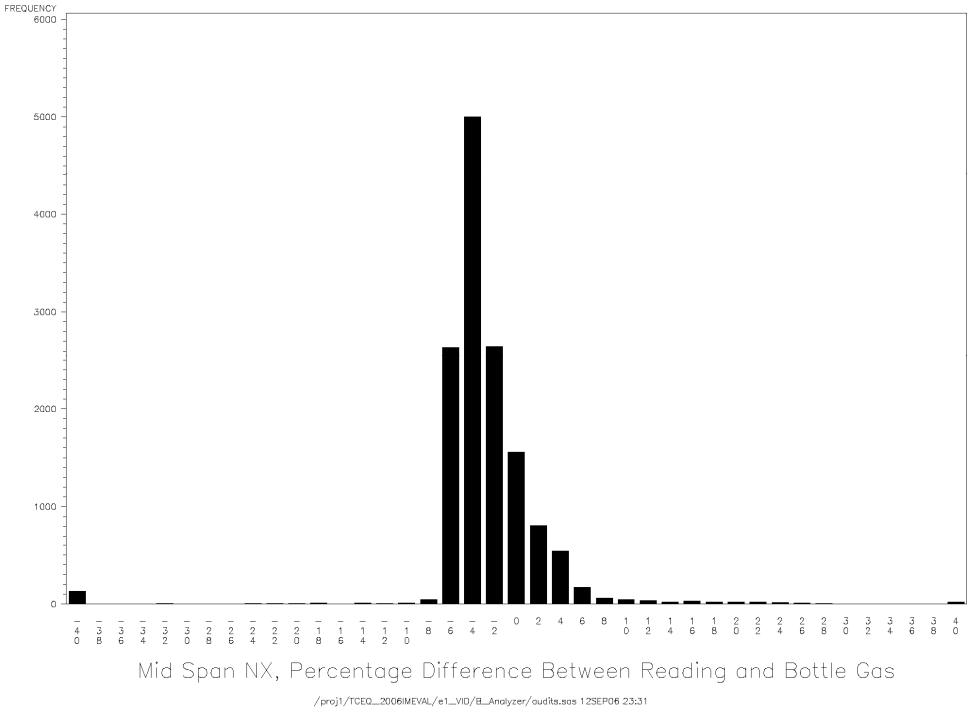


Table 4-23 shows pass/fail results for span gas audits at the low- and mid- span levels. The table includes the pass/fail results from the VID, as well as newly calculated pass/fail results (based on the labeled bottle gas value entered in the VID, the measured emissions concentration, and a 5.5% tolerance). It can be seen from Table 4-23 that there was some disagreement between the newly calculated results and the analyzer's pass/fail results stored in the VID. Most of the discrepancies arise from audit records that were partially incomplete. For example, 1,632 records were found to have a failing result (outside the 5.5% tolerance) for at least one pollutant, but the span gas audit result was recorded as "Missing" instead of "Failed" in the VID. These records all resulted from audits on analyzers from a single manufacturer, and all took place between mid-2003 and mid-2004; apparently the analyzer manufacturer corrected a software problem at that time and this type of result was no longer seen. In all but five of the 1,632 cases, the overall audit result (rather than the span gas portion of the audit result) was appropriately recorded as failed.

Table 4-23. Span Gas Pass/Fail Results from VID Compared to Calculated Results

Calculated Results	VID Result			
	Pass	Fail	Missing	Total
Pass	10,075	37	3,931	14,043
Fail	45	1,632	1,234	2,911
Comb. Pass & Missing	1,114	330	97	1,541
Entirely Missing	0	8	11	19
Total	11,234	2,007	5,273	18,514

Also, in each span gas audit, the analyzer is required to pass for each pollutant at both the low and mid span levels, in order to pass the span gas audit overall. However, Table 4-23 shows that 1,114 audits were recorded as passed in the VID, even though they were missing the reading for one or more pollutants. Most of these cases (1,109 records) arise from gas audits where all of the low-span pollutant concentrations and the mid-span HC concentration were recorded, but no readings for mid-span CO, CO_2, or NOx were recorded. These were all performed on analyzers from a single manufacturer within a six-month period, after which a software problem with the analyzer that allowed these partial gas audits was corrected.

The gas audit procedures specify that if an analyzer fails its gas audit, it must be calibrated (and repaired and re-calibrated as necessary) until it can be brought within the proper tolerance. The calibration data described in the section above was combined with the audit gas data to determine whether the calibrations were actually taking place after the failed audits. In 24% of cases, an analyzer that failed an audit was calibrated or re-audited and passed within the next 60 minutes. In an additional 38% of cases, the failing analyzer was calibrated or re-audited

and passed within 24 hours, and another 31% of failing analyzers were calibrated or re-audited and passed within one week. The remaining 7% percent of failed audits took from one week up to three months to achieve a passing audit or successful calibration. It is possible that the audit found more serious problems with these analyzers, and they were taken off-line until an analyzer repair technician was able to undertake repairs on the analyzer.

4.4.4 Analyzer Lockouts

A Texas I/M gas analyzer or dynamometer is required to automatically lock itself out from performing I/M inspections if it is not successfully calibrated or verified on a regular basis. The calibration/verification requirements include:

1) Gas analyzers must be successfully calibrated and verified (with BAR-97 calibration-blend gases) at least every 72 hours, or they cannot be used for ASM or TSI inspections

2) Gas analyzers must pass an internal leak check at least every 72 hours, or they cannot be used for ASM or TSI inspections

3) Dynamometer calibrations must be successfully verified (using a coast-down check) at least every 72 hours, or they cannot be used for ASM inspections

4) Analyzers that fail a gas audit (as a component of an overt station audit) must be successfully calibrated and pass a re-audit before being used for ASM or TSI inspections. This requirement is evaluated in the following section.

Calibration records, dynamometer coast-down check records, leak check records, and vehicle inspection records were used to determine whether analyzer and dynamometer calibrations and checks were taking place as required, and whether un-calibrated/checked analyzers or dynamometers were in fact locked out until passing a calibration.

The regularity of the three types of 72-hour calibrations and checks (gas calibration, internal leak check, and dynamometer cost-down check) was investigated first. Each type of calibration/check was analyzed separately, since the different checks and calibrations were often performed at different times and recorded in separate records. It was not found to be meaningful to identify calibration/check lapses by simply calculating the time between passed calibrations and checks. The 72-hour deadline frequently fell on a Sunday, holiday, or other time that the station was not open, so the analyzer or dynamometer would legitimately remain un-calibrated/checked beyond 72 hours, until the station re-opened.

Instead, we attempted to determine whether analyzers did lock themselves out from performing I/M inspections if more than 72 hours had passed since the previous successful calibration or check. To do this, the dataset of calibration and check records was added to the dataset of I/M inspection records. Only I/M inspection records for the HGB or DFW areas in calendar years 2004 or 2005 were used, and only if the inspection involved a TSI or ASM inspection (safety-only inspections or OBD tests were excluded). Then, for each gas analyzer, any I/M inspections having date/times more than 72 hours after the most recent analyzer gas

calibration were identified. These inspections should not have been allowed by the analyzer software; the analyzer should have been locked out from performing vehicle inspections until it passed a calibration.

The results for each type of calibration or check are shown in Table 4-24. For each calibration or check, the number of I/M inspections taking place while the analyzer should have been locked out is listed. This result is also presented as a percentage of the total number of I/M inspections performed. The total number of I/M inspections is lower for the dynamometer coast-down checks because TSI inspections do not require a dynamometer and are not included (i.e., TSI tests may be legitimately performed if a dynamometer is locked out). It can be seen from the table that although the percentage of inspections performed by analyzers that were overdue for a calibration or check was small compared to the total inspections performed, a relatively large number of emissions inspections appear to have been performed at times when the analyzers should have been locked out.

Table 4-24. I/M Inspections More Than 72 Hours After Successful Calibration or Check

Calibration Type	I/M Inspections 72+ Hours After Passed Calibration or Check	I/M Inspections 72+ Hours After Passed Calibration Or Check (% of total inspections)	Total I/M Inspections
Span Gas Calibration	35,622	0.86%	4,166,280
Leak Check	7,950	0.19%	4,166,280
Dynamometer Check	47,579	1.25%	3,791,179

Table 4-24 lists the number of inspections performed on analyzers that had not passed all three calibrations / checks within a 72 hour period. In order to determine why this was occurring, a review of the sequence of calibration/check records and vehicle inspection records for several different analyzers suggested that some analyzers that ***passed only one*** type of calibration or check (instead of all three) were still permitted to perform inspections. For example, passing a leak check would reset the 72-hour clock for each of the analyzer's gas calibration, leak check, and dynamometer coast-down check sequences, thereby allowing the analyzer to continue testing even though it had not passed a gas calibration or a dynamometer coast-down check in more than 72 hours.

To further narrow down why inspections were occurring when a lockout should have been in place, two additional analyses were performed:

1. How many inspections were performed on analyzers that ***had received at least one, but not passed any,*** of the three tests within the past 72 hours? Analysis indicated that 5,041, or 0.12% of total vehicle inspections, were performed on analyzers that ***had received at least one, but not passed any,*** of the three tests within the past 72 hours. This suggests that, for these analyzers, merely receiving one of the calibrations or checks would be sufficient to "reset the clock" for all three requirements.

2. How many inspections were performed on analyzers that had not received any calibrations or checks within the past 72 hours? Analysis indicated that 664, or 0.02% of total vehicle inspections were performed on analyzers that had not received any calibrations or checks within the past 72 hours. This suggests that, for these analyzers, lockouts aren't enforced whatsoever for any of these three requirements. This is a very small fraction of the total number of inspections, and could even be attributable to just a few missing calibration records. For example, if one calibration record for one analyzer was somehow erased from the VID or otherwise not stored in the VID, and that analyzer was used for 67 inspections in the 72 hour period before its next calibration, that single missing calibration record would account for a full 10% of the 664 total anomalous inspection records (note that we did not verify whether this was actually the case, since the occurrence of a missing record cannot be confirmed).

Gas Audits and Re-Audits

An analyzer that fails the span gas audit portion of an overt station audit is required to undergo successful analyzer span gas calibration or pass a re-audit before it is again allowed to perform ASM or TSI emissions inspections. The data set of gas audits, calibrations, and re-audits was combined with the ASM and TSI records from the vehicle inspection database (OBD inspection records were excluded, since they do not require use of the gas analyzer) to determine whether analyzers were locked out from the time an initial gas audit was failed until the analyzer was successfully calibrated or passed a re-audit. By comparing the date and time of analyzer audits to the date and time of the vehicle inspections, it was found that analyzers were almost always locked out after failing a gas audit. However, 944 vehicle inspections (0.02% of total vehicle inspections) did take place after an analyzer failed a gas audit but before that analyzer was successfully recalibrated or passed a re-audit. Once again, just a few missing calibration or audit records could be the cause of the 944 inspections appearing to take place during times the analyzer should be locked out.

4.5 VID Emissions Data Checks for Evidence of Station Fraud[30]

We examined station and inspector triggers in two years of the Texas VID to look for evidence of station and inspector fraud. This is a process-based measure for inspection.

A set of station and inspector performance parameters known as triggers are calculated on a quarterly basis by TCEQ and given to DPS to help identify stations and inspectors that may be performing fraudulent emissions inspections. There are 26 triggers each for stations and for inspectors. Since there were 11 quarters between May 1, 2003 and December 21, 2005, we received 26 triggers * 11 quarters * 2 types (stations and inspectors) for a total of 572 quarterly reports from TCEQ. Table 4-25 shows all the triggers for stations and inspectors. The same 26 triggers are calculated for both inspectors and stations.

Table 4-25. List of Triggers

Trigger Name	Inspector	Station
Friendly	Yes	Yes
HD Vehicle Tests	Yes	Yes
Unusual Test Times	Yes	Yes
Invalid VINS	Yes	Yes
Offline Test Per Day	Yes	Yes
Test Performed Per Day	Yes	Yes
Test Performed Under 10 Mins Per Day	Yes	Yes
Time Between Initial and Repeat Tests	Yes	Yes
DLC Damaged or Not Found	Yes	Yes
OBD AC Monitor	Yes	Yes
OBD HD Not Ready	Yes	Yes
OBD HD	Yes	Yes
OBD KOER Fail MIL Pass	Yes	Yes
OBD Noncomms	Yes	Yes
OBD Rejects for MIL Not On KOEO	Yes	Yes
OBD Rejects for NR	Yes	Yes
HC 5015	Yes	Yes
HC 2525	Yes	Yes
CO 5015	Yes	Yes
CO 2525	Yes	Yes
NO 5015	Yes	Yes
NO 2525	Yes	Yes
TSI CO High	Yes	Yes
TSI CO Idle	Yes	Yes
TSI HC High	Yes	Yes
TSI HC Idle	Yes	Yes

[30] This section responds to the Work Plan's Task 3 Element 1D. Check VID Data for Evidence of Station Fraud and was written by T.J. Petroski.

Trigger values are calculated for each station and each inspector. Any station or inspector over a fixed threshold (set by the VID vendor) that made the trigger list was provided to us by TCEQ. As a result, the number of stations and inspectors triggered each quarter changes. In addition, the number of stations and inspectors performing I/M tests changes each quarter as well. For example, since a station or inspector may not be performing emissions tests over the entire period of evaluation, they may be on the trigger list in one quarter but not the next.

Based on the I/M tests records, we determined the number of stations and inspectors in each of the eleven quarters. The first quarter in our dataset is not a full quarter because it includes data from May 1, 2003 through June 30, 2003. That quarter does not include the month of April 2003. Tables 4-26 and 4-27 show the counts of stations and inspectors per quarter, respectively.

Table 4-26. Number of Unique Stations in the I/M Test Records

	Year and Quarter	Dates of Quarter	Count
1	2nd Quarter of 2003	May 1, 2003* – June 30, 2003	2,437
2	3rd Quarter of 2003	July 1, 2003 – September 30, 2003	2,536
3	4th Quarter of 2003	October 1, 2003 – December 31, 2003	2,591
4	1st Quarter of 2004	January 1, 2004 – March 31, 2004	2,667
5	2nd Quarter of 2004	April 1, 2004 – June 30, 2004	2,749
6	3rd Quarter of 2004	July 1, 2004 – September 30, 2004	2,830
7	4th Quarter of 2004	October 1, 2004 – December 31, 2004	2,826
8	1st Quarter of 2005	January 1, 2005 – March 31, 2005	2,894
9	2nd Quarter of 2005	April 1, 2005 – June 30, 2005	2,910
10	3rd Quarter of 2005	July 1, 2005 – September 30, 2005	3,019
11	4th Quarter of 2005	October 1, 2005 – December 31, 2005	2,962

*** The period from April 1, 2003 to April 30, 2003 is not contained in the I/M test records.**

Table 4-27. Number of Unique Inspectors in the I/M Test Records

	Year and Quarter	Dates of Quarter	Count
1	2nd Quarter of 2003	May 1, 2003* – June 30, 2003	7,907
2	3rd Quarter of 2003	July 1, 2003 – September 30, 2003	8,401
3	4th Quarter of 2003	October 1, 2003 – December 31, 2003	8,467
4	1st Quarter of 2004	January 1, 2004 – March 31, 2004	8,751
5	2nd Quarter of 2004	April 1, 2004 – June 30, 2004	9,132
6	3rd Quarter of 2004	July 1, 2004 – September 30, 2004	9,212
7	4th Quarter of 2004	October 1, 2004 – December 31, 2004	8,995
8	1st Quarter of 2005	January 1, 2005 – March 31, 2005	9,227
9	2nd Quarter of 2005	April 1, 2005 – June 30, 2005	9,424
10	3rd Quarter of 2005	July 1, 2005 – September 30, 2005	9,489
11	4th Quarter of 2005	October 1, 2005 – December 31, 2005	9,403

*** The period from April 1, 2003 to April 30, 2003 is not contained in the I/M test records.**

We also tracked the number of stations and inspectors making each trigger list per quarter. Since there are 572 different totals in all, too numerous to list in table form, in Figure 4-46 we show the ratio of Triggered Stations to Total Stations as it changes over the eleven quarters. Figure 4-47 shows the ratio of Triggered Inspectors to Total Inspectors. Figures 4-46 and 4-47 do not indicate an improving or worsening trend in the fraction of stations or inspectors being put on trigger lists.

The top curve on each plot gives the fraction of stations and inspectors that received at least one trigger. Figure 4-46 indicates that 93% of stations receive at least one trigger each quarter. Figure 4-47 indicates that 46% of inspectors receive at least one trigger each quarter. With such high levels of triggering constantly going, we question the usefulness of the triggering effort. Virtually all of the stations and half of the inspectors are getting bad marks. In addition, the methods use to calculate triggers are secret and, therefore, are not open to real evaluation and criticism.

Figure 4-46. Percent of Unique Stations That Receive Specific Triggers

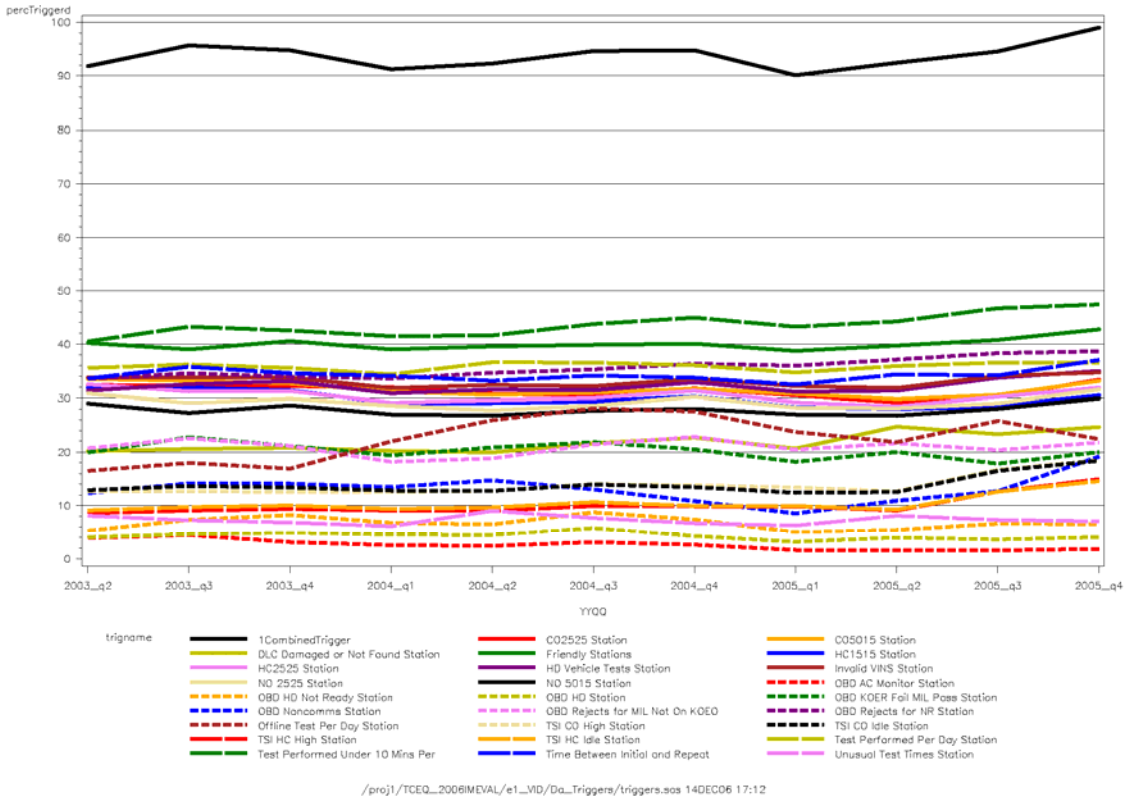
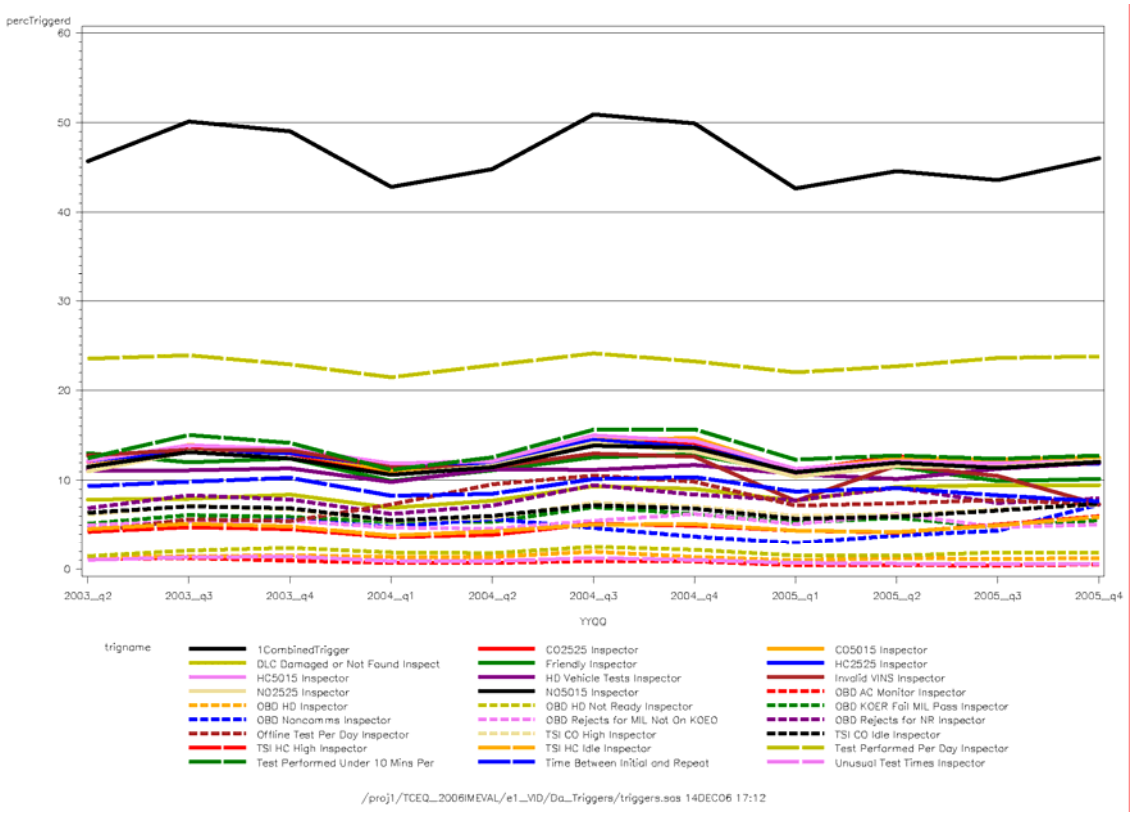


Figure 4-47. Percent of Unique Inspectors That Receive Specific Triggers



The triggers were also analyzed to determine:

1) The number of times a station or inspector made a quarterly report during the evaluation period. The maximum potential number of times is 11. Tables 4-28 and 4-29 show the counts of stations and inspectors making the quarterly reports. For example, in Table 4-28, 2,896 inspectors were found in 4 of the 11 quarterly reports.

Table 4-28. Number of Inspectors Making Quarterly Reports

Number of Quarterly Reports	Count	Percent
1	9,757	32.2
2	6,877	22.7
3	4,285	14.14
4	2,896	9.56
5	1,960	6.47
6	1,415	4.67
7	997	3.29
8	678	2.24
9	488	1.61
10	416	1.37
11	530	1.75

Table 4-29. Number of Stations Making Quarterly Reports

Number of Quarterly Reports	Count	Percent
1	3,650	18.92
2	3,006	15.59
3	2,372	12.3
4	1,996	10.35
5	1,641	8.51
6	1,469	7.62
7	1,225	6.35
8	1,036	5.37
9	856	4.44
10	844	4.38
11	1,192	6.18

2) The count of unique triggers per station and inspector during the evaluation period. The maximum potential number of times is 26. Tables 4-30 and 4-31 show the count of unique triggers per station and inspector, respectively. For example, in Table 4-30, 828 inspectors were found on 10 different trigger lists over the course of 11 quarterly reports.

Table 4-30. Count of Unique Triggers per Inspector

Number of Unique Triggers	Count	Percent
1	181	1.79
2	333	3.3
3	408	4.04
4	532	5.27
5	620	6.14
6	689	6.82
7	732	7.24
8	792	7.84
9	814	8.06
10	828	8.19
11	727	7.2
12	700	6.93
13	663	6.56
14	589	5.83
15	479	4.74
16	366	3.62
17	245	2.42
18	197	1.95
19	106	1.05
20	62	0.61
21	30	0.3
22	8	0.08
23	3	0.03
24	0	0.00
25	0	0.00
26	0	0.00

Table 4-31. Count of Unique Triggers per Station

Number of Unique Triggers	Count	Percent
1	10	0.26
2	19	0.49
3	38	0.99
4	58	1.51
5	111	2.89
6	176	4.58
7	205	5.33
8	245	6.37
9	260	6.76
10	238	6.19
11	218	5.67
12	212	5.51
13	284	7.38
14	278	7.23
15	306	7.96
16	280	7.28
17	276	7.18
18	238	6.19
19	157	4.08
20	118	3.07
21	60	1.56
22	33	0.86
23	22	0.57
24	3	0.08
25	1	0.03
26	0	0.00

3) The number of times a station or inspector made any trigger list in any quarter. The maximum potential number of times is 286. Tables 4-32 and 4-33 show the number of times a station and inspector, respectively, makes any trigger in any quarter. To reduce the size of the table, the counts were placed in bins. For example, in Table 4-32, 343 inspectors were found in anywhere from 50 to 60 of the 286 different triggers/quarterly lists.

Table 4-32. Count of Inspectors Making Any Trigger List in Any Quarter

Total Quarterly Report Bins	Count	Percent
1-10	3237	32.04
10-20	2671	26.44
20-30	1779	17.61
30-40	1036	10.25
40-50	642	6.35
50-60	343	3.39
60-70	207	2.05
70-80	111	1.1
80-90	43	0.43
90-100	21	0.21
100-110	9	0.09
110-120	2	0.02
120-130	1	0.01
130-140	2	0.02

Table 4-33. Count of Stations Making Any Trigger List in Any Quarter

Total Quarterly Report Bins	Count	Percent
1-10	415	10.79
10-20	515	13.39
20-30	463	12.04
30-40	426	11.08
40-50	374	9.72
50-60	374	9.72
60-70	314	8.16
70-80	296	7.7
80-90	266	6.92
90-100	151	3.93
100-110	134	3.48
110-120	68	1.77
120-130	34	0.88
130-140	9	0.23
140-150	6	0.16
150-160	1	0.03

4.6 OBDII Inspection Analyzer Communication Performance[31]

We analyzed VID OBD data to look for proper scanner communication. This is a process-based measure for inspection. It is possible that certain models of scanners communicate improperly with certain model year, make, and model vehicles. If this is the case, the OBD results in the VID for certain vehicle descriptions and for certain scanner models will be inconsistent with the results for other vehicle descriptions and scanner models. The results of these communication problems would cause some vehicles to be failed at a higher or lower rate than the vehicles actually should be failing at. An analysis of the OBD data in the VID would reveal if certain scanner models had this type of problem.

The objective of this task was to analyze VID data to determine if certain models of OBDII inspection analyzers appear to have communication problems with certain makes, models, or model year vehicles, which would result in higher or lower fail rates than appropriate for those vehicle categories.

Analysis and Results

For this task, we reviewed OBDII inspection records to identify all tests with an "N" (no communication/signal) in the "OBD2_DLC_RES" field of the test record. For these records, analysis was performed to identify the following:

- Rate of failure to communicate by analyzer manufacturer
- Rate of failure to communicate by vehicle make
- Rate of failure to communicate by vehicle model
- Rate of failure to communicate by vehicle model year

Results are presented for these four categories below.

43,978 of the 8,348,608 OBD test records had no information stored in the OBDII communication result field. All these records had null values for ready result, fault code result, and downloaded MIL status. All but five of these records had null values for OBDII pass/fail results (5 of the 43,978 records had a "pass" in this field). 54 OBD test records had vehicle model years earlier than 1996 (ranging from 1970 through 1995). These records were excluded from the following results.

[31] This section responds to the Work Plan's Task 3 Element 1E: Investigate OBD Failure Rates by Vehicle Description and OBD Scan Tool and was written by M.A. Sabisch.

Communication Rates by Vehicle Model Year - Table 4-34 provides a summary of communication rates by model year of vehicles tested in the program.

Table 4-34. OBD Communication Rates by Vehicle Model Year

Model Year	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model yr	% of overall tests by model yr
	Count	Percent	Count	Percent	Count	Percent		
1996	5801	0.7835	2358	0.3185	732216	98.8980	740375	8.9153
1997	5787	0.6539	1574	0.1779	877584	99.1682	884945	10.6561
1998	1999	0.2124	1026	0.1090	938029	99.6786	941054	11.3317
1999	2008	0.1896	1078	0.1018	1055889	99.7086	1058975	12.7517
2000	1941	0.1622	1138	0.0951	1193707	99.7427	1196786	14.4112
2001	1400	0.1113	1073	0.0853	1255178	99.8034	1257651	15.1441
2002	1137	0.0893	801	0.0629	1271599	99.8478	1273537	15.3354
2003	1018	0.1337	704	0.0925	759524	99.7738	761246	9.1666
2004	478	0.2800	237	0.1388	169985	99.5811	170700	2.0555
2005	105	0.5622	38	0.2034	18535	99.2344	18678	0.2249
2006	7	**1.1364**	3	0.4870	606	98.3766	616	0.0074
2007	0	0.0000	0	0.0000	18	100.0000	18	0.0002
Total	21,681	0.2611	10,030	0.1208	8,272,870	99.6182	8,304,581	100.00

The "MODEL_YEAR" field from the vehicle test result tables was used to determine model year. From this table, it can be seen that 8,304,581 OBDII tests had some type of result in the OBDII communication result (OBD2_DLC_RES) field. Values and percentages shown in the table are normalized by vehicle model year. For example, 884,945 OBDII tests were conducted on model year 1997 vehicles, which is approximately 10.7% of all OBDII tests conducted. Of these, 1574 test records (0.1779% of all MY 1997 vehicle OBDII tests) had an OBDII fail to communicate status. In comparison, 0.3185% of all 1996 vehicles were unable to communicate, and 0.0925% of all 2003 vehicles were unable to communicate. Overall, low numbers were seen for "failure to communicate" test results, and overall "failure to communicate" rates were well under 1%. With the exception of model year 2006 vehicles, 1996 vehicles had the highest "fail to communicate" rate. This is expected, as manufacturers were first implementing OBDII in 1996 model year vehicles. The higher "failure to communicate" rate for 2006 vehicles may be due to the small number of tests (lending a higher uncertainty in the "fail to communicate" percentage) and also due to implementation of the Controller Area Network (CAN) communication protocol into a larger percentage of the overall vehicle fleet. As equipment becomes standardized to CAN this percentage is likely to drop. The overall program-wide communication rate between vehicles and analyzers is 99.88%.

Communication Rates by Equipment Manufacturer - Table 4-35 provides results of communication rates among the various analyzer manufacturers.

Table 4-35. OBD Communication Rates by Equipment Manufacturer

Equipment Manufacturer (EM)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by EM	% of tests by EM
	Count	Percent	Count	Percent	Count	Percent		
ES (ESP)	9,560	0.2037	6,280	0.1338	4,676,529	99.6624	4,692,369	56.5
JB (John Bean / Snap-on)	120	0.3899	183	0.5947	30,471	99.0154	30,774	0.4
SE (Sun / Snap-on)	3,518	0.4071	2,705	0.3130	857,930	99.2799	864,153	10.4
WW (Worldwide)	8,518	0.3135	864	0.0318	2,707,933	99.6547	2,717,315	32.7
Total	21,716	0.2615	10,032	0.1208	8,272,863	99.6177	8,304,611	100.0

Again, the percentages shown for the "damaged, inaccessible or cannot be found," the "will not communicate" and the "successfully communicates" columns pertain to all tests conducted by each type of analyzer (not percentage of all tests). The final right two columns provide counts of tests and percentages of tests by each analyzer manufacturer relative to the total number of tests.

Communication Rates by Vehicle Make - To assess communication rates by vehicle make, we merged vehicle registration records with vehicle test records by VIN. The "VEHMK" field from the registration database was reviewed but found to have numerous inconsistencies and errors. Similarly, the "MAKE" field from the vehicle test result tables was evaluated and also found to have a number of inconsistencies. To obtain a consistent "make" list, VINs from the emission test records were decoded using the ERG VIN Decoder, and the "make" output from this decoding process was merged with the vehicle test records and used for this evaluation.

Table 4-36 provides a summary of communication rates among the various vehicle makes. Incident rates greater than 1% for "damaged, inaccessible, or cannot be found" or "no communication" rest results are highlighted and bold-faced in the table. Somewhat surprising are the high incident rates seen for both Ford Trucks and for Hummers. However, review of these test records revealed the "Ford Trucks" were in fact recreational vehicles (motorhomes). These Ford chassis motorhome tests comprise less than 0.03% of all OBDII tests conducted over the period of evaluation. Only 14 tests were recorded for Hummers.

Table 4-36. OBD Communication Rates by Vehicle Make

Vehicle Make	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by make	% of overall tests by make
	Count	Percent	Count	Percent	Count	Percent		
Unlisted	674	1.9028	224	0.6324	34523	97.4648	35421	0.4265
ACURA	64	0.0780	4	0.0049	82002	99.9171	82070	0.9882
AMERICAN	0	0.0000		0.0000	6	100.0000	6	0.0001
ASTON MARTIN	1	0.8000		0.0000	124	99.2000	125	0.0015
AUDI	11	0.0562	2	0.0102	19553	99.9336	19566	0.2356
BENTLEY	0	0.0000		0.0000	218	100.0000	218	0.0026
BMW	121	0.1159	6	0.0057	104261	99.8783	104388	1.2570
BUICK	43	0.0362	12	0.0101	118792	99.9537	118847	1.4311
CADILLAC	69	0.0693	9	0.0090	99437	99.9216	99515	1.1983
CHECKER	0	0.0000		0.0000	3	100.0000	3	0.0000
CHEV/SUZUKI	0	0.0000		0.0000	2	100.0000	2	0.0000
CHEVROLET	3893	0.2770	2963	0.2108	1398644	99.5122	1405500	16.9241
CHRYSLER	152	0.0940	19	0.0118	161485	99.8942	161656	1.9465
CONSULIER	0	0.0000		0.0000	7	100.0000	7	0.0001
DAEWOO	11	0.1132	2	0.0206	9701	99.8662	9714	0.1170
DAIMLER	0	0.0000		0.0000	4	100.0000	4	0.0000
DATSUN	0	0.0000		0.0000	36	100.0000	36	0.0004
DODGE	919	0.1671	438	0.0796	548706	99.7533	550063	6.6235
DODGE/MITS	0	0.0000		0.0000	29	100.0000	29	0.0003
EAGLE	4	0.3010		0.0000	1325	99.6990	1329	0.0160
FERRARI	8	**1.7021**	2	0.4255	460	97.8723	470	0.0057
FORD	10369	0.5800	4754	0.2659	1772513	99.1540	1787636	21.5255
FORD TRUCK	1377	**61.9433**	261	**11.7409**	585	26.3158	2223	0.0268
FORD/MAZDA	0	0.0000		0.0000	2045	100.0000	2045	0.0246
GM	1	0.0145		0.0000	6905	99.9855	6906	0.0832
GM CANADA	0	0.0000		0.0000	23	100.0000	23	0.0003
GMC	951	0.3878	906	0.3695	243346	99.2427	245203	2.9526
HONDA	327	0.0599	32	0.0059	545976	99.9343	546335	6.5786
HUMMER	3	**21.4286**	2	**14.2857**	9	64.2857	14	0.0002

Vehicle Make	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by make	% of overall tests by make
	Count	Percent	Count	Percent	Count	Percent		
HYUNDAI	131	0.1714	8	0.0105	76292	99.8181	76431	0.9203
IMPERIAL	0	0.0000		0.0000	8	100.0000	8	0.0001
INFINITI	59	0.0990	6	0.0101	59534	99.8909	59599	0.7176
ISUZU	195	0.3070	46	0.0724	63275	99.6206	63516	0.7648
JAGUAR	18	0.0672	5	0.0187	26776	99.9142	26799	0.3227
JEEP	93	0.0472	27	0.0137	197003	99.9391	197123	2.3736
KIA	34	0.0576	7	0.0119	58974	99.9305	59015	0.7106
LAND ROVER	18	0.1223	1	0.0068	14701	99.8709	14720	0.1772
LEXUS	46	0.0291	6	0.0038	158176	99.9671	158228	1.9053
LINCOLN	110	0.1192	17	0.0184	92146	99.8624	92273	1.1111
LOTUS	95	**62.5000**		0.0000	57	37.5000	152	0.0018
MASERATI	24	**18.6047**		0.0000	105	81.3953	129	0.0016
MAZDA	258	0.1672	35	0.0227	154028	99.8101	154321	1.8582
MERCEDES	77	0.0778	2	0.0020	98911	99.9202	98990	1.1920
MERCURY	106	0.0682	27	0.0174	155193	99.9144	155326	1.8703
MITSUBISHI	167	0.0998	28	0.0167	167120	99.8835	167315	2.0147
NISSAN	462	0.1190	55	0.0142	387749	99.8668	388266	4.6752
OLDSMOBILE	58	0.0701	8	0.0097	82688	99.9202	82754	0.9965
PLYM/MITS	0	0.0000		0.0000	11	100.0000	11	0.0001
PLYMOUTH	76	0.1163	10	0.0153	65281	99.8684	65367	0.7871
PLYMOUTH TRK	0	0.0000		0.0000	2	100.0000	2	0.0000
PONTIAC	118	0.0613	27	0.0140	192365	99.9247	192510	2.3181
PORSCHE	18	0.1650		0.0000	10893	99.8350	10911	0.1314
RENAULT	0	0.0000		0.0000	1	100.0000	1	0.0000
ROLLS ROYCE	0	0.0000	1	0.2358	423	99.7642	424	0.0051
SAAB	14	0.2008	1	0.0143	6956	99.7848	6971	0.0839
SATURN	135	0.1277	19	0.0180	105538	99.8543	105692	1.2727
SUBARU	15	0.0959		0.0000	15621	99.9041	15636	0.1883
SUZUKI	10	0.0746	3	0.0224	13384	99.9030	13397	0.1613
TOYOTA	315	0.0408	37	0.0048	770925	99.9544	771277	9.2872
TRIUMPH	0	0.0000		0.0000	3	100.0000	3	0.0000

Vehicle Make	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by make	% of overall tests by make
	Count	Percent	Count	Percent	Count	Percent		
TVR & OTHERS	0	0.0000		0.0000	1	100.0000	1	0.0000
VOLVO	56	0.1180	5	0.0105	47408	99.8715	47469	0.5716
VW	128	0.1270	15	0.0149	100614	99.8581	100757	1.2132
Total	21834	0.2629	10032	0.1208	8272882	99.6163	8304748	100.0000

Communication Rates by Vehicle Model - To assess communication rates by vehicle models, we reviewed the following model designation fields:

- The "MODEL" field from the vehicle test result tables was seen to have a number of inconsistencies and errors (as it's manual keyboard entry).

- veh_modl (derived from the merged registration records) was also seen to have a number of inconsistencies and errors.

- The "MODEL_CD" field from the emission test records was based on table lookup values and therefore appeared to be a fairly consistent descriptor for the vehicle's model designation. The Texas analyzer specification reports this "model code" is "The NCIC model code or acceptable TCEQ code, otherwise left blank." In order to correlate this "model code" to an actual vehicle model, all vehicle emission test record VINS were decoded using ERG's VIN Decoder, and the vehicle "series" (i.e., model) resulting from this decoding process was merged into the test record. An output table correlating "series" with "model code" was then developed using the most frequently occurring series associated with each model code.

Table 4-37 lists communication rates for vehicle model codes for those cases where "damaged, inaccessible, or cannot be found" or "no communication" rates were greater than 1%. The complete table is given in Appendix B. The series was derived from the decoded VIN, assigned to each model code as described above, and is shown in the table.

Table 4-37. OBD Communication Rates by Vehicle Model Code for Elevated Miscommunications

Model Code	Series (Model)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model	% of overall tests by model
		Count	Percent	Count	Percent	Count	Percent		
0	Motorhome	25	42.3729	5	8.4746	29	49.1525	59	0.0007
13	C2500 P/U 2WD	2	0.2469	30	3.7037	778	96.0494	810	0.0098
14	C3500 P/U 2WD	1	0.2331	24	5.5944	404	94.1725	429	0.0052
16	G2500 Van 2WD	19	1.4493	45	3.4325	1247	95.1182	1311	0.0158
17	G3500 Van 2WD	129	5.3683	123	5.1186	2151	89.5131	2403	0.0289
21	G3500 Van 2WD	34	4.0621	66	7.8853	737	88.0526	837	0.0101
40	Motorhome	69	49.6403	25	17.986	45	32.3741	139	0.0017
93	Ram Van/Wgn	2	1.0152	1	0.5076	194	98.4772	197	0.0024
94	Ram Van/Wgn	1	1.7857	1	1.7857	54	96.4286	56	0.0007
96	Ram Wgn Bus	1	1.7241	1	1.7241	56	96.5517	58	0.0007
100	Ram P/U 2WD	8	10.2564	2	2.5641	68	87.1795	78	0.0009
101	Ram P/U 2WD	0	0.0000	5	6.9444	67	93.0556	72	0.0009
102	Ram P/U 2WD	9	21.9512	1	2.4390	31	75.6098	41	0.0005
107	Ram P/U 2WD	0	0.0000	1	10.000	9	90.0000	10	0.0001
109	Ram P/U 2WD	2	33.3333		0.0000	4	66.6667	6	0.0001
114	Ram P/U 2WD	57	25.7919	3	1.3575	161	72.8507	221	0.0027
120	F RV	72	69.9029	8	7.7670	23	22.3301	103	0.0012
132	F250 Spr Cab 2WD	4	0.9217	34	7.8341	396	91.2442	434	0.0052
133	F250 Spr Cab 2WD	839	7.6245	373	3.3897	9792	88.9858	11004	0.1325
134	F350 DRW Chassis Cab	6	3.5294	35	20.588	129	75.8824	170	0.0020
138	E350 Extended Wgn	0	0.0000	3	42.857	4	57.1429	7	0.0001
145	E250 Cargo/Regular V	4	1.4184	24	8.5106	254	90.0709	282	0.0034
146	E350 Extended Wgn	0	0.0000	26	7.5362	319	92.4638	345	0.0042
16	G2500 Van 2WD	16	5.3333		0.0000	284	94.6667	300	0.0036
17	G3500 Van 2WD	92	13.1617	2	0.2861	605	86.5522	699	0.0084
180	Sierra 2500 P/U 2	87	1.6808	89	1.7195	5000	96.5997	5176	0.0623
181	Sierra 3500 P/U 2	58	4.9743	23	1.9726	1085	93.0532	1166	0.0140
182	3500 Van 2WD	78	12.7243	18	2.9364	517	84.3393	613	0.0074
183	Savanna 1500 2WD	71	47.0199		0.0000	80	52.9801	151	0.0018
184	Savanna 2500 2WD	15	2.9297	10	1.9531	487	95.1172	512	0.0062
185	Savanna 3500 2WD	80	8.3420	45	4.6924	834	86.9656	959	0.0115
200	Sentra / 200SX	98	1.4721	31	0.4657	6528	98.0622	6657	0.0802
21	G3500 Van 2WD	81	15.7282		0.0000	434	84.2718	515	0.0062
233	Trooper 4WD	0	0.0000		0.0000	10	100.0000	10	0.0001
234		89	18.6975	13	2.7311	374	78.5714	476	0.0057
260	S60	2	22.2222	3	33.333	4	44.4444	9	0.0001
262	Grnd Cher. 2WD	0	0.0000	2	40.000	3	60.0000	5	0.0001
280	C280	57	47.8992		0.0000	62	52.1008	119	0.0014
310	Defender	25	52.0833		0.0000	23	47.9167	48	0.0006
320	S320	200	9.0580	79	3.5779	1929	87.3641	2208	0.0266
340	3500 Van 2WD	9	16.6667	4	7.4074	41	75.9259	54	0.0007
360	F RV	99	37.6426	14	5.3232	150	57.0342	263	0.0032
380	Motorhome	109	51.6588	14	6.6351	88	41.7062	211	0.0025
440	F RV	106	71.1409	5	3.3557	38	25.5034	149	0.0018
469	Tundra SR5	9	32.1429		0.0000	19	67.8571	28	0.0003
470	Tundra SR5	10	34.4828	1	3.4483	18	62.0690	29	0.0003
480	F RV	19	28.7879	11	16.667	36	54.5455	66	0.0008
525	525iA	34	43.5897		0.0000	44	56.4103	78	0.0009
540	540i	44	35.4839	4	3.2258	76	61.2903	124	0.0015
550	550 Maranello	12	7.1429	4	2.3810	152	90.4762	168	0.0020
560	F RV	4	66.6667		0.0000	2	33.3333	6	0.0001
580	Motorhome	421	48.2798	66	7.5688	385	44.1514	872	0.0105

Model Code	Series (Model)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model	% of overall tests by model
		Count	Percent	Count	Percent	Count	Percent		
581	E350 Cargo Van	0	0.0000		0.0000	1	100.0000	1	0.0000
660	F RV	38	57.5758	9	13.636	19	28.7879	66	0.0008
720	F RV	2	66.6667		0.0000	1	33.3333	3	0.0000
820	3500 Van 2WD	16	5.3512	73	24.415	210	70.2341	299	0.0036
830	Motorhome	22	6.1972	25	7.0423	308	86.7606	355	0.0043
840	Ram Wgn Bus	0	0.0000	14	35.000	26	65.0000	40	0.0005
860		76	69.7248	19	17.431	14	12.8440	109	0.0013
929	929	4	50.0000		0.0000	4	50.0000	8	0.0001
940	Motorhome	8	30.7692	2	7.6923	16	61.5385	26	0.0003
96	Ram P/U	19	4.6914	7	1.7284	379	93.5802	405	0.0049
970	Motorhome	5	41.6667		0.0000	7	58.3333	12	0.0001
C10	Tahoe 2WD	10	1.8727	23	4.3071	501	93.8202	534	0.0064
C25	C2500 P/U 2WD	660	1.8610	791	2.2304	34014	95.9086	35465	0.4270
C35	C3500 P/U 2WD	598	3.9976	460	3.0751	13901	92.9273	14959	0.1801
COB	Mustang Cobra GT	22	44.8980		0.0000	27	55.1020	49	0.0006
CU1	Cutlass Sup SL	36	50.7042	1	1.4085	34	47.8873	71	0.0009
CW1	E350 Super Wgn	106	40.6130	12	4.5977	143	54.7893	261	0.0031
CW2	E350 Super Wgn	253	8.9685	135	4.7855	2433	86.2460	2821	0.0340
CW3	E350 Super Wgn	141	7.1248	164	8.2870	1674	84.5882	1979	0.0238
DEN	Yukon 4WD Luxury	5	1.6949		0.0000	290	98.3051	295	0.0036
E30	E300	1	6.6667		0.0000	14	93.3333	15	0.0002
EC1	E150 Cargo Van	7	1.8667	3	0.8000	365	97.3333	375	0.0045
EC2	E250 Cargo/Regular V	249	3.0029	268	3.2320	7775	93.7651	8292	0.0998
EC3	E350 Extended Wgn	291	4.0682	395	5.5222	6467	90.4096	7153	0.0861
EUR	Eurovan GLS	50	24.1546		0.0000	157	75.8454	207	0.0025
EXC	Excursion Limited 2W	50	1.0487	119	2.4958	4599	96.4555	4768	0.0574
EXP	Explorer XL	1	1.0309	1	1.0309	95	97.9381	97	0.0012
F10	F150 Super Cab Style	72	20.6304	3	0.8596	274	78.5100	349	0.0042
F25	F250 Regular Cab Sty	3670	21.3571	866	5.0396	12648	73.6034	17184	0.2069
F35	F350 DRW Chassis Cab	1301	24.5982	343	6.4852	3645	68.9166	5289	0.0637
F45		168	25.8462	35	5.3846	447	68.7692	650	0.0078
F55		17	12.1429	11	7.8571	112	80.0000	140	0.0017
F65	F700 (Gas)	41	82.0000	5	10.000	4	8.0000	50	0.0006
FLE	Fleetwood	629	47.8327		0.0000	686	52.1673	1315	0.0158
FRE	Freelander Class C	0	0.0000	25	50.000	25	50.0000	50	0.0006
G35	G3500 Van 2WD	3	1.2605	5	2.1008	230	96.6387	238	0.0029
HUM		17	2.1118	18	2.2360	770	95.6522	805	0.0097
M5	M5	371	47.9948		0.0000	402	52.0052	773	0.0093
MAG		1	4.5455		0.0000	21	95.4545	22	0.0003
MK5		0	0.0000	1	100.00		0.0000	1	0.0000
NSX	NSX	2	1.0471		0.0000	189	98.9529	191	0.0023
NY		2	1.3793		0.0000	143	98.6207	145	0.0017
OAS	Trooper 4WD	4	1.5748		0.0000	250	98.4252	254	0.0031
PRV	Previa 2WD	8	1.5038	2	0.3759	522	98.1203	532	0.0064
R25	Ram P/U 2WD	151	3.8045	93	2.3432	3725	93.8524	3969	0.0478
R35	Ram P/U 2WD	174	21.5881	17	2.1092	615	76.3027	806	0.0097
RAH	Ranger Regular Cab 2	22	31.8841		0.0000	47	68.1159	69	0.0008
V25	Ram P/U 2WD	36	1.6327	43	1.9501	2126	96.4172	2205	0.0266
V35	Ram Wgn Bus	59	2.4989	53	2.2448	2249	95.2562	2361	0.0284
WAG	Wrangler 4WD	1	10.0000		0.0000	9	90.0000	10	0.0001
WIL	Park Avenue Ultra	10	90.9091		0.0000	1	9.0909	11	0.0001
	Total Overall	**23909**	0.2879	**10072**	0.1213	**8270883**	99.5908	**8304864**	**100.00**

Incident rates greater than 1% for any model for “damaged, inaccessible, or cannot be found” or “no communication” rest results are shown highlighted with bold-faced font in the table. The first row in this table (1,630,306 tests) had no associated model code in the test record. In general, the higher failure-to-communicate rates are seen for heavier light-duty trucks such as motorhomes, ¾-ton, and 1-ton trucks.

4.7 VID Handling of OBDII Codes[32]

We analyzed VID OBD data to look for proper handling of OBD scanner information by the VID. This is a process-based measure for inspection. Some I/M programs do not follow EPA protocol for determining whether a car passes or fails an OBD inspection when not ready, pending codes, and fail to communicate messages are produced by the OBD scanner. An analysis of the VID records for these messages and the resulting designation of the vehicle as pass or fail will verify that Texas is handling these messages correctly.

The objective of this task was to analyze OBDII-inspection records to ensure OBDII test results are appropriate for various OBDII test dispositions, such as a vehicle with too many OBDII monitors "not ready," a vehicle with "pending" diagnostic trouble codes (DTCs), or a vehicle that does not achieve communication with the OBDII analyzer.

Program Description and Results of Analysis

Proper handing of various OBDII testing conditions is defined in Parts 85.2207 and 85.2222 of Title 40 of the Code of Federal Regulations and also in various OBDII implementation guidance documents issued by the US EPA. Appropriate responses to the various test possibilities are summarized here, and served as the basis for analysis for this task.

Agreement between OBDII test result and overall test result – A vehicle that fails the OBDII inspection should fail the overall inspection, excluding any test exceptions such as converting to a backup tailpipe test for certain vehicles, or heavy-duty vehicles (> 8500 lbs. GVWR) for which the OBDII test pass/fail results are not enforced.

To determine if OBDII failures are properly enforced, that is, reflected in the overall inspection disposition, a query was performed to quantify the number of vehicles that failed the OBDII portion of the test ("F" in the "OBD2_PF_FL" field) but passed the overall OBDII test ("P" in the "OVERALL_RESULTS" field). The results are shown in Table 4-38.

[32] This section responds to the Work Plan's Task 3 Element 1F: Show Proper Handling of OBD Codes (not ready, pending codes, and fail to communicate) and was written by M.A. Sabisch.

Table 4-38. Comparison of OBDII Test Result with Overall Test Result

Result of OBDII Test	Overall Test Result		Total
	Fail	Pass	
Fail	391,913 (4.7%)	1,190 (0.01%)	393,103 (4.7%)
Pass	224,695 (2.7%)	7,740,515 (92.6%)	7,965,210 (95.3%)
Total	616,608 (7.4%)	7,741,705 (92.6%)	8,358,313 (100%)

1,190 tests with dispositions in each field were seen to fail the OBDII portion of the test but pass the overall test. Additional analysis was performed to determine the cause of this apparent discrepancy. 280 of these 1190 records had corresponding passing tailpipe test results and certificates, indicating these tests were converted to a fallback tailpipe test. However, the remaining 910 tests (0.011% of the 8,358,313 OBDII test records) did not have any tailpipe test results, but had an OBDII test fail and a fail result for the emissions portion of the inspection (emissions pass/fail flag field in the test record). These 910 tests were all performed on light-duty (<8500 lbs. GVWR) gasoline-powered vehicles. Waivers were not issued for any of these tests. The following additional observations were noted regarding these 910 tests:

- Certificates were issued for the majority of these tests (866 of the 910)
- All 910 of these test records were created with one brand of analyzer, and continued through five software version numbers. These test records were observed for all months between June 2004 and December 2005, inclusive.
- The following reasons for OBDII test failures were noted:
  - 241 of these 910 tests failed the OBDII portion of the test due to a MIL-commanded-on status and stored DTCs.
  - 30 of these 910 tests failed for analyzer to vehicle communication problems (DLC is damaged, inaccessible, or cannot be found, or analyzer is connected to DLC but no communication is occurring)
  - 490 of these 910 tests failed ONLY for readiness status
  - The remaining 149 tests had a fail result for either the inspector keyboard-entry MIL check (key-on, engine off bulb check) or the inspector keyboard-entry MIL illumination (key-on, engine running MIL illumination) test.

Summary: 99.99% of all OBDII test records had a match between the OBDII test result and the overall test result. Discrepancies were seen between the OBDII test disposition and the overall test disposition in 910 tests (0.011% of all OBDII test records), where the OBDII test is failed but the overall test is granted a “pass.” These conflicting results appear to be associated with only one analyzer manufacturer. Discussion with TCEQ indicated this was corrected in the Spring of 2006, which was after the period of evaluation.

Malfunction Indicator Light (MIL) bulb check: This is also referred to as the Key On / Engine Off (KOEO) check. The inspector turns the vehicle's ignition key to the "on" position, but does not start the vehicle, in order to illuminate the MIL. Results are manually entered into the analyzer (via keyboard) by the inspector. If the MIL does not illuminate, the vehicle should fail the OBDII portion of the inspection.

To perform this analysis, the results for the inspector keyboard-entered MIL bulb check ("OBD2_MIL_CHECK" field of the test record) were compared with results of the overall OBDII test result ("OBD2_PF_FLAG" field), to ensure that a MIL bulb check failure always results in an OBDII test failure. The "OBD2_MIL_CHECK" results are "Y", which is a pass (yes, the MIL did illuminate), and "N", which is a fail (no, the MIL did not illuminate). Results are provided in Table 4-39.

Table 4-39. Comparison of KOEO MIL Bulb Check Result with Overall OBDII Test Result

Result of KOEO MIL Bulb Check	Overall OBDII Test Result		Total
	Fail	Pass	
N (Fail)	14,897 (0.18%)	0 (0.0%)	14,897 (0.18%)
Y (Pass)	379,323 (4.54%)	7,969,355 (95.3%)	8,348,678 (99.8%)
Total	394,220 (4.71%)	7,969,355 (95.3%)	8,363,575 (100%)

Summary: This comparison shows that the MIL bulb check appears to be enforced as a condition for OBDII failure. However, since the KOEO MIL Bulb Check is manually entered by the inspector, accuracy of this entry is not automatically enforced by the analyzer.

Readiness Evaluation – Federal guidelines recommend two or fewer unset non-continuous monitors be allowed for 1996-2000 vehicles, and only one (or none) unset non-continuous monitors be allowed for 2001 and newer vehicles. Vehicles with higher counts of unset non-continuous monitors should not receive a pass result. They should be failed or rejected on the basis of the OBD system's readiness status. The Texas program has the capability of allowing conversion to a tailpipe test for certain vehicles (as long as the vehicle's downloaded MIL status is not commanded "on") through the use of VID-configurable system files.

To perform this analysis, the OBD readiness status of test records was compared on a model-year basis to evaluate conformance with federal guidelines. 1996 through 2000 vehicles with three or more "not ready" non-continuous monitors would have an OBDII readiness failure ("F" in the "OBD2_READY_RES" field of the test record), and an OBDII test result of fail ("F" in the "OBD2_PF_FLAG" field of the test record). 1996 through 2000 vehicles with two or

fewer "not ready" non-continuous monitors should have an OBDII readiness result of pass ("P" in the "OBD2_READY_RES" of the test record). Similarly, 2001 and newer vehicles with two or more "not ready" non-continuous monitors should have an OBDII readiness failure ("F" in the "OBD2_READY_RES" of the test record), and an OBDII test record result of fail ("F" in the "OBD2_PF_FLAG" field of the test record). 2001 and newer vehicles with one or fewer "not ready" non-continuous monitors should have an OBDII readiness result of pass ("P" in the "OBD2_READY_RES" field of the test record).

Table 4-40 compares OBD readiness status with the number of unset monitors for all OBDII tests. Only non-continuous and "enabled" monitors are presented in this comparison.

Table 4-40. Unset Monitors Versus Test Readiness Status

Count of Unset Non-Continuous Monitors	Counts of Tests of Vehicles Model Year 1996 through 2000		Counts of Tests of Vehicles Model Year 2001 and newer	
	OBDII "Not Ready"	OBDII "Ready"	OBDII "Not Ready"	OBDII "Ready"
0	252	4,051,191	8	3,206,563
1	0	413,559	0	146,494
2	1	215,532	0	88,055
3	70,653	2,231	23,230	591
4	52,553	1,811	15,872	434
5	36,468	1,616	11,679	369
6	1,250	46	609	9
7	1	0	0	0
8	0	0	0	0
Total Count	161,178	4685986	51,398	3,442,515

Data from this evaluation suggests two unset monitors are permitted for all model years (2001 model year split is not enforced). TCEQ confirmed that two monitors are permitted, regardless of vehicle model year; however, analyzer software is currently being installed that will address the 2001 model year split. Results in Table 4-40 also suggest some vehicles with three or more unset readiness monitors still receive a readiness result of "pass" (5,704 model year 1996-2000 vehicle tests and 1,403 model year 2001 and newer vehicle tests). In addition, 261 tests appear to have received an OBD "not ready" status despite having an allowable number of unset monitors. Additional analysis of each of these results is provided below.

Readiness Evaluation: Vehicles failing OBDII readiness with fewer than three unset monitors – All 261 test records with a "not ready" status but with fewer than 3 unset monitors were created by analyzers of one manufacturer. Additional investigation indicated an OBD system failure to communicate status for these records, in which case the OBD readiness status

should be null, not fail. This suggests this is an issue pertaining to the way the readiness status field is populated during a failure-to-communicate test outcome, rather than improper test execution.

Readiness Evaluation: Vehicles passing OBDII readiness with greater than two unset monitors – The following additional observations were noted regarding the 7,107 tests with 3 or more unset monitors and an OBDII readiness result of "pass":

- These tests were only seen for two brands of analyzers. 95% of the records were limited to one analyzer brand and were seen for tests conducted throughout the entire period of evaluation. The remaining 5% of records were created on the other analyzer brand, and these records were limited to the period of January through November 2004 (a software update implemented in November 2004 appears to have addressed this issue for this type of analyzer).
- 96% of these tests were granted an overall pass (and issued a certificate).
- 98% of these vehicles were light-duty vehicles (< 8500 lbs. GVWR).

Discussion with TCEQ indicates these results appear to have occurred due to an error in the analyzer's software that has subsequently been corrected for both manufacturers. This software correction was made in 2006, which is after the evaluation period covered by this analysis.

"By-Make" counts of these tests are shown in Table 4-41, and Appendix C provides "By-Model" counts of these tests. These tables show the makes and models as stored in the vehicle test record. These makes and models are not derived from VIN decoding.

Table 4-41. Counts of Vehicles With More than Three Unset Monitors and an OBDII Readiness Result of "Pass"

1996 – 2000 Vehicle		2001 + Vehicle	
Make	**Counts**	**Make**	**Count**
ACUR	24	ACUR	2
AUDI	3	AMGN	1
BENT	1	ASTO	1
BMW	19	BMW	1
BUIC	35	BUIC	9
CADI	30	CADI	7
CHEV	799	CHEV	73
CHRY	102	CHRY	19
DAEW	7	DAEW	2
DODG	381	DODG	40
EGIL	5	FORD	145

1996 – 2000 Vehicle		2001 + Vehicle	
Make	**Counts**	**Make**	**Count**
FORD	1572	GMC	6
FTWD	1	HOND	8
GEO	51	HYUN	5
GMC	136	ISU	5
HOLI	1	JAGU	3
HOND	241	JEEP	8
HYUN	57	KIA	7
INFI	13	LEXS	7
ISU	44	LINC	2
ITAS	1	LNDR	3
JAGU	6	MAZD	11
JEEP	22	MERZ	6
KIA	42	MITS	11
LEXS	20	NISS	11
LINC	28	OLDS	1
LNDR	1	OTHR	948
MAZD	188	PLYM	2
MERC	145	PONT	19
MERZ	24	STRN	1
MITS	188	SUBA	2
NISS	307	SUZI	2
OLDS	61	TOYT	31
OTHR	510	VOLK	4
PLYM	132	Total	1403
PONT	147		
PORS	1		
STRN	66		
SUBA	12		
SUZI	11		
TOYT	209		
VOLK	27		
VOLV	34		
Total	5,704		

Summary: The Texas I/M program allows two non-continuous monitors to be unset for OBDII “readiness” for 1996 and newer model year vehicles.

261 vehicles with fewer than three unset readiness monitors had a “fail” result stored in the readiness result field of the test record, but additional investigation indicated these vehicles had a fail-to-communicate status, that is, no communication was established between the analyzer and the vehicle.

Vehicles with more than two unset readiness monitors had a pass result for readiness status and were allowed to continue with the OBDII inspection in 7,107 tests (0.09% of all OBD tests conducted over the period of evaluation). This suggests that some vehicles could be passing OBDII inspections with more than 2 unset monitors, which could mask malfunctioning

components that would otherwise result in an OBDII test failure. An analysis of unset readiness monitors masking potential malfunctions is provided in the results given in Section 5.4.

Readiness Evaluation: Comparison of readiness result with overall pass/fail result – We then compared the pass/fail disposition of the readiness result field of the test record with the overall OBDII test disposition to see of any vehicles with a "not ready" status (as determined automatically by the analyzer) received an overall OBDII test result of "pass". To perform this analysis, we compared the "OBD2_READY_RES" field to the "OBD2_PF_FLAG" fields in the analyzer OBDII test records. The results are shown in Table 4-42.

Table 4-42. Comparison of Readiness Status Field with Overall OBDII Test Result

Readiness Status Check	Overall OBDII Test Result		Total
	Fail	Pass	
Fail (Not Ready)	209,097 (2.5%)	3,488 (0.04%)	212,585 (2.6%)
Pass (Ready)	180,641 (2.2%)	7,947,891 (95.3%)	8,128,532 (97.5%)
Total	389,738 (4.7%)	7,951,379 (95.3%)	8,341,117 (100%)

As can be seen in Table 4-42, 3,488 of the vehicles with a "not ready" status received an overall "pass" result for the OBDII portion of the test. However, review of these test records indicated these were categorized as heavy-duty (>8500 lbs GVWR) vehicles. OBDII results were not enforced for heavy-duty vehicles over the period of evaluation.

Summary: The OBD readiness status (as determined by the analyzer and stored in the OBD2_READY_RES" field of the test record) was enforced for all OBDII tests performed on light-duty (<8500 lbs. GVWR) vehicles during the period of evaluation.

MIL commanded on – If a vehicle has a MIL commanded on status (and has stored diagnostic trouble codes), that vehicle should fail the OBD inspection, regardless of readiness status. To perform this analysis, all OBDII test records were reviewed to determine the overall OBDII pass/fail status in comparison with the downloaded MIL command status results. Specifically, any vehicle with "F" in the "OBD2_MIL_STATUS" should also have "F" in the "OBD2_PF_FLAG" field (if DTCs are present). Table 4-42 provides results of this review.

Table 4-43. Comparison of Downloaded MIL Command Status with Overall OBDII Test Result

Result of Downloaded MIL Status	Overall OBDII Test Result		Total
	Fail	Pass	
Fail	187,521 (2.3%)	46,780 (0.6%)	234,301 (2.8%)
Pass	200,907 (2.4%)	7,901,817 (94.8%)	8,102,724 (97.2%)
Total	388,428 (4.7%)	7,948,597 (95.3%)	8,337,025 (100%)

From Table 4-43, it can be seen that 46,780 test records (roughly 0.6% of all OBDII test records) have a MIL commanded on status yet receive an overall OBDII pass result. However, 44,443 of these tests had no stored DTCs, in which case it is appropriate to pass the test. The remaining 2,338 test records did have at least one DTC, with a downloaded MIL commanded on status, and an overall OBDII result of pass, but these vehicles were categorized as heavy-duty (> 8500 lbs. GVWR) in the test records. OBDII test results are not enforced on heavy-duty vehicles.

Summary: The downloaded OBD MIL command status was enforced for all OBDII tests conducted on light-duty vehicles (< 8500 lbs. GVWR) with stored DTCs during the period of evaluation.

Diagnostic Link Connector Communication Status – According to federal guidelines, a diagnostic link connector (DLC) that is missing, tampered, or otherwise inoperable is a basis for failure, but may be "rejected" for a DLC that is inaccessible or cannot be located. Failure to communicate with an OBDII analyzer is also a basis for failure. To perform this analysis, the result stored in the "OBD2_DLC_RES" field was compared with that in the "OBD2_PF_FLAG" field. No test results with a "D" (damaged), "N" (connected but will not communicate), "L" (inspector cannot find DLC), or "I" (DLC is inaccessible) in the "OBD2_DLC_RES" should have a "P" in the "OBD2_PF_FLAG". Results of this analysis are shown in Table 4-44.

Table 4-44. Comparison of DLC Communication Status with Overall OBDII Test Results

DLC Communication Status	Overall OBDII Test Results	
	Fail	Pass
"D" (damaged)	2,351	380
"I" (DLC is inaccessible)	1,569	686
"L" (inspector cannot find DLC)	2,540	14,151
"N" (connected but will not communicate)	421	9,451
Total count of "D", "I", "L", and "N" Tests	6,884	24,668
"P" (communication successful)	387,550	7,947,155
Total	394,434	7,971,823

As can be seen in the table, 24, 668 test records have a DLC communication status of "D", "I", "L", or "N", yet have an OBDII test result of "pass". Review of the test records indicated these 24,668 tests were conducted on heavy-duty vehicles (> 8500 lbs. GVWR). OBDII Pass/Fail was not enforced on heavy-duty vehicles over the period of evaluation.

Summary: DLC fail to communicate was enforced on all OBDII tests conducted on light-duty vehicles (< 8500 lbs. GVWR) during the period of evaluation.

Inspector-Entered Engine-Running MIL Illumination Status – The key-on engine running result manually entered by the inspector is a basis for failure. No vehicle with an "F" in the "OBD2_MIL_ON_RUN" field should have a "P" in the "OBD2_PF_FLAG" field of the OBDII test record.

The "OBD2_MIL_ON RUN" results are "Y", which is a pass (Y = MIL turned off after the vehicle was started) or "N", which is a fail (N = MIL stayed illuminated after the vehicle was started).

Table 4-45 shows results of this analysis.

Table 4-45. Comparison of Inspector-Entered MIL Illumination Status (Engine Running) with Overall OBDII Test Result

Result of MIL Illumination Status	Overall OBDII Test Result		Total
	Fail	Pass	
N (Fail)	83,684 (1.0%)	0 (0.0%)	83,684 (1.0%)
Y (Pass)	310,504 (3.7%)	7,971,814 (95.3%)	8,282,318 (99.0%)
Total	394,188 (4.7%)	7,971,814 (95.3%)	8,366,002 (100%)

Summary: This comparison shows that the MIL Illumination Status appears to be enforced as a condition for OBDII failure. However, since the Key On Engine Running MIL Illumination Status is manually entered by the inspector, accuracy of this entry is not automatically enforced by the analyzer.

4.8 VID OBDII Data Checks for Evidence of Station Fraud[33]

For OBD (1996 and newer) vehicles, a comparison of the inspector-entered information against the vehicle-downloaded information via the OBD connection can help verify if all OBD inspections are performed on the correct vehicle. The vehicle-downloaded information contains the vehicle readiness monitor status. Differences between readiness monitors such as "not supported" to "not ready" or "ready" would indicate a different vehicle was used and may be evidence of a clean scanning. OBD information is in the Texas VID.

In this activity we compared inspector-entered information against vehicle-downloaded information to determine if all inspections are performed on the correct vehicle. We used readiness criteria (supported/enabled status) to look for evidence of clean scanning.

Program Description

"Clean Piping" is a term used to describe a type of vehicle emissions test fraud in which an inspector substitutes a vehicle with passing emission rates in place of a vehicle with high emission rates in order to achieve a pass record for the high-emitting vehicle. Historically, this has been identified through the use of covert audits, notifications by motorists, and analysis of vehicle emission result trends. For a vehicle receiving an OBDII inspection, the analogous practice is typically referred to as "clean scanning," where a vehicle with no MIL illumination is substituted in place of a vehicle with MIL illumination and stored DTCs in an attempt to receive a pass test result. Although identification of emission results trends is not possible with OBDII tests, information downloaded from the OBDII system during an inspection may be used to identify possible clean scanning activities.

Analysis Performed

For this element, we performed several types of analyses in an attempt to identify fraud associated with OBDII inspections. The following strategies were attempted:

- Comparison of VIN downloaded from a vehicle's OBD computer with that contained in the inspection test record.
- Comparison of vehicle-type specific information downloaded from a vehicle's OBDII computer during a vehicle's first test with the same information downloaded during subsequent tests.

[33] This section responds to the Work Plan's Task 3 Element 1D: Analysis of VID Data for Evidence of Station Fraud (OBDII Testing) and was written by M.A. Sabisch.

- Comparison of a vehicle's OBDII monitoring "enabled profile" downloaded during its first test with the "enabled profile" downloaded during subsequent tests.

Comparison of OBD VIN with VIN entered during vehicle inspection - For this analysis, we dropped all test records where no OBDII VIN was present. This reduced the dataset from 8,348,608 records to 901,747 records. For each of these remaining records, the OBD-downloaded VINs were compared with VINs entered (either via keyboard or barcode scan) during the vehicle inspection. Approximately 20% of these records (175,876 records) were found to have VIN to VIN discrepancies. Manual investigation of these records showed a number of the OBD VINs were invalid (approximately 28,000 had obviously errors such as odd characters, repeated characters, or were less than 17 characters in length), and some mismatches were also due to VIN errors in the vehicle test record. However, due to the high mismatch rate and unexpectedly high number of errors seen in the OBD-downloaded VINs, this analysis strategy was abandoned in favor of other strategies with lower false identification rates.

Comparison of vehicle-specific information between the first test and subsequent tests - Three variables were used for this analysis, the OBD-downloaded VIN, the PCM Module ID, and the PID Count. The purpose of this analysis was to use these three values to assign a unique "electronic profile" to a vehicle based on downloaded values from the vehicle's first test, and then compare that profile with the profile seen in subsequent tests in an effort to try to identify instances of clean scanning.

To begin the analysis, a general review of downloaded values for these three variables was performed for all OBDII tests conducted over the two-year audit period, as described below:

- OBDII VIN: As previously indicated, OBDII-downloaded VINs (valid or invalid) were only available in approximately 11% of the 8,348,606 test records. The OBDII VIN was null in the remaining 89% of the OBDII test records. Because of this, use of the OBDII VIN in itself would not be sufficient to positively identify clean scanning.

- PCM Module ID: PCM Module ID was available in approximately 90% of the 8,348,606 test records. Sixty unique PCM Module IDs were seen, but 76% of all PCM Module IDs had a value of "10". Six other PCM Module IDs comprised an additional 18% of the test records, and the remaining 6% of the text records contained the remaining 53 PCM Module IDs. Because of this, as with the OBDII VIN, use of PCM Module ID would not be sufficient to positively identify clean scanning (a substituted vehicle would be likely to have a value of "10" or one of the other six common PCM Module IDs).

- PID Count: 102 unique PID Count values were seen, and approximately 99% of all OBDII test records contained a value for PID Count. Nine PID Count values were seen in 88% of all OBDII test records, the remaining 12% of OBDII test records (1,019,712 records) contained one of the remaining 93 PID Count values.

For any individual vehicle, these downloaded values may vary among analyzer manufacturers (in particular the PCM Module ID and the PID Count), so the analysis was based on vehicle/analyzer combinations. A value for each of these three variables was assigned to each vehicle/analyzer pair based on the vehicle's first inspection conducted with that analyzer. As shown above, many of these values were common among many vehicles, so any subsequent test (with the same analyzer) where a mismatch was seen for any of the three values was flagged.

Comparison of a vehicle's "enabled profile" between the first test and subsequent tests - For this analysis, we identified OBDII monitors that are commonly found to be both "monitored" and "not monitored," depending on the make/model/model year of vehicle being inspected. For example, very few vehicles have monitored PCV or air conditioning systems, so these would be poor indicators of potential clean scanning since the monitored status is almost surely the same for two different vehicles. Similarly, catalysts and oxygen sensors are almost always monitored, so these too would be poor indicators of potential clean scanning. Again, two different vehicles will likely both have these monitored. As shown below, exhaust gas recirculation (EGR) systems, evaporative emission control systems (evap systems), and to a lesser extent heated oxygen sensor systems and secondary air injection systems were seen to have significant percentages of vehicles with both "monitored" and "not monitored" status:

- EGR systems: 34% not monitored, 66% monitored
- evap systems: 16% not monitored, 84% monitored
- heated O_2 systems: 2% not monitored, 98% monitored
- secondary air systems: 93% not monitored, 7% monitored

Since the combined monitored status of these four monitors could provide a distinguishing and characteristic profile from vehicle to vehicle, these four monitors were used for this analysis. The monitored status for every vehicle was classified as "monitored" or "not monitored" based on that vehicle's first inspection during the period of evaluation. Then, the status for each of these four systems was compared with the assigned monitored status for that vehicle for each subsequent retest on the same analyzer. Any tests where the monitored status of any of the four monitors deviated from the assigned status for that vehicle was flagged. This would be a strong indicator that a different vehicle was being substituted for the test.

Results of Analysis

To begin this analysis, all test records that had null values for any of the four evaluated OBDII monitors were dropped. This reduced the analysis dataset from 8,348,608 to 8,269,464 records. An analysis comparing downloaded vehicle OBDII computer information (OBDII VIN, PID count and PCM Module ID) on the initial test in a vehicle/analyzer combination with all subsequent tests was performed, as well as the same analysis comparing the readiness profile described above. Results include all OBDII test records collected during the 2-year audit period. Occasionally, analyzer hardware upgrades or software updates could result in OBDII system PID count mismatches between multiple tests on the same vehicle, and the OBDII-downloaded VIN could be mismatched on multiple tests from the same vehicle in extremely rare instances where the PCM on the vehicle was improperly reprogrammed in an attempt to repair the vehicle. An assessment of the likelihood of fraud is provided for each of the scenarios listed below. It is also worthwhile to note that since each vehicle's OBDII system "profile" was assigned based on the information collected during the vehicle's first test, this analysis would not identify any tests where a vehicle was substituted (i.e., "clean-scanned") during the initial inspection.

The results listed below include the initial test:

- 7,549,621 (91.3% of the 8,269,494 record dataset) tests had matches for both the computer ID info and readiness profile between initial test and all subsequent retests on the same analyzer. Test groups where both parameters match for all tests very likely indicate compliant testing.

- 85,321 (1.03% of the 8,269,494 record dataset) tests had a mismatch for both the computer ID info and the readiness profile between the initial test and at least one retest on the same analyzer. Test pairs where both computer ID information and readiness profile differ are very likely to be performed on two different vehicles (i.e., a strong indication of clean scanning).

- 466,528 (5.64% of the 8,269,494 record dataset) tests had a computer ID mismatch info between the initial test and at least one retest on the same analyzer, but the "readiness profile" matched between the initial test and all subsequent retests on the same analyzer. Since the computer ID serves as a unique identifier for any vehicle, this information should always match for retests on the same vehicle. A mismatch would occur in the following scenarios:

    - if another vehicle was substituted for a retest (clean scanning)
    - if an anomaly in the analyzer software interpreted the computer ID info two different ways on subsequent retests for the same vehicle
    - if a vehicle repair was performed in which the vehicle's PCM was re-programmed with new ID info as a part of a repair

Although the last two scenarios are unlikely, we were not able to quantify the likelihood of this occurring for this analysis. It is possible for two different vehicles to have common readiness profiles, so a readiness profile match does not confirm that clean scanning did not occur. Therefore, this scenario (computer ID mismatch) is felt to be a fairly strong indicator of clean scanning.

- 167,994 (2.03% of the 8,269,494 record dataset) tests had a "readiness profile" mismatch between the initial test and at least one retest on the same analyzer, but the computer ID info matched between the initial test and all subsequent retests on the same analyzer. This scenario is difficult to interpret, since the readiness profile is based on "monitored vs. unmonitored" status of various systems, as opposed to ready/not ready status, and therefore should never change for a vehicle despite the vehicle's state of readiness. Similarly, the computer ID information should be static for any one vehicle except for the case when PCM reprogramming is part of the repair process. Because of the contradictory results, the scenario of a readiness profile mismatch with a computer ID info match is not considered to be a strong indicator of non-compliant testing.

The same analysis was then performed again using the initial test to define the readiness profile and computer ID info for the test groupings, but then removing the "initial" tests from the overall counts of tests. For any vehicle, an "initial" tests was defined as the first test in our dataset or any test following a test in which a certificate was issued. The following results were seen from the dataset with excluded "initial" tests:

- 501,985 (73.0 % of the 687,808 record dataset) tests had matches for both the computer ID information and readiness profile between initial test and all subsequent retests on the same analyzer (most likely compliant testing).

- 47,938 (7.0 % of the 687,808 record dataset) tests had a mismatch for both the computer ID information and the readiness profile between the initial test and at least one retest on the same analyzer (strong indication of clean scanning).

- 103,135 (15.0 % of the 687,808 record dataset) tests had a computer ID mismatch info between the initial test and at least one retest on the same analyzer, but the "readiness profile" matched between the initial test and all subsequent retests on the same analyzer (fairly strong indicator of clean scanning).

- 34,750 (5.0 % of the 687,808 record dataset) tests had a "readiness profile" mismatch between the initial test and at least one retest on the same analyzer, but the computer ID information matched between the initial test and all subsequent retests on the same analyzer (not considered to be a strong indication of clean scanning).

A summary of this information is provided in Table 4-46.

Table 4-46. Percentages of Tests with Various OBDII Fraud Indicators

Retest Match Scenario	Complete Dataset Including Initial Tests (8,269,494 tests total)	Retest-only Dataset (687,808 tests total)
All match (compliant)	91.3%	73.0%
Readiness mismatch (ambiguous)	2.0%	5.0 %
PCM ID info mismatch (fraud likely)	5.6%	15.0 %
Both mismatch (fraud very likely)	1.0%	7.0 %
Estimated % of clean scanning	1.0 % to 9 %	7 % to 27 %

Next, using the complete dataset, which includes tests classified as initial tests, the following general statistics were seen for stations and inspectors with computer ID information or "readiness profile" mismatches.

- Over the two-year audit period, 97% of the 3875 inspection stations had at least one test record with either a readiness profile or computer ID information mismatch between an initial test and a subsequent test for the same vehicle (tested using the same analyzer as the initial test). The maximum number of mismatch records for any one station was 3,264 records over the two-year period, which is 15% of this station's 21,603 records. This station had four analyzers. Of all stations with mismatch records, stations had an average of 192 mismatch OBDII records over the two-year period.

- Over the two-year audit period, 83% of the 15,573 inspectors had at least one test record with either a readiness profile or computer ID information mismatch between an initial test and a subsequent test on the same vehicle using the same analyzer. The maximum number of mismatch records for any one inspector was 1,273 records over the two-year period, which is 21% of that inspector's 6,201 test records. Of all inspectors with mismatch records, inspectors had an average of 55 mismatching OBDII records over the two-year period.

5.0 Repair

We used two years of Texas VID data to analyze repair activities. The analysis will demonstrate the extent and properties of repairs directed by the I/M program. This task will cover process-based activities for repair.

5.1 Number and Types of Repairs[34]

We performed this analysis on the repair data contained in two years of the Texas VID. The inspectors at I/M stations enter vehicle repair information into the VID prior to emissions tests that follow repairs. A simple count of the number of repairs in the VID and a distribution of the repair types are evidence that the I/M program is causing repairs to be performed. As for repairs reported for its LIRAP(Low Income and Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program) program, since the repairs reported are documented on paper and not electronically, LIRAP repairs will be described generally. [Section 4.3.1 of Reference 1]

In an effort to determine the number and types of repairs performed as a result of the Texas I/M program, we analyzed two sets of data: the Texas VID and detailed repair information collected from DPS Recognized Emissions Repair Facilities (RERF).

General I/M Repairs

The Texas VID, as provided by TCEQ, contains a large number of observations, but relatively little detail on the nature of repairs performed. The five repair categories listed in the VID, along with the corresponding number of performed repairs, are presented in Table 5-1 by model year group.

[34] This section responds to the Work Plan's Task 3 Element 2A: Count the Number of Repairs and the Various Types of Repairs and was written by S.W. Fincher.

Table 5-1. Repairs Listed in the VID

Repair Type	Model Year	Number of Repairs	% of Repair Type	% of Total
Fuel System	pre-1980	114	0.12	0.02
	1980-1989	17089	17.82	3.06
	1990-1999	65043	67.83	11.65
	post-2000	13642	14.23	2.44
	Total	*95888*	*100.00*	*17.17*
Ignition / Electrical system	pre-1980	114	0.14	0.02
	1980-1989	17952	22.80	3.21
	1990-1999	54057	68.67	9.68
	post-2000	6602	8.39	1.18
	Total	*78725*	*100.00*	*14.10*
Emissions system	pre-1980	179	0.08	0.03
	1980-1989	46562	19.54	8.34
	1990-1999	169713	71.22	30.39
	post-2000	21846	9.17	3.91
	Total	*238300*	*100.00*	*42.67*
Engine Mechanical	pre-1980	12	0.14	0.00
	1980-1989	1625	19.29	0.29
	1990-1999	5807	68.93	1.04
	post-2000	980	11.63	0.18
	Total	*8424*	*100.00*	*1.51*
Miscellaneous	pre-1980	125	0.09	0.02
	1980-1989	22679	16.54	4.06
	1990-1999	93453	68.18	16.74
	post-2000	20818	15.19	3.73
	Total	*137075*	*100.00*	*24.55*
	Grand Total	***558412***		***100.00***

RERF Repairs

Relative to the VID, the separate RERF dataset obtained from DPS contains more comprehensive information about the nature of repairs performed. However, repairs made at RERFs only make up a fraction of overall repairs made throughout the I/M areas statewide. Nonetheless, the distribution of repairs performed at RERFs serves to illustrate the wide variety of repairs undertaken as a result of the Texas I/M program. Table 5-2 shows counts of repairs reported by stations participating in the RERF program.

Table 5-2. Repairs Performed at RERF Stations

Repair Type	Defective, Not Repaired	Repaired	% Repaired	Total Vehicles with This Defect	Defect % of Total
AIS	1	284	99.6	285	0.74
Air Filter	0	30	100.0	30	0.08
Air Flow Sensor(s) (all)	0	29	100.0	29	0.07
All other types of repairs	63	399	86.4	462	1.19
Back Pressure	0	2	100.0	2	0.01
Battery	1	83	98.8	84	0.22
Belt(s)	0	2	100.0	2	0.01
Block	1	22	95.7	23	0.06
Bypass/Diverter/Switch Valve(s)	0	9	100.0	9	0.02
CAT	38	4729	99.2	4767	12.30
Cam Timing/Belt/Chain	0	4	100.0	4	0.01
Camshaft	1	36	97.3	37	0.10
Camshaft Position (CMP) Sensor	0	4	100.0	4	0.01
Canister	0	4	100.0	4	0.01
Carburetor - External	0	8	100.0	8	0.02
Carburetor - Internal	0	15	100.0	15	0.04
Charging System	0	20	100.0	20	0.05
Clear Diagnostic Trouble Codes (DTC)	0	8	100.0	8	0.02
Coil(s)/Secondary	0	14	100.0	14	0.04
Cold Start System/Choke	0	2	100.0	2	0.01
Crankshaft Position (CP) Sensor	0	1	100.0	1	0.00
Cylinder Head Structure/Head Gasket	0	4	100.0	4	0.01
Diagnosis (Costs associated with determining what repairs to perform), VIE	1	17	94.4	18	0.05
ECM	4	469	99.2	473	1.22
EGR	40	4385	99.1	4425	11.42
EVAP	6	534	98.9	540	1.39
Electronic Control System	0	25	100.0	25	0.06
Emissions System	63	7332	99.1	7395	19.09
Empty/Melted/Damaged	0	78	100.0	78	0.20

Repair Type	Defective, Not Repaired	Repaired	% Repaired	Total Vehicles with This Defect	Defect % of Total
Eng. Cooling	1	389	99.7	390	1.01
Engine Coolant Temperature (ECT) Sensor	0	38	100.0	38	0.10
Engine Crankcase Oil	0	10	100.0	10	0.03
Engine Exhaust	5	215	97.7	220	0.57
Engine Mechanical	12	407	97.1	419	1.08
Engine Valve	3	89	96.7	92	0.24
Exhaust Manifold/Gaskets	0	5	100.0	5	0.01
Fan	0	1	100.0	1	0.00
Final Drive Ratio	0	2	100.0	2	0.01
Flow Passages	0	66	100.0	66	0.17
Fuel	0	5	100.0	5	0.01
Fuel Cap	0	1	100.0	1	0.00
Fuel Distribution	0	8	100.0	8	0.02
Fuel Pressure Control	0	5	100.0	5	0.01
Fuel System	90	4317	98.0	4407	11.37
Hot/Cold Intake-Air System and Control/Thermostatic Air Cleaner (TAC)	0	5	100.0	5	0.01
Idle Air Control (IAC)/Idle Speed Control (ISC)	0	3	100.0	3	0.01
Idle Mixture Control	0	6	100.0	6	0.02
Idle Speed Adjustment	0	79	100.0	79	0.20
Ignition Control Module (ICM)	0	4	100.0	4	0.01
Ignition/Electrical System	32	2547	98.8	2579	6.66
Injector(s)	0	12	100.0	12	0.03
Inlet Air Temperature (IAT) Sensor	0	31	100.0	31	0.08
Intake Manifold/Gaskets	0	7	100.0	7	0.02
Internal (hydraulic/mechanical)	0	1	100.0	1	0.00
Internal Short-Block	0	8	100.0	8	0.02
Knock Sensor (KS)	0	2	100.0	2	0.01
Lines/Hoses/Filters	0	26	100.0	26	0.07
Low Efficiency	0	91	100.0	91	0.23

Repair Type	Defective, Not Repaired	Repaired	% Repaired	Total Vehicles with This Defect	Defect % of Total
Manifold Absolute Pressure (MAP) Sensor, Manifold Differential Pressure Sensor, Manifold Vacuum Zone Sensor, Barometric Pressure (BARO) Sensor	0	3	100.0	3	0.01
Mechanical Control System (includes vacuum)	0	145	100.0	145	0.37
Metering Device (if applicable)	0	41	100.0	41	0.11
Miscellaneous	24	2057	98.8	2081	5.37
Muffler/Tailpipe	0	1	100.0	1	0.00
O2 Sensor	26	2416	98.9	2442	6.30
Oil Change	0	1	100.0	1	0.00
Open Circuit	0	4	100.0	4	0.01
Other	0	3	100.0	3	0.01
Other (including valve adjustment)	0	1	100.0	1	0.00
Other Seals/Gaskets	0	1	100.0	1	0.00
Other Sensor(s)	2	101	98.1	103	0.27
Other Vacuum/False Air Leaks	0	10	100.0	10	0.03
Oxygen Sensor(O2S), Heated Oxygen Sensor(HO2S)	1	110	99.1	111	0.29
PCV	1	608	99.8	609	1.57
Plumbing	0	4	100.0	4	0.01
Powertrain Control Module (PCM), Engine Control Module (ECM), Program Read-Only Memory (PROM) Computer Chip	0	11	100.0	11	0.03
Primary/Reference (Circuit & Components)	0	15	100.0	15	0.04
Pump	0	1	100.0	1	0.00
Pump(s)	0	2	100.0	2	0.01
Purge Valves/Solenoids/etc.	0	1	100.0	1	0.00
Radiator, Coolers and Caps	0	3	100.0	3	0.01
Reed, Check, and other Valves	0	2	100.0	2	0.01
Secondary Air Injection Reaction (AIR) tube	0	2	100.0	2	0.01
Shorted Circuit	0	29	100.0	29	0.07
Spark Plug Wires	11	1559	99.3	1570	4.05

Repair Type	Defective, Not Repaired	Repaired	% Repaired	Total Vehicles with This Defect	Defect % of Total
Spark Plugs	17	2254	99.3	2271	5.86
Spark Timing	0	58	100.0	58	0.15
TAC	0	80	100.0	80	0.21
Thermostat	0	6	100.0	6	0.02
Throttle Body	0	22	100.0	22	0.06
Throttle Position Sensor (TPS)	0	18	100.0	18	0.05
Timing	9	1168	99.2	1177	3.04
Trans/Final Drive	2	116	98.3	118	0.30
Valve	0	12	100.0	12	0.03
Valve/Actuator Assembly(ies)	0	77	100.0	77	0.20
Valves (Mechanical)	0	3	100.0	3	0.01
Vehicle Fluids	2	315	99.4	317	0.82
Vehicle Speed Sensor (VSS)	0	96	100.0	96	0.25
Vent Lines/Hoses/Purge Hoses	0	2	100.0	2	0.01
Grand Total	457	38287	98.8	38744	100.00

Low Income and Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program (LIRAP)

Texas has put in place a program to financially assist low income individuals with repairing or retiring vehicles that fail emissions testing. It is called the AirCheckTexas Repair & Replacement Assistance Program.

To qualify, a vehicle owner's net family income must be no greater than double the federal poverty level, which varies by family unit size. The owner's vehicle must have failed an emissions test within the 30 days prior to LIRAP application, must have a current valid registration, and must have been registered in an I/M program county for the past 12 months. In addition, the vehicle must have passed (or be able to pass) a safety inspection, must be drivable to the repair facility, and (in the case of repairs) must be repaired or retrofitted at a RERF.

Assistance provided under the LIRAP program includes a minimum of $30 and a maximum of $600 for use in retrofits or repairs performed at RERFs. Assistance increases to a minimum of $600 and a maximum of $1,000 if a vehicle is selected for replacement.

9,649 of the repairs made at RERFs were performed under the LIRAP program during the evaluation period.

5.2 Emissions Changes Associated with Repairs[35]

One way to measure the effectiveness of the Texas I/M program is to assess emissions from vehicles both before and after repairs and to calculate the average emissions change produced by different repair types. Different types of repairs tend to produce characteristic changes in emissions [Reference 3].

In the discussion below, we compare the average emissions and the emissions changes produced by repairs during the evaluation period in the Texas I/M program with similar quantities from the British Columbia I/M program. We chose to make the comparison with the British Columbia I/M program because during the period from 1995 to 1999, British Columbia used the ASM2525 test as the primary test to evaluate vehicles in their I/M program. In addition, the British Columbia I/M program during this period, had some of the most complete and most detailed I/M program vehicle repair records in North America.

As we have seen earlier in this report, the Texas I/M program uses five categories to classify repairs. On the other hand, British Columbia used approximately 34 categories of repairs. To attempt to make the comparison of the emissions effects of repairs for Texas with those of British Columbia, we have re-categorized the British Columbia repairs in terms of the five categories used by Texas. Fuel system repairs for Texas includes the British Columbia repairs for idle air/fuel mixture, idle speed, choke system, and fuel metering system. The ignition/electrical system repairs of Texas includes the British Columbia repairs for spark plugs, ignition wires, distributor cap and rotor, spark advance control, spark timing, throttle position sensor, wide open throttle sensor, manifold absolute pressure sensor, mass air flow sensor, coolant temperature sensor, thermal vacuum switch, and engine computer. The emissions system repairs of Texas include the British Columbia repairs for thermostatic air cleaner, positive crankcase ventilation, air injection system, evaporative system, gas cap seal, catalytic convertor, fuel filler restricter, oxygen sensor, and exhaust gas recirculation. The engine mechanical repairs for Texas include the internal engine repairs of British Columbia. Finally, the miscellaneous repairs of Texas include British Columbia repairs for vacuum leaks, air filter, other sensors and switches, and other repairs.

[35] This section responds to the Work Plan's Task 3 Element 2B: Calculate Emissions Changes Associated with Repair Types and was written by S.W. Fincher.

The fleet make up in British Columbia between 1995 and 1999 contained more older technology vehicles and fewer newer technology vehicles in comparison with the Texas fleet of 2004 and 2005. Accordingly, the average emissions for different slices of the Texas fleet will tend to be lower both before and after repair than those seen in the British Columbia dataset. Nevertheless, the average emissions for the British Columbia I/M program serves as a reference for judging the results of repairs in the Texas fleet.

Emissions Changes as a Result of Repair

The average emissions of all Texas vehicles that received repairs are shown in Table 5-3a. Both ASM 5015 and ASM 2525 test results are presented. Average emissions for both inspections prior to and following repair cycles are shown, along with the average change between the two. The corresponding change in emissions for the ASM 2525 mode in British Columbia is shown by the values in Table 5-3b. The average emissions before and after repair in Texas are lower than the corresponding values in British Columbia. The average emissions change for Texas for HC, CO, and NOx, are -69%, -82%, and -65%. The average emissions change for British Columbia for HC, CO, and NOx were -66%, -78%, and -33%. The percent emission changes for HC and CO for the two jurisdictions are quite close. On the other hand, the percent emissions change for NO is substantially larger than the NO emissions change observed in British Columbia.

Tables 5-4a and 5-5a present the same types of Texas emissions averages as those shown in Table 5-3a, but they are stratified by inspection year and model year group, respectively. These tables show that when stratifying by either inspection year or model year, emissions of HC, CO, and NOx all decrease with increasing year, for both the ASM 5015 and ASM 2525 tests.

The average emissions for the five years of British Columbia data in Table 5-4b do not show any particular trend with time for the before repair average emissions. However, the after repair emissions show a steady lowering of emissions values from 1995 to 1999. Table 5-5b shows the average British Columbia emissions for three model year groups. Because the British Columbia dataset included inspections only until 1999, it does not contain any vehicles with model years after 1999. In addition, the Texas dataset has very few observations for pre-1980 model year vehicles as shown by Table 5-5a. Accordingly, comparison of average emissions between Texas and British Columbia, as a function of model year, must be made primarily through a comparison of the model years from the 1980s and 1990s. The comparison indicates that the average emissions

before and after repair in Texas as measured in calendar years 2004 and 2005 are somewhat lower than the average emissions measured in British Columbia in the mid to late 1990s.

Table 5-3. Average Emissions Before and After Repairs

a) Texas Data

ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
		Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
				Conc.	(%)			Conc.	(%)			Conc.	(%)
5015	448440	117	42	-74	-63%	0.70	0.14	-0.55	-79%	792	303	-490	-62%
2525	448440	101	31	-70	-69%	0.66	0.12	-0.54	-82%	692	243	-449	-65%

b) British Columbia Data

ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
		Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
				Conc.	(%)			Conc.	(%)			Conc.	(%)
2525	65558	140	48	-92	-66%	1.33	0.29	-1.04	-78%	1048	702	-346	-33%

Table 5-4. Average Emissions Before and After Repairs by Inspection Year

a) Texas Data

Inspection Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
			Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
					Conc.	(%)			Conc.	(%)			Conc.	(%)
2003	5015	116592	143	52	-91	-64%	0.69	0.15	-0.54	-78%	930	355	-576	-62%
2004	5015	174745	120	43	-77	-64%	0.71	0.15	-0.57	-80%	801	308	-494	-62%
2005	5015	157365	94	35	-59	-63%	0.68	0.14	-0.54	-79%	680	259	-421	-62%
2003	2525	116592	120	38	-82	-68%	0.66	0.13	-0.53	-80%	819	297	-522	-64%
2004	2525	174745	103	31	-72	-70%	0.68	0.12	-0.56	-82%	707	249	-459	-65%
2005	2525	157365	83	25	-58	-70%	0.65	0.11	-0.54	-83%	581	198	-383	-66%

b) British Columbia Data

Inspection Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
			Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
					Conc.	(%)			Conc.	(%)			Conc.	(%)
1995	2525	6858	140	55	-85	-61%	1.23	0.33	-0.90	-73%	1021	771	-250	-24%
1996	2525	11476	143	54	-89	-62%	1.23	0.30	-0.93	-76%	1055	744	-311	-29%
1997	2525	20277	141	48	-92	-66%	1.32	0.29	-1.03	-78%	1056	709	-347	-33%
1998	2525	16852	137	44	-93	-68%	1.40	0.29	-1.12	-80%	1070	681	-388	-36%
1999	2525	10095	141	44	-97	-69%	1.43	0.27	-1.17	-81%	1006	625	-380	-38%

Table 5-5. Average Emissions Before and After Repairs by Model Year Group

a) Texas Data

Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
			Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
					Conc.	(%)			Conc.	(%)			Conc.	(%)
pre-1980	5015	329	433	131	-302	-70%	2.24	0.68	-1.56	-70%	1388	816	-572	-41%
1980-1989	5015	78351	240	83	-158	-66%	1.74	0.34	-1.4	-80%	1288	553	-734	-57%
1990-1999	5015	313472	106	40	-67	-63%	0.56	0.12	-0.44	-79%	810	293	-517	-64%
post-1999	5015	56550	0.3	0.5	0.1	33%	0.002	0.002	-0.001	-50%	3	3	0.2	7%
pre-1980	2525	329	385	113	-273	-71%	2.15	0.66	-1.49	-69%	1264	718	-546	-43%
1980-1989	2525	78351	217	64	-153	-71%	1.66	0.3	-1.37	-83%	1142	453	-689	-60%
1990-1999	2525	313472	89	28	-61	-69%	0.53	0.1	-0.43	-81%	703	234	-469	-67%
post-1999	2525	56550	0.3	0.3	0	0%	0.003	0.002	-0.001	-33%	2.8	2.5	-0.3	-11%

b) British Columbia Data

Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
			Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
					Conc.	(%)			Conc.	(%)			Conc.	(%)
1970-1979	2525	5574	193	61	-132	-68%	1.17	0.57	-0.60	-51%	1241	1004	-237	-19%
1980-1989	2525	46130	144	53	-92	-63%	1.42	0.31	-1.10	-78%	1095	762	-332	-30%
1990-1999	2525	13854	105	28	-78	-74%	1.13	0.11	-1.02	-90%	814	378	-436	-54%

Table 5-6a presents the most common repair slates in the Texas VID data, as originally presented and discussed in Table 5-1 above. Average before and after repair emissions levels were calculated for each repair slate to determine the emissions effects of different combinations of repair types.

As shown in Table 5-6a for the ASM2525 mode in Texas, seven combinations of the five repair categories dominate the repair slates used in Texas. When we examined the frequency distribution of the repair slates for the same categorization used in British Columbia, we found that nine repair slates dominated the British Columbia repairs. For completeness, Table 5-6b shows the average emissions before and after repair for all nine slates for the British Columbia dataset. Comparison of the average emissions in British Columbia with the average emissions in Texas should be made between the same named repair slates. For example, the average ASM2525 HC emissions before and after repair for emissions systems repairs on 1980 to 1989 vehicles were 197 ppm and 62 ppm in Texas while they were 128 ppm and 44 ppm in British Columbia. As before, we see that average emissions before and after repairs are lower in the Texas dataset than in the British Columbia dataset.

In general, we observe that the recategorization of the British Columbia repair types into the five categories used by Texas produces average emissions before and after repair that no longer carry the repair-specific emissions change information that was characteristic of the original data from British Columbia. Consequently, comparing emissions changes as a function of repair slate when using a highly aggregated repair categorization scheme as used by Texas may not be beneficial to the evaluation of the effects of repairs on emissions.

Table 5-6. Average Emissions Before and After Repairs by Repair Slate and Model Year Group

a) Texas Data

Repair Slate	Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
				Before Repair	After Repair	Change Conc.	Change (%)	Before Repair	After Repair	Change Conc.	Change (%)	Before Repair	After Repair	Change Conc.	Change (%)
Miscellaneous	pre-1980	5015	54	379	141	-238	-63%	3.23	0.97	-2.25	-70%	1106	692	-414	-37%
Engine Mechanical	pre-1980	5015	7	849	99	-750	-88%	2.67	0.73	-1.94	-73%	937	799	-138	-15%
Emissions System	pre-1980	5015	113	332	121	-211	-64%	1.42	0.52	-0.91	-64%	2100	937	-1164	-55%
Emissions System & Misc	pre-1980	5015	3	71	124	53	75%	0.03	0.18	0.15	500%	2771	2049	-722	-26%
Ignition/Electrical System	pre-1980	5015	64	515	121	-395	-77%	1.96	0.47	-1.49	-76%	1213	836	-377	-31%
Fuel System	pre-1980	5015	77	513	146	-368	-72%	2.71	0.67	-2.04	-75%	750	712	-38	-5%
Fuel System & Emissions System	pre-1980	5015	1	397	384	-13	-3%	9.4	9.7	0.3	3%	407	108	-299	-73%
Miscellaneous	1980-1989	5015	13878	229	85	-145	-63%	1.81	0.4	-1.41	-78%	1244	581	-663	-53%
Engine Mechanical	1980-1989	5015	1014	254	83	-172	-68%	2	0.38	-1.62	-81%	1188	562	-626	-53%
Emissions System	1980-1989	5015	33682	220	82	-138	-63%	1.42	0.28	-1.14	-80%	1554	567	-988	-64%
Emissions System & Misc	1980-1989	5015	1487	210	82	-127	-60%	1.82	0.43	-1.39	-76%	1482	640	-842	-57%
Ignition/Electrical System	1980-1989	5015	12754	314	85	-229	-73%	1.94	0.33	-1.61	-83%	964	503	-461	-48%
Fuel System	1980-1989	5015	11420	235	79	-156	-66%	2.19	0.37	-1.82	-83%	971	516	-455	-47%
Fuel System & Emissions System	1980-1989	5015	1078	206	86	-121	-59%	2.04	0.42	-1.62	-79%	1195	606	-589	-49%
Miscellaneous	1990-1999	5015	67424	76	32	-43	-57%	0.45	0.12	-0.34	-76%	611	246	-364	-60%
Engine Mechanical	1990-1999	5015	4213	102	31	-71	-70%	0.54	0.1	-0.43	-80%	603	225	-378	-63%
Emissions System	1990-1999	5015	134348	109	43	-66	-61%	0.52	0.11	-0.41	-79%	1025	332	-692	-68%
Emissions System & Misc	1990-1999	5015	4598	116	52	-64	-55%	0.65	0.2	-0.45	-69%	1156	452	-703	-61%
Ignition/Electrical System	1990-1999	5015	42260	159	47	-112	-70%	0.74	0.14	-0.6	-81%	707	292	-415	-59%

Repair Slate	Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
				Before Repair	After Repair	Change Conc.	Change (%)	Before Repair	After Repair	Change Conc.	Change (%)	Before Repair	After Repair	Change Conc.	Change (%)
Fuel System	1990-1999	5015	49954	88	31	-57	-65%	0.57	0.1	-0.48	-84%	542	225	-317	-58%
Fuel System & Emissions System	1990-1999	5015	2868	124	49	-75	-60%	0.75	0.17	-0.59	-79%	1016	383	-634	-62%
Miscellaneous	post-1999	5015	17669	0.2	0.4	0.2	100%	0.001	0.001	0	0%	2	3	1.2	60%
Engine Mechanical	post-1999	5015	834	0.7	0.2	-0.6	-86%	0.008	0.001	-0.007	-88%	4	3	-0.2	-5%
Emissions System	post-1999	5015	19270	0.4	0.5	0.1	25%	0.003	0.002	-0.001	-33%	4	3	-0.7	-18%
Emissions System & Misc	post-1999	5015	324	0.4	0.7	0.3	75%	0.002	0.002	0	0%	4	6	1.2	30%
Ignition/Electrical System	post-1999	5015	5882	0.5	0.5	0	0%	0.002	0.002	0	0%	3	3	0.7	23%
Fuel System	post-1999	5015	11848	0.3	0.5	0.2	67%	0.003	0.002	-0.001	-33%	3	3	0	0%
Fuel System & Emissions System	post-1999	5015	224	0.4	1.1	0.7	175%	0.001	0.003	0.002	200%	6	10	4.1	68%
Miscellaneous	pre-1980	2525	54	375	121	-254	-68%	3.08	0.83	-2.25	-73%	1079	606	-472	-44%
Engine Mechanical	pre-1980	2525	7	847	88	-760	-90%	3.22	0.85	-2.37	-74%	911	585	-326	-36%
Emissions System	pre-1980	2525	113	294	103	-191	-65%	1.39	0.52	-0.87	-63%	1938	818	-1120	-58%
Emissions System & Misc	pre-1980	2525	3	63	102	39	62%	0.2	0.16	-0.04	-20%	2696	1665	-1031	-38%
Ignition/Electrical System	pre-1980	2525	64	417	103	-314	-75%	1.93	0.52	-1.41	-73%	967	730	-237	-25%
Fuel System	pre-1980	2525	77	447	128	-319	-71%	2.42	0.66	-1.76	-73%	709	650	-59	-8%
Fuel System & Emissions System	pre-1980	2525	1	357	384	27	8%	9.7	10.1	0.4	4%	416	126	-290	-70%
Miscellaneous	1980-1989	2525	13878	208	66	-141	-68%	1.74	0.36	-1.38	-79%	1104	481	-623	-56%
Engine Mechanical	1980-1989	2525	1014	232	64	-169	-73%	1.97	0.33	-1.64	-83%	1086	466	-620	-57%
Emissions System	1980-1989	2525	33682	197	62	-135	-69%	1.34	0.25	-1.1	-82%	1381	462	-920	-67%
Emissions System & Misc	1980-1989	2525	1487	193	64	-129	-67%	1.74	0.38	-1.36	-78%	1323	516	-807	-61%
Ignition/Electrical System	1980-1989	2525	12754	278	66	-212	-76%	1.85	0.3	-1.55	-84%	846	410	-436	-52%
Fuel System	1980-1989	2525	11420	217	63	-154	-71%	2.1	0.33	-1.77	-84%	864	428	-437	-51%

Repair Slate	Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
				Before Repair	After Repair	Change Conc.	Change (%)	Before Repair	After Repair	Change Conc.	Change (%)	Before Repair	After Repair	Change Conc.	Change (%)
Fuel System & Emissions System	1980-1989	2525	1078	191	68	-124	-65%	1.99	0.37	-1.62	-81%	1042	501	-541	-52%
Miscellaneous	1990-1999	2525	67424	64	23	-42	-66%	0.44	0.09	-0.35	-80%	532	198	-334	-63%
Engine Mechanical	1990-1999	2525	4213	86	22	-64	-74%	0.51	0.08	-0.43	-84%	533	178	-355	-67%
Emissions System	1990-1999	2525	134348	91	30	-61	-67%	0.49	0.09	-0.4	-82%	896	264	-632	-71%
Emissions System & Misc	1990-1999	2525	4598	98	36	-62	-63%	0.61	0.16	-0.45	-74%	1030	376	-655	-64%
Ignition/Electrical System	1990-1999	2525	42260	130	33	-97	-75%	0.69	0.12	-0.58	-84%	590	232	-358	-61%
Fuel System	1990-1999	2525	49954	74	22	-52	-70%	0.55	0.08	-0.47	-85%	466	178	-288	-62%
Fuel System & Emissions System	1990-1999	2525	2868	107	37	-70	-65%	0.71	0.14	-0.57	-80%	918	311	-607	-66%
Miscellaneous	post-1999	2525	17669	0.2	0.3	0.1	50%	0.002	0.001	-0.001	-50%	1.9	2.5	0.6	32%
Engine Mechanical	post-1999	2525	834	0.9	0.2	-0.7	-78%	0.016	0.001	-0.015	-94%	3.6	0.3	-3.3	-92%
Emissions System	post-1999	2525	19270	0.4	0.3	-0.1	-25%	0.004	0.002	-0.002	-50%	3.5	2.6	-0.9	-26%
Emissions System & Misc	post-1999	2525	324	0.2	0.5	0.3	150%	0.001	0.001	0	0%	0.7	5.4	4.7	671%
Ignition/Electrical System	post-1999	2525	5882	0.4	0.3	-0.1	-25%	0.002	0.001	-0.001	-50%	2.2	2.3	0	0%
Fuel System	post-1999	2525	11848	0.2	0.3	0.1	50%	0.002	0.002	-0.001	-50%	2.8	2.3	-0.6	-21%
Fuel System & Emissions System	post-1999	2525	224	3.1	0.9	-2.3	-74%	0.001	0.003	0.002	200%	13.2	8.7	-4.5	-34%

b) British Columbia Data

Repair Slate	Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
				Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
						Conc.	(%)			Conc.	(%)			Conc.	(%)
Other	1970-1979	2525	33	119	82	-37	-31%	1.18	0.65	-0.53	-45%	871	971	100	11%
Emissions System	1970-1979	2525	134	122	67	-55	-45%	0.80	0.41	-0.39	-48%	2367	854	-1513	-64%
Fuel System	1970-1979	2525	1884	126	65	-61	-48%	1.44	0.65	-0.79	-55%	1035	1098	63	6%
Fuel System & Emission System	1970-1979	2525	508	137	67	-70	-51%	1.36	0.56	-0.80	-59%	1361	982	-379	-28%
Ignition/Electrical System	1970-1979	2525	151	517	48	-469	-91%	0.60	0.44	-0.17	-28%	1570	1079	-491	-31%
Ignition/Electrical System & Emissions System	1970-1979	2525	80	279	43	-236	-85%	0.45	0.20	-0.24	-54%	2185	788	-1396	-64%
Ignition/Electrical System & Fuel System	1970-1979	2525	1830	233	59	-173	-74%	1.07	0.57	-0.50	-46%	1169	980	-189	-16%
Ignition/Electrical System & Fuel System & Emissions System	1970-1979	2525	887	231	57	-174	-75%	0.93	0.47	-0.46	-50%	1443	885	-559	-39%
Engine Mechanical	1970-1979	2525	67	278	59	-219	-79%	0.97	0.59	-0.38	-39%	1503	1172	-330	-22%
Other	1980-1989	2525	752	126	53	-73	-58%	1.53	0.33	-1.19	-78%	793	687	-107	-13%
Emissions System	1980-1989	2525	9562	128	44	-84	-66%	1.34	0.19	-1.15	-86%	1281	611	-670	-52%
Fuel System	1980-1989	2525	8541	122	59	-63	-52%	1.62	0.43	-1.19	-74%	869	956	88	10%
Fuel System & Emission System	1980-1989	2525	4976	144	51	-94	-65%	1.82	0.30	-1.52	-84%	1047	769	-278	-27%
Ignition/Electrical System	1980-1989	2525	2842	183	54	-129	-71%	0.98	0.28	-0.70	-71%	973	670	-303	-31%
Ignition/Electrical System & Emissions System	1980-1989	2525	4804	150	48	-102	-68%	1.31	0.20	-1.11	-84%	1175	606	-569	-48%
Ignition/Electrical System & Fuel System	1980-1989	2525	7643	161	59	-103	-64%	1.26	0.42	-0.84	-67%	1022	863	-158	-15%

Repair Slate	Model Year	ASM Mode	N	ASM2525 HC (ppm)				ASM2525 CO (%)				ASM2525 NO (ppm)			
				Before Repair	After Repair	Change		Before Repair	After Repair	Change		Before Repair	After Repair	Change	
						Conc.	(%)			Conc.	(%)			Conc.	(%)
Ignition/Electrical System & Fuel System & Emissions System	1980-1989	2525	6235	159	55	-104	-65%	1.44	0.32	-1.13	-78%	1260	771	-489	-39%
Engine Mechanical	1980-1989	2525	775	139	51	-88	-63%	1.01	0.28	-0.74	-73%	1221	752	-469	-38%
Other	1990-1999	2525	416	84	25	-59	-70%	0.97	0.11	-0.86	-88%	630	344	-286	-45%
Emissions System	1990-1999	2525	5559	104	26	-78	-75%	1.27	0.10	-1.17	-92%	920	390	-530	-58%
Fuel System	1990-1999	2525	658	62	23	-39	-63%	0.77	0.11	-0.66	-85%	417	308	-110	-26%
Fuel System & Emission System	1990-1999	2525	799	110	27	-83	-76%	1.60	0.12	-1.48	-93%	681	396	-285	-42%
Ignition/Electrical System	1990-1999	2525	1469	104	30	-73	-71%	0.62	0.13	-0.49	-79%	696	373	-323	-46%
Ignition/Electrical System & Emissions System	1990-1999	2525	2694	127	32	-95	-75%	1.26	0.12	-1.14	-90%	866	386	-480	-55%
Ignition/Electrical System & Fuel System	1990-1999	2525	731	95	29	-66	-70%	0.76	0.13	-0.62	-82%	590	325	-265	-45%
Ignition/Electrical System & Fuel System & Emissions System	1990-1999	2525	920	118	30	-88	-74%	1.26	0.12	-1.14	-91%	747	349	-398	-53%
Engine Mechanical	1990-1999	2525	608	77	26	-51	-66%	0.58	0.10	-0.47	-82%	992	422	-570	-57%

Issues with the Repair Data in the VID and RERF Datasets

There are several issues with the repair data contained in both the VID and RERF datasets that make analysis difficult. Future changes in the way data is collected and stored may alleviate many of these issues. These issues are described below.

VID Dataset – A general problem with the VID dataset is that only five different repair types are accounted for, and these types are too general to permit a detailed analysis of the data. These types include fuel system, ignition/electrical system, emissions system, engine mechanical, and miscellaneous. As listed in Table 5-1, "miscellaneous" repairs make up almost one quarter of the reported repairs. The addition of more detailed repair types during the collection of data would allow for more specificity in analysis. Previously, the Texas I/M program did have a more detailed list of repair types. However, because TCEQ believed that a large fraction of inspectors did not fill out the repair list correctly, TCEQ adopted the simpler list which was used during this evaluation period.

An extensive list of repair types is successfully used by the inspectors in the British Columbia I/M program, which is centralized. We performed an analysis of British Columbia repair and emissions data that connected repairs with the emissions changes that they produced [Reference 3]. Table 5-7 shows a relative ranking from that study of different repairs by their influence on ASM emissions. Repairs with the largest influences are at the top of the rankings. The acronyms in the table are also spaced by the size of their relative influence on emissions. The table shows that depending on vehicle technology only 6 to 11 repairs have substantial influences on tailpipe emissions. We recommend that Texas use these in the software to ask inspectors, "Which of the following repairs were performed?" An "Other" category should not be provided since that does not provide any useful information. The repair choices that inspectors see and choose from should be only those that apply to the technology of the vehicle being inspected – as seen in Table 5-7. The answers to this question should be convenient for the inspector to use and will provide the repairs that are known to most greatly affect tailpipe emissions.

Table 5-7. Repairs That Have a Major Influence on Tailpipe Emissions

Technology Category			
Fuel-Injected Three-Way Catalyst	**Carbureted Three-Way Catalyst**	**Carbureted Oxidation Catalyst**	**Carbureted No Catalyst**
	O2S		
			IGN
		EGR	
	EGR		
MAP	MET	AIR	PLG
	MAP		AIR
CAT	CAT		MET
O2S		CAT	
	PRM	MET	
EGR			
	AIR	PLG	
		IGN	CHK
CTS			
			EGR
	IGN		
ENG			
MAF		CHK	
PRM			
IGN	TIM		
TIM		TIM	
AIR			

AIR = Air Injection System
CAT = Catalytic Converter
CHK = Choke
CTS = Coolant Temperature Sensor
EGR = Exhaust Gas Recirculation
ENG = Internal Engine Repair
IGN = Ignition Wires
MAF = Mass Air Flow Sensor
MAP = Manifold Absolute Pressure Sensor
MET = Fuel Metering (Fuel-Injection or Carburetion)
O2S = Oxygen Sensor
PLG = Spark Plugs
PRM = Engine Computer
TIM = Spark Timing

Another problem, described in the costs section below, exists in the reported values of repair costs. A large number of repairs with a cost of $0 exists in the dataset, along with some extremely high (greater than $2,000) costs as well. The source of these errors is not clear, but the erroneous costs make it difficult to comprehensively assess costs across the entire dataset.

RERF Dataset – The RERF dataset, while very specific with respect to the type of repair performed, lacks cost information for each individual repair performed. Repair costs are only reported as a total of all repairs performed each time a particular vehicle reports to a RERF.

It should also be noted that while the RERF dataset contains extensive vehicle, facility, and costs information, no emissions data from I/M testing is available in it.

5.3 Overall Success of Repairs to Vehicles Failing OBDII[36]

The objective of this task was to determine whether vehicles failing the OBDII inspection are being properly repaired. We performed an analysis of the VID data for OBD failures and the presence of an illuminated MIL and diagnostic test codes before the repair and their non-existence after the repair. This will provide evidence that the I/M program is having a positive effect on the fleet. This analysis is analogous to the tailpipe emissions changes observed with repairs in Section 5.2.

Analysis and Results

For this task, we analyzed vehicle inspection records to identify tests with OBDII failures, and then determine how many of those failures were subsequently corrected. To exclude test failures associated with readiness, test failures due to OBDII/analyzer communication problems, and OBDII tests failures converted to ASM tests, an OBDII test failure was defined to be any test record with one or more stored diagnostic trouble codes (DTCs), a downloaded OBD MIL commanded status of "on," an OBDII test disposition of "fail," and an overall test disposition of "fail." Since OBDII test pass/fail results are not enforced on Class 2 vehicles (vehicles over 8500 lbs GVWR), Class 2 vehicles were excluded from this analysis. Using the preceding definition of fail, 173,169, or 2.12%, of the 8,182,566 light-duty vehicle OBDII test records over the period of evaluation were OBDII fail tests. This count includes both initial fail tests and retests.

Next, all individual vehicle I/M cycles that contained at least one failed OBDII test were identified. I/M cycles were defined to be a single test, or a series of tests, performed on a vehicle until the vehicle passed the overall inspection and received a certificate or until the vehicle received a waiver and a certificate (or until the December 31, 2005, the end of the evaluation period). Thus, if a vehicle failed the initial OBD test, the I/M cycle for that vehicle would be the initial failure, and any and all subsequent tests, until the vehicle passed its inspection and received a certificate, until a waiver and certificate were granted, or until the end of the evaluation period. Once the vehicle was issued a certificate, its next test (most likely for the following year's I/M inspection) would be a new I/M cycle. Since I/M cycles are simply grouped tests associated with one vehicle, for clarity these are referred to as "vehicles" in this discussion, even though some vehicles undergo more than one I/M cycle.

[36] This section responds to the Work Plan's Task 3, Element 2C: Show that Repairs Following an OBD Failure Cause the MIL to Go Out and was written by M.A. Sabisch.

By grouping I/M cycle for vehicles with OBDII failures (as previously defined), 161,113 vehicles were seen to have at least one failed OBDII test. Of these, 134,211 (83.3%) had a final OBDII test disposition of "pass," which for purposes of this analysis was defined as a test with a downloaded MIL status of "pass" (MIL not commanded on) and an OBDII test disposition of "pass." The remaining 26,902 vehicles never received repairs sufficient to extinguish their MILs.

Since this analysis included all light-duty OBDII test records obtained in 2004 and 2005, it is possible that some of the un-repaired vehicles were repaired early in 2006. This would increase the overall "repaired" numbers. Note too that the two allowed unset monitors could mask existing malfunctions in some of these repaired outcomes. The influence of this masking will be explored in Section 5.4.

5.4 Success of Repairs to Specific Emission Control Systems Failing OBDII[37]

We performed an analysis of evaporative OBD diagnostic codes and their associated repairs. Some OBD diagnostic test codes are related to evaporative emissions control components on vehicles. An analysis of the VID will reveal those instances where these codes were found before repair and were non-existent after repairs were made.

The objective of this task was to review vehicle inspection results to identify OBDII test failures associated with evaporative emissions control systems (evap system). The extent of failures associated with evap systems was quantified, and analysis of subsequent test results was performed to indicate how effective the program is in correcting the evap systems problems.

The effectiveness of repairing some other types of failures was also explored, and a comparison was also made between gas cap test results and OBDII evap system results.

Analysis and Results

This task was performed as a continuation of the analysis in Section 5.3. It uses combinations of vehicle and I/M cycle defined in that section. However, for this task, failure modes were assigned to failing vehicles based on the diagnostic trouble codes (DTCs) contained in the failed test records. In addition to analysis of test records with evap system failures (failures with DTCs within the range of P0440 - P0455), analysis was also performed to identify and quantify repairs for the following types of OBDII failures:

- Codes pertaining to insufficient oxygen sensor (O_2 sensor) performance (DTCs within the range of P0130 through P0167),
- Codes pertaining to exhaust gas recirculation (EGR system) malfunctions (DTCs within the range of P0400 through P0408),
- Codes pertaining to secondary air injection system (AI system) malfunctions (DTCs within the range of P0410 through P0417), and
- Codes pertaining to insufficient catalytic converter (catalyst) performance (DTCs within the range of P0420 through P0434)

These four additional categories of codes were included with this analysis because the "readiness status" of these systems, as well as the evap system, are specifically monitored by non-continuous monitors, and therefore the extent to which malfunctions may be masked by

[37] This section responds to the Work Plan's Task 3 Element 2D. OBD Codes Related to Evaporative Emissions Control System Components Found and Corrected and was written by M.A. Sabisch.

unset readiness monitors during a retest (which could result in a false pass) can be quantified. In this analysis, the extent of this potential masking is quantified along with the overall repair rates.

For each of the failure categories, vehicle fail groups are defined as any vehicle I/M cycle group that contains at least one test record with stored DTCs, a downloaded OBD MIL commanded status of "on," an OBDII test disposition of "fail," and an overall test disposition of "fail." Fail groups categorized as successfully repaired were those which had a final test in that I/M cycle with a downloaded MIL status of "pass" (not commanded on) and an OBDII test disposition of "pass." Again, for clarity, these vehicle I/M cycle groups are referred to as "vehicles" in this discussion.

To quantify the upper limit to which readiness may be masking unrepaired malfunctions during OBDII retests, the following distinctions of "repaired" vehicles were made:

- **Total Repaired –** This is the count of all vehicles that had at least one fail test with the final test classified as repaired. No regard is given to which (if any) monitors remain unset.

- **Repaired with Unset Monitors –** This is the count of all "repaired" vehicles that have an unset monitor that may be masking the failure mode seen in the initial fail test. For example, if a vehicle fails for an evap system malfunction, then the evap system monitor is unset on the final "pass" test for this vehicle, thereby possibly masking an unrepaired evap system malfunction. Once this monitor becomes set, any unrepaired malfunction would result in a stored evap system DTC and MIL re-illumination.

- **Confirmed Repaired –** These are the vehicles whose monitors for which the initial failure occurred are set in the final test, indicating that specific type of failure is not being masked by an unset readiness code. We therefore have much higher confidence that these "confirmed repaired" vehicles are indeed properly repaired.

During this analysis of readiness status, some vehicles that failed for a certain system (e.g., EGR) were found to have a "not monitored" status for that monitored system (e.g., EGR not monitored). This is likely due to erroneous readiness status retrieved from certain vehicles and stored in that vehicle's test record. Since by definition this is an impossibility (a system with a stored code must be monitored), this subset of results was classified as "ready."

With regard to criteria used for categorizing "pass" and "fail" tests, it should also be noted that pending DTCs (also referred to as "soft" DTCs) are trouble codes that are insufficient for illuminating the MIL, generally because the number of successive repeat failures necessary

for MIL illumination has not occurred. In accordance with EPA guidance, vehicles are not failed for pending DTCs (stored DTCs but no MIL illumination) in the Texas program. Results from this repair analysis follows that strategy, and therefore only defines tests with MIL illumination and stored DTCs as "fail" tests, and only considers MIL illumination (without regard to stored DTCs) in determining whether a vehicle is successfully repaired.

Finally, it should be kept in mind that when reviewing repair analysis results, a failed OBDII test record could contain more than one DTC. In Texas, up to 10 DTCs may be stored in the test record, and all stored DTCs were used for this analysis. Therefore, some vehicles will be included in more than one set of results. For example, repair results for vehicles with both oxygen sensor DTCs and catalytic converter DTCs will be included in both the oxygen sensor repair analysis and the catalytic converter repair analysis. Because of the inter-dependence of the various systems (e.g., an oxygen sensor failure may lead to a future catalytic converter failure), distinctions were not made regarding the number or types of DTCs in the original fail records. Rather, vehicles were categorized as "repaired" when the MIL was extinguished and the analyzer assigned an overall OBDII pass result, regardless of the number or type of DTCs seen in the initial test failure.

Table 5-8 provides a summary of vehicle repairs performed over the period of evaluation. Since this analysis was performed on 2004 and 2005 data, it is possible that some of the un-repaired vehicles were repaired early in 2006. This would increase the "repaired" counts from the numbers shown in this table.

Table 5-8. System Specific Repair Analysis for Vehicles

Type of Failure (DTC category)	Total vehicles failed (with indicated failure mode DTCs)	Total repaired vehicles (MIL off)	Repaired vehicles with failure mode monitors not yet set	Confirmed Repairs (failure mode monitors set)
Evap System	25,572	21,782 (85.2%)	8,968 (35.2%)	12,814 (50.0%)
O_2 Sensor	36,074	29,758 (82.5%)	1428 (4.0%)	28,330 (78.5%)
EGR System	33,657	27,647 (82.1%)	3153 (9.4%)	24,494 (72.7%)
AI System	1,829	1,397 (76.4%)	264 (14.6%)	1,133 (61.8%)
Catalyst	29,161	24,012 (82.3%)	7,185 (24.7%)	16,827 (57.6%)

As previously indicated, many vehicles were failed with more than one DTC. Therefore, results from some vehicles may be included in more than one category in Table 5-8. Also, only categories directly monitored with non-continuous monitors are tabulated in Table 5-8. Other failure categories for which readiness status would be more difficult to assess are excluded from the table. Table 5-8 indicates that readiness status may be masking 4% to 35% of vehicles that

pass OBDII retests based on MIL status with these types of failures. I/M program modifications that would require confirmation of specific failure-mode monitors being set would likely reduce the extent of potential false passes but at the expense of a potential increase in motorist inconvenience especially for difficult to set monitors. We are not aware of any programs where this is currently performed.

A comparison was also made between OBDII evap system results and gas cap test results, on a by-test basis, for all OBDII tests conducted during 2004 and 2005. Table 5-9 presents a summary of these results.

Table 5-9. Comparison of OBDII Evaporative Emission Control System Test Results with Gas Cap Test Results

OBDII Evap System Test Results	Gas Cap Test Result		Total
	Pass	Fail	
Pass	7,981,108 (99.2%)	82,743 (1.02%)	8,063,851 (99.3%)
Fail	58,293 (0.72%)	3,040 (0.04%)	61,333 (0.8%)
Total	8,039,401 (98.9%)	85,783 (1.1%)	8,125,184 (100%)

As can be seen from this table, approximately 0.8% of the tests had failed the OBDII portion of the test with evap system DTCs, whereas gas cap failures were seen in 1.1% of the tests. Although the OBDII evap system monitoring is designed to be a more comprehensive test since it assesses the integrity of the entire control system, a lower fail rate may in part be due to unset evap system readiness monitors. Evap systems generally require a fairly complex series of vehicle operating conditions before this monitor is set. Although most vehicles passed both tests, very few vehicles (0.04%) failed both tests. Allowable pressure decay limits and even the manner the tests are administered may contribute to differences in fail rates of the two tests and the lack of overlap between the two tests.

5.5 Average Repair Costs[38]

Both the Texas VID and the RERF datasets contain costs for repairs performed. For both datasets, repair costs are manually entered by inspectors. This information was analyzed to determine the amount of money being spent by Texas motorists to repair their vehicles as a result of the I/M program.

Texas VID Data

To effectively analyze average change in emissions due to repairs, as well as repair costs, repair slates were determined for each vehicle for a given I/M cycle. A repair slate is a concatenation of the set of repair types performed in a repair event. In the Texas VID data, the five different repairs types listed in Table 5-1 were combined to produce the seven most common repair slates, which account for approximately 96% of all vehicle and I/M cycle combinations. These slates are presented in Table 5-10.

Approximately one-third of the repair costs in the Texas VID were recorded as $0. It is not clear why this is the case. Because of the large number of repair records affected, no attempt was made to correct the costs as part of this analysis. Nonetheless, the existence of so many repair costs with a value of $0 significantly affected the average and median repair values calculated. Table 5-10 presents the number of records with a cost of $0 by repair slate. Note that about 11-25 % of most slates listed contained $0 repair costs, but fuel system and miscellaneous repairs contained a much higher percentage (about 35% and 52%, respectively).

We also noted than many of the repair costs listed in the VID seemed to be unusually large; many records were in excess of $2000, with some as high as $100,000. We suspect that these repair costs reflect data entry errors by on-site technicians. Figure 5-1 presents a plot of histogram of repairs that cost more than $2000.

[38] This section responds to the Work Plan's Task 3 Element 2E:Calculate Average Repair Costs and Average Cost by Repair Type and was written by S.W. Fincher.

Table 5-10. VID Records with a Repair Cost of $0, by Slate

Repair Slate	**Cost > 0**	**Cost = Zero**	**Total**	**% of Cost = 0**
Fuel System & Emissions System	3716	464	4180	11.10
Emissions System & Miscellaneous	5643	781	6424	12.16
Engine Mechanical	5204	1776	6980	25.44
Ignition / Electrical System	53973	13962	67935	20.55
Fuel System	53815	29264	83079	35.22
Miscellaneous	56571	60991	117562	51.88
Emissions System	160534	47760	208294	22.93
Total (of Selected Repair Slates)	*339456*	*154998*	*494454*	*31.35*

Figure 5-1. Repairs with Cost Greater than $2000

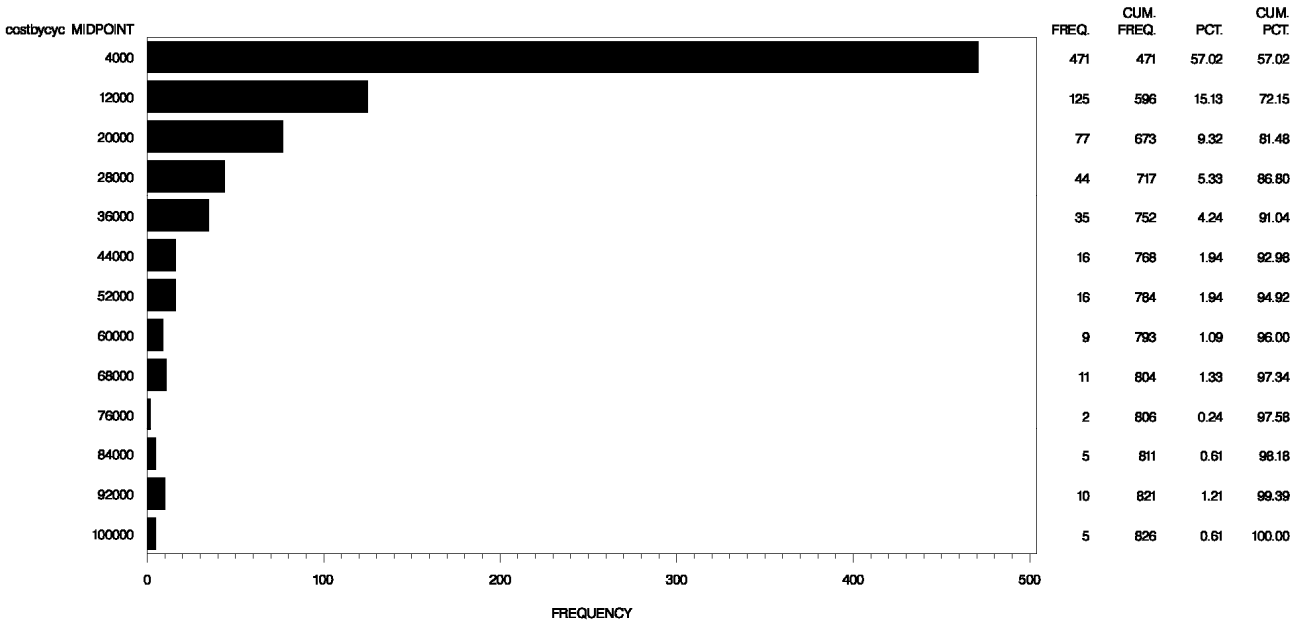


Table 5-11 presents median and mean repair costs for each of the repair types specified in the Texas VID. Mean and median are calculated twice – once including the $0 and >$2000 repair costs found in the dataset (unedited), and once without (edited). According to the unedited dataset, vehicle owners performed 505,829 repairs while spending almost $72 million. According to the edited dataset, which leaves out $0 cost and greater than 2,000 cost observations, vehicle owners performed 348,694 repairs while spending almost $60 million.

Table 5-11. Average Repair Costs

		Original Dataset			Costs Between $0 and $2000		
Year of Inspection	**Repair Slate**	**Number of Repairs**	**Median Repair Cost**	**Mean Repair Cost**	**Number of Repairs**	**Median Repair Cost**	**Mean Repair Cost**
2003 (May 1 - Dec 31)	Fuel System and Emissions System	1088	$200	$276	987	$220	$294
2003 (May 1 - Dec 31)	Emissions System & Miscellaneous	1685	$165	$219	1486	$125	$207
2003 (May 1 - Dec 31)	Engine Mechanical	1967	$90	$226	1492	$185	$237
2003 (May 1 - Dec 31)	Ignition / Electrical System	20839	$75	$126	14346	$65	$110
2003 (May 1 - Dec 31)	Fuel System	22363	$45	$140	14627	$100	$145
2003 (May 1 - Dec 31)	Miscellaneous	28201	$1	$70	16449	$100	$138
2003 (May 1 - Dec 31)	Emissions System	60496	$125	$178	46629	$150	$202
2004	Fuel System and Emissions System	1645	$192	$283	1447	$205	$274
2004	Emissions System & Miscellaneous	2427	$162	$215	1957	$125	$216
2004	Engine Mechanical	2718	$85	$223	2122	$185	$242
2004	Ignition / Electrical System	25585	$69	$135	19490	$100	$139
2004	Fuel System	32844	$40	$122	20196	$100	$150
2004	Miscellaneous	43700	$0	$59	20513	$50	$100
2004	Emissions System	79734	$120	$176	59829	$150	$201
2005	Fuel System and Emissions System	1447	$199	$282	1269	$220	$286
2005	Emissions System & Miscellaneous	2295	$96	$199	1696	$135	$227
2005	Engine Mechanical	2312	$163	$218	2014	$187	$241
2005	Ignition / Electrical System	21511	$80	$150	17935	$100	$144
2005	Fuel System	27872	$50	$121	18821	$100	$152
2005	Miscellaneous	45661	$0	$57	21611	$50	$100
2005	Emissions System	68064	$125	$187	53761	$150	$203

Figures 5-2 and 5-3 present mean repair costs by inspection year and model year, for both the unedited and edited VID datasets. There is a significant amount of variability in the unedited data when compared to the edited data. As shown by these plots, repair costs as a whole have not increased from year to year.

Figure 5-2. Mean Repair Costs by Model Year and Inspection Year (Unedited Dataset)

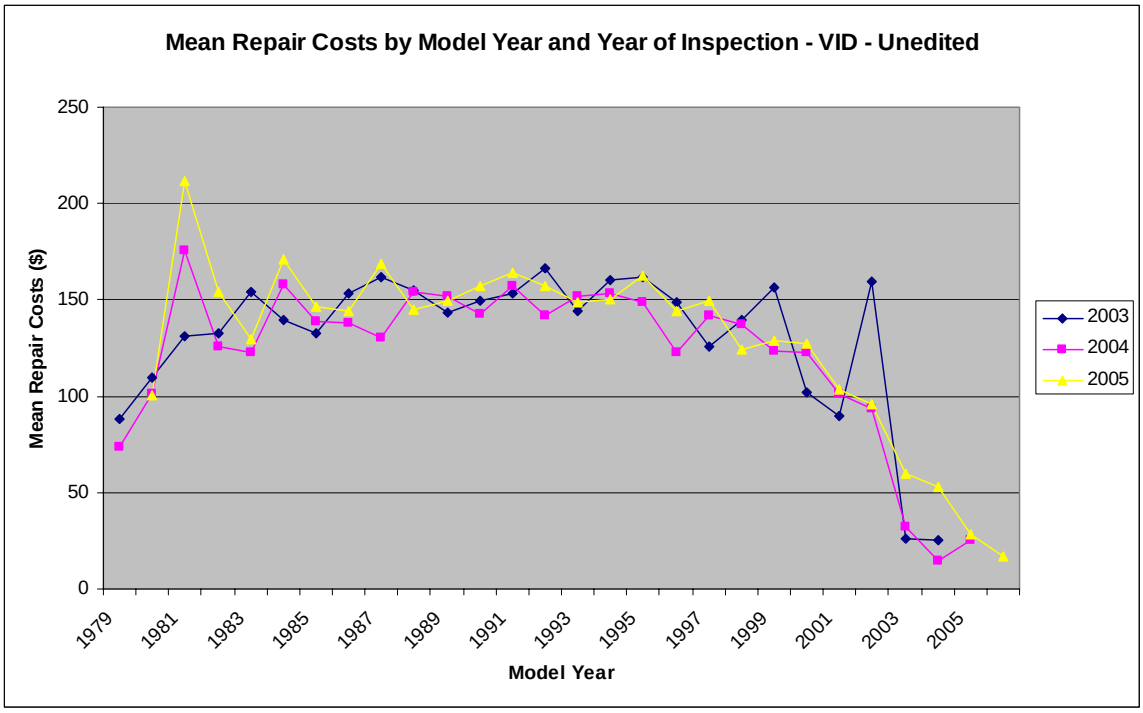
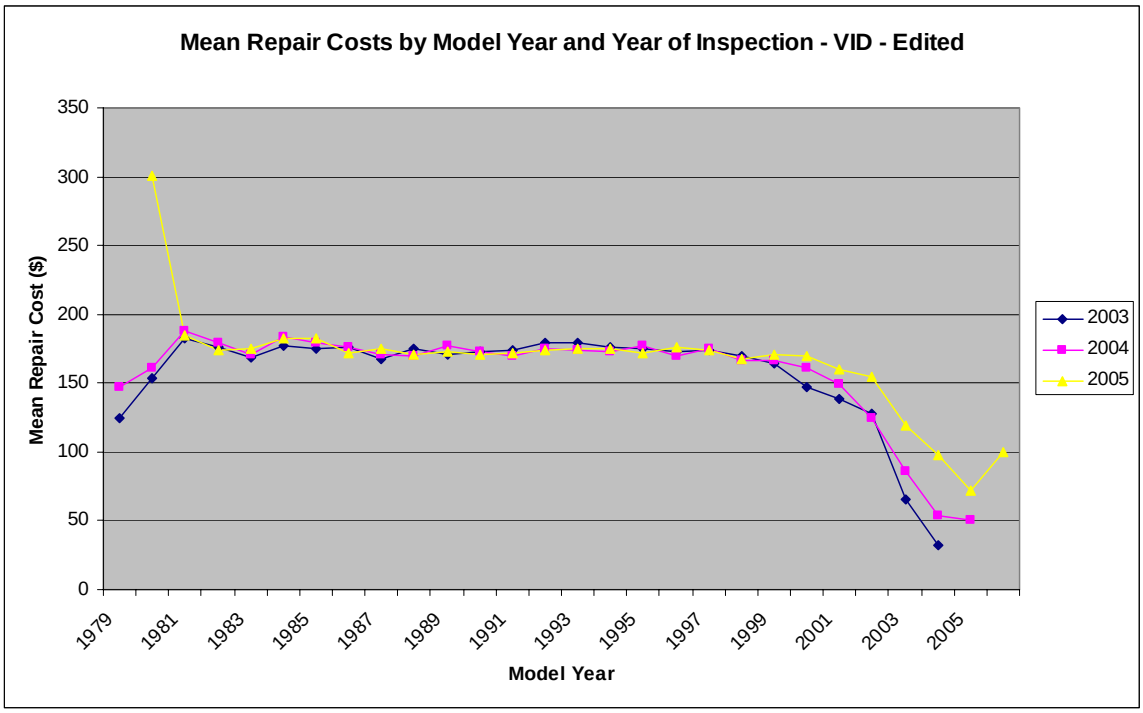


Figure 5-3. Mean Repair Costs by Model Year and Inspection Year (Edited Dataset)



Figures 5-4 and 5-5 present the percentile distribution of repair costs for the most common VID repair slates, for both the unedited and edited datasets. The unedited data contains repairs with an average cost of $0 for all repair slates, but miscellaneous repairs costing $0 extend well into the 50th percentile, considerably more than the other slates.

For both datasets, the range of average costs was most limited for miscellaneous repairs, while the greatest variation in average costs was visible in repairs performed on both the fuel and emissions systems.

Figure 5-4. Distribution of Repair Costs by Slate (Unedited Dataset)

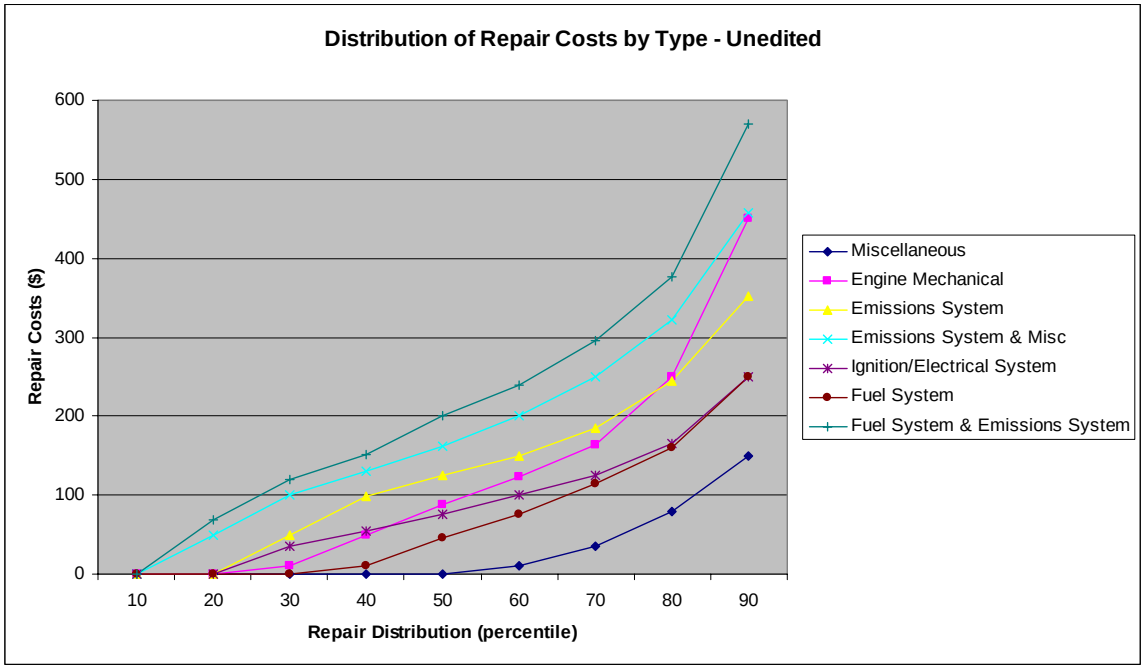
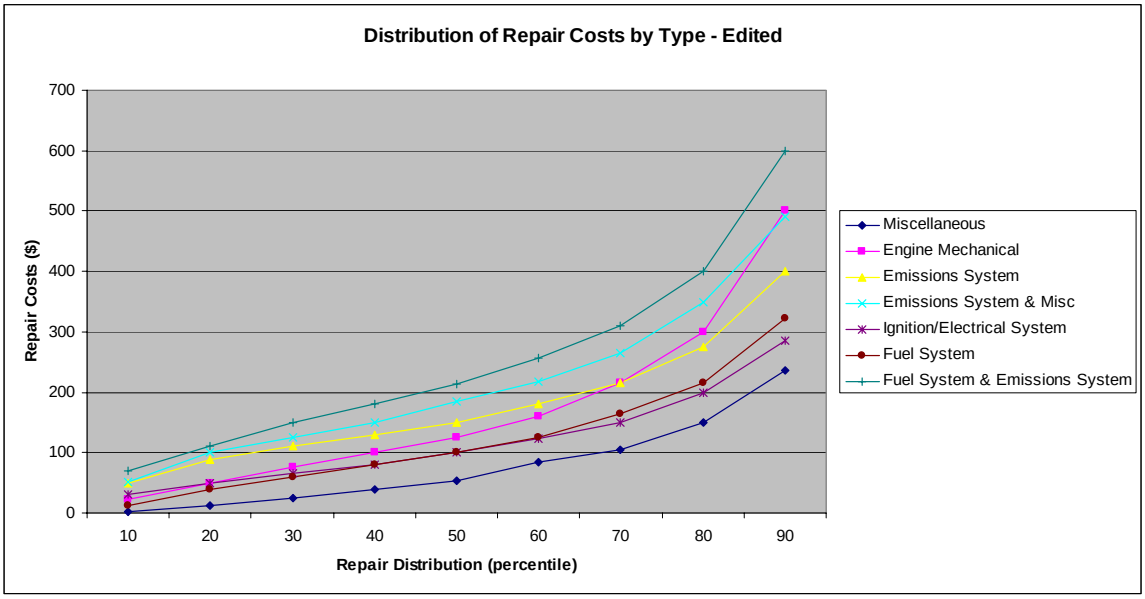


Figure 5-5. Distribution of Repair Costs by Slate (Edited Dataset)



RERF Data

Overall, vehicle owners spent over $18 million on 38,915 repairs at RERFs. The mean and median repair costs were $499 and $516, respectively.

To effectively analyze average change in emissions due to repairs, as well as repair costs, repair slates were determined for each vehicle for a given I/M cycle. A repair slate is a concatenation of the set of repair types performed in a repair event. In the RERF data, the different repair types listed in Table 5-2 were combined to produce the nine most common repair slates, which account for approximately 34% of all vehicle and I/M cycle combinations. To simplify the aggregation of individual repairs into meaningful repair slates, some repairs were combined into a single "subslate" – in this case, repairs to ignition/electrical systems, spark plugs, and spark plug wiring were all considered to be similar repairs.

The most common repair slates observed are presented in Table 5-12.

Table 5-12. Common RERF Repair Slates

Repair Slate	Frequency	Percent
Emissions System & O_2 Sensor	334	1.99
Ignition/Electrical System/Spark Plugs	372	2.22
EGR	711	4.24
Emissions System & Catalyst	776	4.63
Catalyst	787	4.70
Emissions System	812	4.85
Fuel System	988	5.90
Emissions System & EGR	1010	6.03
Other Repair Slates	10964	65.44

Table 5-13 presents median and mean repair costs for each of the repair slates developed for the RERF dataset.

Table 5-13. RERF Repair Slate Average Costs

Year of Inspection	Repair Slate	Number of Repairs	Median Repair Cost	Mean Repair Cost
2003 (May 1 - Dec 31)	Catalyst	187	$387	$447
2003 (May 1 - Dec 31)	EGR	198	$288	$323
2003 (May 1 - Dec 31)	Emissions System	219	$245	$288
2003 (May 1 - Dec 31)	Emissions System & Catalyst	270	$380	$406
2003 (May 1 - Dec 31)	Emissions System & EGR	290	$280	$319
2003 (May 1 - Dec 31)	Emissions System & O2 Sensor	3	$393	$396
2003 (May 1 - Dec 31)	Fuel System	183	$216	$287
2003 (May 1 - Dec 31)	Ignition/ElectricalSystem/Spark Plugs	69	$279	$350
2003 (May 1 - Dec 31)	Other Repair Slates	2976	$460	$447
2004	Catalyst	317	$396	$434
2004	EGR	246	$290	$339
2004	Emissions System	417	$295	$331
2004	Emissions System & Catalyst	280	$425	$459
2004	Emissions System & EGR	391	$300	$387
2004	Emissions System & O2 Sensor	150	$329	$397
2004	Fuel System	579	$328	$382
2004	Ignition/ElectricalSystem/Spark Plugs	196	$317	$371
2004	Other Repair Slates	3897	$510	$497
2005	Catalyst	283	$435	$450
2005	EGR	267	$297	$341
2005	Emissions System	176	$245	$286
2005	Emissions System & Catalyst	226	$387	$436
2005	Emissions System & EGR	329	$297	$334
2005	Emissions System & O2 Sensor	181	$304	$336
2005	Fuel System	226	$307	$368
2005	Ignition/ElectricalSystem/Spark Plugs	107	$297	$345
2005	Other Repair Slates	4091	$510	$479

Figure 5-6 presents mean repair costs by inspection year and model year, for the RERF VID dataset. Average repair costs tend to fall in the $400 - $500 range, which is significantly higher than the$150 - $175 range seen in the VID data. Average repairs costs appear to be lower for 2003 than for other years, but there does not seem to be a significant difference between 2004 and 2005 costs.

Figure 5-6. Mean Repair Costs by Model Year and Inspection Year - RERF

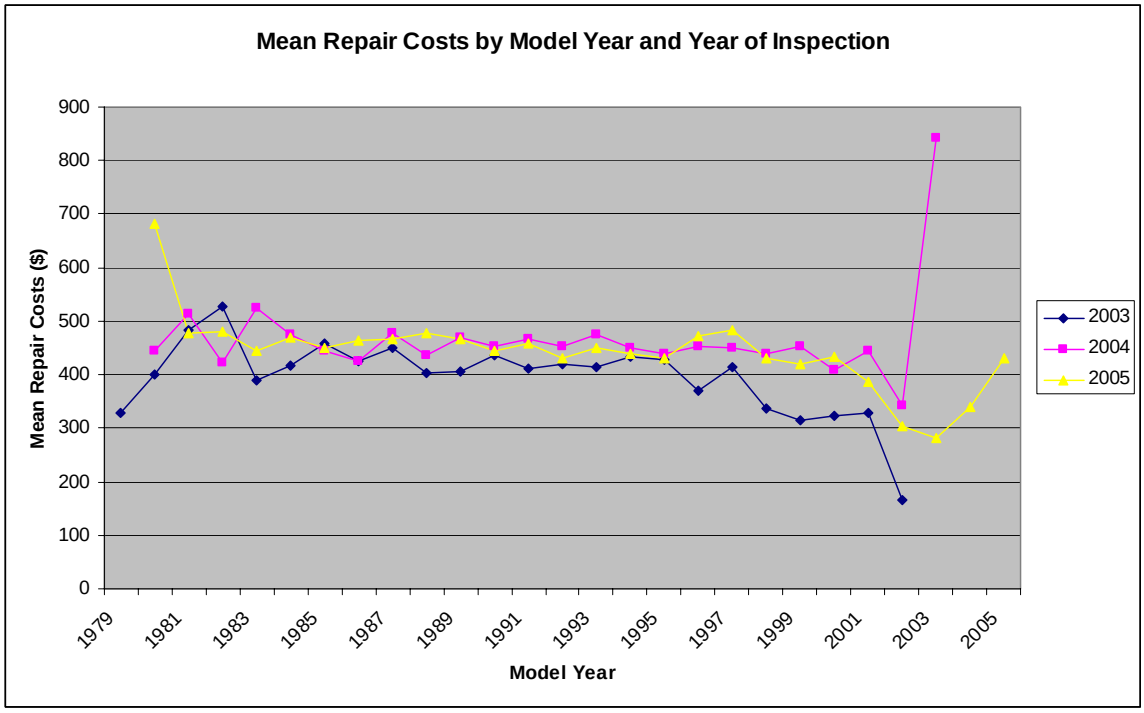
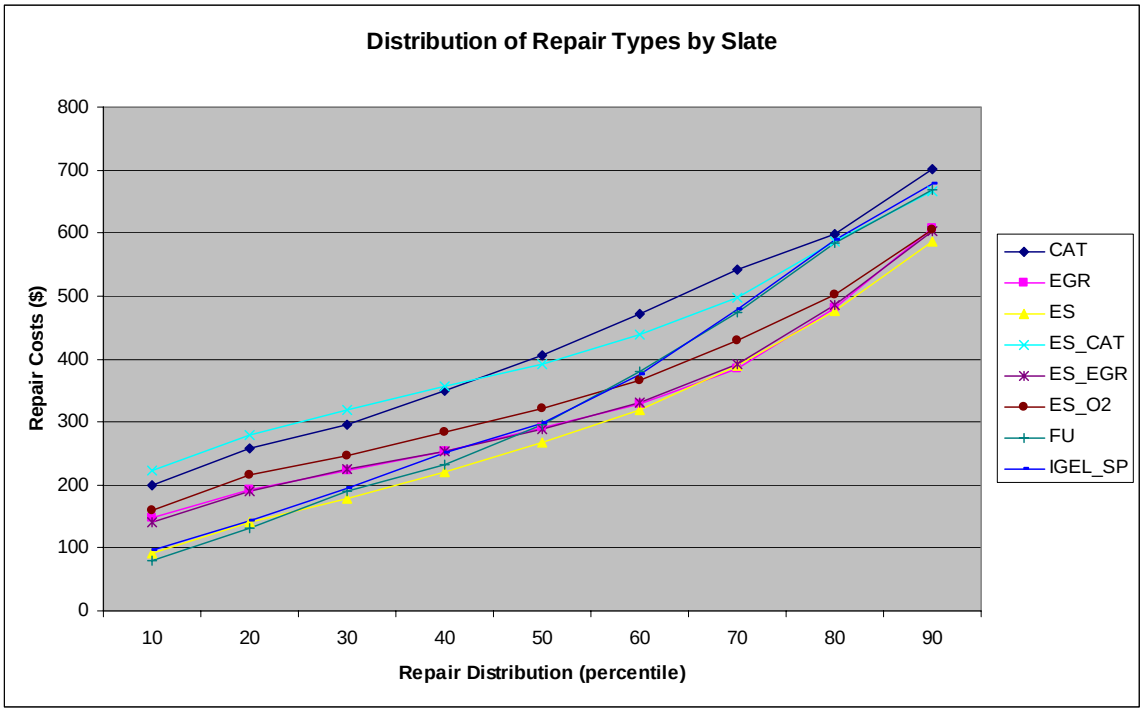


Figure 5-7 presents the percentile distribution of repair costs for the most common RERF repair slates. The range of average costs was most limited for emissions system & catalyst repairs ($225 - $675), while the greatest variation in average costs was visible in repairs performed on the fuel system ($75 - $675).

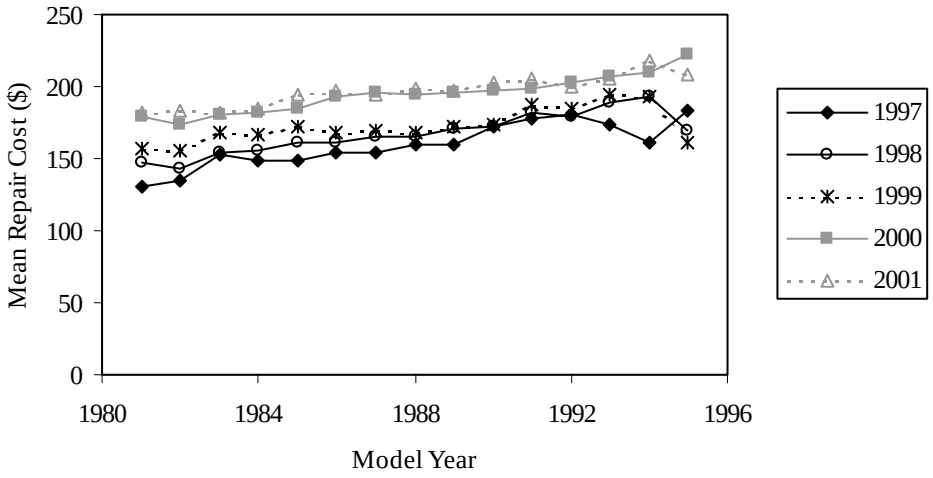
Figure 5-7. Distribution of Repair Costs by Slate - RERF.



Comparison to Arizona I/M Evaluation

To determine how the repair cost data collected as part of the Texas I/M program compared to other I/M programs, we compared the VID and RERF datasets with the I/M data detailed in ERG's analysis of Arizona I/M program repair data [Reference 6]. In Arizona, which has a centralized I/M program, repairs are performed by private repair shops and the costs of the repairs are entered manually by the I/M station inspectors. Average repair costs for the Arizona data are shown by year of inspection and model year in Figure 5-8. One clear difference between the Arizona and Texas datasets is that average repair costs in the Arizona dataset increased over time - almost $50 over 5 years. Repair costs in the Texas data do not show this same trend (see Figures 5-2, 5-3, and 5-6).

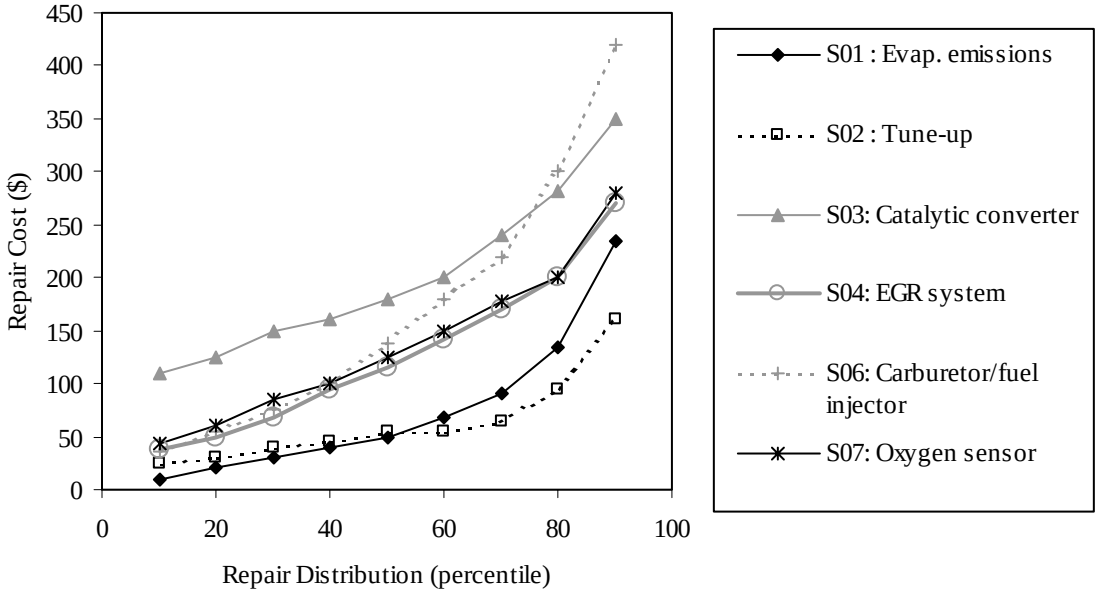
Figure 5-8. Mean Repair Costs by Model Year and Inspection Year – Arizona I/M



Average Arizona repair costs for the 1997 - 2001 timeframe were between approximately $150 to $200. Repair costs in the Texas VID averaged about $175 for mid 2003 - 2005, and costs in the RERF data averaged closer to $450 during the same time period. There is a large difference between costs recorded in the RERF data relative to the other datasets. We attribute this difference to the difference in characteristics of vehicles that go to RERF repair stations.

Repair costs by percentile for the Arizona data are shown in Figure 5-9. Compare this with Figures 5-4, 5-5, and 5-7 for the unedited VID, edited VID, and RERF datasets, respectively. Although the repair slates used for the different datasets do not correlate exactly, note that for both the Arizona data and Texas VID data, the most variation occurs in emissions system slates for both datasets. This may be an indicator that the forms used for collecting repair data are not specific enough. The range of average costs was most limited for tuneups ($25 - $150), while the greatest variation in average costs was visible in repairs performed on the carburetor/fuel injector ($35 - $420).

Figure 5-9. Distribution of Repair Costs by Repair Slate – Arizona I/M



6.0 Enforcement

What is Texas doing to ensure that motorists are participating in the I/M program and that stations are following regulations? In this task, we look at a measure of motorist non-participation and two measures of I/M station performance to demonstrate I/M program enforcement activities. The activities in this task are process-based measures of enforcement.

6.1 Registration Denial[39]

A count of registration denials in I/M areas is an indication of the initial non-compliance rate of vehicles with the I/M requirement. However, it also demonstrates that the registration denial rule helps ensure that vehicles that are eligible for the I/M program ultimately participate.

The objectives of this task were to examine the VID to quantify the extent of registration denials, track vehicles that are denied registration, measure the rate of compliance of the regulated fleet for the registration denial rule, and also report on the ultimate outcome of vehicles that were initially denied registration.

Program Description

A vehicle emissions inspection is generally a prerequisite for gasoline-powered 2 to 24 year old vehicles registering in Texas I/M program areas. The objective of this sticker-based enforcement program is to ensure that vehicles registered and operated in program areas receive and pass emissions inspections prior to registration. Vehicles that fail and do not subsequently pass are denied re-registration. To provide a mechanism for on-road enforcement, registration certificates are affixed to a vehicle's windshield near the safety inspection and emissions certificate. Depending on type and model year of vehicle, the emissions inspection may be an OBDII test, acceleration simulation mode (ASM) emissions test or a two-speed idle (TSI) emissions test.

The Texas Commission on Environmental Quality (TCEQ) and the Texas Department of Transportation (TxDOT) jointly administer the registration denial program. Specifically, vehicles that have failed an emissions test and have not passed a subsequent emissions test within the last 12 months are denied registration.

Excerpts from the Texas Department of Transportation (TxDOT) vehicle registration database listing VINs, license plates, vehicle information, and owner information of vehicles

[39] This section responds to the Work Plan's Task 3 Element 3A: Registration Denial Program and was written by M.A. Sabisch.

with upcoming registration renewals are regularly provided to TCEQ. TCEQ then queries this list against the TCEQ vehicle inspection database (VID) to identify which of the vehicles due for registration have failed their most recent inspection within the last 12 months (no emission test records with a final pass disposition or any type of waiver or exemption). Matches are attempted using VIN, license plate, and vehicle information (make, model, model year) and TCEQ reports an 85% to 90% match rate is achieved with the TxDOT-provided list queried against TCEQ's VID.

Once potentially non-compliant vehicles are identified, their ownership records are confirmed through a National Change of Address (NCOA) database. Letters of non-compliance are then mailed to those registered owners indicating registration will be denied if compliance is not met. A sample of this letter is provided in Appendix D. These notification letters are sent to motorists a minimum of four months prior to their vehicle's registration renewal date.

Those motorists to whom registration denial letters are sent are then flagged in the Registration Denial Program database. Recipients of the registration denial letter are allowed a 45-day response time to come into program compliance. These motorists may call in with various information that will unflag them, including having a:

- Passing Vehicle Inspection Report;
- DPS Affidavit (Form VIE-12);
- DPS Low Mileage Waiver (Form VIE-5);
- DPS Low Income Time Extension (Form VIE-5);
- DPS Individual Vehicle Waiver (Form VIE-5);
- DPS Parts Availability Time Extension (Form VIE-9).

Motorists who call in with information that appears to legitimately confirm compliance are unflagged in the Registration Denial Program database, and that information provided by the motorist is logged. Information from suspicious claims of compliance is also logged and then referred to DPS for investigation. Vehicles that receive and pass an emissions inspection are also automatically unflagged in the Registration Denial Program database. After the 45-day response period, a final query is run against the VID and Registration Denial Program database, and this final list of non-compliant vehicles is sent electronically to TxDOT for registration denial. Vehicle registration notices are then sent to these motorists which require proof of compliance prior to registration.

In addition to “flag” files, TCEQ sends “unflag” files to TxDOT twelve months after a vehicle has been flagged. These vehicles are unflagged in the registration database, regardless of emissions inspection disposition.

Analysis Performed

ERG was provided with several types of data to perform this evaluation:

- Lists of vehicle VINs and plates that had been sent from TCEQ to TxDOT monthly for registration denial (multiple “monthYYflag.txt” text files provided for this analysis). These “flag files” contain records for those vehicles due for registration which have unresolved failures within the previous twelve months and to which mailouts have been sent and not successfully contested.

- Table of vehicles identified by queries against the VID that are due for registration but have an unresolved failure within the last 12 months (“RRD_Cases_Prog_Eval_File” in the “Reg Denial Tables.mdb” database provided for this analysis). This is the list of all vehicles identified prior to the mailout by TCEQ to the motorist.

- Tables of vehicles to be removed from the flag file list due to motorists responses to the mailout, before the “flag” list is sent to TxDOT for registration denial (“RRD_Cases_Evidences_Prog_Eval_File” in the “Reg Denial Tables.mdb” database which was provided for this analysis). This evidence table also lists whether or not the case was forwarded to DPS for investigation.

- Tables listing vehicles to be unflagged, sent from TCEQ to TxDOT, approximately 12 months after the vehicle is flagged, regardless of the vehicle’s current I/M compliance status.

- Schedules for sending mailouts, flag files, unflag files, and performing VID queries for vehicles with pending registrations.

- A handbook describing the registration denial process, including examples of mailout letters, waivers and affidavits, and vehicle inspection reports.

- Certain fields from the current registration database, including diesel indicator, current and previous registration expiration dates, current and previous registration counties, license plate, TxDOT sticker number, VIN, and make, model, and model year.

The TxDOT vehicle registration database provides a current snapshot (as of summer 2006) of the status of vehicles registered or previously registered in Texas. With the exception of Previous Registration Counties and Previous Registration Expiration Date, historical information is not contained in the registration database snapshot that we received for this

analysis. A query performed on the registration database excerpt provided to ERG indicated the Previous Registration Expiration Date was the same date as the Current Registration Expiration Date in approximately 60% of the registration data records. Because of the lack of historical information in the registration database, this database could not be used to evaluate the effectiveness of the registration denial program. As an alternative, the registration denial flag files and VID data were used to assess the registration denial program. Consequently, several assumptions were necessary in performing this evaluation:

- The lists of vehicles due for upcoming registration provided monthly to TCEQ by TxDOT are assumed to be accurate and inclusive of all vehicles registered and operated in program areas.
- Queries performed by TCEQ against the vehicle inspection database using the list of vehicles due for registration provided by TxDOT are effective in identifying all vehicles which have an unresolved failing emissions test within the last 12 months.
- Flag files provided by TCEQ to TxDOT are effectively implemented, and flagged vehicles are indeed denied registration until program compliance is achieved.
- Vehicles subject to the emissions inspection program are effectively prevented from initially registering in a program area without first obtaining a pass emission inspection result or appropriate waiver.

In addition to the above caveats, vehicles cleared for registration by TCEQ (prior to submission of the “flag” file) are assumed to be program compliant. It is also recognized that vehicles that fail to achieve compliance are unflagged after a 12 month period, regardless of compliance, with the assumption that any noncompliance will be identified through on-road enforcement.

Because of the lack of historical registration information, we were unable to quantify the extent of registration denial or measure the rate of compliance of the regulated fleet for the registration denial rule for this task. However, the list of vehicles for which registration was denied was queried against the vehicle inspection database to try to assess the eventual outcome of vehicles initially denied registration. In addition, counts of the number of I/M tests performed and certificates issued in I/M counties in 2005 were compared with the I/M county vehicle registration estimates listed in the October 2005 SIP, as an alternative method of generally assessing the rate of compliance of the regulated fleet.

Results of Analysis

Table 6-1 summarizes vehicle flagging information provided by TCEQ for this evaluation and shows the number of initially unresolved failures to whom mailouts were sent, the number of vehicles removed from the flag list due to response to mailout (prior to TCEQ sending the list to TxDOT), and the number of vehicles whose information was sent to TxDOT to be flagged for registration denial each month of this program evaluation.

Table 6-1. Outcome of Vehicles Due for Registration with an Unresolved VID Failure on Record

Date registration query run against VID	Registration Month(s)	Unresolved failures within 12 months to whom letters were sent (mailouts)	Final VID query date after mailout	Number of vehicles cleared during mailout period	Number of vehicles sent to TxDOT to be flagged for registration denial
5/30/03	December 2003 January 2004 February 2004	10,921	8/19/03	1385	9536
7/29/03	March 2004 April 2004	8873	11/13/03	2387	6486
11/21/03	May 2004 June 2004	6629	2/3/04	1029	5600
2/5/04	July 2004 August 2004	6113	4/12/04	1056	5057
4/6/04	September 2004 October 2004	6817	6/10/04	1611	5206
6/1/04	November 2004 December 2004	5403	8/18/04	963	4440
7/26/04	January 2005 February 2005	5485	9/21/04	791	4694
10/21/04	March 2005	2498	12/13/04	252	2246
11/04/04	April 2005	2309	1/04/05	251	2058
12/3/04	May 2005	2174	2/7/04	317	1857
1/18/04	June 2005	2955	3/7/05	694	2261
2/7/05	July 2005	2870	4/11/05	745	2125
3/7/05	August 2005	2107	5/9/05	411	1696
4/18/05	September 2005	2039	5/6/05	331	1708
5/9/05	October 2005	1888	7/7/05	302	1586
6/6/05	November 2005	1941	8/12/05	414	1533
7/11/05	December 2005	2246	9/14/05	335	1911

To evaluate the effectiveness of the registration denial program, flag files were compared with historical VID data over the period of interest to assess program compliance one to three months prior to, zero to two months following, three to five months following, six to eight months following, nine to eleven months following, and 12 or more months following the date registration was due for flagged vehicles. For months combined in Table 6-1 (December 2003 through February 2004, March and April 2004, May and June 2004, etc.), the flag files were divided equally among the months in order to evaluate compliance on a per-month basis, as shown in Table 6-2. This table shows, for each month over the period evaluation, the total number of vehicles flagged by TCEQ for registration denial, the total count of matches between these flagged vehicles and the VID (using both Plate and VIN match attempts), certifications

issued over various time periods, the count of vehicles found to become compliant within the period of evaluation, and the percentage of vehicles to become compliant relative to the total number of vehicles matched.

Table 6-2. VID Tests and Certifications Compared with Flagged Vehicles

Month of Registration	Number of Vehicles flagged	Flagged vehicles matched with VID		Rate of compliance prior to and after registration due date for flagged vehicles						Vehicles eventually compliant	
		Total Count	% of flagged vehicles	1 to 3 months prior	0 to 2 months after	3 to 5 months after	6 to 8 months after	9 to 11 months after	12 + months after	Total Count	% of matched vehicles
Jan 04	3178	1948	61.3%	371	568	288	161	145	245	1778	91.3%
Feb 04	3179	2001	62.9%	345	448	246	233	175	301	1748	87.4%
Mar 04	3243	2246	69.3%	408	703	220	145	113	236	1825	81.3%
April 04	3243	2611	80.5%	448	604	209	167	190	278	1896	72.6%
May 04	2800	2460	87.9%	447	495	206	130	101	134	1513	61.5%
June 04	2800	2472	88.3%	460	474	200	143	133	113	1523	61.6%
July 04	2528	2280	90.2%	356	474	175	144	77	98	1324	58.1%
Aug 04	2529	2286	90.4%	371	383	177	156	101	104	1292	56.5%
Sept 04	2630	2508	95.4%	375	441	228	175	79	70	1368	54.5%
Oct 04	2630	2489	94.6%	391	438	222	142	87	58	1338	53.8%
Nov 04	2219	2183	98.4%	245	405	196	90	65	32	1033	47.3%
Dec 04	2220	2169	97.7%	277	421	200	95	83	16	1092	50.3%
Jan 05	2347	2305	98.2%	281	416	158	94	75	N/A	1024	44.4%
Feb 05	2347	2289	97.5%	266	437	161	107	72	N/A	1043	45.6%
Mar 05	2246	2196	97.8%	264	419	165	82	21	N/A	951	43.3%
April 05	2058	2012	97.8%	290	351	152	67	N/A	N/A	860	42.7%
May 05	1857	1815	97.7%	261	327	125	44	N/A	N/A	757	41.7%
June 05	2261	2201	97.3%	443	394	172	43	N/A	N/A	1052	47.8%
July 05	2125	2069	97.4%	319	357	164	N/A	N/A	N/A	840	40.6%
Aug 05	1696	1649	97.2%	260	275	84	N/A	N/A	N/A	619	37.5%
Sept 05	1708	1666	97.5%	266	203	44	N/A	N/A	N/A	513	30.8%
Oct 05	1586	1536	96.8%	225	256	N/A	N/A	N/A	N/A	481	31.3%
Nov 05	1533	1491	97.3%	205	197	N/A	N/A	N/A	N/A	402	27.0%
Dec 05	1911	1857	97.2%	222	108	N/A	N/A	N/A	N/A	330	17.8%

Eventual compliance (12 months beyond registration denial date) could not be fully verified for February 2005 and later since no 2006 VID records were included in this evaluation. Therefore, the percentage of vehicles shown to eventually become compliant is artificially low beginning in February 2005 and increasing through December 2005. As an example, any vehicles that became compliant twelve or more months after they were denied registration in January 2005 are not shown in Table 6-3. Any vehicles that became compliant one or more months after they were denied registration in December 2005 are not shown in Table 6-3. Hence, we see the low 17.8% compliance rate seen for December 2005 relative to the much higher compliance rates seen in prior months.

Table 6-3. Comparison of Registration Counts to I/M Tests and Certificates Issued in I/M Counties in 2005

County	Vehicles Subject to Registration	Total I/M Tests performed	Total I/M Certificates Issued
Brazoria	187,015	152,089	131,359
Collin	408,954	375,980	326,025
Dallas	1,436,983	1,515,531	1,337,523
Denton	340,826	272,953	235,062
Ellis	100,367	70,314	59,727
Fort Bend	268,193	188,168	165,046
Galveston	185,807	164,604	141,119
Harris	2,270,977	2,262,638	1,977,645
Johnson	102,214	74,805	63,938
Kaufman	58,925	41,685	36,460
Montgomery	248,950	200,029	173,283
Parker	77,129	51,200	45,413
Rockwall	42,368	32,186	28,563
Tarrant	1,045,220	1,010,133	894,699

Next, a comparison was made between the number of I/M inspections performed and certificates issued in I/M counties in 2005 with counts of vehicles subject to registration in 2005 in those I/M counties as listed in the October 2005 Texas I/M Program SIP. This was not performed as a by-vehicle comparison, but rather a total I/M test count comparison with registration counts to obtain a general estimate of overall tests performed and certificates issued versus subject vehicles. As such, the counts of tests includes some same-vehicle retests or tests on vehicles entering the program, and the certificate counts include any multiple certificates issued to the same vehicle in 2005 (e.g., for resale) or certificates issued to vehicles entering the program. Table 6-3 provides a result of the comparison.

6.2 Covert and Overt I/M Station and Equipment Audits[40]

Due to their overlapping nature, Review of DPS Station and Equipment Audits and Review of DPS Covert and Overt Audit Operations were combined into one analysis. The overall objective of this analysis was to evaluate the efficacy of the overt and covert auditing conducted in the Texas program. The particular review tasks involved:

- Perform a review of and report on I/M station covert and overt audit procedures and results
- Review station and equipment audit training video
- Review the application that takes auditor through the audit process
- Analyze audit results to evaluate the level of surveillance Texas maintains over I/M stations

We reviewed the I/M station audit reports and described the audit program. We reviewed the station and equipment audit training video and the application that takes the auditor through the audit process. A description of the audit program and the statistics for the results of the audits provide evidence that Texas tries to maintain surveillance over I/M stations. The results of the audits also demonstrate the level of maintenance of I/M station equipment and personnel.

We reviewed the DPS station challenge operations and described them. We reviewed the application that takes the auditor through the audit process. DPS also challenges I/M stations with malfunctioning vehicles to determine if stations properly pass and fail vehicles. A description of these operations and the results of the operations demonstrate the level of commitment that Texas has to station enforcement activities.

Program Description

Audit Program Overview - As a decentralized program, Texas is required to maintain a level of surveillance over vehicle inspection stations. Guidelines for I/M program enforcement and Quality Assurance/Quality Control (QA/QC) procedures are given in Part 51 of Title 40 of the Code of Federal Regulations, and also stated in Texas' October 2005 "Texas Inspection and Maintenance State Implementation Plan. These audit requirements served as the basis for this program evaluation.

[40] This section responds to the Work Plan's Task 3 Element 3B: DPS Station and Equipment Audits and Task 3 Element 3C: DPS Covert and Overt Audit Operations and was written by M.A. Sabisch.

To maintain this surveillance, Texas operates on-going overt and covert auditing programs as well as DPS Trooper legal enforcement activities. Texas' SIP commits 31 full-time employees (FTEs) to conduct covert and overt auditing. Results from overt and covert audits are recorded and maintained by DPS. According to the Texas SIP, penalties for violations of program rules and procedures can range from a six-month suspension to a three-year suspension, depending on the number of previous violations or the number of current violations identified. Legal penalties may also be issued in cases of intentional gross misconduct.

The DPS auditing program is comprised of field technicians (overt auditors, gas auditors, and covert auditors), supervising technicians (personnel who supervise the overt, gas, and covert auditors), and Texas Department of Public Safety (DPS) Vehicle Inspection Troopers (VI Troopers). Personnel in the decentralized garages inspecting vehicles are referred to as "inspectors."

TCEQ has developed laptop-based audit application software entitled the Texas Audit Auditor System (TAAS). The TAAS allows DPS auditors to enter all audit information from any type of audit or subaudit including both covert and overt audits. In addition to entry of audit results into the TAAS, audit information may also be entered in the emissions analyzer during an overt audit. This information is subsequently transmitted to the vehicle information database. However, information entered in the analyzer contains less detail than information in the TAAS.

Supervising technicians provide oversight of all audit activity. The Texas Audit Management System (TAMS), using data entered in the TAAS, is used to manage audit scheduling. The TAMS shows the status of all audits that have been scheduled, completed, pending, and cancelled. VI-IIB forms completed weekly by auditors also provide information on stations visited each week.

Several factors are used to determine which stations will be audited. These include regular audit frequency requirements (how long it has been since a station has received a particular type of audit), customer complaints against stations or inspectors, results of queries performed against vehicle inspection information using the vehicle information database's Reporting System, and results from electronic trigger analysis performed against station test records. Use of these various tools is described below for the various types of audits conducted in Texas.

Overt Audit Program Description - A number of different types of audits are classified as overt audits in the Texas program. These include Administrative Audits, Certification Audits, Compliance Audits, Gas Audits, Gas Re-audits, and Investigative Audits. Details on individual

subtasks associated with each of these types of overt audits are provided in the Summary of Audits sections below.

Although the laptop-based TAAS software is intended to be the primary tool used to guide and collect information from overt auditing, a comparison of all overt audit records entered in the analyzer with those entered in the TAAS review over the period of evaluation revealed approximately 5% of audits entered in the analyzer did not appear to have a matching audit record in the TAAS database. These analyzer audit records were therefore combined with the TAAS records to create a comprehensive audit result database for analysis. The methodology for combining and analyzing these results is provided in the Analysis Methodology section below.

Each overt auditor (field technician) is assigned a group of 60 to 80 stations to supervise. DPS reported approximately 47 overt auditors are currently employed in the region of evaluation (as of August 2006) plus additional gas auditors and overt audit supervisors. Overt auditors are responsible for their own audit scheduling but are required to perform one overt audit per station per month. Gas auditors are to perform four gas audits per analyzer per year. Overt auditors are provided lists of complaints against stations, which are used to help determine which stations should be audited. The overt auditors may also use triggers to tailor their audit schedule or the VID Reporting System, which provides information such as clean scanning reports, reports on certificate ID number jumps or excessive missing certificate numbers, reports on "friendly stations" (stations with a high percentages of passes relative to other stations), stations with quick inspections, stations with a high percentage of RPM bypasses, and individual inspector pass/fail statistics.

Dynamometer checks or calibrations are not performed during overt audits. Instead, the program relies on analyzer software which requires 72-hour dynamometer checks including coastdown time checks and parasitic loss horsepower checks. Analyzers with dynamometers that do not pass these checks will be prevented from doing ASM inspections.

Covert Audit Program Description - Covert audits are conducted to identify stations that may be engaged in non-compliant or fraudulent activity. Review of program audit information indicates covert audits may be triggered based both on motorist complaints and on indications of fraud such as clean piping or selling inspection certifications to failing vehicles. However, DPS reports that the VID Reporting System, rather than electronic triggers, is primarily used to identify potentially fraudulent stations that should receive covert audits. In addition, a covert auditor's supervising technician may also request a covert audit be conducted

at a particular station (perhaps based on results from analysis of the Texas Information Management System reports).

Vehicles used in the covert auditing program are uniquely identified in the VID and return no test record to the inspection analyzer during an audit. Tampers are generally induced on covert vehicles, and all inducements are noted in covert audit reports, part of the TAAS audit application. Pre-audit and post-audit emission measurements are conducted on covert vehicles to evaluate the accuracy of emission results measured at emissions inspection stations.

Covert auditors are required to perform one covert audit per analyzer per year. DPS reported approximately 10 covert auditors are currently employed in the region of evaluation (as of August 2006).

After a covert audit is conducted, the station is re-visited and advised that they have been audited and are informed of the covert audit outcome. This re-visit is referred to as a novert audit. Enforcement actions resulting from the covert audit are performed during the novert audit.

DPS Vehicle Inspection Trooper Investigations - In addition to the overt and covert auditing programs, DPS VI Troopers conduct criminal investigations against stations that may be engaged in fraudulent activity. Triggers and the VID Reporting System are available to DPS VI Troopers to assist with identifying stations which should be investigated. DPS reports 20 VI Troopers are employed and conduct criminal investigations in the regions of evaluation. Since these VI Troopers operate independently from the overt/covert auditing programs, results of these criminal investigations were not available for this review.

Enforcements Against Stations - Several avenues are available for enforcing program compliance in the overt and covert audit programs. Immediate lockouts may be imposed, such as when an analyzer fails a gas audit. In addition, a notice of violation may be served (for example, if an operational item is noted as missing during an audit), and the station/inspector may either accept the notice, receive the penalty and establish compliance, or the station/inspector may request a hearing by an administrative law judge. After the hearing, the notice may then go through appeals processes, as necessary.

Lockouts imposed may be cleared remotely through the VID application, but some lockouts which have been issued do require a DPS re-visit.

Auditor Training - During training, auditors are required to accompany a senior auditor, until they become familiar with the auditing process. This on-the-job training generally

continues for four to six weeks. In addition, all auditors are required to attend vehicle inspector training, which is provided by ASE L1 (Advanced Engine Performance Specialist) certified technicians. In-service training is also provided to overt and covert auditors, annually and on an as-needed basis such as during the OBD migration and also during implementation of the TAAS auditing system.

Texas DPS has developed a 15-minute video intended to train DPS gas auditors. As part of the program evaluation, we reviewed and summarized this video, and a summary is available in Appendix E of this report.

Analysis Methodology

Audit results over the period of evaluation were analyzed and compared with federal and state I/M program requirements. These requirements are summarized in Appendix F. The methodology used for consolidating and analyzing audits is provided here. A summary of the results of analysis of audit data collected over the period of evaluation is provided below.

The first step in the process was to determine which of the 19 TAAS (audit application) tables, 6 analyzer "Program Evaluation" tables, and other VID tables were necessary for this analysis. Figure 6-1 illustrates the method for consolidating the audit results into a SAS dataset. All records shown in dataset A were from the TAAS audit database and were merged by key fields shown in the figure and also listed in Table 6-4. Results of queries performed on the vehicle inspection database were also imported into the consolidated audit dataset to provide information regarding the number of analyzers, number of inspectors, number of inspections conducted at each station and county of each station during the period of evaluation. This information was used to determine appropriate auditing rates for evaluating compliance with federal and state audit requirements.

After the primary audit Set A depicted in Figure 6-1 was developed, results of all audits entered in the analyzer were then imported into SAS. All analyzer audits that were duplicates of the TAAS audits (as indicated by station ID and audit date) were dropped from the analyzer audit dataset. All remaining unique analyzer audits were then merged with the main TAAS audit dataset A. Table 6-5 provides a list of fields from analyzer-entered audits.

Figure 6-1. TAAS Audit Database Merge Structure (by-audit observations)

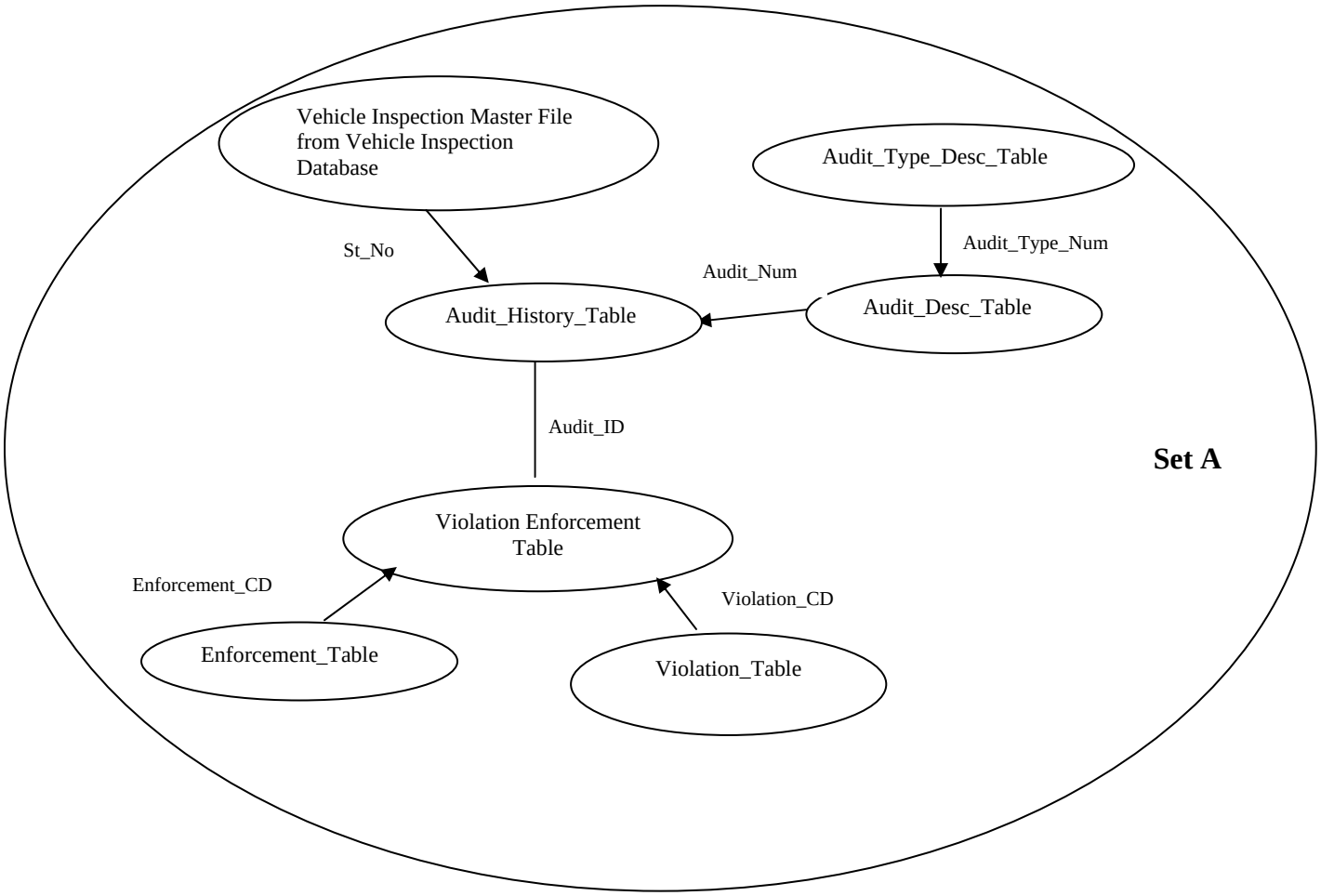


Table 6-4. Set A Dataset – Audit Information from TAAS

Table	Variable Name	Content
Audit Type Desc Table	AUDIT_TYPE_NUM (Key 1)	#s 2,3,4
Audit Type Desc Table	AUDIT_TYPE_DESCRIPTION	“Overt”, “Covert”, “Novert”
Audit Desc Table	AUDIT_NUM (Key 2)	numbers, 1-40
Audit Desc Table	AUDIT_DESC	descriptions of 40 audits
Audit Desc Table	AUDIT_TYPE_NUM (Key 1)	#s 2,3,4
Audit History Table	AUDIT_ID (Key 3)	4-digit #
Audit History Table	AUDIT_NUM (Key 2)	
Audit History Table	ST_NO (Key 6)	2 to 4 digit #
Audit History Table	DATE_ASSIGNED	
Audit History Table	DATE_STARTTIME	
Audit History Table	DATE_ENDTIME	
Audit History Table	DATE_COMPLETED	
Audit History Table	RATING	
Audit History Table	SOURCE_OF_AUDIT_ASSIGNED	
Audit History Table	DPSP_DPS_ID_NO	
Enforcement Table	ENFORCEMENT_CD (Key 5)	Numbers 1-5
Enforcement Table	DESCRIPTION	“Warning”, “Citation”, etc.
Violation Table	VIOLATION_CD (Key 4)	5 digit #
Violation Table	DESCRIPTION	Description of violation
Violation Table	VIOLATOR	I, S, or P
Violation Enforcement Tbl	ST_NO	2 to 4 digit #
Violation Enforcement Tbl	INSP_ID	7 to 8 digit #
Violation Enforcement Tbl	VIOLATION_CD (Key 4)	5 digit #
Violation Enforcement Tbl	ENFORCEMENT_CD (Key 5)	Numbers 1-5
Violation Enforcement Tbl	TICKET_NUM	various alpha & numeric
Violation Enforcement Tbl	AUDIT_ID (Key 3)	3 or 4 digit number
QC’d Station Info File	ST_NO (Key 6)	
QC’d Station Info File	ANALYZER_NO	
QC’d Station Info File	SST_COUNTY	
QC’d Station Info File	OTHERS (if needed)	

Table 6-5. Program Evaluation Performance Audits from Analyzers

Variable Name	Definition	Associated TIMS Field
ETS_SYS_NO	Analyzer system #?	
SYS_NO		
ST_ID	Station ID?	ST_NO (Key 6)
ETS_ID	Analyzer ID	ANALYZER_NO
TODAYS_DT	Self explanatory (SE)	DATE_STARTTIME
STATION_SIGN	SE	AUDIT_TASK_DESC
PRICE_POSTED	SE	AUDIT_TASK_DESC
HOURS_POSTED	SE	AUDIT_TASK_DESC
CERT_OF_APPT	SE	AUDIT_TASK_DESC
INSPECTOR_LICENSE	SE	AUDIT_TASK_DESC
EMISS_FEE_CHARTS	SE	AUDIT_TASK_DESC
CURR_EMISS_MANUAL	SE	AUDIT_TASK_DESC
CERTIFICATES	SE	AUDIT_TASK_DESC
PUBLIC_RELATIONS_PAM	SE	AUDIT_TASK_DESC
TUNE_UP_TOOLS	SE	AUDIT_TASK_DESC
PROPANE_ENRICH_KIT	SE	AUDIT_TASK_DESC
FUEL_INLET_RES_GUAGE	SE	AUDIT_TASK_DESC
FLEX_PROBES	SE	AUDIT_TASK_DESC
SPAN_GAS	SE	AUDIT_TASK_DESC
RULES_REGS_MANUAL	SE	AUDIT_TASK_DESC
BRAKE_TEST_AREA	SE	AUDIT_TASK_DESC
MEASURING_DEVICES	SE	AUDIT_TASK_DESC
LAUNDRY_MARK_PEN	SE	AUDIT_TASK_DESC
SCRAPING_DEVICE	SE	AUDIT_TASK_DESC
TREAD_DEPTH_GUAGE	SE	AUDIT_TASK_DESC
QTR_INCH_RND_HOLE_PUNCH	SE	AUDIT_TASK_DESC
APPR_WIN_TINT_MTR	SE	AUDIT_TASK_DESC
PROCEDURE_CHART	SE	AUDIT_TASK_DESC
OVERALL_RESULT	SE	AUDIT_TASK_DESC
CREATE_DT	Record create date?	
CREATE_LOGIN	Source of record origination?	
UPDATE_DT	date of record update?	
UPDATE_LOGIN	??	
ERROR_CD		
DISPLAY_BOARD	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
APPVD_BAR90_GAS	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
REQ_EQIP	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
TACHO_LEAD	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
GAS_CAP_TESTER	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
INSP_ON_DUTY	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
INSP_BAY	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
ETS_PRINT_SUPPL	Section 3.9.2 of spec indicates P/F	AUDIT_TASK_DESC
DPS_REP_ID	DPS auditor ID #	INSP_ID
VIOLATION_CDS	SE	VIOLATION_CD
ACTION_CDS	SE	
TICKET_NOS	SE	TICKET_NUM

Summary of Overt Audits Conducted over the Period of Evaluation

Overt Audit Counts - As previously indicated, an overt audit could consist of a number of different sets of tasks. The following six categories of audits are classified as overt audits in the Texas Program (as reported from the TAAS):

- Administrative
- Certification
- Compliance
- Gas Audit
- Gas Re-Audit
- Investigative

In the TAAS, each of these six categories was broken down into subcategories, depending on the quarter in which the audit was conducted. However, with the exception of audit task revisions, quarterly audit subcategories were identical among themselves (identical audit steps). The audit steps associated with each of these six overt audit categories are listed below.

Administrative Audit
Did station have required safety equipment?
Did station have operational ASM equipment?
Did station have operational OBD equipment?
Did station have facility requirements (sign, bay, brake test area, etc.)?
Did station have adequate supply of certificates/VI30As?
Did station show proficiency?
Did inspector show proficiency?
Did VI technician collect fees?
Did VI technician sell inspection certificates?
Did VI technician issue supplies?
Did VI technician distribute information?
Did VI technician conduct a voluntary close-out?
Did VI technician clear lock-out?
Did station have operational TSI equipment? (Omitted from Administrative 5)

Certification Audit
Did station show proficiency?
Did inspector show proficiency?
Did VI technician collect fees?
Did VI technician conduct a quality control audit? (Certification 1 only, discontinued 5/31/05)
Did VI technician conduct a missing/voided inspection certificate audit? (Certification 1 only,

discontinued, unknown date)
Did VI technician certify station?
Did VI technician renew station license?
Did VI technician certify inspector?
Did VI technician renew inspector license?

Compliance Audit
Did station have required safety equipment?
Did station have operational ASM equipment?
Did station have operational OBD equipment?
Did station have facility requirements (sign, bay, brake test area, etc.)?
Did station have adequate supply of certificates/VI30As?
Did VI technician collect fees?
Did VI technician sell inspection certificates?
Did VI technician issue supplies?
Did VI technician distribute information?
Did VI technician conduct a voluntary close-out?
Did VI technician clear lock-out?
Did VI technician conduct a novert investigative audit? (Compliance 1 only, discontinued, unknown date)
Did VI technician conduct a quality control audit? (discontinued 5/31/05)
Did VI technician conduct a missing/voided inspection certificate audit?
Did station have operational TSI equipment? (omitted from Compliance 5)
Did the inspector conduct a certificate audit? (omitted from Compliance 5)

Gas Audit
Overall results?
Analyzer calibration
Leak check
Gas cap calibration
Gas audit

Gas Re-Audit
Overall results?
Analyzer calibration
Leak check
Gas cap calibration
Gas audit

Investigative Audit
Did VI technician conduct a novert investigative audit?
Did VI technician conduct a complaint investigative audit?
Did VI technician conduct a quality control audit? (discontinued 5/31/05)
Did VI technician conduct a missing/voided inspection certificate audit?
Did VI technician conduct a follow-up investigative audit?

In addition to the above information stored in the TAAS database, information may be entered into the emissions analyzer during an audit. The following fields are available for information entered into the emissions analyzer.

Overt Audit Information From Analyzer (Perform.dat)

ETS_SYS_NO
SYS_NO
ST_ID
ETS_ID
TODAYS_DT
LAST_REPORT_DT
LAST_CALIBRAT_DT
STATION_SIGN
PRICE_POSTED
HOURS_POSTED
CERT_OF_APPT
INSPECTOR_LICENSE
EMISS_FEE_CHARTS
CURR_EMISS_MANUAL
CERTIFICATES
PUBLIC_RELATIONS_PAM
TUNE_UP_TOOLS
PROPANE_ENRICH_KIT
FUEL_INLET_RES_GUAGE
FLEX_PROBES
SPAN_GAS
RULES_REGS_MANUAL
BRAKE_TEST_AREA
MEASURING_DEVICES
LAUNDRY_MARK_PEN
SCRAPING_DEVICE
TREAD_DEPTH_GUAGE
QTR_INCH_RND_HOLE_PUNCH
APPR_WIN_TINT_MTR
PROCEDURE_CHART
OVERALL_RESULT
CHANGE_ACCESS_CODE
NEW_DATA_DISK
RESET_TAMPER
SOFTWARE_UPDATE
STATION_LOCKOUT
INSPECTOR_LOCKOUT
LETTER_DELIVERED
TECHNICAL_BULLETINS
CREATE_DT
CREATE_LOGIN
UPDATE_DT
UPDATE_LOGIN
ERROR_CD
DISPLAY_BOARD
APPVD_BAR90_GAS
REQ_EQIP
TACHO_LEAD
GAS_CAP_TESTER
INSP_ON_DUTY

INSP_BAY
ETS_PRINT_SUPPL
DPS_REP_ID
BARCODE_SCANNER
CD_ROM
DVD
MODEL_NUM
SERIAL_NUM_1
SERIAL_NUM_2
MANU_ID
VIOLATION_CDS
ACTION_CDS
TICKET_NOS

Since some audit information was included only in the TAAS, some information only included in the analyzer tables (PERFORM.DAT), and some information was contained in both (entry in both systems during one unique audit), a methodology was needed to evaluate the true number and types of audits conducted during the period of evaluation. To do this, the TAAS records were considered the primary source of audit information since the TAAS is intended to be the primary audit result registry and also contains the most detailed and categorical information. The analyzer-registered records (from PERFORM.DAT) were then compared with the TAAS results to identify records only included in PERFORM.DAT. These records were then merged with the TAAS records to obtain a complete database of all overt audits conducted over the period of interest. Again, only counties of interest were retained. Table 6-6 presents the total number of overt audit tasks completed during the period of evaluation, and percentages of individual categories performed relative to overall. In this analysis, results stored only in the analyzer PERFORM.DAT file (not in TAAS) are classified as an individual category.

Table 6-6. Counts of Overt Audit Tasks

Audit Task Category	2004 Count	% of all overt audit tasks	2005 Count	% of all overt audit tasks
TAAS - Administrative	7719	15.97%	7581	16.52%
TAAS - Certification	4152	8.59%	1171	2.55%
TAAS - Compliance	21047	43.54%	22892	49.88%
TAAS - Gas Audit	7965	16.48%	7366	16.05%
TAAS - Gas Re-Audit	841	1.74%	1418	3.09%
TAAS - Investigative	4239	8.77%	3383	7.37%
Analyzer - Perform.dat	2371	4.91%	2080	4.53%
Total Overt Tasks	48334	100.00%	45891	100.00%

After performing the above audit counts and categorization analysis, a comparison was made between the number of overt audits tasks conducted each year with the number of stations in operation each year of evaluation. Analysis of vehicle inspection records in the counties of

interest showed 2,932 stations conducted at least one vehicle inspection in 2004, and 3,213 stations conducted at least one vehicle inspection in 2005.

Comparing the audit subtask results in Table 6-6 with these station counts produced the subtask per station values for each year of evaluation which are given in Table 6-7.

Table 6-7. Average Count of Audit Subparts per Station

Audit Subpart	2004 Count (audits/station)	2005 Count (audits/station)
Administrative	2.6	2.4
Certification	1.4	0.4
Compliance	7.2	7.1
Gas Audit	2.7	2.3
Gas Re-Audit	0.3	0.4
Investigative	1.4	1.1
Perform.dat	0.8	0.6
Total Overall	16.5	14.3

Next, a comparison was made of the number of overt audits conducted each year with the number of analyzers at each station. Vehicle inspection records were used to determine the number of analyzers in use at each station during 2004 and 2005. This analysis indicated that both in 2004 and 2005 stations had between one and four analyzers as shown in Table 6-8.

Table 6-8. Counts of Stations with 1, 2, 3, or 4 Analyzers

Analyzer Count	2004	2005
1 analyzer	2523	2767
2 analyzers	363	397
3 analyzers	40	43
4 analyzers	6	6
Total Stations	2932	3213

Although each of the tasks listed above is classified as an overt audit, these tasks do not comprise a complete overt audit as defined in the CFR or SIP. Typically, multiple tasks are performed during one station visit/audit, although they are classified within the TAAS as multiple individual audits. Therefore, to minimize any double counting of audits, all audit tasks conducted during the same audit week at the same inspection station by the same DPS auditor were classified as a single audit. For 2004, this “grouping” reduced the overt audit task count from 48,334 unique audit records to 31,674 overt audits. For 2005, the count dropped from 45,891 unique audit records to 35,971 overt audits. Note that different tasks could be conducted during different audits, and an analysis was not performed on the task combinations performed during individual overt audits. Consequently, for this review, the weekly grouped audits were

assumed to meet the overt audit requirements as listed in the CFR and Texas' SIP. It should also be noted that analyzer gas audit results stored in the VID are evaluated elsewhere. The gas audit and gas re-audit counts from the TAAS and listed in Table 6-6 were used to evaluate program gas audit compliance.

Tables 6-9 and 6-10 shows the distribution of number of overt audits conducted at stations in 2004 and 2005, using the grouping convention described above. That is, all overt audit tasks conducted during the same audit week at the same inspection station by the same DPS auditor were classified as a single overt audit. The column to the left of each of these tables indicates the number of audits conducted per year at a station, the adjacent four columns indicate the number of stations that received the number of audits listed in the left column. The column to the right of the table provides a running total of "grouped" audits conducted over the year of evaluation. The audit frequency distribution, where the overt audit is the weekly grouped combination of tasks, is also shown graphically in Figure 6-2.

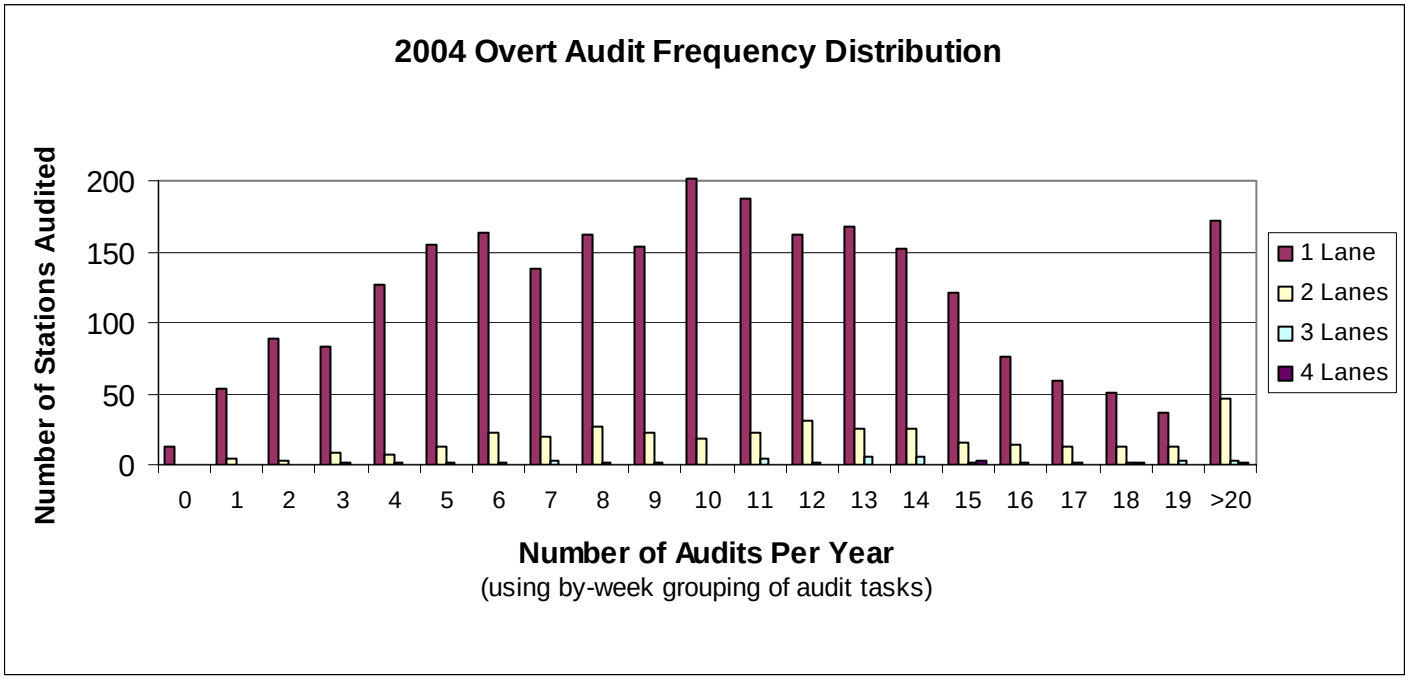
Table 6-9. Overt Audits Conducted at I/M Stations in 2004

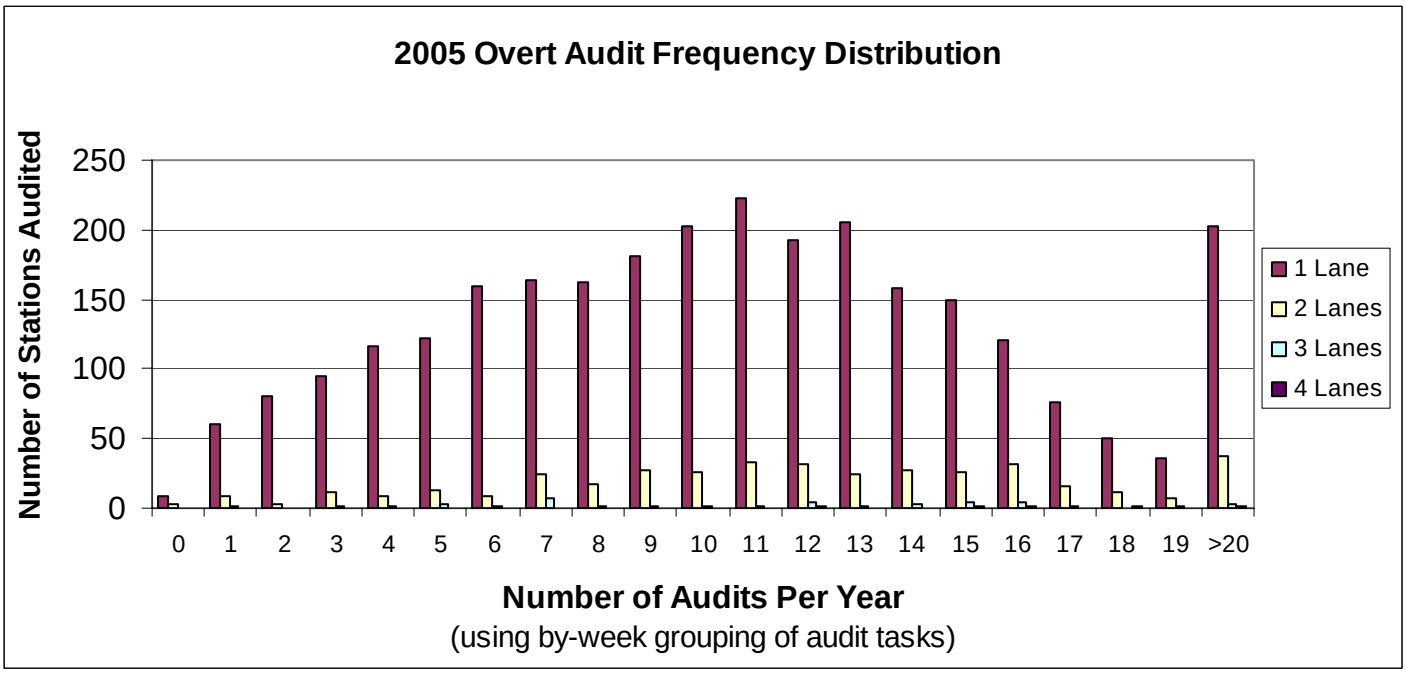
Number of audits performed	Stations with 1 Analyzer	Stations with 2 Analyzers	Stations with 3 Analyzers	Stations with 4 Analyzers	Total 2004 Audits
0	13				N/A
1	53	4			57
2	89	3			184
3	83	8	1		276
4	127	7	1		540
5	155	13	1		845
6	164	23	2		1134
7	138	20	3		1127
8	162	27	2		1528
9	154	22	2		1602
10	201	19			2200
11	188	22	4		2354
12	162	31	1		2328
13	167	26	5		2574
14	152	26	5		2562
15	121	16	2	3	2130
16	76	14	2		1472
17	59	12	2		1241
18	51	12	1	1	1170
19	36	12	3		969
20	26	5			620
21	21	6	1		588
22	16	3	2		462
23	25	7			736
24	15	4			456
25	22	2			600
26	10	5			390
27	13	3			432
28	7	4			308
29	8	1		1	290
30	6	2		1	270
31	2				62
32					0
33		3			99
34	1	1			68
Total	2523 (Stations)	363 (Stations)	40 (Stations)	6 (Stations)	31674 (Audits)

Table 6-10. Overt Audits Conducted at I/M Stations in 2005

Number of audits performed	Stations with 1 Analyzer	Stations with 2 Analyzers	Stations with 3 Analyzers	Stations with 4 Analyzers	Total 2005 Audits
0	8	3			N/A
1	61	8	1		70
2	81	3			168
3	95	11	1		321
4	117	8	1		504
5	122	13	3		690
6	160	9	2		1026
7	164	24	7		1365
8	163	17	1		1448
9	181	28	2		1899
10	202	26	1		2290
11	223	33	1		2827
12	192	32	4	1	2748
13	206	25	2		3029
14	158	27	3		2632
15	149	26	4	1	2700
16	120	32	4	1	2512
17	76	16	2		1598
18	50	11		1	1116
19	36	7	1		836
20	21	9	2		640
21	21	2		1	504
22	21	5		1	594
23	24	1			575
24	15	1			384
25	14	4	1		475
26	11	1			312
27	15	2			459
28	22				616
29	13	2			435
30	5	1			180
31	7	4			341
32	4	2			192
33	4	1			165
34	2	2			136
35					0
36	2	1			108
37	1				37
38					0
39	1				39
Total	2767 (Stations)	397 (Stations)	43 (Stations)	6 (Stations)	35971 (Audits)

Figure 6-2. 2004 and 2005 Overt Audit Frequency Distributions





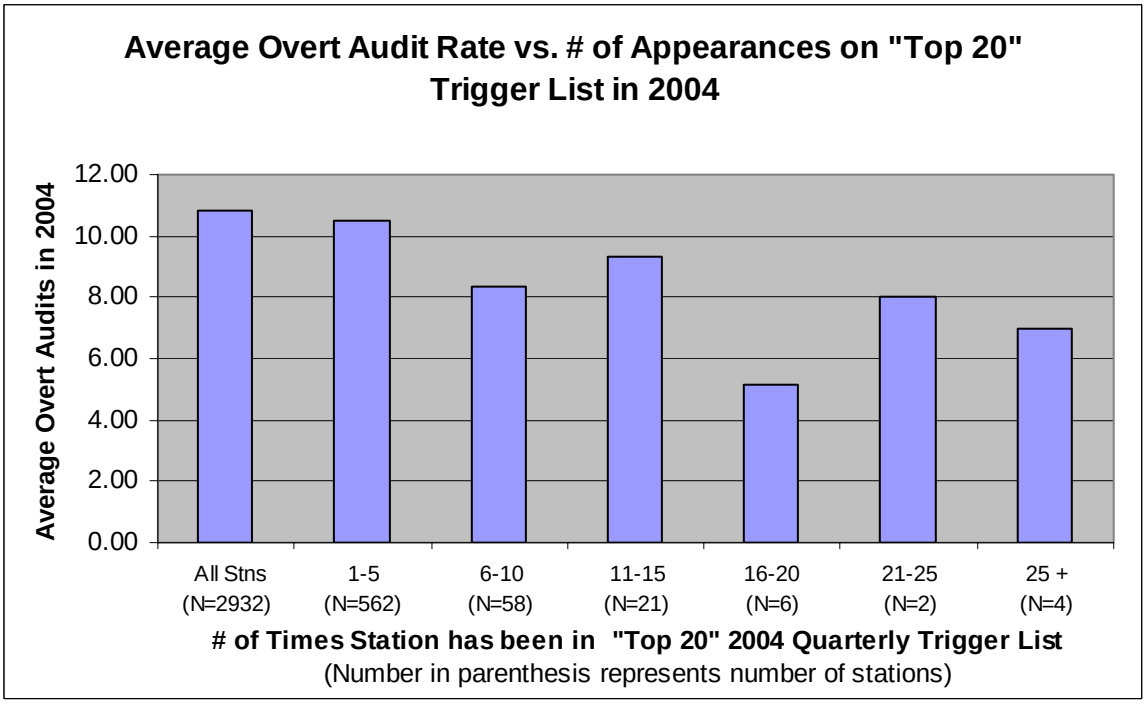
It is possible that a small percentage of the stations shown as having no audits (13 total in 2004 and 11 total in 2005) could result from a mismatch between the station ID number list in the TAAS audit data and the true station ID number contained in the vehicle test records. This could happen since the actual vehicle test records were used to determine the number of stations in operation during each calendar year of evaluation. Overall, however, a good match rate was seen between station ID in the TAAS audit records and the true station ID in the vehicle test records. Only approximately 100 audit records were "orphans" from the 94,255 total audit records (much less than one percent), and many of these could be due to audits that were initiated but not completed.

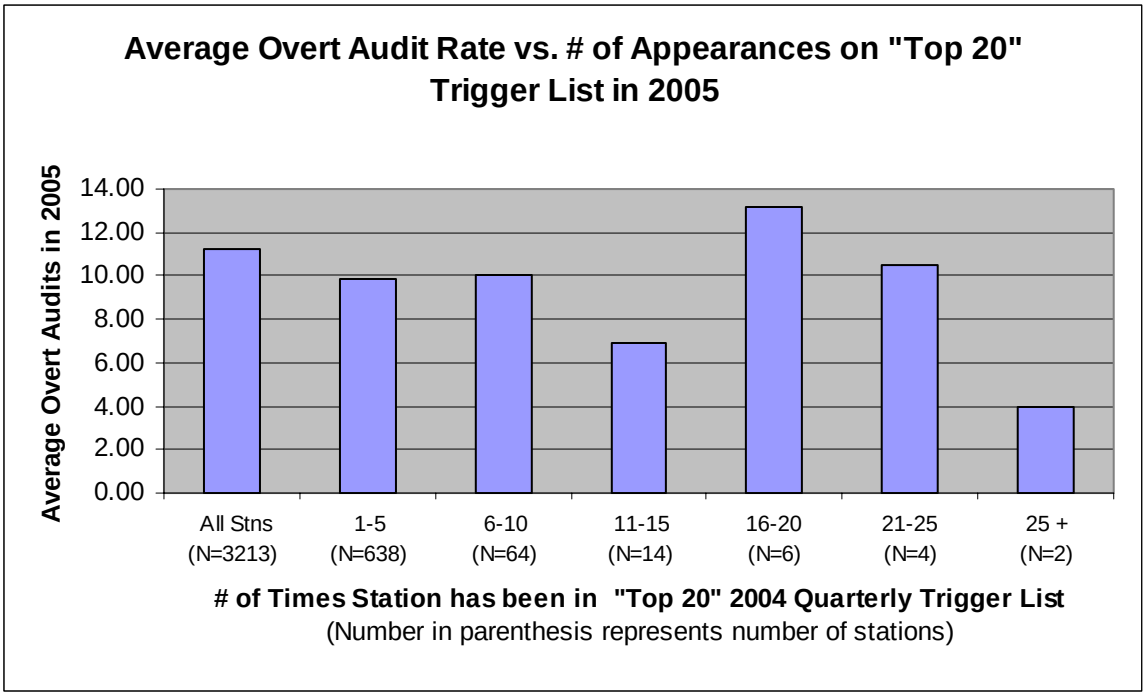
In 2004, the overall average ratio of overt audits to stations is 10.8 overt audits/station, and for 2005 the ratio is 11.2 overt audits/station.

Overt Audits Conducted in Comparison With Station Triggers - Next, we compared overt audit frequency rates with electronic "trigger" rankings, to see if the trigger application had any influence on the audit frequency of certain stations. To do this, lists were developed of the highest 20 ranked stations for each of the 26 triggers in use for each quarter. Those stations in the "top 20" for more than one trigger would be shown multiple times in that quarter. Then, for each year of evaluation, the quarterly lists were consolidated to show how many hits each station received per year. This information was then compared with the number of overt audits conducted per year using the week / station / DPS technician grouping previously described.

Results of this comparison are shown in Figure 6-3. As shown in the x-axis, rates of incidents where stations are in the top 20 of any trigger ranking are binned in groups of 5. For example, 58 of the 2932 stations (2%) operating in the program in 2004 were in the "top 20" quarterly trigger rankings between 6 and 10 times, and these stations received an average of 8.3 audits in 2004. The bar to the left shows the average audit rate for all stations operating in the program area of evaluation, regardless of trigger ranking. These plots do not seem to suggest an increase in overt auditing based solely on trigger data. This is not unexpected, however, as DPS has reported that triggers are primarily used by DPS vehicle inspection officers rather than by overt auditors. As previously indicated, overt auditors may also use motorist complaints against stations and inspectors as well as the VID Reporting System to help tailor audit schedules.

Figure 6-3. Comparison of Overt Audit Rate with Station Trigger Rankings





Overt Auditor Counts - A count was conducted of DPS auditors conducting audits within the area of evaluation, both during 2004 and during 2005. In 2004, three auditors conducted both covert and overt audits, and another 58 DPS auditors conducted only overt audits (no coverts). In 2005, three auditors conducted both covert and overt audits, and another 67 auditors conducted only overt audits (no coverts). However, the percentage of time each of these employees spent conducting audits during each year was not evaluated. These values correlate fairly well with the estimate of 47 overt auditors currently employed in the region of evaluation (as of August 2006). The auditor count from the audit records is likely higher due to auditor turnover during the two years being evaluated.

Enforcement Actions Resulting from Overt Audits - Table 6-11 summarizes enforcement actions resulting from overt audits (from the combined TAAS and analyzer dataset) during 2004 and 2005 in the counties of interest.

Table 6-11. Enforcement Actions from Overt Audits

Action	2004 Count	2005 Count
Enforcement Actions listed in TAAS		
Total TAAS Audits	29303	33891
Citations	50	23
Warnings	71	38
Revocation Recommended	0	0
Suspension Recommended	32	58
Re-education	167	193
Enforcement Actions listed in PERFORM.DAT		
Total PERFORM.DAT Audits	2371	2080
Overall fails	22	31
Station Lockouts	22	5
Inspector Lockouts	7	6
Various Violation Codes Recorded	115	2
Various Action Codes Recorded	115	2
Various Tickets Issued	115	1

Summary of Covert Audits conducted over the Period of Evaluation

Covert Audit Counts - The following lists tasks associated with covert audits, as contained in the TAAS database:

Covert
Did inspector check for insurance?
Did the inspector properly inspect the horn?
Did the inspector properly inspect the windshield wipers?
Did the inspector properly inspect the mirror?

Did the inspector properly inspect the steering system?
Did the inspector properly inspect the seatbelts?
Did the inspector properly inspect the service brake system?
Did the inspector properly inspect the parking brake system?
Did the inspector properly inspect the tires?
Did the inspector properly inspect the wheel assembly?
Did the inspector properly inspect the exhaust system?
Did the inspector properly inspect the EGR system?
Did the inspector properly inspect the TAC system?
Did the inspector properly inspect the PCV system?
Did the inspector properly inspect the AIS system?
Did the inspector properly inspect the EVP system?
Did the inspector properly inspect the CAT system?
Did the inspector properly inspect the high beam indicator?
Did the inspector properly inspect the tail lamps?
Did the inspector properly inspect the stop lamps?
Did the inspector properly inspect the license plate lamp?
Did the inspector properly inspect the cab lamps? (purged from Coverts 1-4, unknown date)
Did the inspector properly inspect the headlights?
Did the inspector properly inspect the turn signal lamps?
Did the inspector properly inspect the rear reflectors?
Did the inspector properly inspect the safety flaps? (purged, unknown date)
Did the inspector properly inspect the sun screening?
Did the inspector properly inspect the fuel filler cap?
School bus: Did the inspector properly inspect the stop sign? (purged, unknown date)
School bus: Did the inspector properly inspect the fire extinguisher? (purged, unknown date)
School bus: Did the inspector properly inspect the warning lamps? (purged, unknown date)
School bus: Did the inspector properly inspect the convex mirror? (purged, unknown date)
Overall results?

After a covert audit is conducted, it is to be followed with a novert audit, at which time someone other than the covert auditor advises the station of the covert audit they received and to either congratulate them on a job well done or describe the deficiencies identified during the audit. Table 6-12 lists the number of covert and novert audits conducted in the counties under evaluation in 2004 and 2005.

Table 6-12. Counts of Covert and Novert Audits

Audit Category	2004 Count	% of covert	2005 Count	% of covert
Covert	3638	100.00%	3067	100.00%
Novert	3234	88.89%	2862	93.32%

As stated in Texas' SIP, covert frequencies are to be scheduled based on the number of full-time employees conducting inspections at an I/M station. Therefore, to evaluate Texas'

covert auditing frequency, an attempt was made to determine the number of inspectors employed at each station within each calendar year of evaluation.

Inspector to station assignments did not appear to be available in the VID inspector or station datafiles (Inspectr.dat or Station.dat), presumably because inspectors may move from station to station and may work at multiple stations within the same time period. Station.dat did list an "inspector limit" field, but those values did not appear to represent true inspector counts per station, as shown in Table 6-13. Note that the total count of stations listed in this table differs from that shown in Table 6-8 because Table 6-8 is derived from vehicle test records and Table 6-13 is derived from a station configuration file.

Table 6-13. Inspector Limits at Inspection Stations

Count of Stations	# of inspector limit
1 station had	a limit of 1 inspector
1 station had	a limit of 5 inspectors
685 stations had	a limit of 10 inspectors
5950 stations had	a limit of 25 inspectors
45 stations had	a limit of 50 inspectors
5 stations had	a limit of 100 inspectors
2 stations had	a limit of 200 inspectors
1 station had	a limit of 300 inspectors
1 station had	a limit of 999 inspectors

Counts of inspectors testing at each station during each year of evaluation was then determined using the vehicle test records provided for this evaluation. Results are shown in Table 6-14.

Table 6-14. Counts of Inspectors Determined Through Vehicle Test Record Evaluation

Number of inspectors	Number of stations in 2004	Number of stations in 2005
1	375	399
2	547	624
3	485	531
4	362	429
5	260	270
6	193	226
7	150	171
8	118	121
9	79	95
10	66	64
11-20	240	230
21-30	29	32
31-40	8	6
41-50	4	7
51-60	9	6
61-70	7	1
71-80	0	1
Total	2932 stations	3213 stations

Of the 2,932 stations in 2004 successfully matched with TAAS records, the mean number of inspectors per station is 5.2. The minimum is 1 and maximum is 67. Of the 3,213 stations in 2005 successfully matched with TAAS records, the mean number of inspectors per station is 5.1, the minimum is 1 and maximum is 71. These high counts are likely due to inspector turnover at stations, inspectors working at more than one station, and many station employees being certified as inspectors and actually testing but perhaps not testing full-time. However, the covert audit frequency rates were to be evaluated based on the number of employees conducting inspections full-time, not employees certified as inspectors (i.e., hours each inspector spends doing inspections at a station). Since this information could not be derived from the above data, for the purposes of this analysis, it was decided the most appropriate approach would be to assume one analyzer is equivalent to one full-time inspector (since two inspectors cannot concurrently use one analyzer. Since it is unlikely one analyzer is in full and continual use 40 hours per week, this approach does not likely underestimate the number of FTEs conducting inspections. Therefore, the analyzer counts used for the overt audit evaluation was also used for the covert audit evaluation.

Since the five types of covert audits were identical and each was an independent audit, it was not necessary to group coverts as was done with the overt audit analysis.

Tables 6-15 and 6-15 show the distribution of number of covert audits conducted at stations in 2004 and 2005. The column to the left of each of these tables indicates the number of audits conducted per year at a station, the adjacent four columns indicate the number of stations that received the number of audits listed in the left column. The column to the right of the table provides a running total of covert audits conducted over the year of evaluation. The audit frequency distribution listed in these tables is also shown graphically in Figure 6-4.

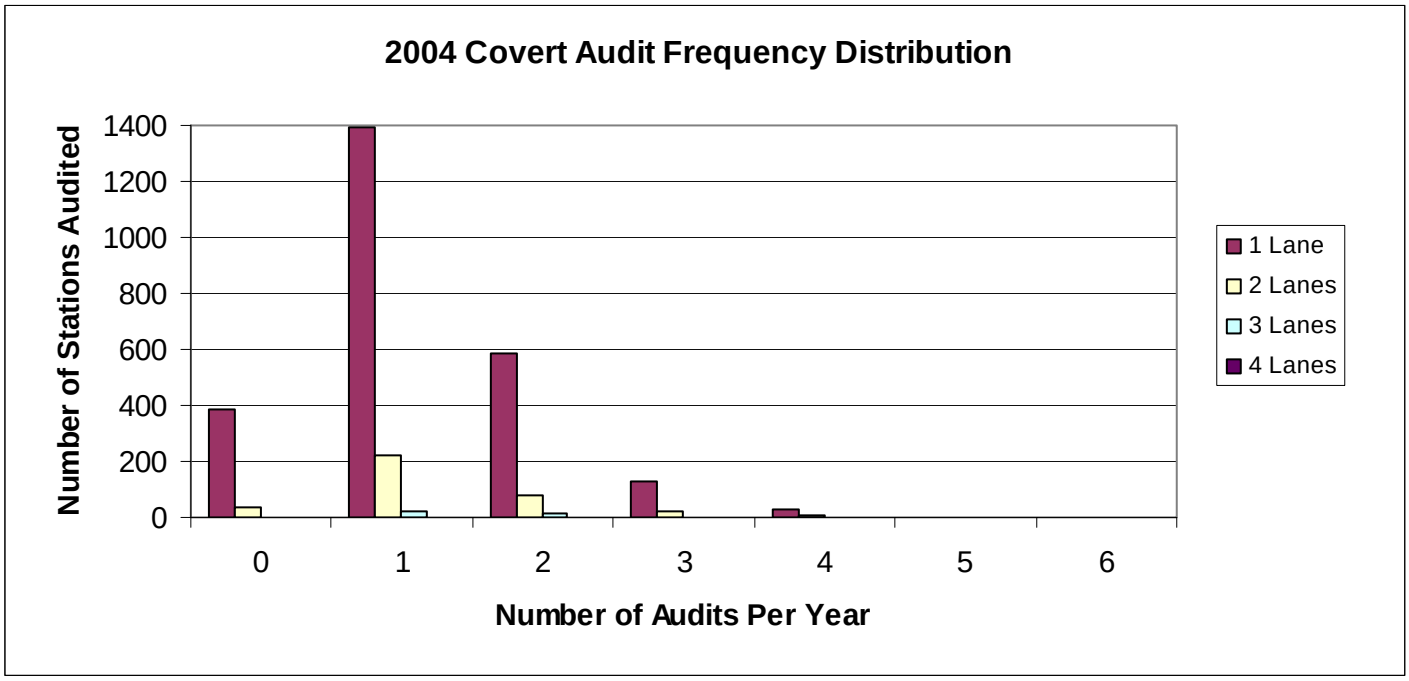
Table 6-15. Covert Audits Conducted at I/M Stations in 2004

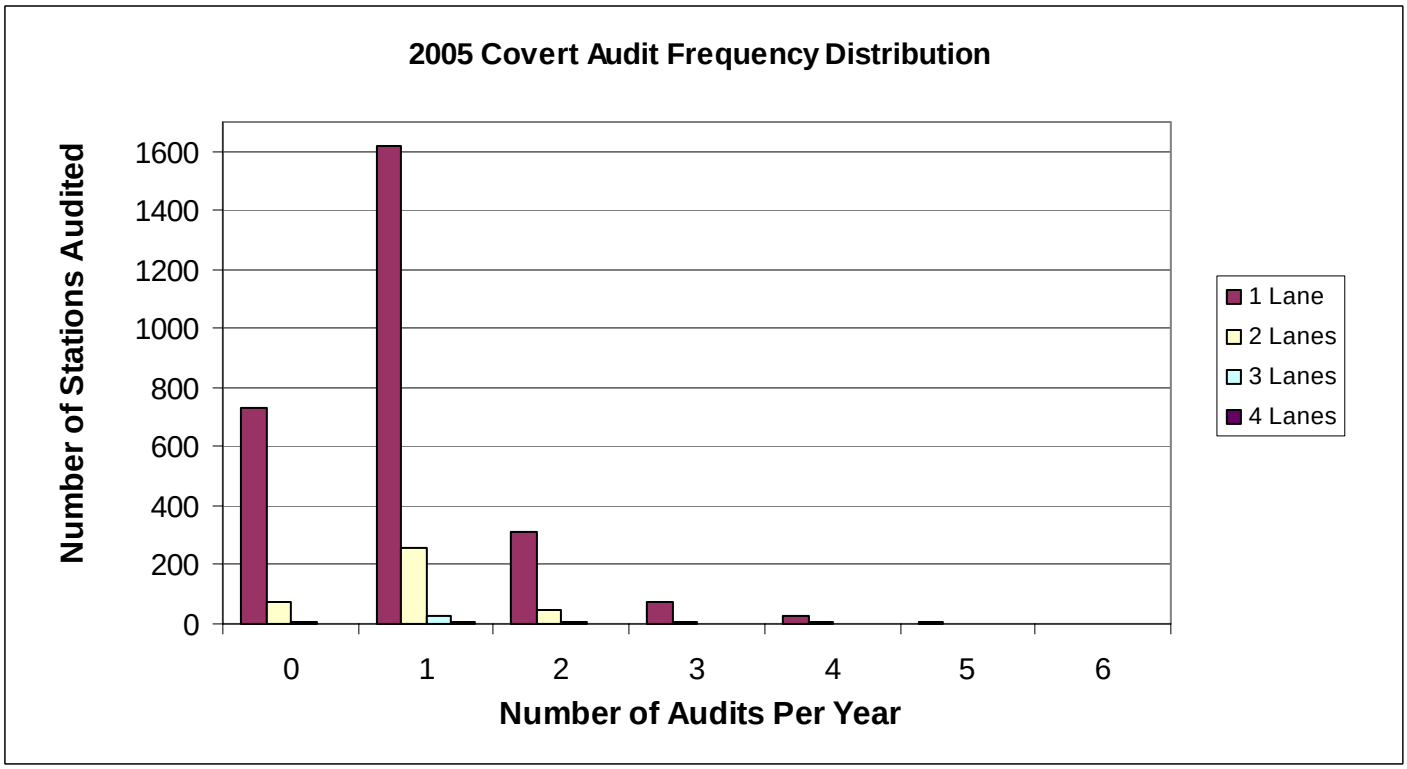
Number of audits performed	Stations with 1 Analyzer	Stations with 2 Analyzers	Stations with 3 Analyzers	Stations with 4 Analyzers	Total 2004 Audits
0	383	33	3		N/A
1	1393	219	23	3	1638
2	588	81	13	2	1368
3	128	24	1	1	462
4	28	5			132
5	3				15
6		1			6
Total	2523 (Stations)	363 (Stations)	40 (Stations)	6 (Stations)	3621 (Audits)

Table 6-16. Covert Audits Conducted at I/M Stations in 2005

Number of audits performed	Stations with 1 Analyzer	Stations with 2 Analyzers	Stations with 3 Analyzers	Stations with 4 Analyzers	Total 2005 Audits
0	729	76	8	1	N/A
1	1622	259	26	4	1911
2	310	50	6	1	734
3	72	7	1		240
4	25	4	2		124
5	8	1			45
6	1				6
Total	2767 (Stations)	397 (Stations)	43 (Stations)	6 (Stations)	3060 (Audits)

Figure 6-4. 2004 and 2005 Overt Audit Frequency Distributions

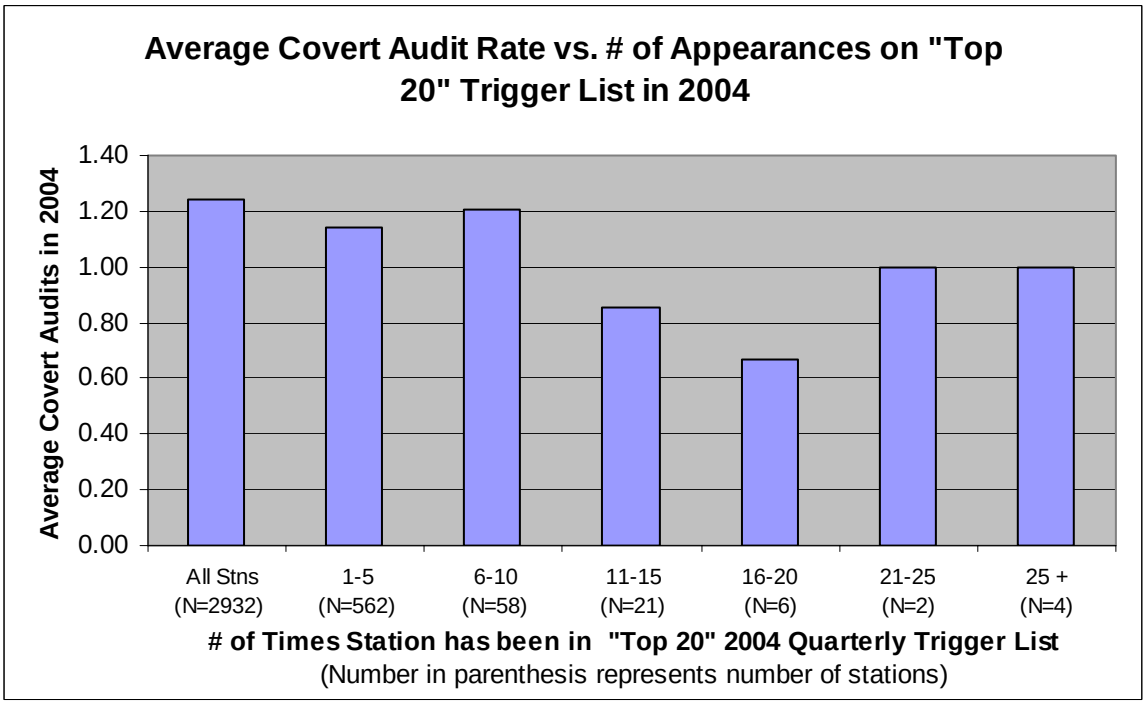


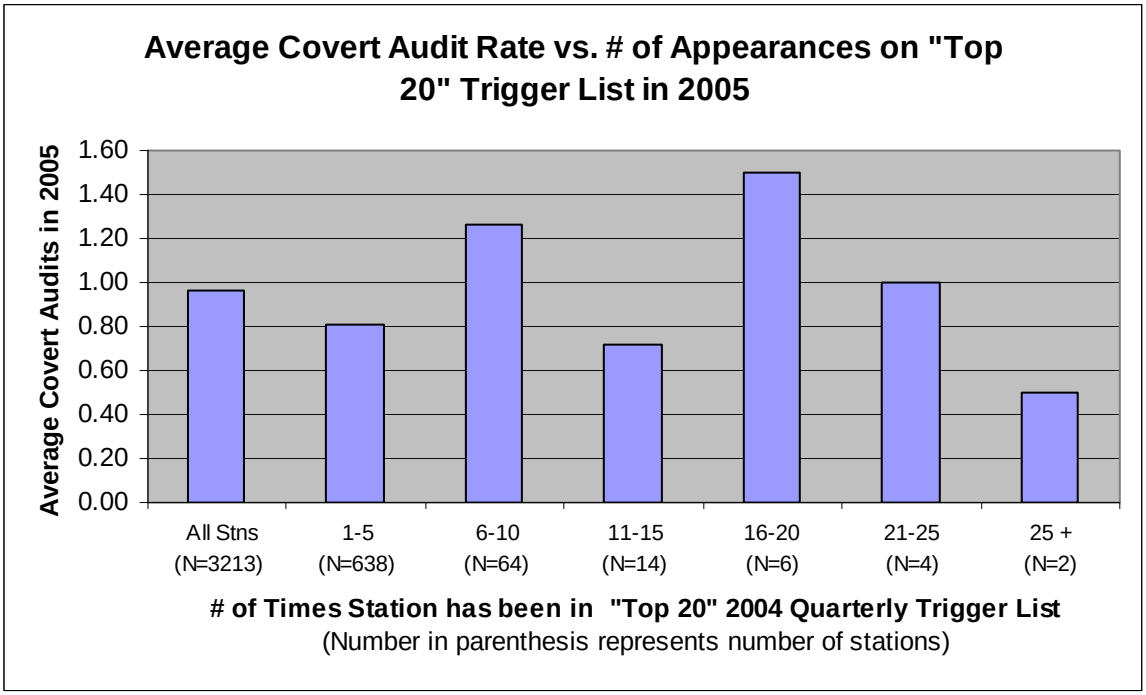


As can be seen from the total covert-audited station counts shown above, 2,513 stations received covert audits in 2004, and 2,399 stations received covert audits in 2005. These station counts are lower than the overall number of I/M stations (2,932 stations in 2004, 3,213 stations in 2005. This indicates some stations may not have received any covert audits during each evaluation year. In 2004, the overall average ratio of covert audits to stations is 1.2 covert audits/station, and for 2005 the ratio is 0.95 covert audits/station. Again, it is possible that a small percentage of the stations shown as having no audits could result from a mismatch between the station ID number list in the TAAS audit data and the true station ID number contained in the vehicle test records. This could also be caused by new stations that have not yet been subject to a covert audit.

Covert Audits Conducted in Comparison With Station Triggers - We then compared covert audit frequency rates with electronic trigger rankings, to see if the trigger application had any influence on the number of times certain stations received covert audits. As with the overt audit evaluation, lists indicating stations with the top 20 quarterly trigger rankings were compared with overt audit frequencies, and the results are shown in Figure 6-5. Again, these plots do not seem to suggest an increase in covert auditing rates based solely on trigger data, which is expected, as DPS covert auditors primarily use scheduling requirements and the VID Reporting System to help tailor covert auditing.

Figure 6-5 Comparison of Covert Audit Rate with Station Trigger Rankings





Covert Auditor Counts - As indicated in the overt audit section, within the program area, three auditors conducted both covert and overt audits in 2004, and three auditors conducted both covert and overt audits in 2005. Twelve auditors conducted only covert audits in 2004 (no overts), and thirteen auditors conducted covert audits in 2005 (no overts). The percentage of time each of these employees spent conducting audits during each year was not evaluated.

Covert Audit Vehicle Counts - Review of the covert vehicle maintenance table in the TAAS database indicates periods of covert vehicle service, region of service (which indicates counties) and vehicle information such as make, model, model year, and VIN. Review of vehicles listed in this table indicates 31 covert vehicles were in service in the counties of interest within the audit period. Twenty-six of those vehicles were in use in 2004, and twenty-seven were in use in 2005 (most of these were in use both years). Vehicle model years ranged from 1987 to 2003. 14 of the covert vehicles in use were pre-1996 (pre-OBDII), and 17 were 1996 or newer. VIN decoding performed indicated all vehicles were originally equipped with some form of fuel injection and all vehicles were originally equipped with catalytic converters.

Enforcement Actions Resulting from Covert Audits - Table 6-17 summarizes enforcement actions resulting from covert audits (recorded in the TAAS database) during 2004 and 2005 in the counties of interest. These enforcement actions are issued during the follow-up novert audit.

Table 6-17. Enforcement Actions from Covert Audits Recorded in TAAS

Action	2004 Count	2005 Count
Total Covert Audits	3638	3067
Citations	125	29
Warnings	119	46
Revocation Recommended	0	0
Suspension Recommended	187	211
Re-education	295	192

7.0 The Annual I/M Benefit

The Annual Benefit is the size of the fleet's "saw tooth" emissions profile that occurs during each cycle as the vehicles in the fleet are repeatedly inspected and repaired. The saw tooth is produced for each vehicle by the annual change in emissions downward from I/M-induced repair and then upward from emissions degradation during the long period before the next I/M cycle. In the analyses performed here, we attempt to measure only the decrease in emissions concentrations at the time of the I/M inspection.

7.1 Estimate of the Annual I/M Benefit from VID Data[41]

We used two and a half years of the Texas VID to calculate the Annual I/M Benefit of using the I/M program. This is a results-based measure of the emissions changes produced by the I/M program. For the Texas I/M program, results-based measures were determined only for tailpipe emissions. For this sub-task the Annual I/M Benefit was calculated on both an ASM and TSI concentration basis for existing in-program data using EPA's Comprehensive Method. Although using VID data is traditional for calculating the Annual I/M Benefit, the approach has at least two inherent problems. In spite of these problems we use the VID data to estimate the Annual I/M Benefit because it is relatively easy to do.

The first problem is a consequence of using the fast-pass ASM algorithm in the I/M program. When the vehicle passes the final test of its annual I/M sequence, the ASM test is a fast-pass test instead of a full-duration ASM test. We know from analysis of ASM data that fast-pass ASM values tend to be higher than the emissions values that are ultimately achieved using a full-duration ASM test. Therefore, the change in emissions caused by the repair is underestimated when fast-pass tests are used at the end of the I/M sequence. We have built models that attempt to predict full-duration ASM test values from fast-pass ASM values. While models can be built, we know that there is a large amount of uncertainty in the predicted full-ASM value. Therefore, we have chosen not to correct the VID ASM test values for fast passes. Accordingly, the calculated benefit of I/M-induced repairs tends to underestimate the emissions reduction.

The other source of bias is produced by regression toward the mean. Because of the emissions variability of the ASM measurements, vehicles that fail the ASM test tend to have a positive random error component in their measured ASM emissions values. This means that the calculated average difference between the before-repair test value and the after-repair test value

[41] This section responds to the Work Plan's Task 3 Element 1H: Calculation of the Annual I/M Benefit Using In-Program Data and was written by T.J. Petroski.

for the dataset will almost always show a decrease even if the repairs produced no real emissions benefit. For this analysis, we did not calculate a correction for this regression-toward-the-mean effect. Accordingly, regression toward the mean tends to overestimate the calculated benefit of I/M-induced repairs.

The VID contains emissions measurements obtained from a vehicle when it first is inspected for its annual inspection and emissions measurements after it has been repaired and meets the Texas I/M requirements. The difference between these two emissions can be expected to represent the improvement in emissions as a result of the repairs. The sum of all of these emissions changes for all vehicles that received repairs is an estimate of the Annual I/M Benefit using in-program data. Note that this difference is measured by the difference in emissions before and after the I/M inspection. Therefore, it represents the change in emissions concentration only at the inspection event. It does not measure the increase in emissions caused by emissions degradation between annual inspection cycles.

We considered emissions averages for four I/M sequence categories. All the various failure patterns described in Section 4.3 were combined into these four categories for the purposes of calculating the Annual I/M Benefit. In addition to using these categories for the in-program data calculation, these same I/M sequence categories will be used in Section 7.2 to calculate the Annual I/M Benefits using out-of-program data. The I/M sequence categories are as follows:

- **Single Pass** (1P) – A vehicle completes its annual I/M requirement with a pass on the first inspection.
- **Single Fail** (1F) – A vehicle receives a single inspection, and it is a fail. The dataset does not contain any evidence that the vehicle returns or any information that it may have been waivered.
- **Initial Fail, then Final Fail** (FF) – A vehicle fails its first annual emissions inspection and then, perhaps after a series of repairs and re-inspections, fails its last annual inspection.
- **Initial Fail, then Final Pass** (FP) – A vehicle fails its first annual emissions inspection and then ultimately passes its last annual inspection to meet the I/M requirements.

The largest numbers of sequences in the evaluation period were 1Ps since most vehicles pass their initial ASM inspection each year. 1Ps make up about 89% of all sequences. The FP sequences are the next most common and make up about 9.6% of all sequences. The 1F and FF sequences are the least common and make up 1.3% and 0.1% of the sequences. Since vehicles

with 1P and 1F sequences are tested only initially (because there is only one test), the final emissions values equal the initial emissions values. Consequently, vehicles with 1P and 1F sequences do not contribute to the calculated Annual I/M Benefit. The vehicles with FF sequences do have different values for the initial and final average emissions; however, the values are not greatly different, which is probably because repairs to these vehicles were not entirely successful.

We calculated the average emission values using completed I/M cycles and presented the results in various ways. Tables 7-1 and 7-2 document the average emission concentration values for ASM and TSI tests, respectively, in both the DFW and HGB I/M program areas during this evaluation period. The values also show the apparent change in emissions concentrations at the inspection event. The first block of data in each table shows the average before repair, after repair, and percent change in ASM emissions for both I/M areas and the two major I/M sequence categories combined. ASM HC decreased 18 to 24%, ASM CO decreased 34 to 41%, ASM NO decreased 16 to 19%, TSI HC decreased 37 to 38%, and TSI CO decreased 33 to 39%. As described above, these changes are confounded by the effects of the fast-pass algorithm and by regression toward the mean.

The second block of data in each of Tables 7-1 and 7-2 shows the emissions averages for the two I/M program areas categorized by the two major I/M sequence categories, 1P and FP. These two categories make up 99% of the I/M sequences in the datasets. The table shows that, of course, for the 1P category the change in emissions is 0% since these vehicles simply initially pass. However, for the FP category, the ASM measurements and TSI measurements show large emissions decreases from 64 to 86%. These reductions are for the vehicles that were failing when they entered the sequence, were repaired, and left the sequence as passing vehicles. Thus, these vehicles are the source of the Annual I/M Benefit. The apparent changes in the emissions concentrations as a result of repair are substantial for the FP sequences. The bottom three blocks of data in the tables show that the emissions average concentrations and emissions reductions for DFW and HGB have approximately the same values.

Another observation that we can make from the data in Tables 7-1 and 7-2 is that the final concentrations of the FP vehicles are comparable to, but slightly larger than, the final concentrations of the 1P vehicles. This seems to indicate that vehicles that fail initially can be repaired to produce large emissions reductions, but as a group, they cannot be repaired to emission levels as low as vehicles that initially pass. One of the factors that complicates this comparison is that the technologies of the 1P vehicles and FP vehicles are probably quite different.

Tables 7-3 and 7-4 show further stratification of the average emissions by car and truck for ASM and TSI tests. The trucks tend to have higher initial and final concentrations than the cars do.

If we next consider only average ASM concentrations for trucks for the HGB I/M program area, we can look at the bottom half of Table 7-3. For HC emissions from trucks, vehicles that had a single pass (1P) had much lower emission concentrations than did vehicles that had single fails (1F). The average emission rates for a 1F sequence, for the initial and final fails of a FF sequence, and for the initial fail of a FP sequence were all approximately the same. Finally, the final pass values for an FP sequence appear to be approximately the same as vehicles that had a 1P sequence. For hydrocarbons, this appears to indicate that the I/M program seems to be causing vehicles that initially fail to be repaired to a passing value which is comparable to the other vehicles that pass the first time. The average passing emissions will tend to be the same because of the fast-pass testing.

For CO emissions, we see that the single pass emissions are much lower than all of the failing emissions for the trucks. In addition, all categories of failing emissions are comparable. Finally, the vehicles that initially failed and ultimately passed had passing emissions that were about the same as vehicles that passed on their first visit to the I/M station. Thus, just as for HC, the I/M program seems to be repairing these failing vehicles to the same level as clean vehicles that are inspected just one time.

For NO emissions from trucks, the same comparisons that were made for HC and CO reveal the same trends.

Table 7-1. Annual I/M Benefit Using VID Data for ASM Emissions

I/M Program Area	I/M Sequence Category	Sequence Count	ASM HC (ppm)						ASM CO (%)						ASM NO (ppm)					
			5015			2525			5015			2525			5015			2525		
			Initial	Final	Change (%)	Initial	Final	Change (%)	Initial	Final	Change (%)	Initial	Final	Change (%)	Initial	Final	Change (%)	Initial	Final	Change (%)
DFW + HGB	1P + FP	4,043,021	82.6	68.1	*-18%*	55.9	42.6	*-24%*	0.300	0.199	*-34%*	0.237	0.139	*-41%*	553.2	463.8	*-16%*	429.0	348.0	*-19%*
DFW + HGB	1P	3,634,897	68.0	67.8	*0%*	41.9	41.7	*0%*	0.199	0.198	*0%*	0.137	0.136	*0%*	461.6	460.2	*0%*	343.9	342.8	*0%*
	FP	408,124	212.7	70.2	*-67%*	181.1	49.9	*-72%*	1.200	0.204	*-83%*	1.134	0.162	*-86%*	1,368.4	495.9	*-64%*	1,186.6	394.3	*-67%*
DFW	1P + FP	2,214,458	81.9	68.0	*-17%*	55.1	42.3	*-23%*	0.3	0.2	*-33%*	0.2	0.1	*-40%*	550.3	464.1	*-16%*	424.3	346.5	*-18%*
HGB	1P + FP	1,828,563	83.4	68.1	*-18%*	56.9	42.9	*-25%*	0.3	0.2	*-35%*	0.2	0.1	*-43%*	556.6	463.4	*-17%*	434.6	349.9	*-20%*
DFW	1P	1,998,674	68.0	67.8	*0%*	41.6	41.6	*0%*	0.205	0.204	*0%*	0.140	0.139	*0%*	461.9	460.8	*0%*	342.3	341.4	*0%*
	FP	215,784	211.2	69.6	*-67%*	179.9	49.5	*-72%*	1.225	0.213	*-83%*	1.158	0.170	*-85%*	1,369.0	494.8	*-64%*	1,184.4	393.2	*-67%*
HGB	1P	1,636,223	68.0	67.8	*0%*	42.1	42.0	*0%*	0.192	0.191	*0%*	0.133	0.133	*0%*	461.3	459.4	*0%*	346.0	344.5	*0%*
	FP	192,340	214.3	70.9	*-67%*	182.4	50.3	*-72%*	1.171	0.194	*-83%*	1.107	0.153	*-86%*	1,367.7	497.1	*-64%*	1,189.0	395.5	*-67%*

Table 7-2. Annual I/M Benefit Using VID Data for TSI Emissions

I/M Program Area	I/M Sequence Category	Sequence Count	TSI HC (ppm)						TSI CO (%)					
			Curb Idle			High Idle			Curb Idle			High Idle		
			Initial	Final	Change (%)	Initial	Final	Change (%)	Initial	Final	Change (%)	Initial	Final	Change (%)
DFW + HGB	1P + FP	421,937	121.6	76.5	*-37%*	65.8	40.8	*-38%*	0.37	0.22	*-39%*	0.31	0.20	*-33%*
DFW + HGB	1P	386,985	75.3	75.1	*0%*	39.9	39.8	*0%*	0.21	0.21	*0%*	0.20	0.20	*0%*
	FP	34,952	634.2	92.1	*-85%*	352.2	51.6	*-85%*	2.04	0.32	*-84%*	1.49	0.27	*-82%*
DFW	1P + FP	211,413	122.8	77.1	*-37%*	64.1	39.5	*-38%*	0.38	0.23	*-38%*	0.31	0.21	*-32%*
HGB	1P + FP	210,524	120.4	75.8	*-37%*	67.5	42.1	*-38%*	0.35	0.21	*-40%*	0.30	0.19	*-35%*
DFW	1P	194,331	75.8	75.6	*0%*	38.6	38.5	*0%*	0.23	0.22	*0%*	0.21	0.21	*0%*
	FP	17,082	657.5	94.5	*-86%*	354.2	50.5	*-86%*	2.13	0.35	*-83%*	1.53	0.30	*-81%*
HGB	1P	192,654	74.8	74.5	*0%*	41.3	41.1	*0%*	0.20	0.20	*0%*	0.19	0.19	*0%*
	FP	17,870	611.9	89.7	*-85%*	350.3	52.5	*-85%*	1.95	0.29	*-85%*	1.46	0.25	*-83%*

Table 7-3. Annual I/M Benefit Using VID Data for ASM Tests by Vehicle Type

I/M Program Area	I/M Sequence Category	Vehicle Type	Count	HC (ppm)				CO (%)				NO (ppm)			
				5015		2525		5015		5015		2525		5015	
				Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
DFW	1F	CAR	18,422	288	288	250	250	1.70	1.70	1.65	1.65	1471	1471	1278	1278
		TRK	9,809	340	340	313	313	1.93	1.93	1.85	1.85	1381	1381	1215	1215
	1P	CAR	1,215,888	63	63	36	36	0.18	0.18	0.12	0.12	417	416	301	300
		TRK	782,786	76	76	50	50	0.24	0.24	0.17	0.17	531	530	406	405
	FF	CAR	1,978	299	310	263	259	1.83	1.81	1.78	1.72	1515	1476	1346	1291
		TRK	906	340	320	313	299	2.18	2.25	2.14	2.21	1320	1286	1189	1141
	FP	CAR	131,311	197	65	162	44	1.19	0.18	1.14	0.14	1374	462	1190	358
		TRK	84,473	234	76	207	58	1.28	0.26	1.19	0.22	1361	546	1176	447
HGB	1F	CAR	17,768	292	292	252	252	1.70	1.70	1.67	1.67	1452	1452	1267	1267
		TRK	10,128	340	340	307	307	1.76	1.76	1.70	1.70	1430	1430	1251	1251
	1P	CAR	949,120	62	62	36	36	0.17	0.17	0.11	0.11	413	411	302	301
		TRK	687,103	76	76	50	50	0.22	0.22	0.16	0.16	528	526	407	405
	FF	CAR	1,893	291	304	250	266	1.81	1.84	1.76	1.82	1487	1491	1325	1303
		TRK	826	362	320	345	307	2.23	2.26	2.20	2.28	1338	1302	1185	1134
	FP	CAR	110,926	199	66	165	44	1.19	0.17	1.13	0.13	1356	461	1182	359
		TRK	81,414	235	78	206	58	1.15	0.22	1.07	0.19	1384	546	1198	446

Table 7-4. Annual I/M Benefit Using VID Data for TSI Tests by Vehicle Type

I/M Program Area	I/M Sequence Category	Vehicle Type	COUNT	HC (ppm)				CO (%)			
				CURB IDLE		FAST IDLE		CURB IDLE		FAST IDLE	
				Initial	Final	Initial	Final	Initial	Final	Initial	Final
DFW	1F	CAR	406	619	619	421	421	2.47	2.47	2.18	2.18
		TRK	1,279	1077	1077	556	556	3.13	3.13	2.17	2.17
	1P	CAR	74,873	60	60	35	34	0.13	0.13	0.12	0.12
		TRK	119,458	85	85	41	41	0.29	0.28	0.26	0.26
	FF	CAR	37	1058	753	948	617	1.92	2.58	1.80	2.68
		TRK	107	971	872	535	538	3.08	2.94	2.12	2.38
	FP	CAR	6,142	377	78	234	47	1.56	0.16	1.38	0.18
		TRK	10,940	753	104	395	52	2.32	0.46	1.59	0.36
HGB	1F	CAR	453	700	700	461	461	2.67	2.67	2.44	2.44
		TRK	1,206	1044	1044	646	646	2.85	2.85	2.22	2.22
	1P	CAR	76,111	59	59	37	37	0.12	0.12	0.12	0.12
		TRK	116,543	85	85	44	44	0.25	0.25	0.24	0.24
	FF	CAR	29	689	493	368	393	4.15	2.34	3.87	2.30
		TRK	89	1285	1234	668	705	3.74	3.47	3.20	2.80
	FP	CAR	7,026	368	76	235	50	1.49	0.17	1.28	0.17
		TRK	10,844	711	99	397	54	2.14	0.37	1.53	0.30

7.2 Estimate of the Annual I/M Benefit from RSD Data[42]

We used remote sensing data taken in the I/M areas to determine the Annual I/M Benefit produced by the I/M program by pairing RSD data with the VID inspections by vehicle.

A vehicle can be measured by RSD at any time before or after its annual I/M inspection. By aligning all of the RSD measurements with respect to the time of I/M repair, the average of the RSD measurements will reveal the change in emissions produced by the I/M program and the rate of emissions degradation between I/M inspections. However, it is important to understand that the set of vehicles with RSDs before the I/M inspection does not contain the same vehicles as those with RSDs after the I/M inspection. Because of the large emissions variability of RSD emissions measurements, the average RSD emissions versus time before and after I/M inspection will have a considerable amount of error even when millions of RSD observations are used. Nevertheless, the calculation provides an estimate of the benefits of the I/M program that is independent of the I/M program itself.

Preparation of RSD Data – In this task, we used the RSD data collected in the Houston/Galveston/Brazoria (HGB) area and the Dallas/Fort Worth (DFW) area to evaluate the Annual I/M Benefit. The goal was to use the RSD data already being collected by the Texas Department of Public Safety (DPS) as an independent means of measuring the benefit.

The RSD data provided by DPS started out with about 10.3 million records. For all of the analyses with the out-of-program (RSD) data, the vehicle license plate was a crucial variable. The license plate allows for matching with inspection and maintenance records as well as determining the county of registration for the vehicle. Therefore, as the first filter on the RSD data, we removed any records that had missing license plate information. This left about 8.8 million records in the RSD data.

This analysis evaluates the inspection and maintenance programs in the HGB and DFW areas. The RSD records were collected in all I/M areas within the state of Texas including the El Paso, Williamson, and Travis counties. Therefore, only RSD data collected in HGB and DFW were kept in the dataset. This left 7.9 million remaining RSD records: 3.8 million records collected in the HGB area and 4.1 million records collected in the DFW area.

When the RSD data were collected, each vehicle was matched by plate with the current Texas registration data to determine the county in which the vehicle was registered. This

[42] This section responds to the Work Plan's Task 3 Element 4B: Use of Out-of-Program Data to Calculate the Annual I/M Benefit and was written by M.F. Weatherby.

registration county information was included in the RSD data fields. For about one quarter of the RSD data, this registration county name was listed as "UNKNOWN." The county of registration is essential to determining whether or not the vehicle was subject to an I/M program when the RSD readings were taken. We could have used the Texas registration data provided for this project to match these RSD vehicles by plate to get the registration county. However, the registration records provided to ERG for this project were a snapshot of the registration data taken at a point in time after all the RSD data were recorded. Matching to this registration database would have caused errors in assigning registration counties to vehicles at the time of their RSD measurements. Therefore, RSD records with an "UNKNOWN" registration county were deleted from the dataset. This left 5.9 million remaining RSD records: 2.8 million in the HGB area and 3.1 million in the DFW area.

The RSD records provided to ERG did not contain any information about the vehicle except the license plate number and the county where the vehicle was registered at the time of the RSD. For the Comprehensive Method [Reference 2] calculations, it is important to determine the fleet characteristics of the vehicles RSDed in the I/M area. Therefore, we needed to determine the vehicle characteristics such as age, technology, and odometer. The potential sources of this information were the registration data, the I/M data, and the ERG VIN decoder. The records from the I/M program do contain odometer and other vehicle characteristics information; however, there are no I/M records for vehicles registered outside the I/M areas. The registration data contained vehicle make and model year but did not contain odometer, vehicle technology information, or vehicle odometer information. Because of this, the vehicle odometer could not be used in the comparison of fleet characteristics. We used the ERG VIN decoder to provide the vehicle characteristics information which included vehicle make, model year, type (car or truck), metering, and emission control systems. The RSD records were matched by Groupid with the rawinfo_vehicle table made in MKmasterfile.sas. Only records with a valid VIN decode were kept, leaving 4.6 million matched RSD records: 2.4 million in the Dallas/Fort Worth area, and 2.2 million in the Houston/Galveston area.

The RSD records provided to ERG by DPS were already checked for validity by the RSD data collection contractor. Therefore, we did not check for validity of the values within each of the RSD data fields with the exception of the missing variable information discussed above. We did, however, calculate the vehicle specific power (VSP) for each vehicle using the RSD speed, acceleration, and the slope at the RSD site. The slope for the RSD site was not included in the RSD data. These data were provided separately by DPS. For about 14% of the data, there was either no slope given or no RSD site name listed in the data, so instead of throwing out the records with no slopes, we did a sensitivity analysis on the records with missing slopes. A

minimum VSP was calculated using the smallest slope seen in those that were provided, which was –2.0 degrees. A maximum VSP was also calculated using the largest slope seen in those that were provided, which was 6.0 degrees. Once these calculations were done, the VSP filters were applied. For vehicles with a RSD site slope, any records with a VSP outside the range of 5-15 kW/Mg were removed from the dataset. For all other records, those that had a minimum or maximum VSP was outside the range of 5-15 kW/Mg were removed from the data. This left 3.3 million remaining records: 1.8 million records in the DFW and 1.5 million records in the HGB area.

Calculation of the Annual I/M Benefit – The calculation of the Annual I/M Benefit was done using the Comprehensive Method outlined by EPA. [Section 6.2 of Reference 2] In this method, RSD data taken in the I/M area is paired with I/M inspections by vehicle.

We calculated the time between the RSD reading and the I/M test and put each observation in month bins – for example, 1 month before the initial test, 2 months before the initial test, 3 months before initial, 1 month after final test, 2 months after final test, 3 months after final test, etc. Any RSD readings that occurred within the I/M cycle, that is, between the initial test and the final test, were removed from the analysis. For these observations it is not possible to determine if the state of repair of the vehicle at the time of the RSD.

We also made a variable that indicates the I/M result. There were four I/M sequence categories outlined in EPA's description of the Comprehensive Method calculations: 1) vehicles that pass their initial I/M tests (1P), 2) vehicles that fail their initial I/M test and then eventually pass (FP), 3) vehicles that fail their I/M test and do not come back for another test (1F), and 4) vehicles that fail their I/M test and fail all other subsequent I/M tests (FF).

We then did plots of the average RSD concentrations for HC, CO, and NO by the month bin, by I/M sequence category, and also by model year group. Because the Texas I/M program is an annual program, for the plots the dataset was limited to only the RSD matches that happened up to 6 months before and 6 months after the I/M test. The HC, CO, and NO plots for the entire dataset are shown in Figures 7-1 through 7-3 for the HGB area and in Figures 7-3 through 7-6 for the DFW area. These figures show the RSD averages (indicated by the dots) and the uncertainties associated with these averages at a 95% confidence level (indicated by the lines).

Figure 7-1. Average RSD HC Versus Month from the I/M Test RSD Readings from the HGB Area

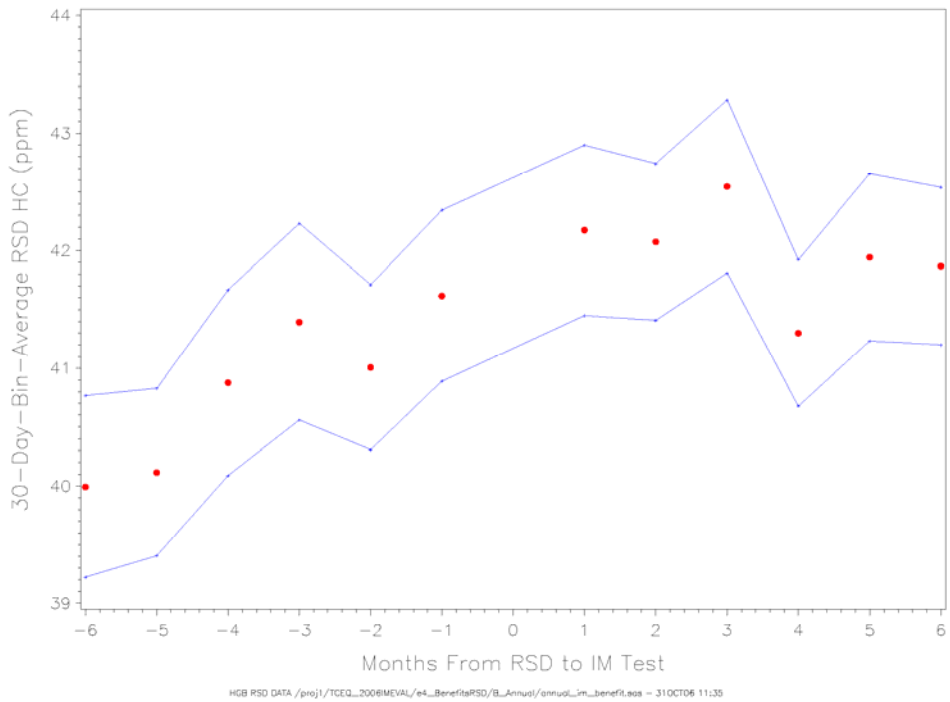


Figure 7-2. Average RSD CO Versus Month from the I/M Test RSD Readings from the HGB Area

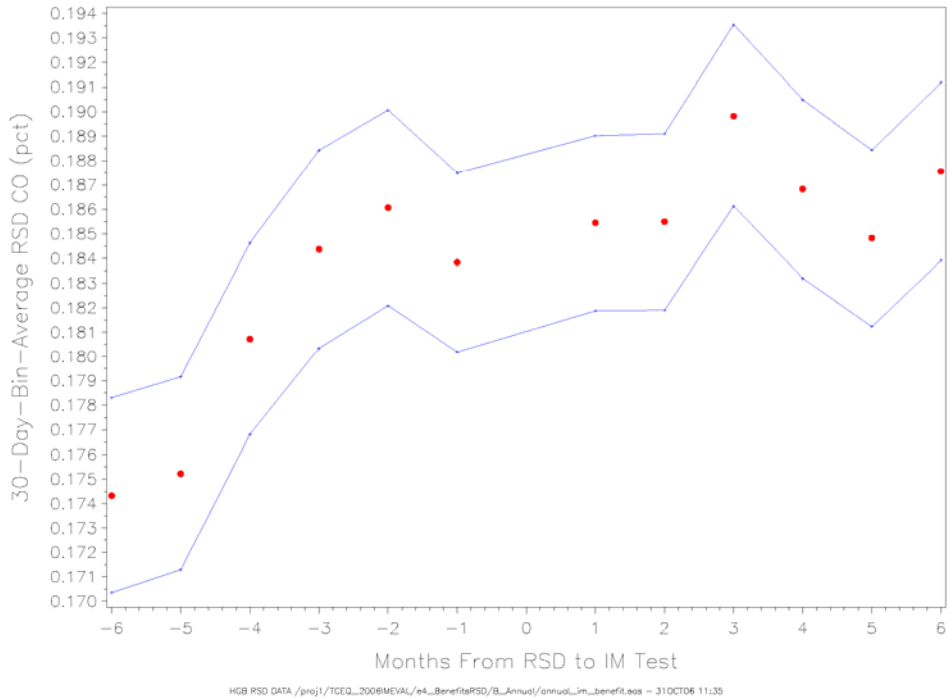


Figure 7-3. Average RSD NO Versus Month from the I/M Test RSD Readings from the HGB Area

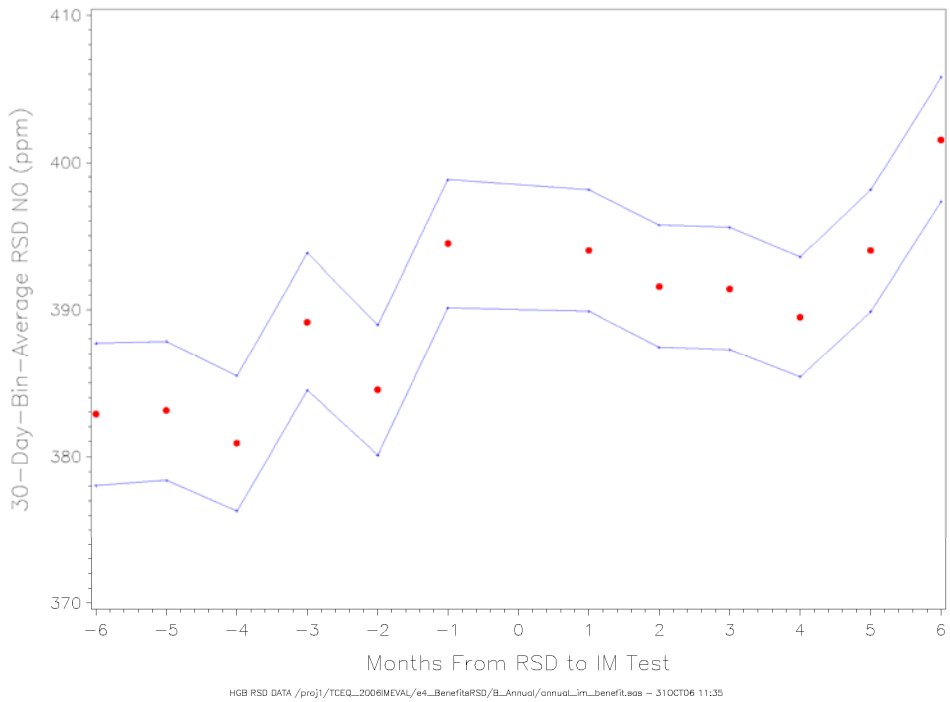


Figure 7-4. Average RSD HC Versus Month from the I/M Test RSD Readings from the DFW Area

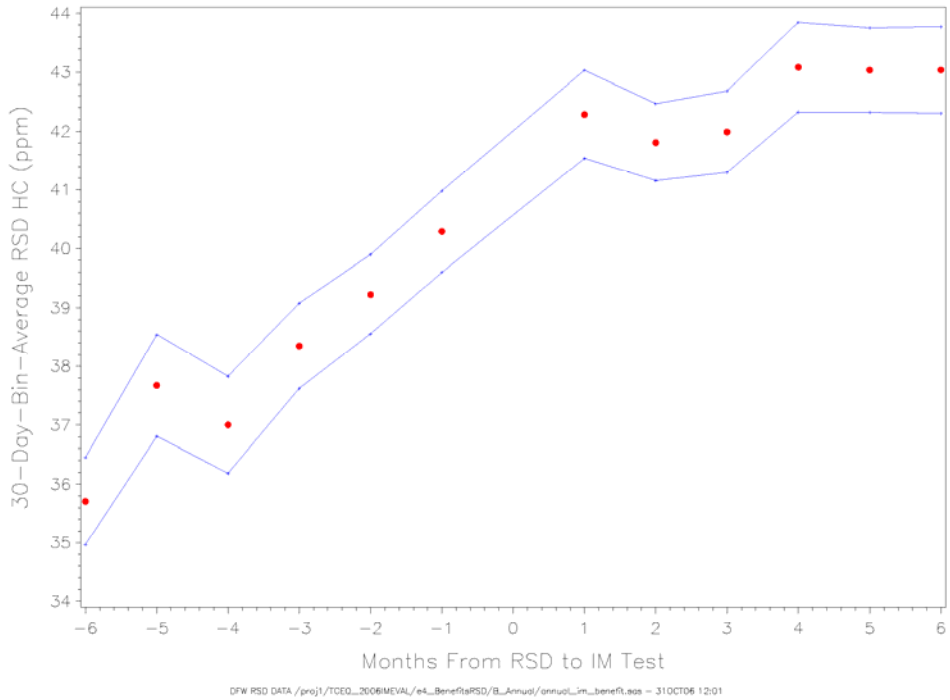


Figure 7-5. Average RSD CO Versus Month from the I/M Test RSD Readings from the DFW Area

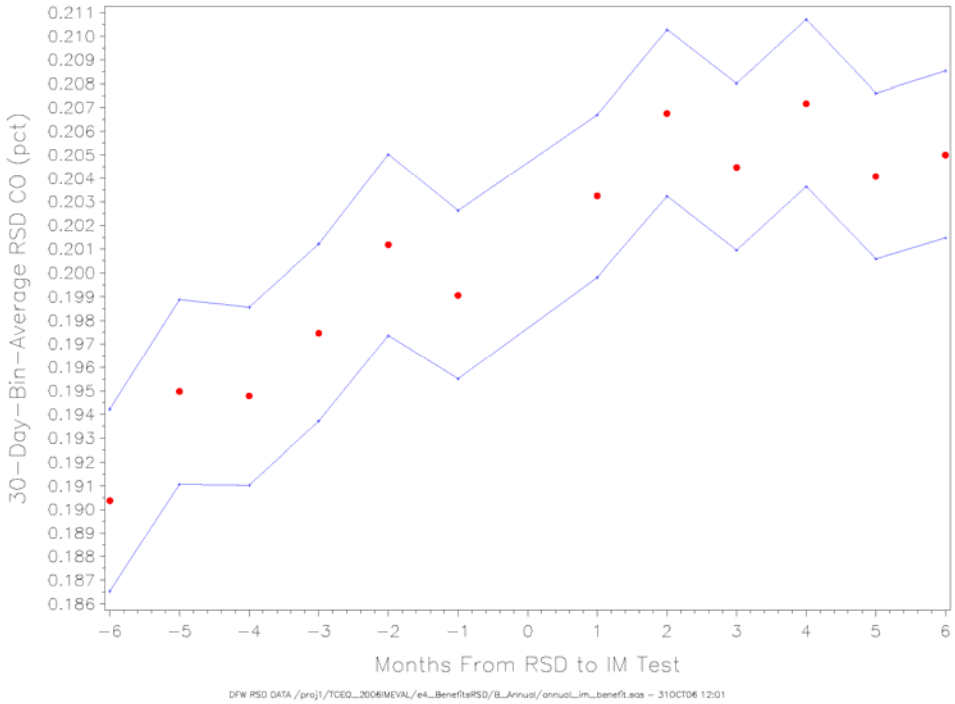
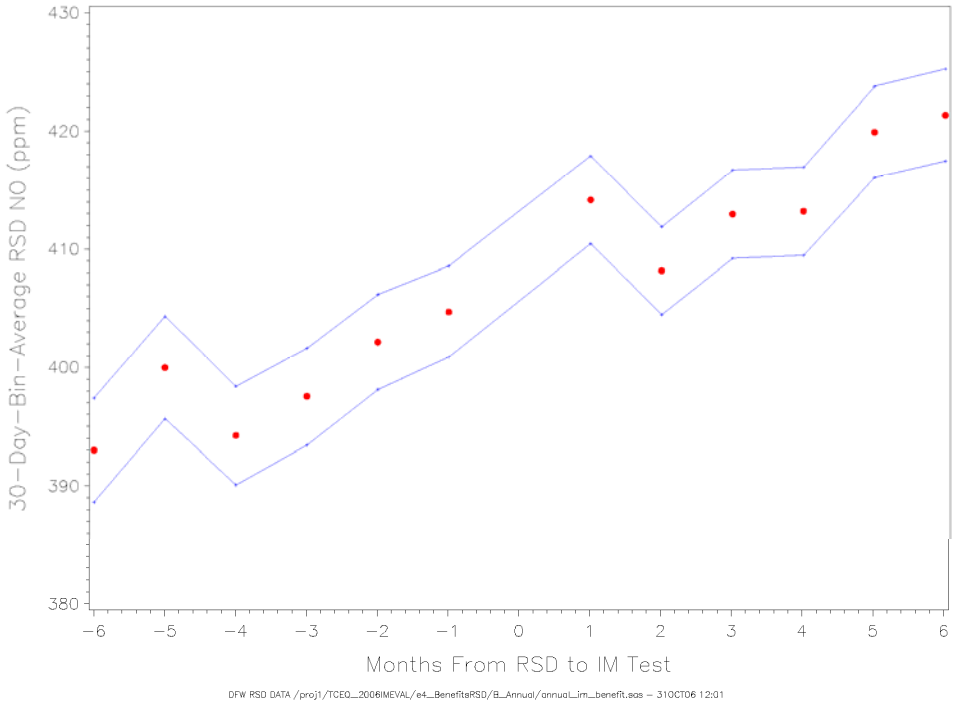


Figure 7-6. Average RSD NO Versus Month from the I/M Test RSD Readings from the DFW Area



These figures above do not show a drop in the average RSD emissions from before to after I/M. However, when the plots are done on a subdivided dataset, some I/M benefits start to become evident. The dataset was categorized by model year group and by the I/M sequence category. Table 7-5 shows the number of records in the RSD-matched-with-I/M dataset (for both HGB and DFW) that fall into each I/M sequence category. The table clearly demonstrates that the 1P and FP I/M sequence categories dominate the I/M program. At this point, we begin considering the separate effects of the 1P and FP categories.

Table 7-5. Number of Vehicles in Each I/M Sequence Category for the Dataset of RSD Events Matched with I/M Tests

I/M Sequence Category	HGB		DFW	
	Number of Vehicles	Percent	Number of Vehicles	Percent
Pass Initial (1P)	2,242,481	94.4%	2,514,084	94.8%
Fail Initial (1F)	237	0.01%	320	0.01%
Fail Initial, Fail Final (FF)	109	0.00%	97	0.00%
Fail Initial, Pass Final (FP)	131,631	5.5%	136,361	5.1%

The same plots were done for the RSD results for the 1P and FP categories for all three pollutants in both I/M program areas. Figures 7-7, 7-9, and 7-11 show the time trend of the monthly average RSD HC, CO, and NO for the HGB area for vehicles that passed initially (1P). Below these figures are Figures 7-8, 7-10, and 7-12 for the corresponding vehicles that failed initially and then ultimately passed (FP).

The 1P plots, which describe 94.4% of the vehicles in the HGB area, show small emission increases from the month before to the month after the I/M test. There is no evidence of a decrease in emissions in the two months before the I/M inspection that could be attributed to pre-inspection repairs. If anything, the long term time trend is generally upward, which we attribute to the general long term emissions deterioration of these vehicles.

The FP plots, which describe 5.5% of the vehicles in the HGB area, show downward jogs in the emissions at the time of the I/M inspection. The jogs are substantial: -16% HC, -18% CO, and -16% NO. Examining the overall trend of each plot shows that downward jogs at the I/M inspection interrupts the generally upward trend of emissions deterioration, which is what the I/M program is designed to do.

Putting vehicles all together ends up showing a slightly increasing trend from before to after I/M as we saw in Figure 7-1, 7-2, and 7-3. The reason for this is that while the FP vehicles

show substantial emissions decreases, they make up only 5.5% of the fleet. The other 94.4% of the fleet is made up of 1P vehicles that have slight emissions increases, which we attribute to the general long term degradation. The plots for the emissions for the DFW area generally show this same trend.

Figure 7-7. Average RSD HC vs. Month After the I/M Test for HGB Vehicles with I/M Sequence Category = 1P

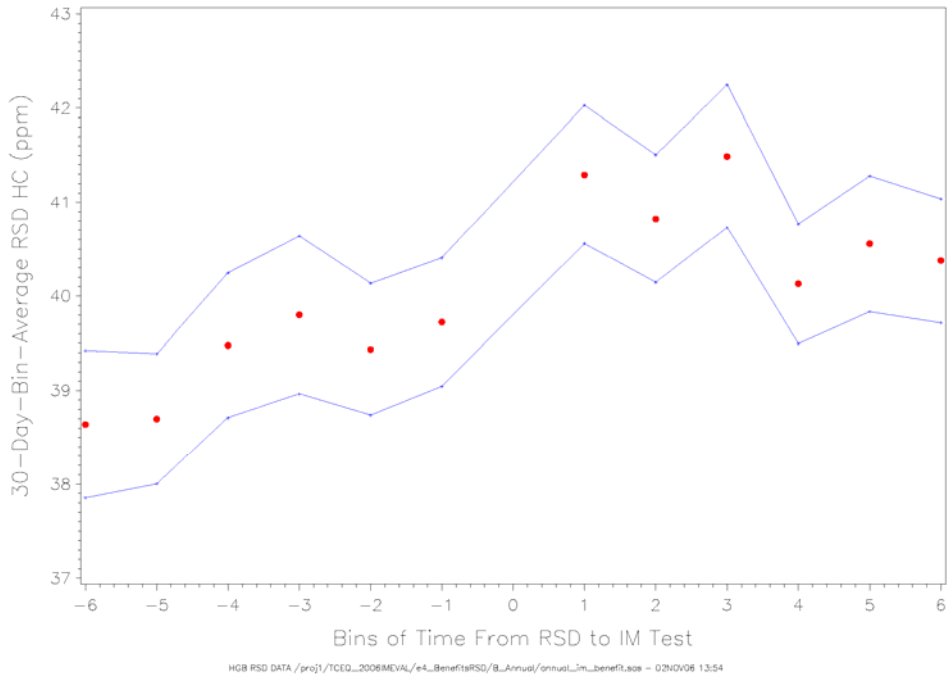


Figure 7-8. Average RSD HC vs. Month After the I/M Test for HGB Vehicles with I/M Sequence Category = FP

Figure 7-9. Average RSD CO vs. Month After the I/M Test for HGB Vehicles with I/M Sequence Category = 1P

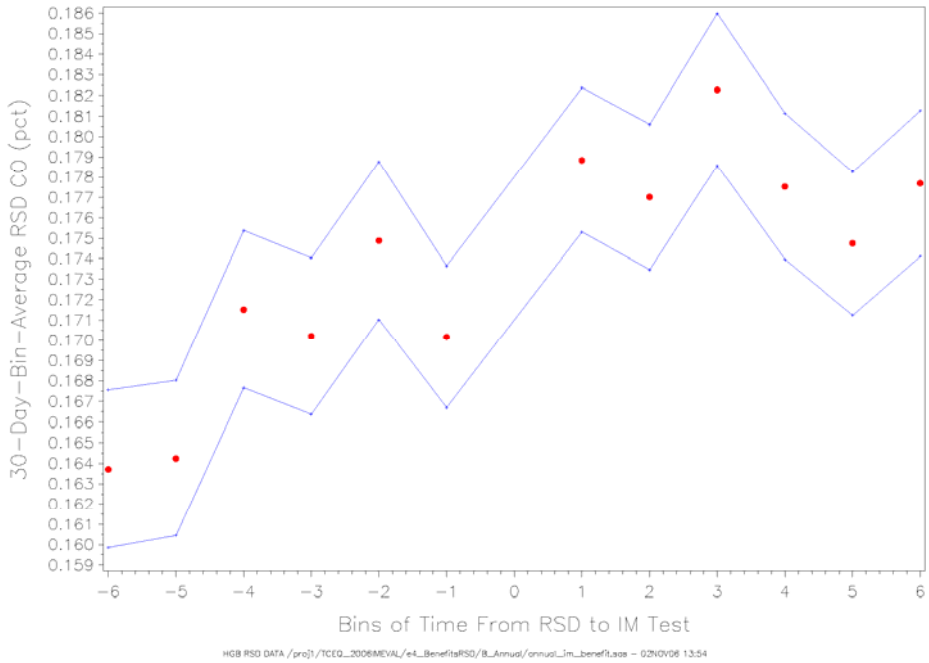


Figure 7-10. Average RSD CO vs. Month After the I/M Test for HGB Vehicles with I/M Sequence Category = FP

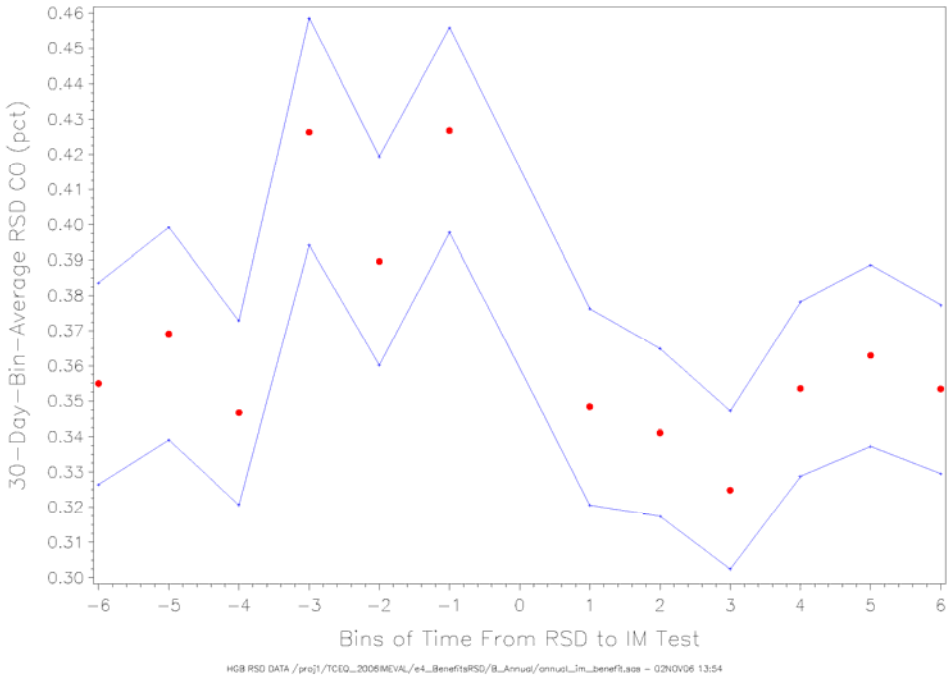


Figure 7-11. Average RSD NO vs. Month After the I/M Test for HGB Vehicles with I/M Sequence Category = 1P

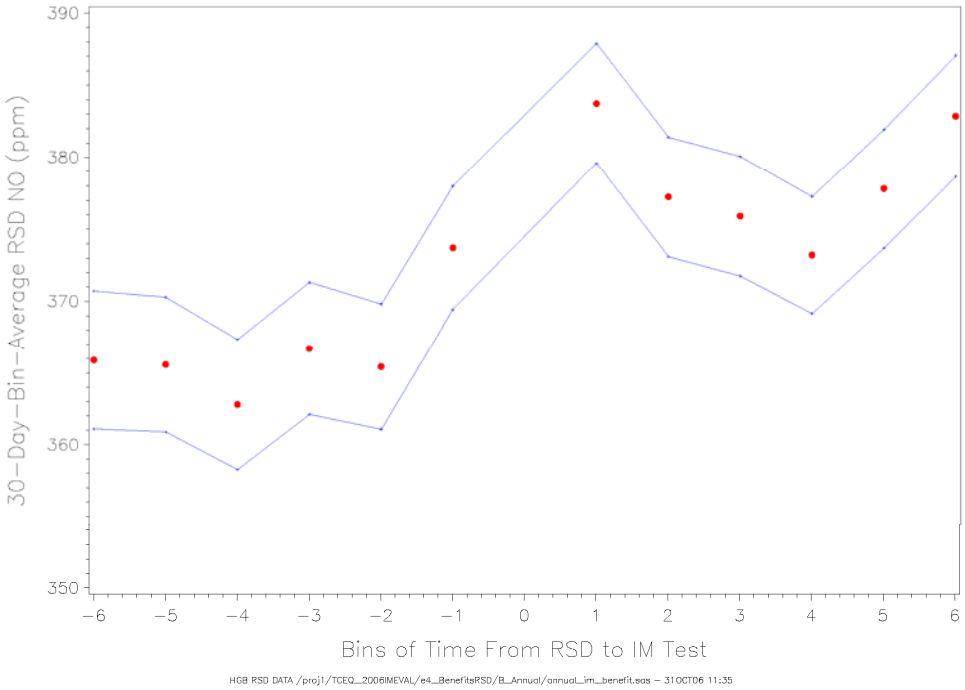
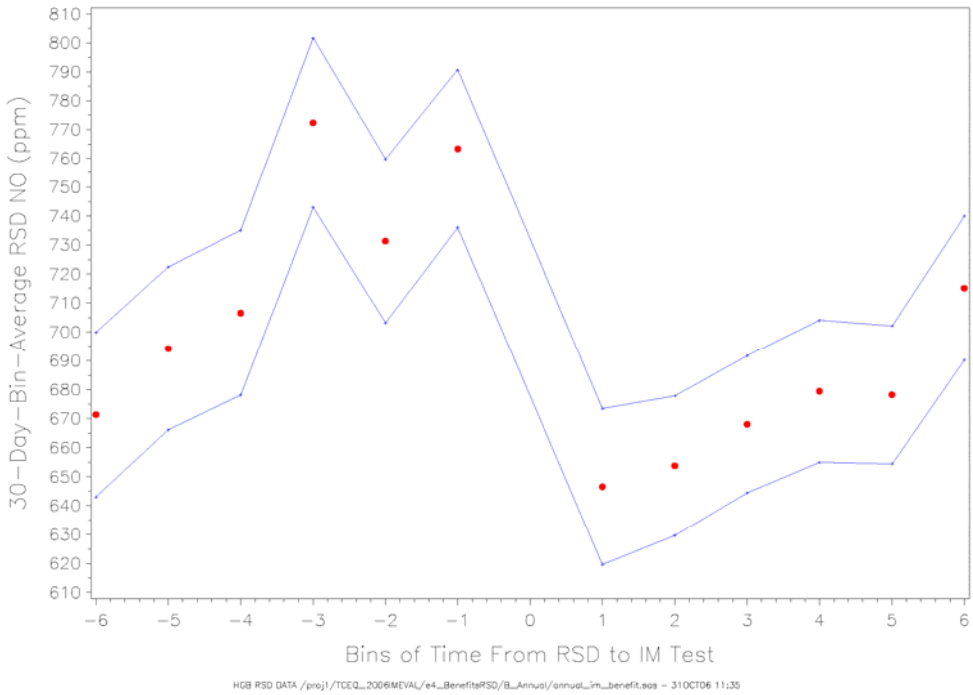


Figure 7-12. Average RSD NO vs. Month After the I/M Test fro HGB Vehicles with I/M Sequence Category = FP



To quantify the Annual I/M Benefit, the month bins were combined to get only one average before the I/M test and another RSD average after the I/M test. The before bin consists of all RSDs that happened from 31 to 90 days before the initial I/M test. The RSDs that happened from 1 to 30 days before the I/M were not included in the bin to minimize the effect of pre-inspection repairs on the before average. This binning methodology was suggested by EPA in the documentation for the Comprehensive Method. The after bin contains all RSD tests that happened from 1 to 90 days after the final I/M test.

The calculations for the before and after I/M RSD averages were done for the entire RSD matched I/M dataset as well as by each of the two major I/M sequence categories, FP and 1P. Also, when we looked at the fleet characteristics of the I/M fleet versus this dataset of RSDs matched with I/M, the RSD matched fleet has a larger percentage of new vehicles. Therefore, each of the I/M category bins were also separated by model year group to look at the Annual I/M Benefit. The benefit for each model year group could be weighted by the percentage of vehicles in each model year group in the I/M fleet to determine the overall benefit.

These before and after I/M average RSDs for the FP vehicles and the 1P vehicles were plotted for both the HGB and DFW areas for each of the model year groups. These plots are shown in Figures 7-13 through 7-24. The lines show the RSD averages and error bars show the 95% confidence level uncertainties for the averages. The plots for FP vehicles in Figures 7-13 to 7-18 show that in most cases the emissions of FP vehicles decrease; however, in many cases the decrease is not statistically significant – even with over 100,000 RSD observations in the FP category. The plots for 1P vehicles in Figures 7-19 to 7-24 show that in most cases the emissions of 1P vehicles increase across the I/M inspections; however, in many cases the increase is not statistically significant even with over 2-million RSD observations in the 1P category.

Figure 7-13. Average RSD HC by Model Year Group Before and After I/M Test for HGB Vehicles with I/M Sequence Category = FP

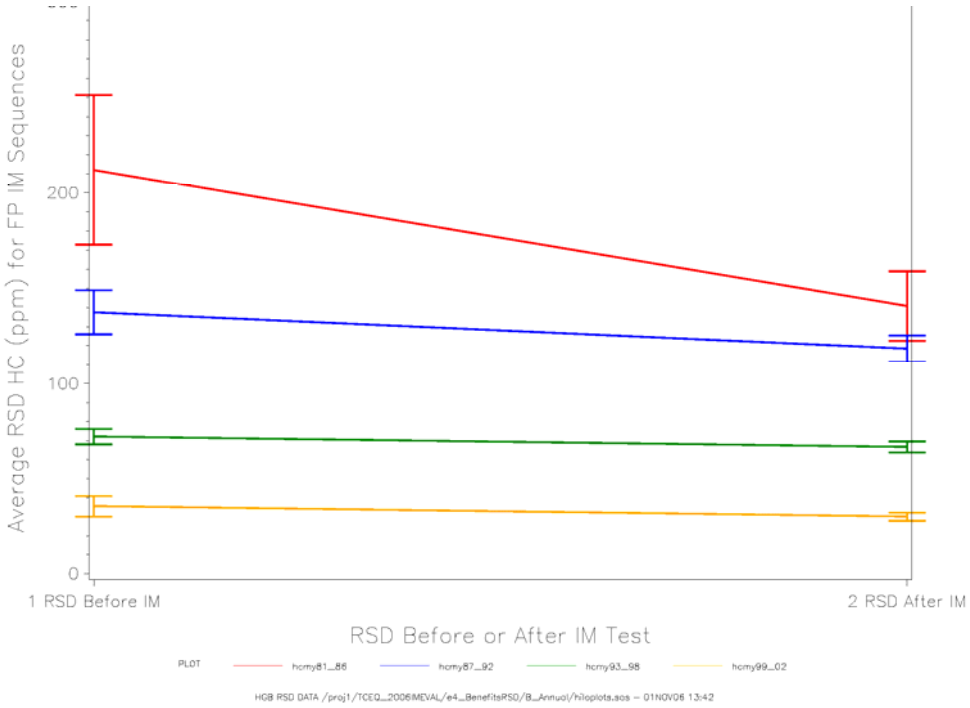


Figure 7-14. Average RSD HC by Model Year Group Before and After I/M Test for DFW Vehicles with I/M Sequence Category = FP

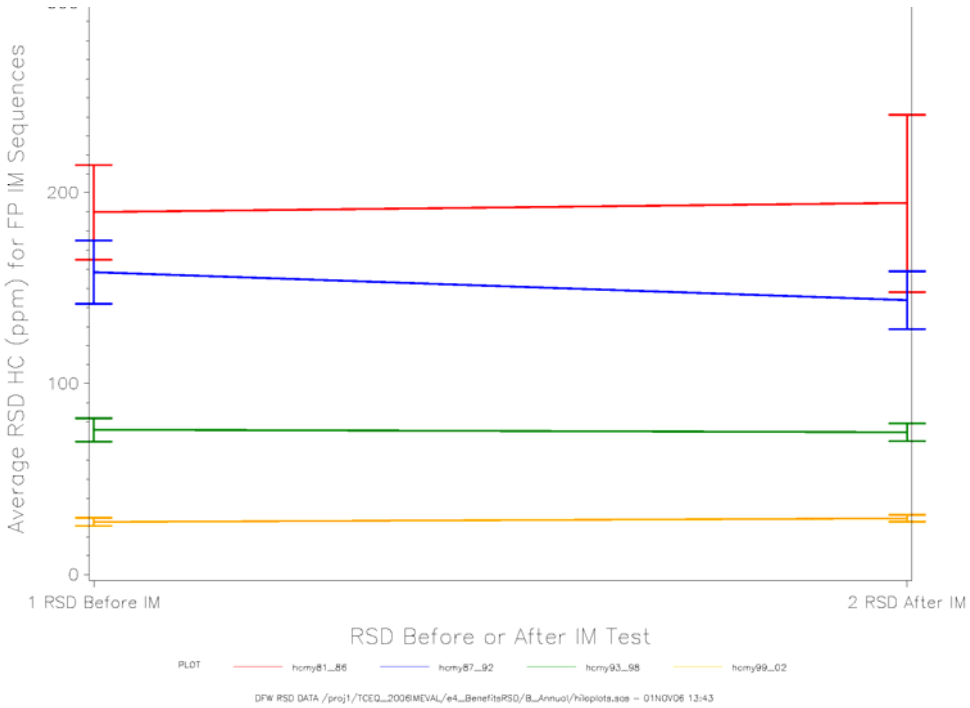


Figure 7-15. Average RSD CO by Model Year Group Before and After I/M Test for HGB Vehicles with I/M Sequence Category = FP

Figure 7-16. Average RSD CO by Model Year Group Before and After I/M Test for DFW Vehicles with I/M Sequence Category = FP

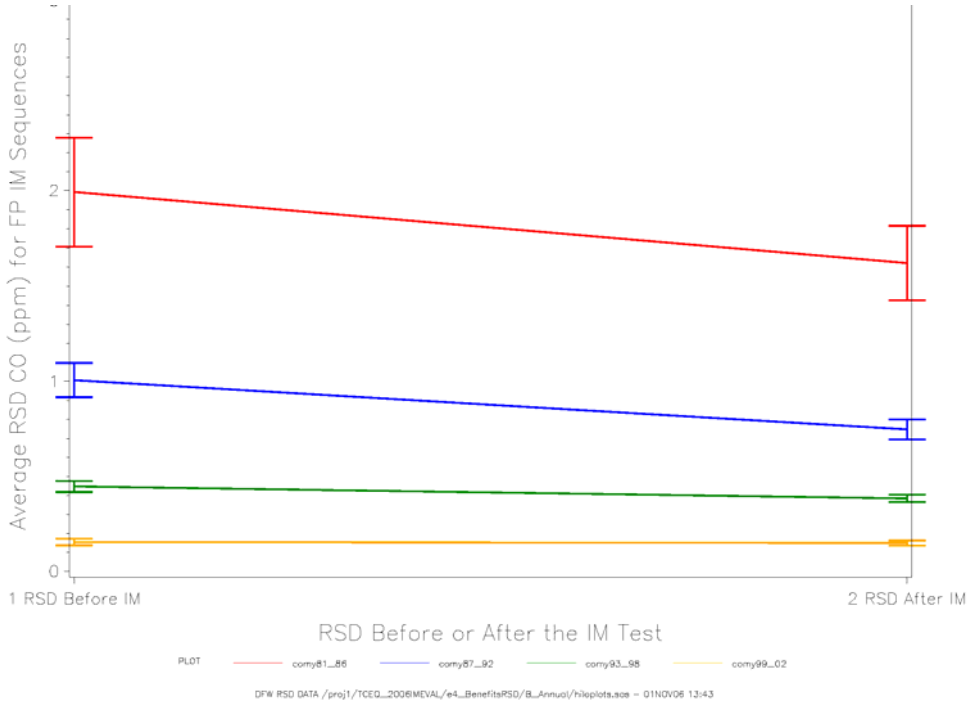


Figure 7-17. Average RSD NOx by Model Year Group Before and After I/M Test for HGB Vehicles with I/M Sequence Category = FP

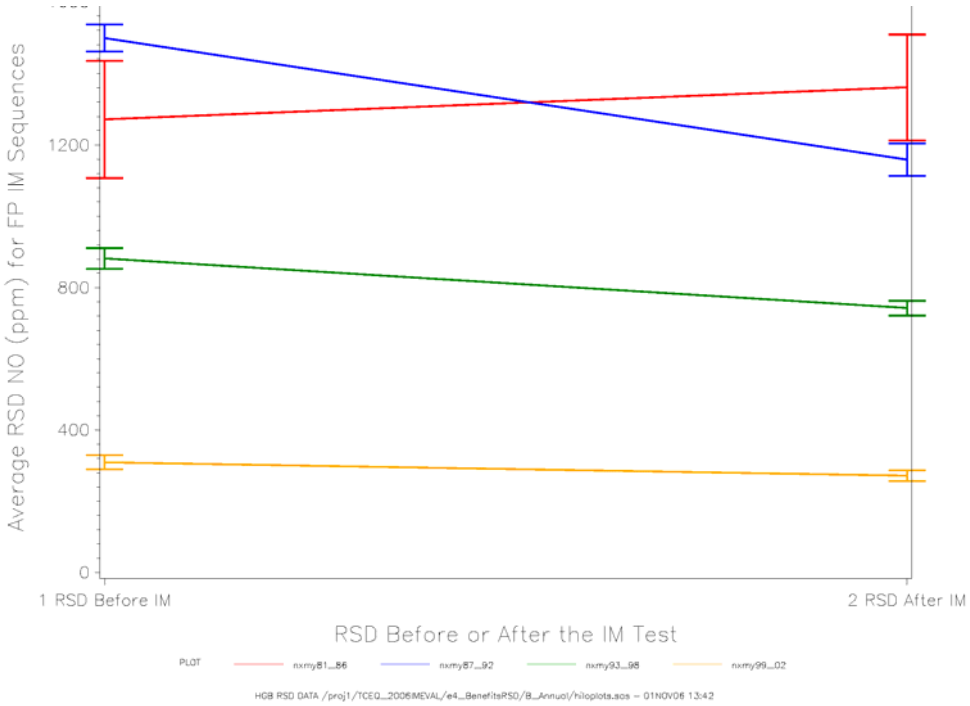


Figure 7-18. Average RSD NOx by Model Year Group Before and After I/M Test for DFW Vehicles with I/M Sequence Category = FP

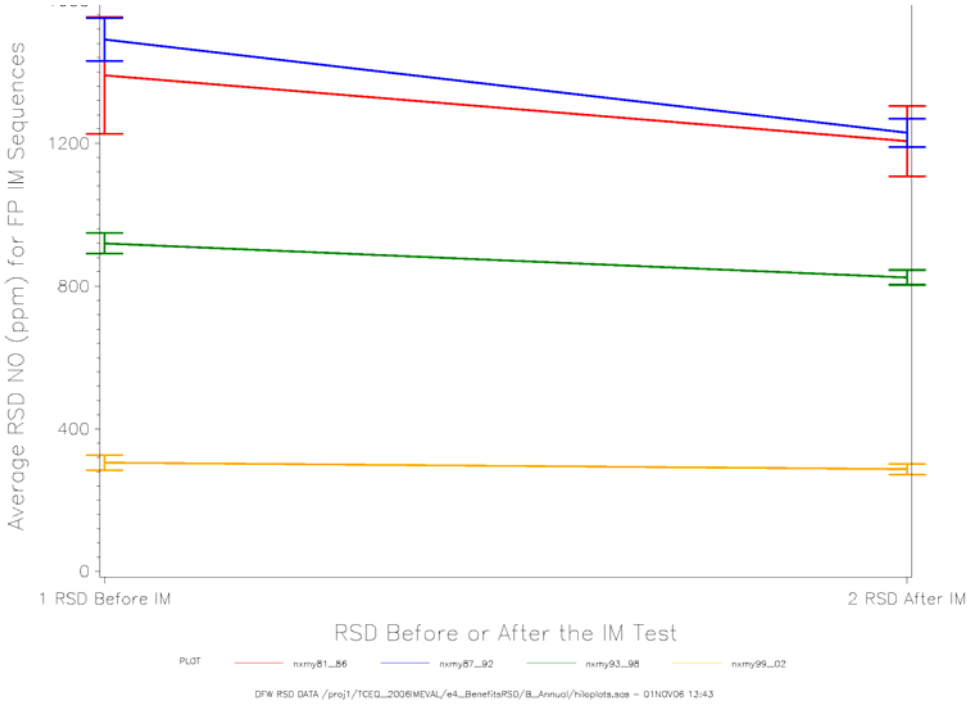


Figure 7-19. Average RSD HC by Model Year Group Before and After I/M Test for HGB Vehicles with I/M Sequence Category = 1P

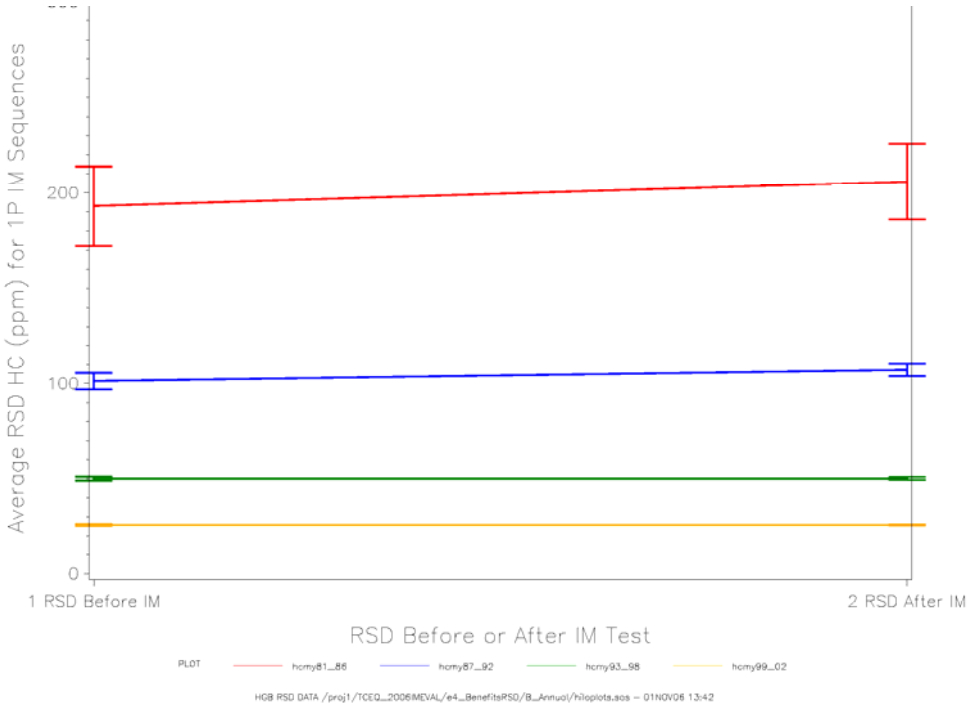


Figure 7-20. Average RSD HC by Model Year Group Before and After I/M Test for DFW Vehicles with I/M Sequence Category = 1P

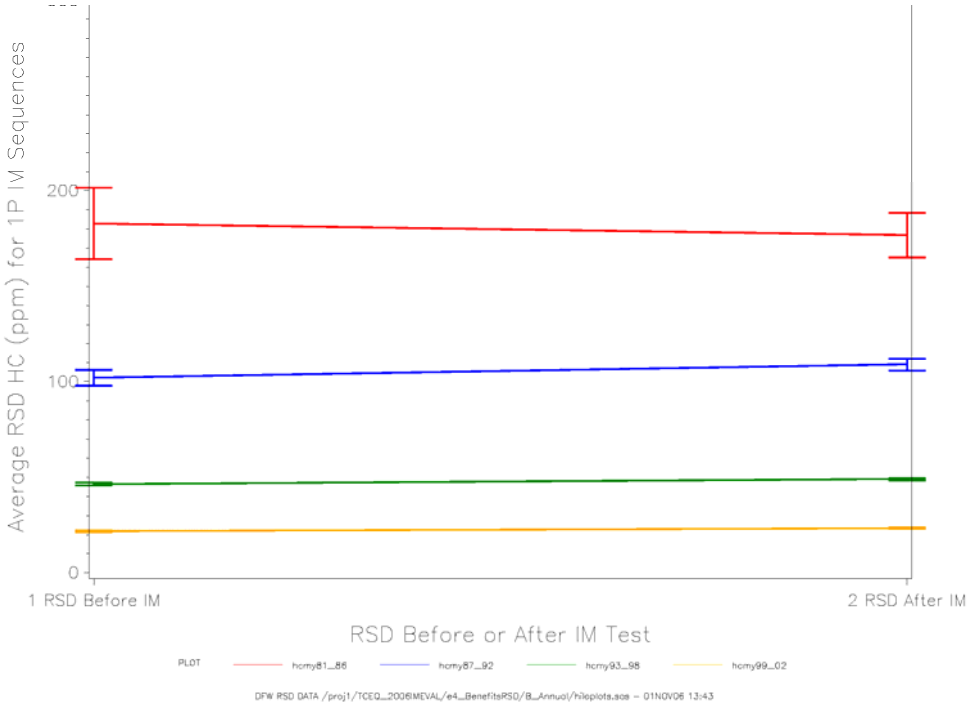


Figure 7-21. Average RSD CO by Model Year Group Before and After I/M Test for HGB Vehicles with I/M Sequence Category = 1P

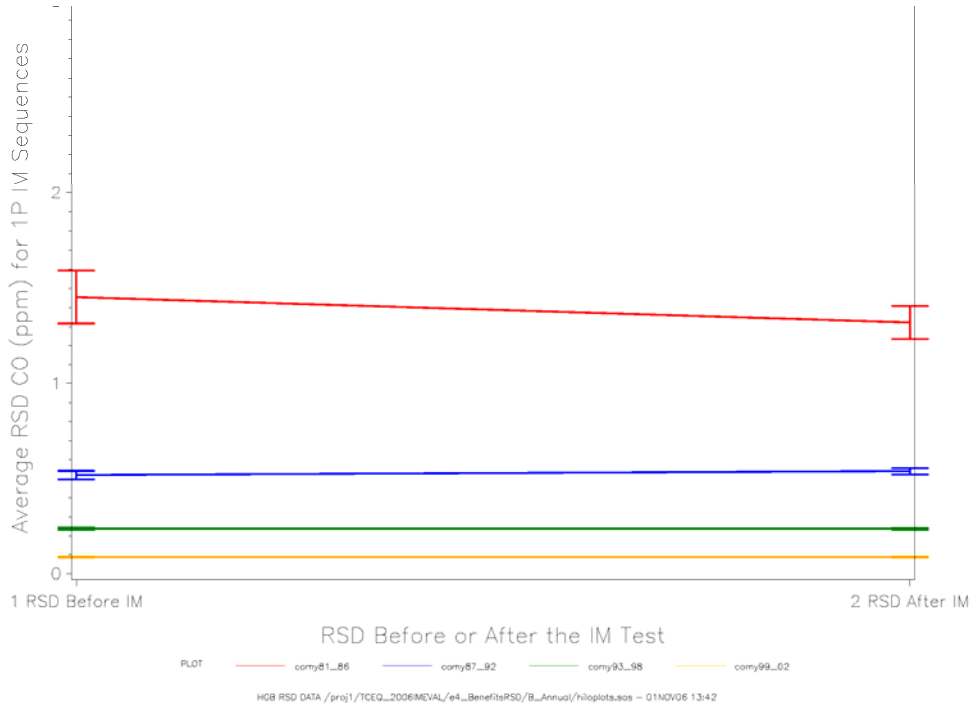


Figure 7-22. Average RSD CO by Model Year Group Before and After I/M Test for DFW Vehicles with I/M Sequence Category = 1P

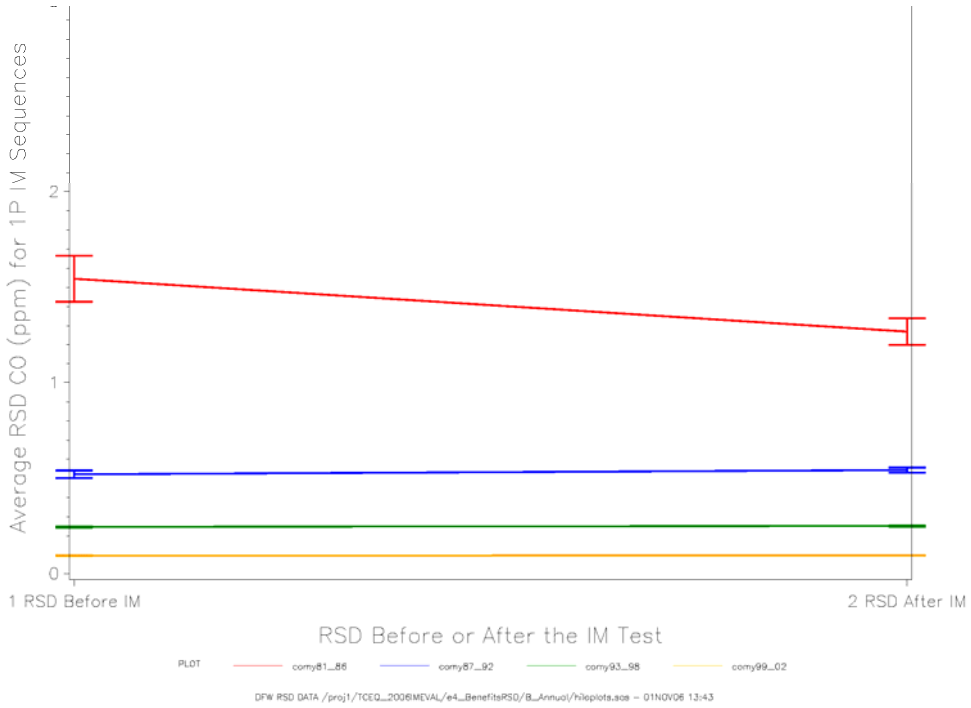


Figure 7-23. Average RSD NOx by Model Year Group Before and After I/M Test for HGB Vehicles with I/M Sequence Category = 1P

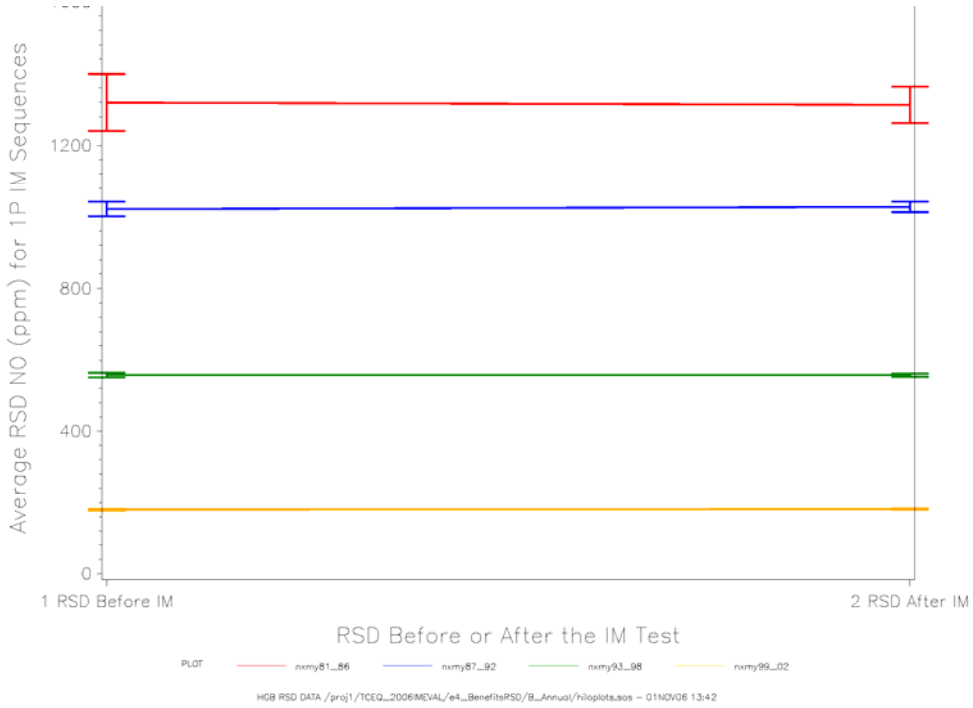


Figure 7-24. Average RSD NOx by Model Year Group Before and After I/M Test for DFW Vehicles with I/M Sequence Category = 1P

Tables 7-6 and 7-7 contains the numerical values for the before and after I/M RSD averages that were shown in the figures above. The values in Table 7-6 show that in 20 of the 24 cases the average emissions decreased for the FP vehicles. The values in Table 7-7 show that for 1P vehicles the emission changes were small. Of the 24 cases, 4 decreased, 7 stayed about the same, and 13 increased.

Table 7-6. RSD Averages Before and After an I/M Test for HGB and DFW for I/M Sequence Category = FP

Houston Galveston Brazoria (HGB) Area						
	RSD HC (ppm)		**RSD CO (%)**		**RSD NO (ppm)**	
MY Group	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**
1981-1986	212	141	2.56	1.31	1272	1360
1987-1992	138	119	0.84	0.65	1536	1159
1993-1998	72	67	0.40	0.35	882	742
1999-2002	36	30	0.16	0.12	309	272
Dallas Fort Worth (DFW) Area						
	RSD HC (ppm)		**RSD CO (%)**		**RSD NO (ppm)**	
MY Group	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**
1981-1986	190	195	1.99	1.62	1390	1205
1987-1992	158	144	1.00	0.75	1491	1229
1993-1998	76	75	0.44	0.39	919	824
1999-2002	28	30	0.15	0.15	305	287

Table 7-7. RSD Averages Before and After an I/M Test for HGB and DFW for I/M Sequence Category = 1P

Houston Galveston Brazoria (HGB) Area						
	RSD HC (ppm)		**RSD CO (%)**		**RSD NO (ppm)**	
MY Group	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**
1981-1986	193	206	1.45	1.32	1319	1312
1987-1992	101	107	0.52	0.54	1021	1027
1993-1998	50	50	0.24	0.24	556	556
1999-2002	26	26	0.09	0.09	180	182
Dallas Fort Worth (DFW) Area						
	RSD HC (ppm)		**RSD CO (%)**		**RSD NO (ppm)**	
MY Group	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**
1981-1986	183	177	1.54	1.27	1081	1170
1987-1992	102	109	0.52	0.54	1010	1025
1993-1998	47	49	0.25	0.25	562	566
1999-2002	22	24	0.09	0.09	186	191

The results in Tables 7-6 and 7-7 show the change in RSD averages from before to after an I/M test for different model year groups. To get the net overall effect on emissions of the I/M program, we need to combine these results. Because RSD measurements are primarily taken on freeway on-ramps, the vehicles that are RSDed are somewhat newer on the average than the I/M

fleet. In this analysis we have not combined the model year results to account for this difference in vehicle model year distribution.

At this point we have determined the net emissions changes for the RSD fleet. These overall results are shown in Table 7-8. The first block of data does not show a drop in the RSD averages from before to after an I/M test for the entire RSD matched I/M fleet. Instead, the RSD data shows emissions increases. However, as discussed above, for the vehicles that do actually receive a failing test and then a repair to pass the final I/M test, the RSD averages do drop. This suggests that the I/M program is causing an I/M benefit for those vehicles even though the emissions do not drop for the entire dataset.

Of course, the increases in Table 7-8 do not mean that the I/M program is serving no useful purpose. It could very well be that in the absence of the I/M program, annual fleet emissions would increase by much larger amounts.

Table 7-8. RSD Average Concentrations to Evaluate the Annual I/M Benefit

I/M Program Area	I/M Sequence Category	Sequence Count			RSD HC (ppm)			RSD CO (%)			RSD NO (ppm)		
		Before I/M	After I/M	Total	Before I/M	After I/M	Change (%)	Before I/M	After I/M	Change (%)	Before I/M	After I/M	Change (%)
DFW + HGB	1P + FP	402,004	721,983	1,123,987	39.9	42.1	*6%*	0.193	0.197	*2%*	393.7	402.8	*2%*
DFW + HGB	1P	381,479	688,976	1,070,455	38.2	40.8	*7%*	0.180	0.188	*4%*	373.1	388.7	*4%*
	FP	20,525	33,006	53,531	71.8	69.9	*-3%*	0.438	0.375	*-14%*	777.7	696.5	*-10%*
DFW	1P + FP	214,113	388,860	602,973	38.7	42.2	*9%*	0.199	0.206	*3%*	398.5	413.4	*4%*
HGB	1P + FP	187,891	333,122	521,013	41.2	42.3	*3%*	0.186	0.187	*1%*	386.7	392.3	*1%*
DFW	1P	203,659	371,793	575,452	37.0	40.5	*9%*	0.186	0.195	*5%*	379.2	397.0	*5%*
	FP	10,454	17,067	27,521	74.4	76.0	*2%*	0.467	0.411	*-12%*	802.5	733.3	*-9%*
HGB	1P	177,820	317,183	495,003	39.6	41.2	*4%*	0.173	0.179	*3%*	366.1	379.0	*4%*
	FP	10,071	15,939	26,010	69.2	63.4	*-8%*	0.408	0.337	*-17%*	751.9	657.1	*-13%*

8.0 The Total I/M Benefit

The Total I/M Benefit is the difference in emissions between the I/M fleet and a hypothetical fleet with the same characteristics and driving environment, but a fleet whose vehicles have never been in an I/M program.

8.1 Estimate of the Total I/M Benefit from RSD Data[43]

According to EPA's Reference method [Reference 2], the Total I/M Benefit can be calculated using RSD data. This calculation can be done by comparing RSD emissions for vehicles registered in an I/M area with vehicles registered in non-I/M areas. This is a results-based measure of the emissions changes produced by the I/M program The Total I/M Benefit is the difference in emissions between an I/M fleet and a non-I/M fleet with the same characteristics and driving environment.

Currently, the RSD measurements in Texas are taken only in the 15 county areas that have I/M programs. This means there is no source of a large number of RSD measurements on a fleet of vehicles in non-I/M areas to be used as the reference area dataset for calculating the total I/M benefit of Texas I/M programs using the EPA Reference Method. In the future, if Texas wants to calculate the Total I/M Benefit using the EPA Reference Method with RSD data, Texas will need to acquire a large amount of RSD measurements in a non-I/M area such as San Antonio. Nevertheless, we proceeded with the analysis of RSD data to attempt to estimate the Total I/M Benefit for the HGB and DFW I/M areas.

To calculate the Total I/M Benefit, we attempted a modification of the EPA Reference Method applied to existing RSD data. This was to be done by comparing RSD emissions for vehicles registered in the I/M area with vehicles registered in non-I/M areas. We divided the RSD data into subsets within the two I/M areas being analyzed. For the HGB area and for the DFW area, the data were divided into 5 subsets:

1) vehicles that were registered within the I/M area (we referred to these as the Core);

2) vehicles that were registered in counties directly adjacent to the I/M area (we referred to this as Ring 1);

3) vehicles that were registered in the counties adjacent to the first ring of the I/M area (we referred to this as Ring 2);

[43] This section responds to the Work Plan's Task 3 Element 4A: Use of Out-of-Program Data to Calculate the Total I/M Benefit and was written by T.H. DeFries and M.F. Weatherby.

4) vehicles that were registered in any other non-I/M county within the state of Texas (we referred to this as Other);

5) vehicles that were registered in any other I/M county within the state of Texas.

We performed the analysis by using the remote sensing data that was collected in the counties of the Core areas shown in Figure 8-1. The analysis was performed separately for the HGB Core area and for the DFW Core area. In either of these Core areas, vehicles that had RSD measurements taken on them as they drove in the Core areas, would be from vehicles registered inside and outside of the Core area. We thought that it would be possible that the emissions for vehicles registered in a Core area, registered in Ring 1, registered in Ring 2, and registered in Other non-I/M areas could be different and could be used to estimate the Total I/M Benefit of the I/M program in the Core area. This particular approach for the EPA Reference Method is specifically disallowed by the EPA guidance. However, in the absence of any significant amount of RSD data in non-I/M areas, we decided to perform the analysis to see what trends would result.

Figure 8-1. Designation of Vehicle Registration Counties for Total I/M Benefit Analysis

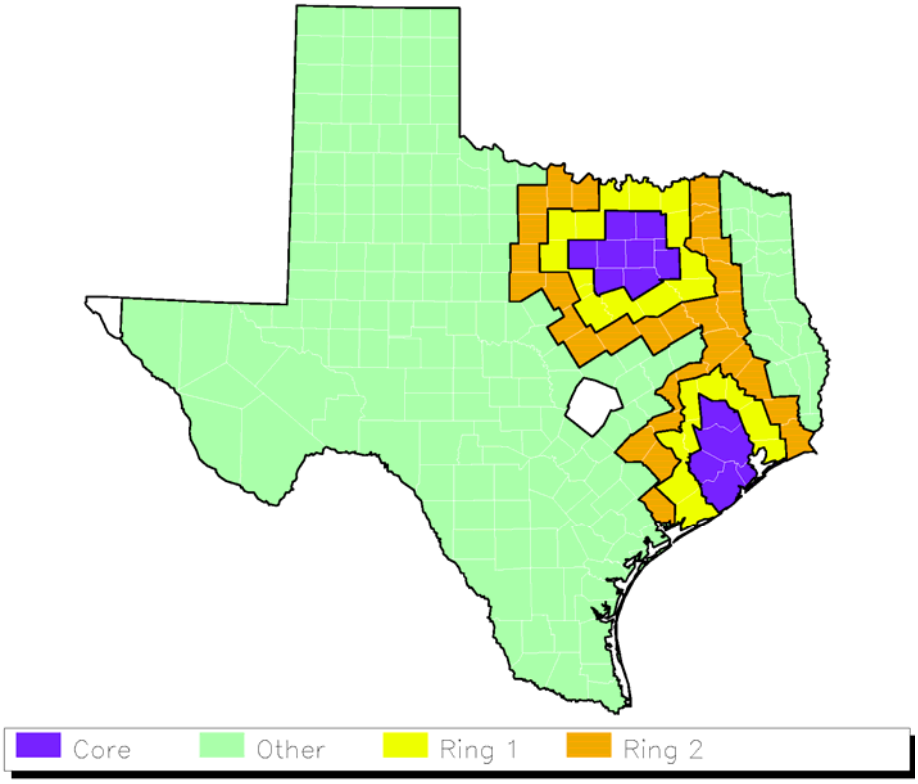


Table 8-1 shows the counts of RSD records for the HGB and the DFW areas that were within Core, Ring 1, and Ring 2 data subsets. For the calculation of the Total I/M Benefit using EPA's Reference Method, the I/M area consisted of all the vehicles that were registered in the Core, and the "reference" area consisted of all vehicles that were registered in the Ring 1, Ring 2, and Other counties.

Table 8-1. Registration Area of the RSD Vehicles for Valid HGB and DFW RSD Records

Vehicle Registration Area	HGB Area	DFW Area
Core	1,489,056	1,622,590
Ring 1	14,449	38,761
Ring 2	10,481	11,405
Other	19,990	85,460

Once these datasets were identified, we compared the RSD measurements for vehicles that were registered in the Core counties with vehicles that were registered in the Ring 1, Ring 2, and Other counties but driven within the Core counties.

The early analysis results for the HGB area and the DFW area were quite similar. Therefore, we combined all of the data from both areas for the presentation in this section. We saw distinct differences in the model year average RSD measured concentrations for HC, CO, and NO as a function of model year and as a function of the Core, Ring 1, Ring 2, and Other areas. The differences in emissions between Ring 2 counties and Other counties were not large enough to make the differences statistically significant given the relatively low numbers of observations for vehicles that were registered in those two areas. Therefore, we combined RSD observations for Ring 2 with Other and designated them as Outside Ring 1.

Figures 8-2, 8-4, and 8-6 show the model year average RSD concentrations as a function of model year for vehicles driving in the Core HGB and Core DFW areas. The three curves are for the vehicles registered in the Core, registered in Ring 1, and registered Outside of Ring 1. As expected, all three curves show higher emissions concentrations for older model years and lower emissions concentrations for newer model years. The up and down scatter of the data points on a given registration area curve is larger at older model years than newer model years since there were fewer older model year vehicles in the fleet. The emissions curve for the Core area is shown as the thin solid line without symbols, the emissions for Ring 1 are shown as a red line with solid dots, and the emissions for vehicles registered Outside Ring 1 are shown as a blue line with open circles. The emissions trends for the three sets of vehicles registered in the Core Ring 1 and Outside Ring 1 have similar relative positions for HC, CO, and NO. Relative to the

emissions of vehicles registered in the Core, vehicles registered in Ring 1 and driving in the Core have slightly higher CO and NO concentrations for most model years since about 1985 and have higher HC emissions for most model years since about 1992. For vehicles registered outside of Ring 1, the HC, CO, and NO emissions concentrations are greater than the emissions concentrations for vehicles registered in the Core for model years newer than about 1997.

Figures 8-3, 8-5, and 8-7 show the same model year average emissions concentrations. However, the plots express the concentrations relative to the average emissions concentrations in Core registered vehicles. These plots show an increasing trend in the emissions concentrations of vehicles registered in Ring 1 and Outside Ring 1 as model years increase relative to the Core registered vehicles concentrations for the same corresponding model years. For all three pollutants, the emissions concentrations for vehicles registered in Ring 1 are higher on the average than those registered outside of Ring 1.

On the surface, these trends seem contrary to the expected effects of the I/M program on vehicles that are registered in the Core. Specifically, we would expect that vehicles registered outside of the Core would have higher emissions than those registered in the Core because vehicles outside of the Core do not participate in the I/M program. We believe that one of the explanations for this trend, which is especially the case for vehicles registered outside of Ring 1, is a consequence of the distance that vehicles outside of Ring 1 must drive to get to the Core and be observed by RSD. Such vehicles must be in relatively good mechanical condition otherwise their drivers would not usually attempt the trip. Consequently, we believe that vehicles Outside Ring 1 are a special sample of all of the vehicles that are registered and drive outside of Ring 1. This good mechanical condition sample of vehicles from Outside Ring 1 tend to have lower emissions for all but the newest model years of vehicles that are registered and drive within the Core.

Therefore, this analysis confirms the requirement by EPA guidance that to use the EPA Reference Method RSD measurements must be taken on vehicles registered and driving within the I/M area and on another set of vehicles registered and driving within a non-I/M area, which has similar characteristics as the I/M area. We suggest that a non-I/M area that corresponds to the DFW and HGB areas that may meet this requirement is the San Antonio area.

Figure 8-2. Average RSD HC Concentrations for Vehicles Driven in Core Areas

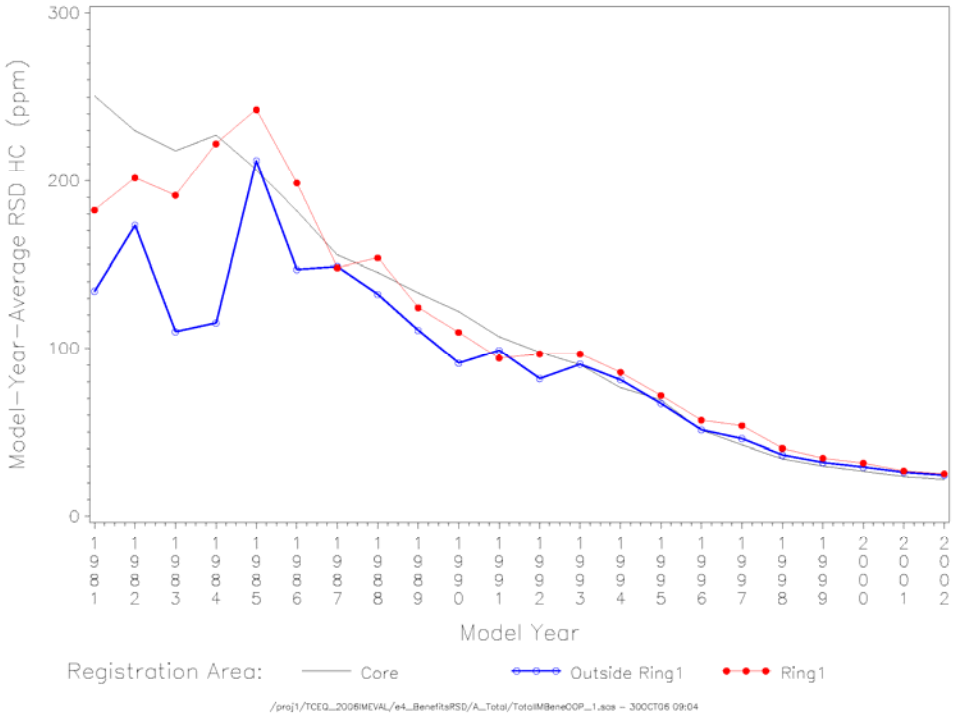


Figure 8-3. Ratio of Average RSD HC Concentrations for Vehicles Driven in Core Areas

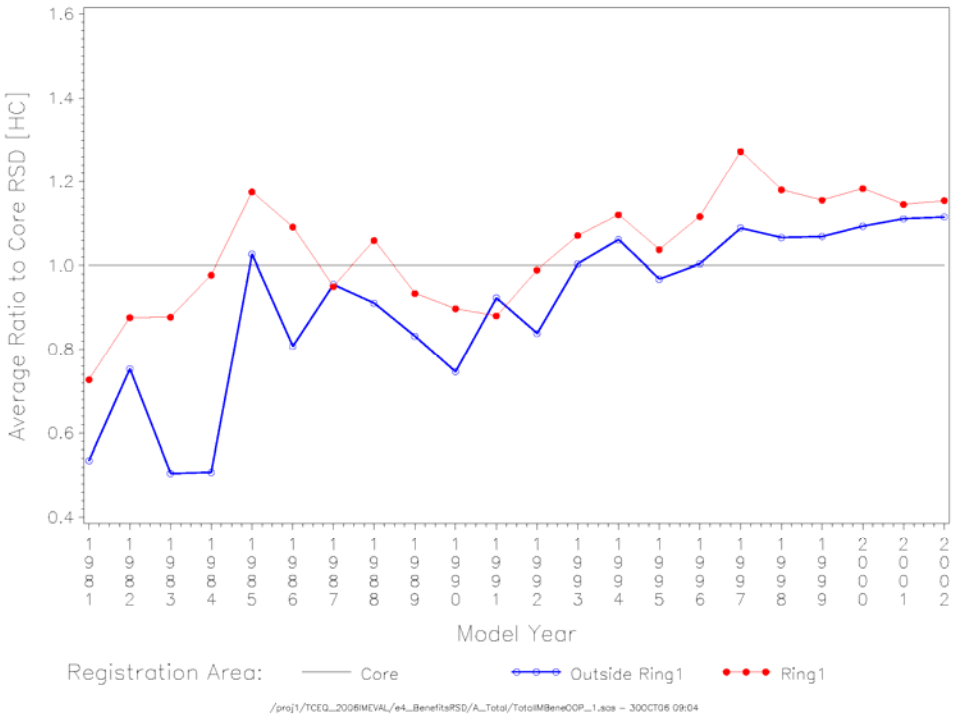


Figure 8-4. Average RSD CO Concentrations for Vehicles Driven in Core Areas

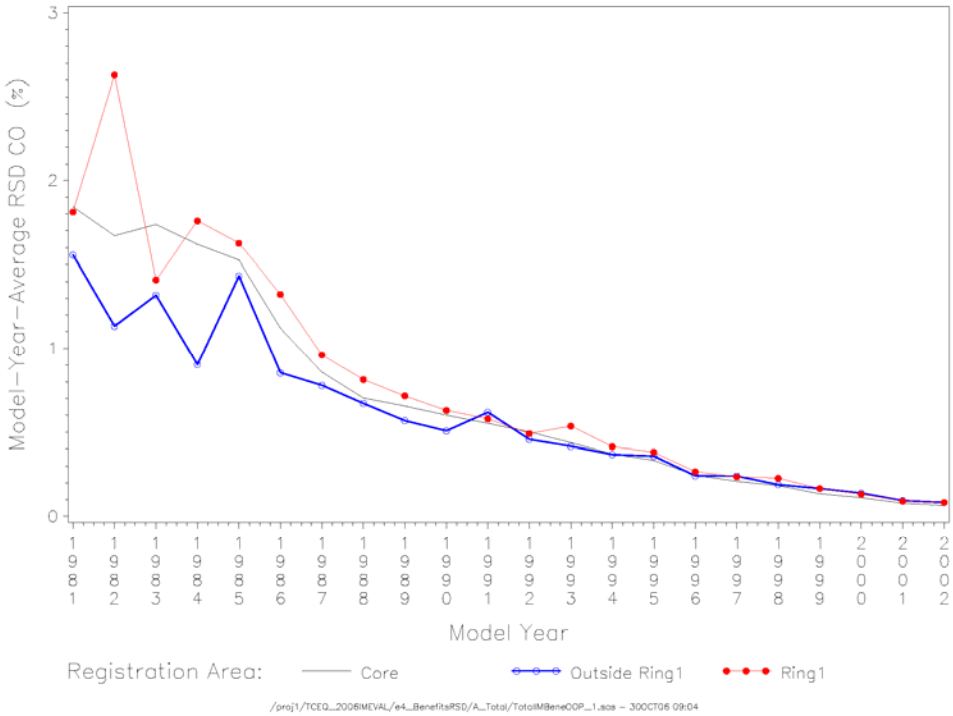


Figure 8-5. Ratio of Average RSD CO Concentrations for Vehicles Driven in Core Areas

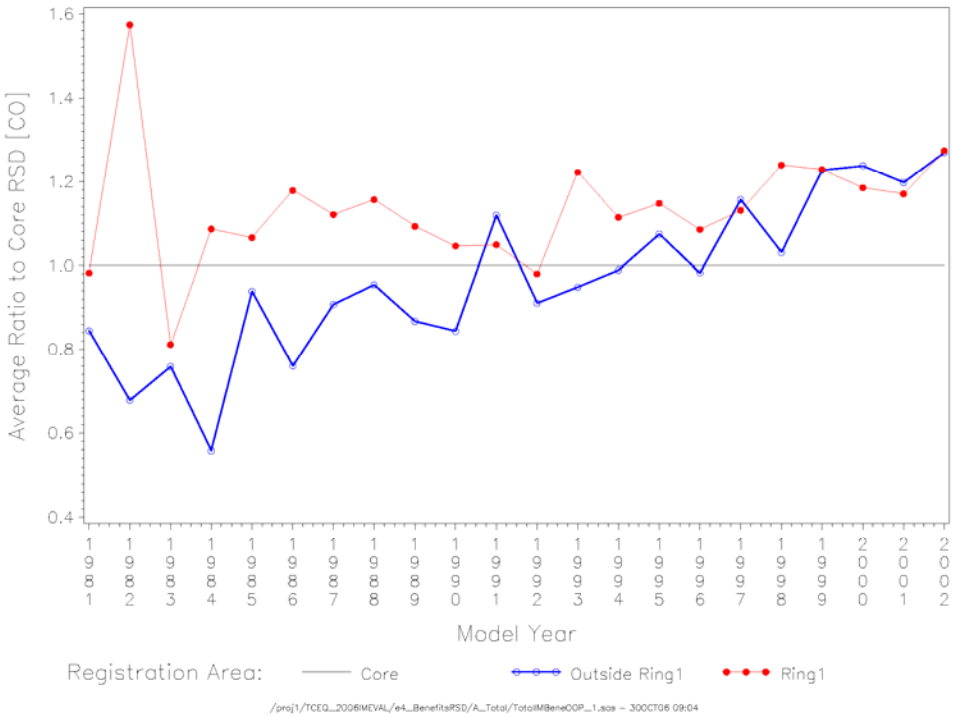


Figure 8-6. Average RSD NO Concentrations for Vehicles Driven in Core Areas

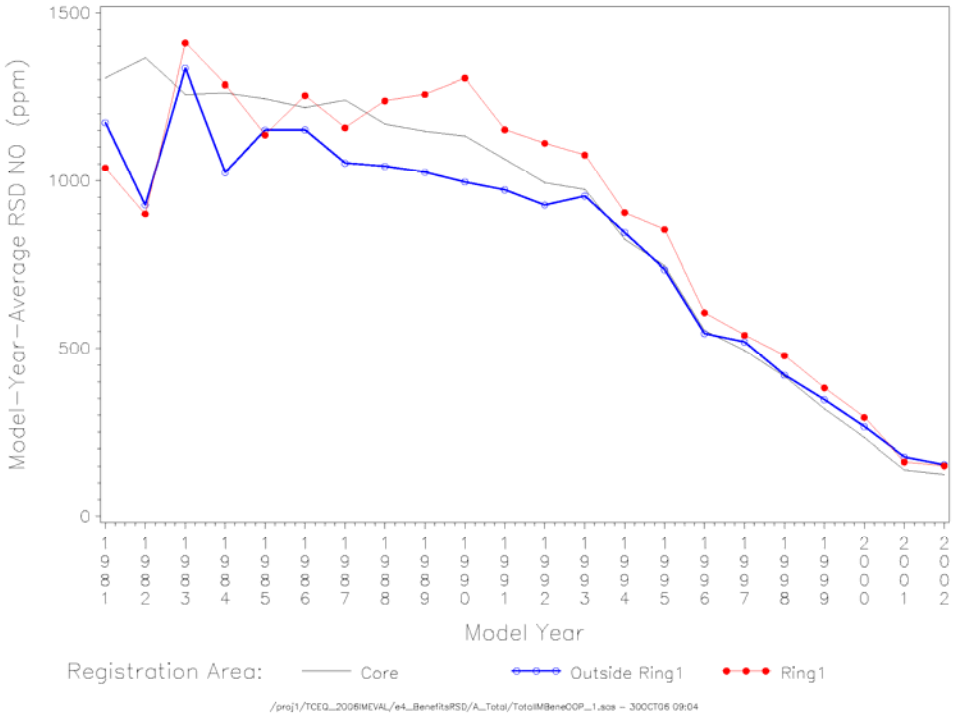
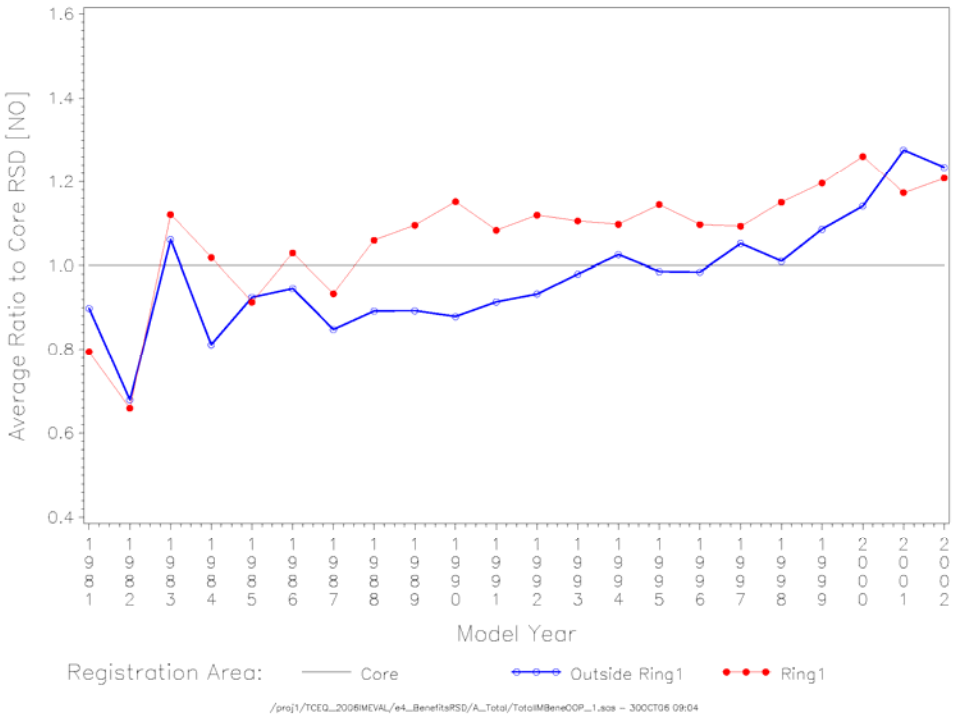


Figure 8-7. Ratio of Average RSD NO Concentrations for Vehicles Driven in Core Areas



9.0 References

1. Jim Lindner, "Draft Guidance on Use of In-Program Data for Evaluation of I/M Program Performance," EPA420-P-01-003, www.epa.gov/otaq/regs/im/obd/p01003.pdf, August 2001.

2. "Guidance on Use of Remote Sensing for Evaluation of I/M Program Performance," EPA420-B-04-010, www.epa.gov/otaq/regs/im/obd/420b04010.pdf, July 2004.

3. T.H. DeFries, B. Limsakul, M.F. Weatherby, S. Kishan, H.J. Williamson, "Relationships between the Repairs and Emissions of Light-Duty Gasoline Vehicles and Technologies," Final Report, TCET-040921, prepared for Texas Council on Environmental Technology, September 21, 2004.

4. T.H. DeFries, A.D. Burnette, S. Kishan, Y. Meng, "Evaluation of the Texas Motorist's Choice Program," ERG Report No. TNRCC-000531, May 31, 2000.

5. Katie N. Womak, "2004 Parking Lot Survey," Texas Transportation Institute, February 2005.

6. T.H. DeFries, C.F. Palacios, S. Kishan, "Analysis of Arizona I/M Program Repair Data," Final Report, AZDEQ-020628d, prepared for Arizona Department of Environmental Quality, June 28, 2002.

Appendix A

Preparation of the Texas I/M Program Data for 2004-2005[44]

[44] This appendix was written by T.J. Petroski.

The DFW and HGB I/M program evaluation data were provided to ERG by Guy Hoffman at TCEQ and by Jimmy Guckian at DPS. The information from TCEQ consisted of a registration snap shot, quarterly trigger reports, audit files, and VID files based on the "Specifications For Vehicle Exhaust Gas Analyzer Systems For Use In The Texas Vehicle Emissions Resting Program" guidance document including station, analyzer, inspector, and vehicle data. The information from DPS consisted of RERF data, RSD Measurements, and RSD site slopes. Table A-1 summarizes the data received and the time period each dataset encompasses.

Table A-1. Data and Dates Covered

Data Type	Time Period	Source
ETS Systems.dat	Snap Shot on May 3, 2006	TCEQ
Station.dat	Snap Shot on May 3, 2006	TCEQ
Inspector.dat	Snap Shot on May 3, 2006	TCEQ
Trigger Reports–Inspector	Quarterly Reports from May 1, 2003 – December 31, 2005	TCEQ
Trigger Reports–Station	Quarterly Reports from May 1, 2003 – December 31, 2005	TCEQ
Perform.dat	Snap Shot on May 3, 2006	TCEQ
AuditGas.dat	May 1, 2003 – December 31, 2005	TCEQ
Cal.dat	May 1, 2003 – December 31, 2005	TCEQ
Vehicle.dat	May 1, 2003 – December 31, 2005	TCEQ
Registration	Snap Shot on May 10, 2006	TCEQ
Covert Vehicles	May 1, 2003 – December 31, 2005	TCEQ
RSD Measurements	April 1, 2004 – December 31, 2005	DPS
Recognized Emission Repair Facility	1996 – March 2006	DPS
TTI Parking Lot Survey	Summer 2004	TCEQ
I/M History & Description	October 26, 2005 Texas I/M SIP	TCEQ
Registration denial databases	April 2001– April 2006	TCEQ
Audit Tables	Calendar Years 2003 – 2005	TCEQ

These data were read in and then edited before they were used for the analysis in this project. The same edits were applied to both the DFW and HGB I/M program area data. First, we combined data for each vehicle into a single group. We did this by assigning a GroupID, the correct VIN for the vehicle. Next, the raw data was filtered by performing a series of checks to eliminate suspect records so that all our analyses used consistent and edited datasets. Thirdly, we determined I/M cycles for each of these GroupIDs. I/M cycles are important for various reasons including determining pass/fail sequences, emission test type sequences, and Annual I/M

Benefit calculations. These three edits (plus VSP calculations) are described in detail in the remainder of this appendix.

Assigning GroupIDs

In the Texas I/M program evaluation, we combined several different datasets containing VINs. These datasets include the I/M test records, registration data, and DPS repair data. We wanted to combine data for each vehicle into a single "group" so that we could link all of the data for a vehicle together to do analyses on each vehicle. We wanted to use the VIN as the identifier for a vehicle. VINs are unique to each vehicle and distinguish each vehicle from other vehicles. One difficulty with this method is that some VINs in the datasets have transcription errors. One technique we used to help correct VIN transcription errors was to use the license plate to help the VIN make each group – even if a VIN has a few errors in it. Using the plate worked well because one plate can not be assigned to multiple VINs, but there are also various reasons why plates may not be the same:

- The vehicle may have been assigned a new plate. This usually happens every 7 years, but it can happen more often, e.g., a vanity plate. Newly assigned plates should not match the plate of a different vehicle.

- The inspector can make typographical errors when entering the plate into the analyzer. These commonly include substitutions, like 2 for Z, and 5 for S, and position switches like AB for BA. Plate typographical errors can produce a "chronological island", i.e., VIN is the same, but plate switches back and forth unexpectedly. For example, first visit, the plate says 123A**B**C, but second visit plate changes to 123A**8**C, but by third visit, the plate is correct again as 123A**B**C. Sometimes, plates with typographical errors will inadvertently match the actual plate of a different vehicle. Although infrequent, this type of plate error will just happen to match another very similar VIN.

- The inspector can just be lazy and just enter a plate that has little similarity to the actual plate, like Z23JDF for Z29XYZ. Plate laziness can produce "chronological islands." Sometimes lazy plates will inadvertently match the actual plate of a different vehicle.

However, if a group has observations making a "chronological island," this does not affect our groupings. The island observations have the same VIN as the rest of the group, so, the observations are most likely for that vehicle. Even if an observation's plate in a group is the same as the plate in another group, that is acceptable for I/M tests, registration, and DPS repair data. Those data belong to the group because the VIN defines the vehicle.

In addition, a plate that appears in multiple groups is a problem when we want to match an RSD observation to a group. We would not know which group to associate the RSD observation with. Fortunately, 99.4% of plates are found in only one group. So, if we have an RSD observation that has a plate that appears in more than one group, we will drop the RSD measurement. We would lose only 0.6% of RSD measurements based on duplicate plates in multiple groups.

There are two types of grouping errors of which we are aware and would want to avoid, but still occur in the dataset. These errors affect all analyses – not just RSD analyses, but these errors are small. The following describes the two errors:

- A group that contains observations for two or more different vehicles. We would want to split these observations into two or more separate groups.
- Two or more groups that have observations for the same vehicle. We would want to combine these groups.

After considering these limitations, the approach we used to group similar VINs together and to assign the most likely VIN for that vehicle to the group was to first sort the dataset by the following order of variables: plate, VIN check digit error, num_vinplates , and finally VIN.

If the plate is exactly the same, the VINs should be the same or very similar because it is supposed to be the same vehicle. We sorted by check digit error because we wanted any check digit error-free VINs to be at the top of the list. We then sorted by num_vinplates. Num_vinplates is calculated by concatenating the VIN and plate together, then counting the number of these combinations in the dataset. The more combinations of VIN and plate we count, the more likely that this VIN and plate belong together. Lastly, we sort by VIN because the first VIN in this list is our first choice for GroupID. After the sorting, we compared the first 17-digit VIN to the second 17-digit VIN in the list, first character to first character, second character to second character, etc. The VINs are determined to be the same if they contain less than three differences. Then, the second VIN is compared to the third VIN in the same manner until all VINs within the same plate are checked. If a VIN for a vehicle is not similar to the assigned GroupID for that group, the VIN for that vehicle gets assigned its own VIN as the GroupID.

Once Group IDs have been assigned to all records, the dataset is then sorted by the GroupID. This brings together the same GroupIDs even though the plate may have changed at some point. Some groups will not be perfect because some groups should be split and some should be combined.

Analysis Dataset

To complete many of the elements in this task, the raw dataset was passed through a series of filters. Before the filters were applied, any I/M test records for vehicles not tested in the 9-county DFW or the 5-county HGB I/M program areas were deleted. 1,218,419 records were removed, most of these tests were performed in El Paso, Williamson, and Travis counties. These counties are not included as part of the current I/M program evaluation.

The following is a list of ten reasons why I/M test records were flagged then removed from the raw DFW and HGB I/M program area emissions test dataset:

1) Aborted tests.

2) Two stickers were issued. This is not an I/M test, one sticker was replaced with another.

3) Covert vehicles used by DPS for audit purposes only.

4) Safety-Only tests since they contain no emissions data.

5) Missing or Invalid GroupIDs. If a GroupID starts off with any of the following first three characters, it is designated as an invalid groupid. They include: “XXX”,”AAA”,”000”,”N0N”,”NNE”,”0BS”,”OBD”, “111”,”222”,”333”,”444”,”555”,”666”,”777”,”888”,”999”,”123”

6) Emissions Test Pass/Fail flag was missing and Overall Result was missing.

7) Duplicate ASM or TSI emissions tests. For example, a vehicle may fail its overall test because it failed the safety test. Since it passed the emissions test, if the vehicle returns within 15 days to the same station, the vehicle only retests the failed safety portion so we do not want to count the passing emissions test twice if it occurs in the data more than once.

8) Duplicate OBD II emissions tests. This is kept separate from ASM/TSI tests because the variables are very different.

9) Dilution condition ended the test.

10) Time ran out during the test.

After the ten filters were applied, 1,169,723 records (7% of raw data) did not pass at least one filter and were removed. A total of 15,437,696 records passed all filters and were used in further analyses. Table A-2 provides counts of records flagged by each filter.

Table A-2. Filters Applied to I/M Test Records

Filter	Number of Records Flagged
1: Aborted Tests	518,617
2: Two Certifications Issued (Sticker Replacement)	6,190
3: Covert Vehicles	8,037
4: Safety-Only Tests	4,126
5: Missing or Invalid Group IDs	2,218
6: Missing Emissions & Overall Pass/Fail Flags	395,789
7: Duplicate ASM or TSI Emissions Tests	517,256
8: Duplicate OBD II Tests	190,766
9: Dilution Condition Ended the Test	617
10: Time ran out during test	4,007
Failed at Least One Filter	1,169,723
Passed All Ten Filters	15,437,696

Determination of I/M Cycles

Using the I/M tests that passed all ten filters, the I/M test records were sorted by GroupID and start date/time of the I/M test. The first instance for each GroupID became the initial overall test for first I/M cycle occurring in the dataset for that GroupID. If this first I/M test occurs near the beginning of the dataset, it is unknown whether this is truly an overall initial test. For the present analysis, this was ignored. Now, there are two ways we designated the end of an I/M cycle:

- When a vehicle is certified, that is, issued a window sticker (whether the vehicle passes its final test or is given a waiver) marks the end of an I/M cycle. The next I/M test that follows the certifying test, independent of time, was designated another overall initial test in the next I/M cycle for that GroupID, or

- If the overall result was a pass, the emission pass/fail result was a pass, and the test was not aborted, but the test type was either a Voluntary Emissions Test ("I") or a Required Emissions Only Test ("O"), this was designated as the end of an I/M cycle. In these cases, no certifications were issued, but the vehicle will have a series of emissions tests ending in a final pass similar to the majority of I/M cycles described in the first case.

Some I/M cycles designated here will have started and ended mid-cycle especially those cycles at the beginning and ending of the dataset, respectively. It is difficult to differentiate these cycles unless we obtain additional data before and after the time period under consideration. Table A-3 provides a distribution of I/M cycles per vehicle. Of the identified I/M cycles, 99.6% of the vehicles had three or fewer cycles. Table A-4 provides a distribution

number of emissions tests per I/M cycles. 94% of the vehicles had only one emissions test and another 5.9% had two emissions tests.

Table A-3. Distribution of I/M Cycles Per Vehicle

I/M Cycles	Number of Vehicles	Percent
1	2,661,494	34.5
2	3,383,174	43.8
3	1,643,936	21.3
4	32,664	0.42
5	1,055	0.01
6	76	0.00
7	23	0.00
8	4	0.00
9	2	0.00
10	2	0.00
11	2	0.00
12	1	0.00
13	3	0.00
14	1	0.00
15	2	0.00
17	1	0.00
30	1	0.00
Total	7,722,441	100.00

Table A-4. Number of Emissions Test per I/M Cycle

Tests in an I/M Cycle	I/M Cycles	Percent
1	13,590,690	93.8
2	847,390	5.9
3	46,544	0.3
4	2,842	0.02
5	2200	0.0
6	16	0.0
7	2	0.0
8	2	0.0
Total	14,487,706	100.0

Even though it is difficult to accurately define I/M cycles that begin before or end after the dataset under consideration (May 1, 2003 - December 31, 2005), we made an attempt to further classify I/M cycles in the following four categories. An initial test is defined as either the first time we see an I/M test record for a GroupID or is the first test record following a verified certification in the dataset.

1) Initial test (first time GroupID is encountered) occurred during the first three months of the dataset, but unsure whether it is a true initial test (i.e., the true

initial test may have occurred prior to May 1, 2003) AND the Final test is a Certified test.

2) Initial test (first time GroupID is encountered) occurred during the first three months of the dataset, but unsure whether it is a true Initial test AND the Final test is NOT a Certified test.

3) Initial test (either definition applies) occurs after the first three months of the dataset and assumed to be a true Initial test AND the Final test is a Certified test.

4) Initial test (either definition applies) occurs after the first three months of the dataset and assumed to be a true Initial test AND the Final test is NOT a Certified test.

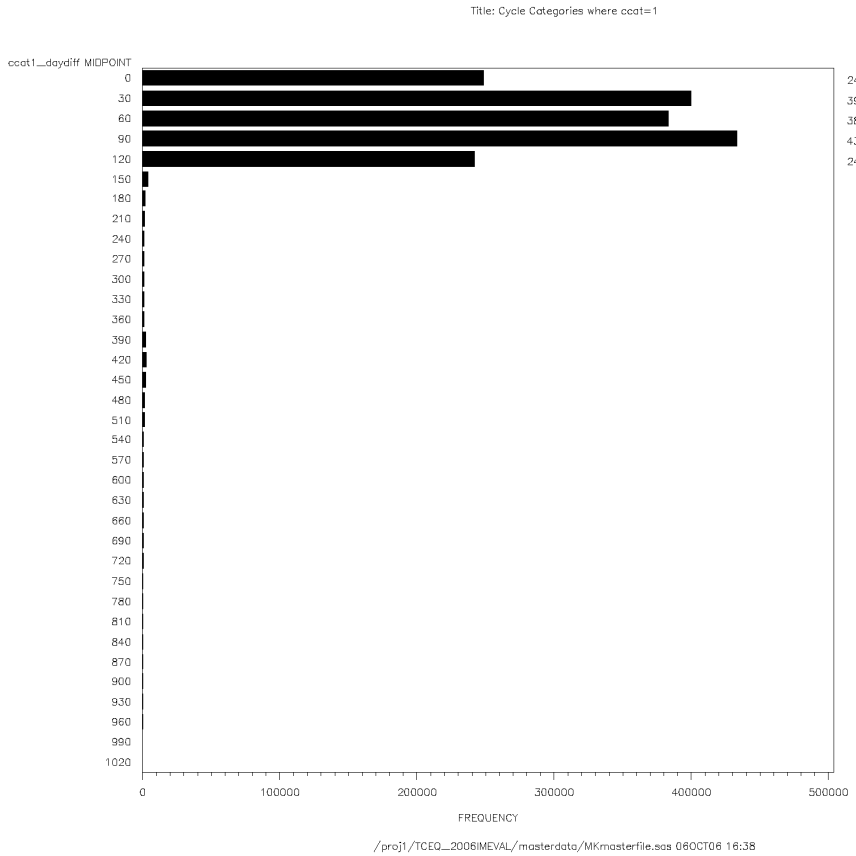
Table A-5 shows the distribution of I/M cycle categories. The third category which represents those I/M cycles with assumed true Initial Tests followed by an eventual Final certifying test make up 87% of the data. The first category represents those I/M cycles which had a Final certifying test, but we were unsure of the initial test because that test occurred very early in the dataset. The second and fourth categories are basically I/M cycles without certifying tests and they account for a very small portion of the data (~0.8%). These I/M cycles occur for reasons such as uncorrected errors in the data, improperly Grouping or not Grouping VINs, or vehicles that started the I/M inspection process, but never finished.

Table A-5. I/M Cycle Categories

I/M Cycle Category	Frequency	Percent
1	173,3781	11.97
2	16,040	0.11
3	12,640,906	87.25
4	96,979	0.67
Total	14,487,706	100.00

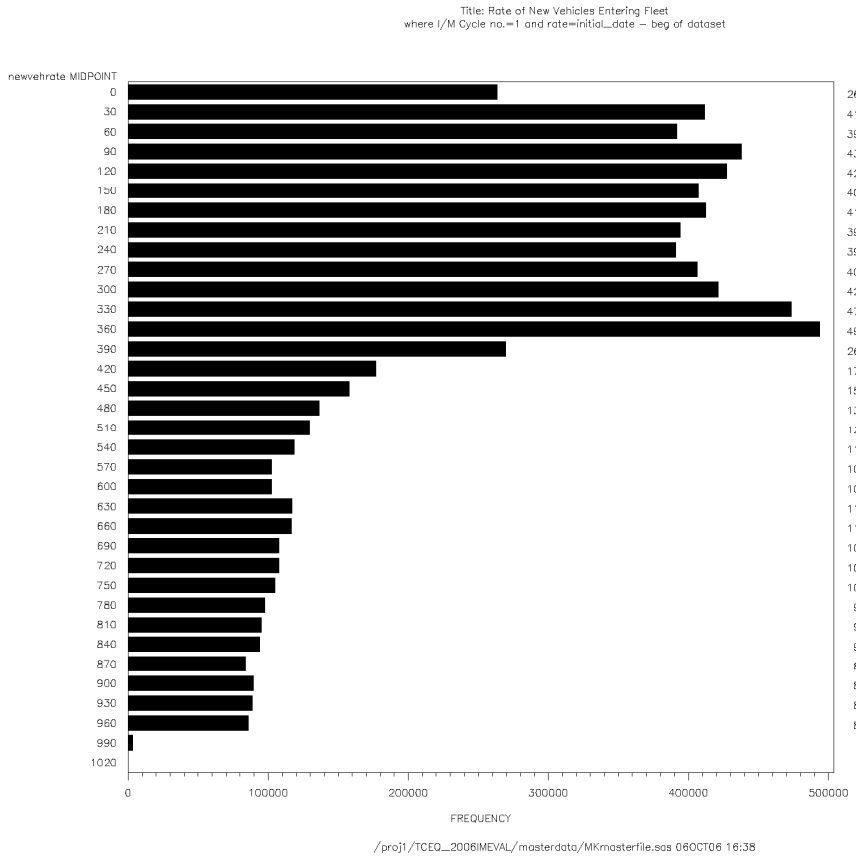
For the first I/M cycle category, Figure A-1 shows the distribution of the number of days between the beginning of the dataset and final non-certifying test. Over 98% of those cycles are certified within four months of the beginning of the dataset. Some of the I/M cycles are probably complete I/M cycles especially the cycles with final tests greater than 90 days from the beginning of the dataset. However, without test records prior to May 1, 2003, we can not accurately differentiate these cycles. A recommendation for future I/M evaluations is to incorporate several months of data before the program evaluation period to properly identify cycles.

Figure A-1. Number Days to Certification for I/M Cycles Starting in First 90 Days of Dataset



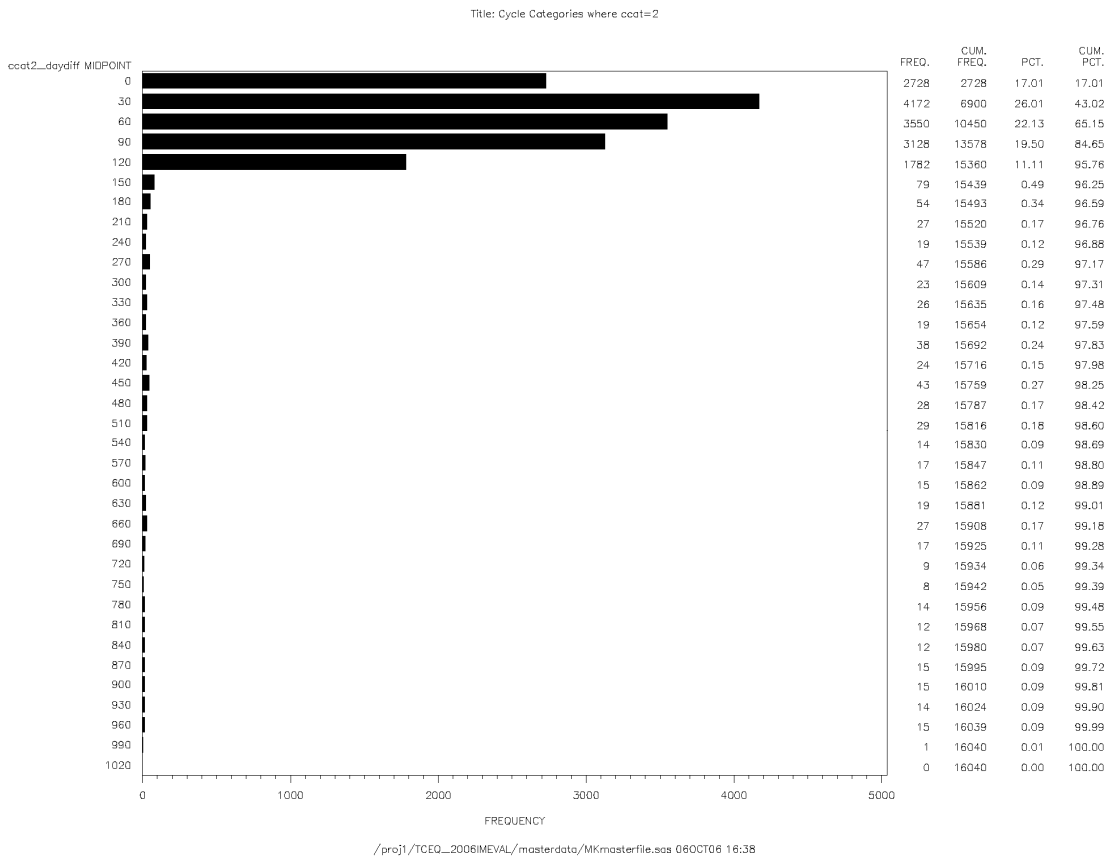
For those vehicles in the first I/M cycle category, we subtracted the beginning date of the dataset from the initial test date to get a measure of the number of new vehicles entering the fleet. Figure A-2 demonstrates the rate at which new vehicles are entering the fleet. For the first 12 to 15 months, all vehicles are treated as new, but once we get beyond the 15 months, we get a better measure of vehicles entering the fleet. On average, approximately 100,000 vehicles per month are entering the I/M fleet for the first time.

Figure A-2. Rate at which New Vehicles Enter the I/M Fleet



For the second I/M cycle category, Figure A-3 shows the distribution of the number of days between the beginning of the dataset and the final non-certifying test. Although a very small percentage of the I/M cycles (~0.11%), over 95% of those cycles are completed but are not certified within four months of the beginning of the dataset. Many of these I/M cycles may be a result of incomplete groupings. A final certifying test may exist in the dataset, but it can not be linked to previous tests. A recommendation is to accurately record not only VINs, but license plates in the VID.

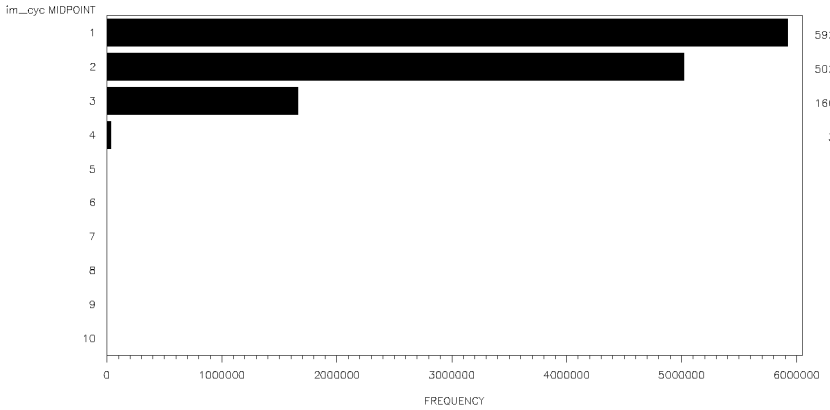
Figure A-3. Days to Certification for I/M Cycles Starting in First 90 Days of Dataset



For the third I/M cycle category, which represents completed I/M cycles with a true initial test and final certifying test, Figure A-4 shows that the initial test can be verified as a true initial 55% of the time because a previous certification occurred in the dataset. The other 45% of the initial I/M tests are assumed to be true because they occur more than 90-days into the dataset. Figure A-5 shows the distribution of the number of days in an I/M cycle, i.e., final date – initial date of an I/M cycle. 99% of these I/M cycles are completed with three to four weeks of the initial test. This shows that when vehicles start the I/M process, they are certifying their vehicles in a short time frame. There are cycles that last the length of the dataset (> 840 days), but these cases occur less than 0.5% of the time and most likely represent VINs not perfectly grouped together. Figure A-6 shows the number of days between certifying cycles when we had two or more I/M cycles per vehicle. Vehicles are not returning at exactly one year intervals, vehicles are taking any where from 11 to 18 months or more after their last certification to re-certify their vehicle.

Figure A-4. Counts of Multiple I/M Cycles

Title: Distribution of I/M cycle counts within Completed Cycles, where ccat=3



im_cyc MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
1	5922481	5922481	46.85	46.85
2	5021073	10943554	39.72	86.57
3	1662621	12606175	13.15	99.73
4	33372	12639547	0.26	99.99
5	1148	12640695	0.01	100.00
6	109	12640804	0.00	100.00
7	34	12640838	0.00	100.00
8	13	12640851	0.00	100.00
9	10	12640861	0.00	100.00
10	45	12640906	0.00	100.00

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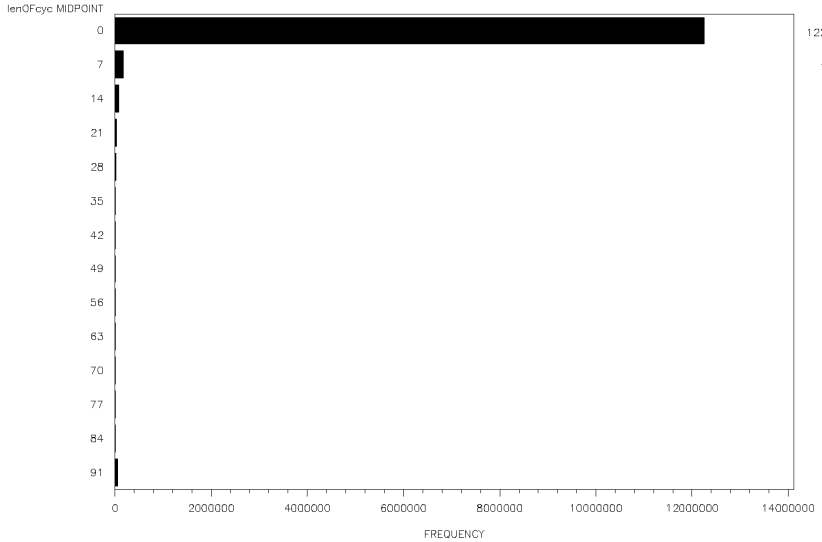
Figure A-5. Number of Days to Complete Certifying I/M Cycles

Title: Number of Days Between Initial and Final Test within Completed Cycles, where ccat=3



lenOFcyc MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	12249778	12249778	96.91	96.91
7	167751	12417529	1.33	98.23
14	81576	12499105	0.65	98.88
21	26677	12525782	0.21	99.09
28	16757	12542539	0.13	99.22
35	11215	12553754	0.09	99.31
42	8291	12562045	0.07	99.38
49	6319	12568364	0.05	99.43
56	5387	12573751	0.04	99.47
63	4478	12578229	0.04	99.50
70	3925	12582154	0.03	99.54
77	3373	12585527	0.03	99.56
84	2946	12588473	0.02	99.59
91	52433	12640906	0.41	100.00

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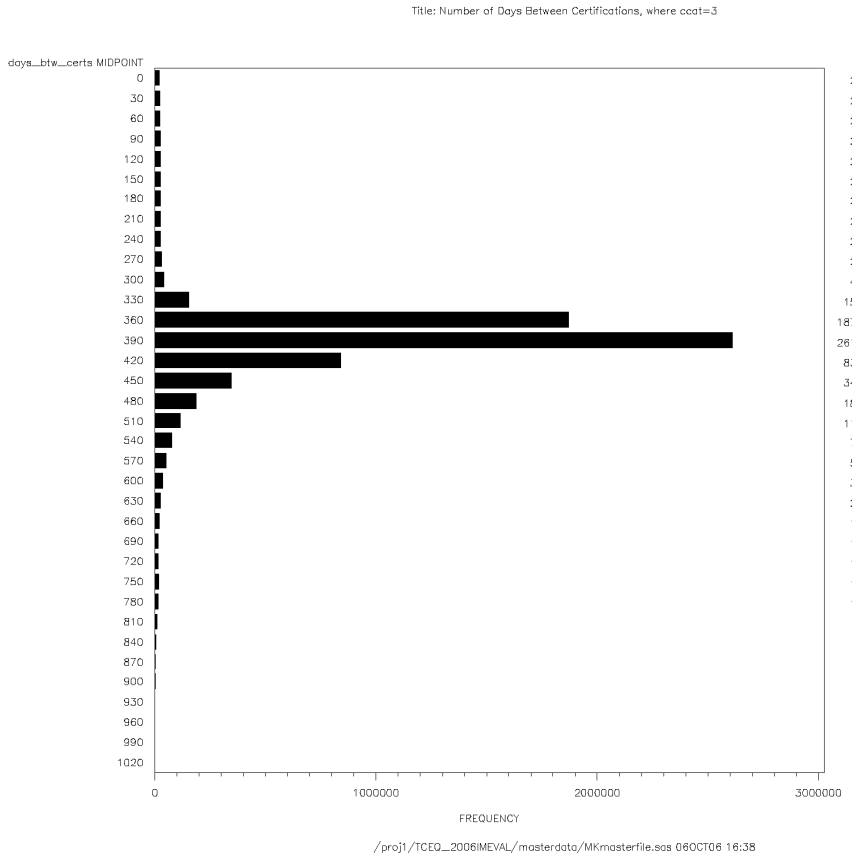
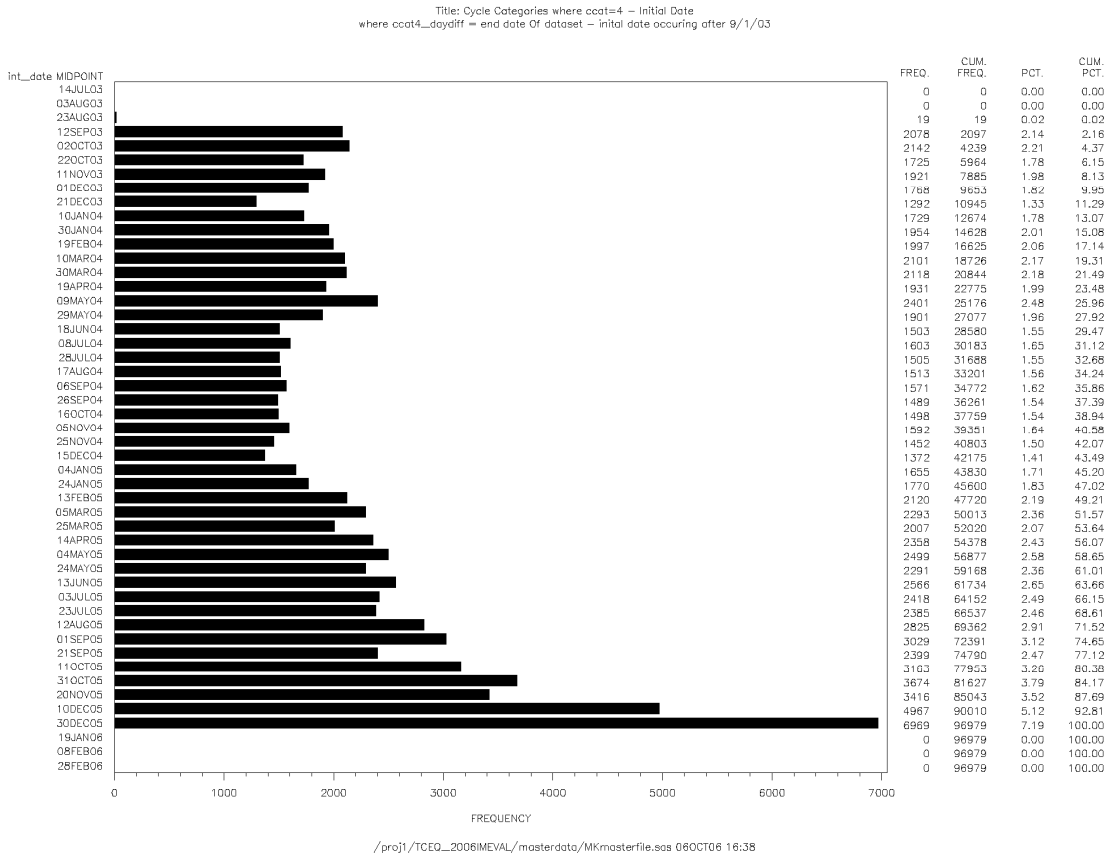
Figure A-6. Number of Days Between Certifications



FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
21130	21130	0.31	0.31
22729	43859	0.34	0.65
24108	67967	0.36	1.01
24935	92902	0.37	1.38
25467	118369	0.38	1.76
25366	143735	0.38	2.14
25302	169037	0.38	2.52
25748	194785	0.38	2.90
26239	221024	0.39	3.29
29368	250392	0.44	3.73
40432	290824	0.60	4.33
153717	444541	2.29	6.62
1871210	2315751	27.88	34.51
2611446	4927197	38.91	73.42
839999	5767196	12.52	85.93
346689	6113885	5.17	91.10
187145	6301030	2.79	93.89
114865	6415895	1.71	95.60
75852	6491747	1.13	96.73
51174	6542921	0.76	97.49
36400	6579321	0.54	98.03
26616	6605937	0.40	98.43
19372	6625309	0.29	98.72
15083	6640392	0.22	98.94
16000	6656392	0.24	99.18
17944	6674336	0.27	99.45
14853	6689189	0.22	99.67
9473	6698662	0.14	99.81
5758	6704420	0.09	99.90
3390	6707810	0.05	99.95
1988	6709798	0.03	99.98
1132	6710930	0.02	99.99
391	6711321	0.01	100.00
1	6711322	0.00	100.00
0	6711322	0.00	100.00

For the fourth I/M cycle category, where the initial test date is assumed to be a true initial test, but the final test in the dataset is not a certifying test, Figure A-7 shows as the initial date gets closer to the end of the dataset, there is an increase in the number of non-certifying “final” tests. Many of these cycles are probably completing at dates beyond the end of the dataset. Another recommendation for future I/M program evaluations is to incorporate several months of data after the two-year period of interest to better define I/M cycles. Since there is some lag between the end of a two-year period and the start of an I/M program evaluation, this recommendation could be easily implemented for future evaluations.

Figure A-7. Counts of Non-certifying I/M cycles



Vehicle Specific Power Calculation

The following formula was used to calculate the Vehicle Specific Power for RSD measurements.

VSP = 4.364 * sin(SLOPE) * SPEED +

0.22 * SPEED * ACCL +
0.0657 * SPEED +
0.0000270 * SPEED * SPEED * SPEED;

where SPEED is speed in units of miles/hour

ACCL is acceleration in units of miles/hour/second

SLOPE is slope in radians as required by SAS, however slope was originally provided by ESP in degrees.

Appendix B

OBD Communication Rates by Vehicle Model Code

Model Code	Series (Model)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model	% of overall tests by model
		Count	Percent	Count	Percent	Count	Percent		
N/A	Unlisted	2535	0.1555	1142	0.0700	1626629	99.7745	1630306	19.6307
0	Motorhome	25	**42.3729**	5	**8.4746**	29	49.1525	59	0.0007
10	Astro 2WD	3	0.5435	1	0.1812	548	99.2754	552	0.0066
11	Blazer 2WD	1	0.1143		0.0000	874	99.8857	875	0.0105
12	C1500 P/U 2WD	9	0.1917	11	0.2343	4675	99.5740	4695	0.0565
13	C2500 P/U 2WD	2	0.2469	30	**3.7037**	778	96.0494	810	0.0098
14	C3500 P/U 2WD	1	0.2331	24	**5.5944**	404	94.1725	429	0.0052
15	G1500 Van 2WD	1	0.3311		0.0000	301	99.6689	302	0.0036
16	G2500 Van 2WD	19	**1.4493**	45	**3.4325**	1247	95.1182	1311	0.0158
17	G3500 Van 2WD	129	**5.3683**	123	**5.1186**	2151	89.5131	2403	0.0289
19	Venture 2WD Ext	0	0.0000		0.0000	7	100.0000	7	0.0001
20	Motorhome	0	0.0000		0.0000	1	100.0000	1	0.0000
21	G3500 Van 2WD	34	**4.0621**	66	**7.8853**	737	88.0526	837	0.0101
22	Tahoe 2WD	5	0.2376	1	0.0475	2098	99.7148	2104	0.0253
23	C1500 Sub. 2WD	2	0.1022	3	0.1534	1951	99.7444	1956	0.0236
24	S Series P/U 2WD	1	0.1333	1	0.1333	748	99.7333	750	0.0090
40	Motorhome	69	**49.6403**	25	**17.986**	45	32.3741	139	0.0017
50	Twn & Ctry LX FW	1	0.1969		0.0000	507	99.8031	508	0.0061
90	Ram P/U 2WD	0	0.0000		0.0000	41	100.0000	41	0.0005
91	Caravan SE FWD	1	0.0819		0.0000	1220	99.9181	1221	0.0147
92	Ram Van/Wgn	0	0.0000		0.0000	8	100.0000	8	0.0001
93	Ram Van/Wgn	2	**1.0152**	1	0.5076	194	98.4772	197	0.0024
94	Ram Van/Wgn	1	**1.7857**	1	**1.7857**	54	96.4286	56	0.0007
95	Ram Van/Wgn	0	0.0000		0.0000	74	100.0000	74	0.0009
96	Ram Wgn Bus	1	**1.7241**	1	**1.7241**	56	96.5517	58	0.0007
97	Ram Van/Wgn	1	0.7092	1	0.7092	139	98.5816	141	0.0017
98	Ram P/U 2WD	0	0.0000		0.0000	4	100.0000	4	0.0000
99	Ram P/U 2WD	6	0.2630	4	0.1754	2271	99.5616	2281	0.0275
100	Ram P/U 2WD	8	**10.2564**	2	**2.5641**	68	87.1795	78	0.0009
101	Ram P/U 2WD	0	0.0000	5	**6.9444**	67	93.0556	72	0.0009

Model Code	Series (Model)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model	% of overall tests by model
		Count	Percent	Count	Percent	Count	Percent		
102	Ram P/U 2WD	9	**21.9512**	1	**2.4390**	31	75.6098	41	0.0005
103	Ram P/U 2WD	0	0.0000		0.0000	5	100.0000	5	0.0001
104	Dakota 2WD	0	0.0000	1	0.1592	627	99.8408	628	0.0076
105	Ram P/U 2WD	0	0.0000		0.0000	20	100.0000	20	0.0002
106	Ram P/U 2WD	0	0.0000	1	0.3521	283	99.6479	284	0.0034
107	Ram P/U 2WD	0	0.0000	1	**10.000**	9	90.0000	10	0.0001
108	Ram Wgn Bus	0	0.0000		0.0000	8	100.0000	8	0.0001
109	Ram P/U 2WD	2	**33.3333**		0.0000	4	66.6667	6	0.0001
110	Ram P/U 2WD	0	0.0000		0.0000	2	100.0000	2	0.0000
111		0	0.0000		0.0000	1	100.0000	1	0.0000
112	Durango 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
113	New Beetle	0	0.0000		0.0000	8	100.0000	8	0.0001
114	Ram P/U 2WD	57	**25.7919**	3	**1.3575**	161	72.8507	221	0.0027
116	Ram P/U 2WD	0	0.0000		0.0000	58	100.0000	58	0.0007
120	F RV	72	**69.9029**	8	**7.7670**	23	22.3301	103	0.0012
122	S80	0	0.0000		0.0000	11	100.0000	11	0.0001
130	F150 Spr Cb Style	0	0.0000		0.0000	7	100.0000	7	0.0001
131	F150 Spr Cb Style	31	0.4206	12	0.1628	7327	99.4166	7370	0.0887
132	F250 Spr Cab 2WD	4	0.9217	34	**7.8341**	396	91.2442	434	0.0052
133	F250 Spr Cab 2WD	839	**7.6245**	373	**3.3897**	9792	88.9858	11004	0.1325
134	F350 DRW Chassis Cab	6	**3.5294**	35	**20.588**	129	75.8824	170	0.0020
136	Windstar LX Wgn	0	0.0000		0.0000	5	100.0000	5	0.0001
138	E350 Extended Wgn	0	0.0000	3	**42.857**	4	57.1429	7	0.0001
140	E150 Cargo/Regular V	0	0.0000		0.0000	7	100.0000	7	0.0001
141	Explorer XLT 2WD	13	0.2957	5	0.1137	4379	99.5906	4397	0.0529
142	Ranger Supercab 2WD	2	0.1015	1	0.0507	1968	99.8478	1971	0.0237
143	Windstar LX Wgn	7	0.5291	7	0.5291	1309	98.9418	1323	0.0159
144	E150 Cargo/Regular V	1	0.2717	2	0.5435	365	99.1848	368	0.0044
145	E250 Cargo/Regular V	4	**1.4184**	24	**8.5106**	254	90.0709	282	0.0034
146	E350 Extended Wgn	0	0.0000	26	**7.5362**	319	92.4638	345	0.0042

Model Code	Series (Model)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model	% of overall tests by model
		Count	Percent	Count	Percent	Count	Percent		
147	Explorer RHD (US Pos	0	0.0000		0.0000	44	100.0000	44	0.0005
15	C1500 P/U 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
16	G2500 Van 2WD	16	**5.3333**		0.0000	284	94.6667	300	0.0036
17	G3500 Van 2WD	92	**13.1617**	2	0.2861	605	86.5522	699	0.0084
172	Jimmy 2WD	0	0.0000		0.0000	6	100.0000	6	0.0001
174	Safari 2WD	0	0.0000		0.0000	9	100.0000	9	0.0001
175	Sierra 1500 P/U 4	0	0.0000		0.0000	200	100.0000	200	0.0024
176	Sonoma P/U 2WD	0	0.0000		0.0000	5	100.0000	5	0.0001
179	Yukon 4WD	0	0.0000		0.0000	7	100.0000	7	0.0001
180	Sierra 2500 P/U 2	87	**1.6808**	89	**1.7195**	5000	96.5997	5176	0.0623
181	Sierra 3500 P/U 2	58	**4.9743**	23	**1.9726**	1085	93.0532	1166	0.0140
182	3500 Van 2WD	78	**12.7243**	18	**2.9364**	517	84.3393	613	0.0074
183	Savanna 1500 2WD	71	**47.0199**		0.0000	80	52.9801	151	0.0018
184	Savanna 2500 2WD	15	**2.9297**	10	**1.9531**	487	95.1172	512	0.0062
185	Savanna 3500 2WD	80	**8.3420**	45	**4.6924**	834	86.9656	959	0.0115
190	190E	0	0.0000		0.0000	1	100.0000	1	0.0000
2	540i	0	0.0000		0.0000	1	100.0000	1	0.0000
200	Sentra / 200SX	98	**1.4721**	31	0.4657	6528	98.0622	6657	0.0802
206		0	0.0000		0.0000	1	100.0000	1	0.0000
21	G3500 Van 2WD	81	**15.7282**		0.0000	434	84.2718	515	0.0062
210	Odyssey	0	0.0000		0.0000	792	100.0000	792	0.0095
211	Passport 2WD	1	0.5525		0.0000	180	99.4475	181	0.0022
220	C220	0	0.0000		0.0000	8	100.0000	8	0.0001
228	Eclipse Spyder	0	0.0000		0.0000	1	100.0000	1	0.0000
22C	CL	0	0.0000		0.0000	767	100.0000	767	0.0092
230	SLK230	0	0.0000		0.0000	1404	100.0000	1404	0.0169
231	Truck Regular Bed	7	0.1545		0.0000	4525	99.8455	4532	0.0546
232	Amigo/Rodeo 2WD	0	0.0000		0.0000	36	100.0000	36	0.0004
233	Trooper 4WD	0	0.0000		0.0000	10	100.0000	10	0.0001
234		89	**18.6975**	13	**2.7311**	374	78.5714	476	0.0057

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236	Sonoma P/U 2WD	0	0.0000		0.0000	4	100.0000	4	0.0000
23C	CL	0	0.0000		0.0000	984	100.0000	984	0.0118
240	240SX	4	0.2926	2	0.1463	1361	99.5611	1367	0.0165
24l	XK8 / XKR	0	0.0000		0.0000	2	100.0000	2	0.0000
250	ES300	0	0.0000		0.0000	10	100.0000	10	0.0001
251	Wrangler 4WD	0	0.0000		0.0000	1	100.0000	1	0.0000
253	Twn & Cntry AWD	8	0.2434		0.0000	3279	99.7566	3287	0.0396
254	Grnd Cher 2WD	25	0.0555	6	0.0133	45004	99.9312	45035	0.5423
255	Comanche P/U 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
257	Wrangler 4WD	0	0.0000		0.0000	3	100.0000	3	0.0000
258	Liberty Sport 4WD	0	0.0000		0.0000	1	100.0000	1	0.0000
25T	TL	6	0.4699		0.0000	1271	99.5301	1277	0.0154
260	S60	2	**22.2222**	3	**33.333**	4	44.4444	9	0.0001
262	Grnd Cher. 2WD	0	0.0000	2	**40.000**	3	60.0000	5	0.0001
264	Wrangler 4WD	0	0.0000		0.0000	16	100.0000	16	0.0002
265	Wrangler 4WD	6	0.0931		0.0000	6437	99.9069	6443	0.0776
266	Wrangler 4WD	0	0.0000		0.0000	363	100.0000	363	0.0044
267	Grand Cherokee 2WD	0	0.0000		0.0000	52	100.0000	52	0.0006
268	Wrangler 4WD	0	0.0000		0.0000	15	100.0000	15	0.0002
269	Wrangler 4WD	0	0.0000		0.0000	1	100.0000	1	0.0000
28	323i	0	0.0000		0.0000	16	100.0000	16	0.0002
280	C280	57	**47.8992**		0.0000	62	52.1008	119	0.0014
281	Mustang GT	0	0.0000		0.0000	1	100.0000	1	0.0000
28i	328i	0	0.0000		0.0000	216	100.0000	216	0.0026
290	Sportage	0	0.0000		0.0000	10	100.0000	10	0.0001
2P2	Firebird	0	0.0000		0.0000	7	100.0000	7	0.0001
300	ES300	32	0.0523	1	0.0016	61137	99.9461	61170	0.7366
305	Navigator 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
308	456 GTA (Auto)	0	0.0000		0.0000	1	100.0000	1	0.0000
30C	CL	0	0.0000		0.0000	1201	100.0000	1201	0.0145

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310	Defender	25	**52.0833**		0.0000	23	47.9167	48	0.0006
312	Discovery Series II;	0	0.0000		0.0000	130	100.0000	130	0.0016
313	Range Rover Cls E	0	0.0000		0.0000	24	100.0000	24	0.0003
318	318i	0	0.0000		0.0000	61	100.0000	61	0.0007
320	S320	200	**9.0580**	79	**3.5779**	1929	87.3641	2208	0.0266
322	B-Series Reg Cab	0	0.0000		0.0000	1	100.0000	1	0.0000
323	323i	0	0.0000		0.0000	72	100.0000	72	0.0009
324	B-Series Reg Cab	0	0.0000		0.0000	24	100.0000	24	0.0003
325	325i	0	0.0000		0.0000	71	100.0000	71	0.0009
327	B-Series Spr Cab 2	0	0.0000		0.0000	75	100.0000	75	0.0009
328	B-Series Spr Cab 2	0	0.0000		0.0000	37	100.0000	37	0.0004
329	MPV 4dr Wgn	0	0.0000		0.0000	187	100.0000	187	0.0023
32T	TL	7	0.0630		0.0000	11111	99.9370	11118	0.1339
32i	325i	0	0.0000		0.0000	177	100.0000	177	0.0021
330	Intrepid	0	0.0000		0.0000	5	100.0000	5	0.0001
332	Tribute LX 2WD	0	0.0000		0.0000	15	100.0000	15	0.0002
340	3500 Van 2WD	9	**16.6667**	4	**7.4074**	41	75.9259	54	0.0007
34l	S-Type	0	0.0000		0.0000	4	100.0000	4	0.0000
350	E320W	0	0.0000		0.0000	1	100.0000	1	0.0000
356	911 Carrera	0	0.0000		0.0000	1	100.0000	1	0.0000
35R	RL	3	0.0882		0.0000	3398	99.9118	3401	0.0410
360	F RV	99	**37.6426**	14	**5.3232**	150	57.0342	263	0.0032
365	Mountaineer 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
370	Mountaineer 2WD	0	0.0000		0.0000	3	100.0000	3	0.0000
371	Villager Wgn	0	0.0000		0.0000	163	100.0000	163	0.0020
380	Motorhome	109	**51.6588**	14	**6.6351**	88	41.7062	211	0.0025
381	Montero Sport 2WD	1	0.0898	1	0.0898	1112	99.8205	1114	0.0134
390	Pathfinder	0	0.0000		0.0000	670	100.0000	670	0.0081
391	Quest	1	0.3322		0.0000	300	99.6678	301	0.0036
392	P/U Crew Cab	0	0.0000		0.0000	203	100.0000	203	0.0024

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393	Xterra	0	0.0000		0.0000	34	100.0000	34	0.0004
394	Xterra	0	0.0000	1	0.1957	510	99.8043	511	0.0062
3GT	3000 GT	5	0.3425	2	0.1370	1453	99.5205	1460	0.0176
3TI	318ti	0	0.0000		0.0000	29	100.0000	29	0.0003
400	LS400	15	0.1249	4	0.0333	11990	99.8418	12009	0.1446
410	Bravada 4WD	0	0.0000		0.0000	47	100.0000	47	0.0006
411	Silhouette 2WD	0	0.0000		0.0000	124	100.0000	124	0.0015
420	S420	1	0.1587		0.0000	629	99.8413	630	0.0076
422	Voyager FWD	0	0.0000		0.0000	257	100.0000	257	0.0031
42l	S-Type	0	0.0000		0.0000	9	100.0000	9	0.0001
430	S430V	0	0.0000		0.0000	44	100.0000	44	0.0005
440	F RV	106	**71.1409**	5	**3.3557**	38	25.5034	149	0.0018
442	Alero GL	0	0.0000		0.0000	6	100.0000	6	0.0001
450	E430W	0	0.0000		0.0000	2	100.0000	2	0.0000
451	Grand Vitara XL7 4WD	0	0.0000		0.0000	2	100.0000	2	0.0000
452	Grand Vitara XL7 4WD	0	0.0000		0.0000	3	100.0000	3	0.0000
453	Vitara / Grand Vitara	0	0.0000		0.0000	2	100.0000	2	0.0000
456	456 GTA (Auto)	0	0.0000		0.0000	12	100.0000	12	0.0001
460	4Runner SR5	1	0.0667		0.0000	1498	99.9333	1499	0.0180
461	Highlander	0	0.0000		0.0000	30	100.0000	30	0.0004
462	Land Cruiser	0	0.0000		0.0000	233	100.0000	233	0.0028
463	Sienna	0	0.0000		0.0000	4	100.0000	4	0.0000
464	RAV4	0	0.0000		0.0000	635	100.0000	635	0.0076
465	Tundra SR5	0	0.0000		0.0000	14	100.0000	14	0.0002
466	Tacoma Deluxe	0	0.0000		0.0000	1327	100.0000	1327	0.0160
467	Tacoma Deluxe	0	0.0000		0.0000	2	100.0000	2	0.0000
468	Tundra SR5	0	0.0000		0.0000	313	100.0000	313	0.0038
469	Tundra SR5	9	**32.1429**		0.0000	19	67.8571	28	0.0003
470	Tundra SR5	10	**34.4828**	1	**3.4483**	18	62.0690	29	0.0003
471	Sienna	0	0.0000		0.0000	41	100.0000	41	0.0005

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472	Sienna	0	0.0000		0.0000	3	100.0000	3	0.0000
473	Sienna	0	0.0000		0.0000	2	100.0000	2	0.0000
475	Sienna	0	0.0000		0.0000	10	100.0000	10	0.0001
480	F RV	19	**28.7879**	11	**16.667**	36	54.5455	66	0.0008
490	Multi-Van Weekender	0	0.0000		0.0000	3	100.0000	3	0.0000
4RN	4Runner 2WD	14	0.0371		0.0000	37736	99.9629	37750	0.4546
500	528i	10	0.0924		0.0000	10818	99.9076	10828	0.1304
520		0	0.0000		0.0000	2	100.0000	2	0.0000
525	525iA	34	**43.5897**		0.0000	44	56.4103	78	0.0009
528	528i	0	0.0000		0.0000	282	100.0000	282	0.0034
530	530iA	0	0.0000		0.0000	66	100.0000	66	0.0008
540	540i	44	**35.4839**	4	**3.2258**	76	61.2903	124	0.0015
54i	540i	0	0.0000		0.0000	51	100.0000	51	0.0006
550	550 Maranello	12	**7.1429**	4	2.3810	152	90.4762	168	0.0020
560	F RV	4	**66.6667**		0.0000	2	33.3333	6	0.0001
580	Motorhome	421	**48.2798**	66	**7.5688**	385	44.1514	872	0.0105
581	E350 Cargo Van	0	**0.0000**		0.0000	1	100.0000	1	0.0000
5iA	540i	0	0.0000		0.0000	8	100.0000	8	0.0001
60	DeVille	0	0.0000		0.0000	9	100.0000	9	0.0001
600	CL55AMG	1	0.3215		0.0000	310	99.6785	311	0.0037
616	626	0	0.0000		0.0000	2	100.0000	2	0.0000
626	626	45	0.1076	5	0.0120	41776	99.8805	41826	0.5036
640	K1500 Suburban 4WD	0	0.0000		0.0000	1	100.0000	1	0.0000
660	F RV	38	**57.5758**	9	**13.636**	19	28.7879	66	0.0008
7	S500	0	0.0000		0.0000	22	100.0000	22	0.0003
700	740iL (Auto)	9	0.2347		0.0000	3825	99.7653	3834	0.0462
720	F RV	2	**66.6667**		0.0000	1	33.3333	3	0.0000
735		0	0.0000		0.0000	2	100.0000	2	0.0000
740	740iL (Auto)	0	0.0000		0.0000	16	100.0000	16	0.0002
745	745i	0	0.0000		0.0000	14	100.0000	14	0.0002

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74i	740iL (Auto)	0	0.0000		0.0000	54	100.0000	54	0.0007
750		0	0.0000		0.0000	1	100.0000	1	0.0000
75l	750iL (Auto)	0	0.0000		0.0000	1	100.0000	1	0.0000
780	S70 / V70	0	0.0000		0.0000	1	100.0000	1	0.0000
7LR	Focus LX	0	0.0000		0.0000	1	100.0000	1	0.0000
800	840Ci	0	0.0000		0.0000	42	100.0000	42	0.0005
820	3500 Van 2WD	16	**5.3512**	73	**24.415**	210	70.2341	299	0.0036
830	Motorhome	22	**6.1972**	25	7.0423	308	86.7606	355	0.0043
840	Ram Wgn Bus	0	0.0000	14	**35.000**	26	65.0000	40	0.0005
84c		0	0.0000		0.0000	1	100.0000	1	0.0000
850	850	25	0.6159	95	2.3405	3939	97.0436	4059	0.0489
85F	850	2	0.1661		0.0000	1202	99.8339	1204	0.0145
860		76	**69.7248**	19	**17.431**	14	12.8440	109	0.0013
88	Delta 88	0	0.0000		0.0000	2121	100.0000	2121	0.0255
900	900SE / 900CSE	2	0.2068		0.0000	965	99.7932	967	0.0116
90A	9000S / 9000CD / 900	1	0.7937		0.0000	125	99.2063	126	0.0015
911	911 Carrera	0	0.0000		0.0000	315	100.0000	315	0.0038
92	3-Sep	0	0.0000		0.0000	1	100.0000	1	0.0000
928	928	0	N/A		N/A		N/A	0	0.0000
929	929	4	**50.0000**		0.0000	4	50.0000	8	0.0001
93	3-Sep	0	0.0000		0.0000	10	100.0000	10	0.0001
930	Mustang	0	0.0000		0.0000	2	100.0000	2	0.0000
94	Ram P/U 2WD	58	0.0957	13	0.0215	60516	99.8828	60587	0.7295
940	Motorhome	8	**30.7692**	2	**7.6923**	16	61.5385	26	0.0003
95	5-Sep	0	0.0000		0.0000	13	100.0000	13	0.0002
96	Ram P/U	19	**4.6914**	7	**1.7284**	379	93.5802	405	0.0049
960	960	13	0.6109		0.0000	2115	99.3891	2128	0.0256
970	Motorhome	5	**41.6667**		0.0000	7	58.3333	12	0.0001
98	98 Regency Elite	0	0.0000		0.0000	325	100.0000	325	0.0039
980	3500 Van 2WD	0	0.0000		0.0000	25	100.0000	25	0.0003

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994		0	0.0000		0.0000	1	100.0000	1	0.0000
A+K	CL	0	0.0000		0.0000	376	100.0000	376	0.0045
A80	A4/S4	0	0.0000		0.0000	6	100.0000	6	0.0001
AA4	A4	9	0.1952		0.0000	4602	99.8048	4611	0.0555
AA6	A6	0	0.0000		0.0000	1430	100.0000	1430	0.0172
AA8	A8	0	0.0000		0.0000	228	100.0000	228	0.0027
ACC	Accord	204	0.1092	12	0.0064	186640	99.8844	186856	2.2500
ACL	CL	0	0.0000		0.0000	820	100.0000	820	0.0099
ACV	Achieva SL/SC	4	0.0954	1	0.0238	4189	99.8808	4194	0.0505
AER	Aerostar XLT Wgn	7	0.1636	2	0.0467	4271	99.7897	4280	0.0515
ALO	Alero GL	4	0.0227	1	0.0057	17651	99.9717	17656	0.2126
ALT	Altima	111	0.1577	12	0.0170	70278	99.8253	70401	0.8477
AMG	Amigo/Rodeo 2WD	1	0.0799		0.0000	1250	99.9201	1251	0.0151
APO	LeSabre Custom	0	0.0000		0.0000	5	100.0000	5	0.0001
ARI	Intrepid	0	0.0000		0.0000	1	100.0000	1	0.0000
ARL	RL	0	0.0000		0.0000	18	100.0000	18	0.0002
ARN	Arnage Red Label	0	0.0000		0.0000	104	100.0000	104	0.0013
AS4	A4/S4	0	0.0000		0.0000	433	100.0000	433	0.0052
AS6	A6	0	0.0000		0.0000	1	100.0000	1	0.0000
ASP	Aspire	6	0.2354	3	0.1177	2540	99.6469	2549	0.0307
AST	Astro 2WD	20	0.1181	6	0.0354	16908	99.8465	16934	0.2039
ATL	TL	0	0.0000		0.0000	119	100.0000	119	0.0014
AUR	Aurora	11	0.2011		0.0000	5458	99.7989	5469	0.0659
AVA	Avalon	13	0.0294		0.0000	44246	99.9706	44259	0.5329
AVE	Sephia/Spectra	0	0.0000		0.0000	3	100.0000	3	0.0000
AVN	Avenger	8	0.1375	2	0.0344	5808	99.8281	5818	0.0701
AXX	Maxima	0	0.0000		0.0000	1	100.0000	1	0.0000
AZU	Azure	0	0.0000		0.0000	14	100.0000	14	0.0002
B22	B-Series Super Cab 2	0	0.0000		0.0000	1	100.0000	1	0.0000
B23	P/U (not Cab Plus	1	0.0952		0.0000	1049	99.9048	1050	0.0126

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B25	Truck - 2 Air bags	0	0.0000		0.0000	47	100.0000	47	0.0006
B26	Truck - 2 Air bags	0	0.0000		0.0000	1	100.0000	1	0.0000
B30	P/U (not Cab Plus	0	0.0000		0.0000	145	100.0000	145	0.0017
B40	P/U (not Cab Plus	0	0.0000		0.0000	314	100.0000	314	0.0038
BEE	New Beetle	5	0.0685		0.0000	7293	99.9315	7298	0.0879
BER	Beretta	1	0.0763		0.0000	1309	99.9237	1310	0.0158
BLZ	S10 Blazer 2WD	44	0.1087	12	0.0296	40423	99.8617	40479	0.4874
BON	Bonneville SE	9	0.0832	2	0.0185	10808	99.8983	10819	0.1303
BOX	986 Boxster	5	0.1243		0.0000	4019	99.8757	4024	0.0485
BRO	Bronco 4WD	3	0.3750		0.0000	797	99.6250	800	0.0096
BRZ	Breeze	14	0.1590	1	0.0114	8789	99.8296	8804	0.1060
BUG	New Beetle	2	0.3273		0.0000	609	99.6727	611	0.0074
BVD	Bravada 4WD	2	0.0920		0.0000	2171	99.9080	2173	0.0262
C10	Tahoe 2WD	10	**1.8727**	23	**4.3071**	501	93.8202	534	0.0064
C15	C1500 P/U 2WD	127	0.0684	35	0.0188	185602	99.9128	185764	2.2368
C22	C220	6	0.5803		0.0000	1028	99.4197	1034	0.0125
C23	C230	3	0.0522		0.0000	5739	99.9478	5742	0.0691
C25	C2500 P/U 2WD	660	**1.8610**	791	**2.2304**	34014	95.9086	35465	0.4270
C28	C280	1	0.0250		0.0000	3995	99.9750	3996	0.0481
C35	C3500 P/U 2WD	598	**3.9976**	460	**3.0751**	13901	92.9273	14959	0.1801
C36	C36 AMG	0	0.0000		0.0000	20	100.0000	20	0.0002
C43		0	0.0000		0.0000	36	100.0000	36	0.0004
C70	C70	0	0.0000		0.0000	1292	100.0000	1292	0.0156
CAB	Cabrio Convertible	5	0.1646	1	0.0329	3032	99.8025	3038	0.0366
CAL	Cutlass Cierra SL	0	0.0000		0.0000	2	100.0000	2	0.0000
CAM	Camry	100	0.0443	11	0.0049	225392	99.9508	225503	2.7153
CAP	Caprice Classic	3	0.1637		0.0000	1830	99.8363	1833	0.0221
CAR	911 Carrera	3	0.2918		0.0000	1025	99.7082	1028	0.0124
CAT	Catera	1	0.0166		0.0000	6018	99.9834	6019	0.0725
CAV	Cavalier	100	0.1144	9	0.0103	87327	99.8753	87436	1.0528

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CCR	Grand Marquis GS	0	0.0000		0.0000	2	100.0000	2	0.0000
CEL	Corsica	0	0.0000		0.0000	4	100.0000	4	0.0000
CEN	Century Custom	13	0.0455	1	0.0035	28535	99.9510	28549	0.3438
CH2	Cavalier	0	0.0000		0.0000	2	100.0000	2	0.0000
CHA		0	0.0000		0.0000	3	100.0000	3	0.0000
CHK	Town & Country AWD	0	0.0000		0.0000	199	100.0000	199	0.0024
CI1	Civic del Sol	0	0.0000		0.0000	544	100.0000	544	0.0066
CIE	Cutlass Cierra SL	3	0.1830		0.0000	1636	99.8170	1639	0.0197
CIM	Cimarron	0	N/A		N/A		N/A	0	0.0000
CIR	Cirrus LX/LXi	12	0.1612	2	0.0269	7429	99.8119	7443	0.0896
CIV	Civic	70	0.0512	14	0.0102	136586	99.9385	136670	1.6457
CL3	CLK320	4	0.2189		0.0000	1823	99.7811	1827	0.0220
CL4	CLK430	1	0.0503		0.0000	1988	99.9497	1989	0.0239
CL5	CL500	1	0.2667		0.0000	374	99.7333	375	0.0045
CL6	CL600	0	0.0000		0.0000	50	100.0000	50	0.0006
CLT	Acclaim LE/LX	0	0.0000		0.0000	2	100.0000	2	0.0000
CNC	Concorde LX/LXi	19	0.1291		0.0000	14698	99.8709	14717	0.1772
CNT	Contour LX/SE	32	0.0988	7	0.0216	32348	99.8796	32387	0.3900
CO1		0	0.0000		0.0000	6	100.0000	6	0.0001
COA	Corolla	72	0.0682	6	0.0057	105463	99.9261	105541	1.2708
COB	Mustang Cobra GT	22	**44.8980**		0.0000	27	55.1020	49	0.0006
COL	Cougar XR7	0	0.0000		0.0000	1	100.0000	1	0.0000
CON	Continental	8	0.0962	2	0.0241	8305	99.8797	8315	0.1001
COQ	LTD Crown Vic	0	0.0000		0.0000	1	100.0000	1	0.0000
COR	Corolla	0	0.0000		0.0000	15	100.0000	15	0.0002
COU	Cougar	30	0.1731	5	0.0289	17295	99.7980	17330	0.2087
CRE	Solara	0	0.0000		0.0000	29	100.0000	29	0.0003
CRL	Breeze	0	0.0000		0.0000	1	100.0000	1	0.0000
CRS	Corsica	4	0.0795	5	0.0994	5023	99.8211	5032	0.0606
CRV	CR-V	3	0.0186		0.0000	16164	99.9814	16167	0.1947

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CST	Celica	10	0.1065		0.0000	9379	99.8935	9389	0.1131
CU1	Cutlass Sup SL	36	**50.7042**	1	**1.4085**	34	47.8873	71	0.0009
CUS	LS	0	0.0000		0.0000	6	100.0000	6	0.0001
CUT	Cutlass GL	5	0.0663	1	0.0133	7532	99.9204	7538	0.0908
CVC	LTD Crown Vic	24	0.0761	7	0.0222	31487	99.9016	31518	0.3795
CVN	Caravan	30	0.0811	8	0.0216	36966	99.8973	37004	0.4456
CVR	Corvette	0	0.0000		0.0000	11	100.0000	11	0.0001
CVT	Corvette	2	0.0131		0.0000	15302	99.9869	15304	0.1843
CW1	E350 Super Wgn	106	**40.6130**	12	**4.5977**	143	54.7893	261	0.0031
CW2	E350 Super Wgn	253	**8.9685**	135	**4.7855**	2433	86.2460	2821	0.0340
CW3	E350 Super Wgn	141	**7.1248**	164	**8.2870**	1674	84.5882	1979	0.0238
DAK	Dakota 2WD	21	0.1141	2	0.0109	18383	99.8750	18406	0.2216
DB6		0	0.0000		0.0000	1	100.0000	1	0.0000
DB7		0	0.0000		0.0000	7	100.0000	7	0.0001
DEF	Defender	0	0.0000		0.0000	45	100.0000	45	0.0005
DEN	Yukon 4WD Luxury	5	**1.6949**		0.0000	290	98.3051	295	0.0036
DEV	DeVille	20	0.0440	2	0.0044	45448	99.9516	45470	0.5475
DIA	Diamante	11	0.1892	1	0.0172	5802	99.7936	5814	0.0700
DIS	Discovery Series II;	6	0.1279		0.0000	4686	99.8721	4692	0.0565
DL	S60	0	0.0000		0.0000	1	100.0000	1	0.0000
DL1	Delta 88LSS	0	0.0000		0.0000	4	100.0000	4	0.0000
DLM	Delta 88	0	0.0000		0.0000	2	100.0000	2	0.0000
DLT	Delta 88/88LS	2	0.1232		0.0000	1622	99.8768	1624	0.0196
DUR	Durango 2WD	9	0.0520		0.0000	17302	99.9480	17311	0.2084
DYN	Delta 88/88LS	0	0.0000		0.0000	4	100.0000	4	0.0000
E30	E300	1	**6.6667**		0.0000	14	93.3333	15	0.0002
E32	E320	18	0.1214		0.0000	14807	99.8786	14825	0.1785
E42	E420	1	0.0591		0.0000	1691	99.9409	1692	0.0204
E43	E430W	2	0.1604		0.0000	1245	99.8396	1247	0.0150
E55	E55AMG	0	0.0000		0.0000	66	100.0000	66	0.0008

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EC1	E150 Cargo Van	7	**1.8667**	3	0.8000	365	97.3333	375	0.0045
EC2	E250 Cargo/Regular V	249	**3.0029**	268	**3.2320**	7775	93.7651	8292	0.0998
EC3	E350 Extended Wgn	291	**4.0682**	395	**5.5222**	6467	90.4096	7153	0.0861
ECH	Echo	0	0.0000		0.0000	3076	100.0000	3076	0.0370
ECL	Eclipse	34	0.1304	6	0.0230	26028	99.8466	26068	0.3139
ECO	E150 Cargo Van	0	0.0000		0.0000	19	100.0000	19	0.0002
ELA	LS400	0	0.0000		0.0000	1	100.0000	1	0.0000
ELD	Eldorado	5	0.0891		0.0000	5605	99.9109	5610	0.0676
ELE	Park Avenue	0	0.0000		0.0000	240	100.0000	240	0.0029
ELL	C1500 P/U 2WD	0	0.0000		0.0000	3	100.0000	3	0.0000
ELN	Elantra	48	0.2356	1	0.0049	20327	99.7595	20376	0.2454
ENV	Jimmy/Envoy 2WD	0	0.0000		0.0000	948	100.0000	948	0.0114
EPD	Expedition	98	0.0772	47	0.0370	126775	99.8858	126920	1.5283
ES1	Esteem	1	0.1198		0.0000	834	99.8802	835	0.0101
ESC	Escort SE	50	0.0729	9	0.0131	68541	99.9140	68600	0.8260
ESP	Esprit V-8	0	0.0000		0.0000	28	100.0000	28	0.0003
EST	Esteem	0	0.0000		0.0000	1092	100.0000	1092	0.0131
EUR	Eurovan GLS	50	**24.1546**		0.0000	157	75.8454	207	0.0025
EV1	SL2 / SW2	0	0.0000		0.0000	4	100.0000	4	0.0000
EVE	Corvette	0	0.0000		0.0000	26	100.0000	26	0.0003
EXC	Excursion Limited 2W	50	**1.0487**	119	**2.4958**	4599	96.4555	4768	0.0574
EXE	PT Cruiser LHD	0	0.0000		0.0000	1	100.0000	1	0.0000
EXP	Explorer XL	1	**1.0309**	1	**1.0309**	95	97.9381	97	0.0012
F10	F150 Super Cab Style	72	**20.6304**	3	0.8596	274	78.5100	349	0.0042
F15	F150 Super Cab Style	201	0.1431	53	0.0377	140216	99.8192	140470	1.6914
F25	F250 Regular Cab Sty	3670	**21.3571**	866	**5.0396**	12648	73.6034	17184	0.2069
F35	F350 DRW Chassis Cab	1301	**24.5982**	343	**6.4852**	3645	68.9166	5289	0.0637
F45		168	**25.8462**	35	**5.3846**	447	68.7692	650	0.0078
F55		17	**12.1429**	11	**7.8571**	112	80.0000	140	0.0017
F65	F700 (Gas)	41	**82.0000**	5	**10.000**	4	8.0000	50	0.0006

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FAI	Focus SE	0	0.0000		0.0000	1	100.0000	1	0.0000
FAL	Focus LX	0	0.0000		0.0000	1	100.0000	1	0.0000
FAV	Avenger Sport	0	0.0000		0.0000	1	100.0000	1	0.0000
FB1	Formula / Trans Am	0	0.0000		0.0000	20	100.0000	20	0.0002
FBD	Firebird	14	0.0766	3	0.0164	18253	99.9070	18270	0.2200
FES		0	0.0000		0.0000	1	100.0000	1	0.0000
FI1	Focus SE	0	0.0000		0.0000	1	100.0000	1	0.0000
FIE	Formula / Trans Am	0	0.0000		0.0000	1	100.0000	1	0.0000
FLE	Fleetwood	629	**47.8327**		0.0000	686	52.1673	1315	0.0158
FOC	Focus SE	6	0.1699		0.0000	3525	99.8301	3531	0.0425
FOR	Forester	0	0.0000		0.0000	926	100.0000	926	0.0112
FRE	Freelander Class C	0	0.0000	25	**50.000**	25	50.0000	50	0.0006
FRO	Focus LX	0	0.0000		0.0000	1	100.0000	1	0.0000
FRT	P/U King Cab	8	0.0399	2	0.0100	20017	99.9501	20027	0.2411
FUT	Focus SE	0	0.0000		0.0000	2	100.0000	2	0.0000
G15	G1500 Van 2WD	2	0.2869		0.0000	695	99.7131	697	0.0084
G20	G20	21	0.4110	1	0.0196	5088	99.5695	5110	0.0615
G25	G2500 Van 2WD	1	0.4292		0.0000	232	99.5708	233	0.0028
G35	G3500 Van 2WD	3	**1.2605**	5	**2.1008**	230	96.6387	238	0.0029
G40	Regal Gran Sport	0	0.0000		0.0000	1	100.0000	1	0.0000
GAL	Galant	54	0.1353	11	0.0276	39859	99.8372	39924	0.4807
GCK	Grand Cherokee 2WD	4	0.0259		0.0000	15421	99.9741	15425	0.1857
GLE	S40 / V40	0	0.0000		0.0000	1	100.0000	1	0.0000
GLT	850	0	0.0000		0.0000	7	100.0000	7	0.0001
GOL	Golf / GTI / Jetta	7	0.2229	1	0.0318	3132	99.7452	3140	0.0378
GRA	Grand Prix SE	17	0.0497	3	0.0088	34190	99.9415	34210	0.4119
GRD	Grand Am SE	0	0.0000		0.0000	1	100.0000	1	0.0000
GRM	Grand Am SE	27	0.0470	8	0.0139	57404	99.9391	57439	0.6916
GS	Riviera	0	0.0000		0.0000	1	100.0000	1	0.0000
GS3	GS300	2	0.0160		0.0000	12504	99.9840	12506	0.1506

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GS4	GS400	0	0.0000		0.0000	2512	100.0000	2512	0.0302
GTI	Golf / GTI / Jetta	5	0.2149	1	0.0430	2321	99.7422	2327	0.0280
GTO		0	0.0000		0.0000	18	100.0000	18	0.0002
GVT	Vitara / Grand Vitar	1	0.0873		0.0000	1145	99.9127	1146	0.0138
HEA		0	0.0000		0.0000	4	100.0000	4	0.0000
HOM	Sonoma P/U 2WD	1	0.0580		0.0000	1724	99.9420	1725	0.0208
HUM		17	**2.1118**	18	**2.2360**	770	95.6522	805	0.0097
I30	I30	24	0.1395	3	0.0174	17179	99.8431	17206	0.2072
IMP	Impala	13	0.0372	1	0.0029	34946	99.9600	34960	0.4210
INT	Intrepid	68	0.1169	9	0.0155	58071	99.8676	58148	0.7002
J10	Wrangler 4WD	0	0.0000		0.0000	9	100.0000	9	0.0001
J12	XJ12	0	0.0000		0.0000	26	100.0000	26	0.0003
J20	Wrangler 4WD	0	0.0000		0.0000	10	100.0000	10	0.0001
J30	J30	8	0.2572		0.0000	3103	99.7428	3111	0.0375
JAV	Impreza	0	0.0000		0.0000	1	100.0000	1	0.0000
JET	Jetta	45	0.1457	4	0.0130	30826	99.8413	30875	0.3718
JMY	Jimmy 2WD	7	0.1038	1	0.0148	6738	99.8814	6746	0.0812
L45	LX450	0	0.0000		0.0000	722	100.0000	722	0.0087
L47	LX470	0	0.0000		0.0000	3571	100.0000	3571	0.0430
LA1	Lumina	0	0.0000		0.0000	2	100.0000	2	0.0000
LAN	Lancer	8	0.0935		0.0000	8550	99.9065	8558	0.1030
LAS	Laser / Laser RS	0	0.0000		0.0000	1	100.0000	1	0.0000
LBN	Le Baron	0	0.0000		0.0000	3	100.0000	3	0.0000
LCR	Land Cruiser	3	0.0756		0.0000	3966	99.9244	3969	0.0478
LEG	Legacy	5	0.0768		0.0000	6506	99.9232	6511	0.0784
LES	LeSabre Custom	3	0.0178	3	0.0178	16872	99.9645	16878	0.2032
LHS	LHS	6	0.1130		0.0000	5303	99.8870	5309	0.0639
LIM		0	0.0000		0.0000	93	100.0000	93	0.0011
LLS	LS	0	0.0000		0.0000	18	100.0000	18	0.0002
LMA	Lumina 2WD	0	0.0000		0.0000	21	100.0000	21	0.0003

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LN7	Grand Marquis LS	0	0.0000		0.0000	14	100.0000	14	0.0002
LS6	LS	3	0.0618		0.0000	4853	99.9382	4856	0.0585
LS8	LS	0	0.0000		0.0000	7	100.0000	7	0.0001
LSE	LS1 / LW1 Auto	0	0.0000		0.0000	75	100.0000	75	0.0009
LSS	Delta 88LSS	1	0.0970		0.0000	1030	99.9030	1031	0.0124
LT2	LTD Crown Vic	0	0.0000		0.0000	2	100.0000	2	0.0000
LTD	LTD Crown Vic L	0	0.0000		0.0000	4	100.0000	4	0.0000
LUM	Lumina LS	28	0.0731	12	0.0313	38253	99.8955	38293	0.4611
LWA	LS1 / LW1 Auto	0	0.0000		0.0000	8	100.0000	8	0.0001
LYN	Mountaineer 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
M3	M3	5	0.1959		0.0000	2547	99.8041	2552	0.0307
M5	M5	371	**47.9948**		0.0000	402	52.0052	773	0.0093
M6	M5	0	0.0000		0.0000	1	100.0000	1	0.0000
MAG		1	**4.5455**		0.0000	21	95.4545	22	0.0003
MAL	Malibu	17	0.0250	6	0.0088	68063	99.9662	68086	0.8198
MAR	Grand Marquis LS	3	0.0145	1	0.0048	20691	99.9807	20695	0.2492
MAU	Grand Marquis LS	0	0.0000		0.0000	36	100.0000	36	0.0004
MAV	Mustang	0	0.0000		0.0000	1	100.0000	1	0.0000
MAX	Maxima	121	0.1885	16	0.0249	64040	99.7865	64177	0.7728
MET	Geo Metro LSi	11	0.1661	2	0.0302	6610	99.8037	6623	0.0797
MGO		0	0.0000		0.0000	2	100.0000	2	0.0000
MI1	MX5 Miata	0	0.0000		0.0000	13	100.0000	13	0.0002
MIA	MX5 Miata	33	0.3846	2	0.0233	8546	99.5921	8581	0.1033
MIL	Millenia	11	0.1297	3	0.0354	8464	99.8349	8478	0.1021
MIR	Mirage	17	0.1212	1	0.0071	14014	99.8717	14032	0.1690
MIS	MX5 Miata	0	0.0000		0.0000	9	100.0000	9	0.0001
MK2	Continental	0	0.0000		0.0000	1	100.0000	1	0.0000
MK3	Mark VIII LSC	0	0.0000		0.0000	1	100.0000	1	0.0000
MK4	Mark VIII	0	0.0000		0.0000	1	100.0000	1	0.0000
MK5		0	0.0000	1	**100.00**		0.0000	1	0.0000

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MK6	Grand Marquis LS	0	0.0000		0.0000	1	100.0000	1	0.0000
MK7	Mark VIII	0	0.0000		0.0000	1	100.0000	1	0.0000
MK8	Mark VIII	2	0.2215		0.0000	901	99.7785	903	0.0109
ML3	ML320	1	0.0198		0.0000	5043	99.9802	5044	0.0607
ML4	ML430	1	0.1294		0.0000	772	99.8706	773	0.0093
MOC	Monte Carlo LS	6	0.0296		0.0000	20252	99.9704	20258	0.2439
MON	Montero Sport 2WD	5	0.0355	1	0.0071	14072	99.9574	14078	0.1695
MPV	MPV 4dr Wgn	10	0.2378		0.0000	4195	99.7622	4205	0.0506
MR2	MR2 Spyder	0	0.0000		0.0000	1053	100.0000	1053	0.0127
MTA	Montana 2WD	0	0.0000	1	0.0336	2971	99.9664	2972	0.0358
MTH	Monte Carlo LS	0	0.0000		0.0000	2	100.0000	2	0.0000
MTN	Mountaineer	7	0.0795	3	0.0341	8799	99.8865	8809	0.1061
MTX	Montero Sport 2WD	0	0.0000		0.0000	8	100.0000	8	0.0001
MUS	Mustang	48	0.0547	15	0.0171	87767	99.9283	87830	1.0576
MX3		0	0.0000		0.0000	1	100.0000	1	0.0000
MX6	626 / MX6	0	0.0000		0.0000	398	100.0000	398	0.0048
MYS	Mystique GS	8	0.0938	4	0.0469	8515	99.8593	8527	0.1027
NAT	Montero Sport 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
NAV	Navigator 2WD	13	0.0746	2	0.0115	17420	99.9140	17435	0.2099
NEO	Neon Highline	39	0.0796	6	0.0123	48928	99.9081	48973	0.5897
NEV	Mustang	0	0.0000		0.0000	1	100.0000	1	0.0000
NOV	Nova	0	0.0000		0.0000	2	100.0000	2	0.0000
NSX	NSX	2	**1.0471**		0.0000	189	98.9529	191	0.0023
NUB	Nubira	1	0.0515		0.0000	1940	99.9485	1941	0.0234
NX	Mustang GT	0	0.0000		0.0000	1	100.0000	1	0.0000
NY		2	**1.3793**		0.0000	143	98.6207	145	0.0017
OAS	Trooper 4WD	4	**1.5748**		0.0000	250	98.4252	254	0.0031
ODY	Odyssey	5	0.0328	2	0.0131	15255	99.9541	15262	0.1838
OTH	C1500 P/U 2WD	4632	0.2268	2376	0.1164	2035054	99.6568	2042062	24.5887
OTR		5	0.4921	5	0.4921	1006	99.0157	1016	0.0122

Model Code	Series (Model)	DLC is damaged, inaccessible, or cannot be found		Vehicle will not communicate with analyzer		Vehicle successfully communicates with analyzer		Total count of tests by model	% of overall tests by model
		Count	Percent	Count	Percent	Count	Percent		
PAS	Passat	27	0.1192	3	0.0132	22618	99.8675	22648	0.2727
PAV	Park Avenue	1	0.0191	1	0.0191	5242	99.9619	5244	0.0631
PIN	LTD Crown Victoria	0	0.0000		0.0000	1	100.0000	1	0.0000
PRE	Prelude	19	0.2516	2	0.0265	7531	99.7219	7552	0.0909
PRI	Geo Prizm Lsi	13	0.1028	3	0.0237	12624	99.8734	12640	0.1522
PRO	Protege	19	0.0524	9	0.0248	36209	99.9227	36237	0.4363
PRV	Previa 2WD	8	**1.5038**	2	0.3759	522	98.1203	532	0.0064
PRW	Prowler	0	0.0000		0.0000	226	100.0000	226	0.0027
PTH	Pathfinder	13	0.0952		0.0000	13642	99.9048	13655	0.1644
PUL	P/U King Cab	0	0.0000		0.0000	4	100.0000	4	0.0000
PUP	Truck Regular Bed	13	0.3173	1	0.0244	4083	99.6583	4097	0.0493
PWA	Silver Dawn	0	0.0000		0.0000	5	100.0000	5	0.0001
Q45	Q45	3	0.0541		0.0000	5540	99.9459	5543	0.0667
QST	Quest	4	0.0424		0.0000	9436	99.9576	9440	0.1137
QTO	A6	2	0.1129		0.0000	1769	99.8871	1771	0.0213
QUA		0	0.0000		0.0000	3	100.0000	3	0.0000
QX4	QX4	0	0.0000		0.0000	379	100.0000	379	0.0046
QXA	QX4	0	0.0000		0.0000	3178	100.0000	3178	0.0383
R25	Ram P/U 2WD	151	**3.8045**	93	**2.3432**	3725	93.8524	3969	0.0478
R35	Ram P/U 2WD	174	**21.5881**	17	**2.1092**	615	76.3027	806	0.0097
RAB	New Beetle	0	0.0000		0.0000	1	100.0000	1	0.0000
RAH	Ranger Regular Cab 2	22	**31.8841**		0.0000	47	68.1159	69	0.0008
RAN	Ranger Regular Cab 2	0	0.0000		0.0000	2	100.0000	2	0.0000
RAV	RAV4	3	0.0252		0.0000	11915	99.9748	11918	0.1435
RCH	Ram P/U	0	0.0000		0.0000	1	100.0000	1	0.0000
REG	Regal LS	8	0.0430	1	0.0054	18616	99.9517	18625	0.2243
RIV	Riviera	8	0.3682		0.0000	2165	99.6318	2173	0.0262
RLY	Savanna 3500 2WD	0	0.0000		0.0000	1	100.0000	1	0.0000
RNG	Ranger Regular Cab 2	37	0.0772	13	0.0271	47852	99.8956	47902	0.5768
ROA	RoadMaster ITT Limit	0	0.0000		0.0000	976	100.0000	976	0.0118

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		Count	Percent	Count	Percent	Count	Percent		
ROD	Rodeo 2WD	23	0.1068	3	0.0139	21504	99.8792	21530	0.2592
RRV	Range Rover Class E	2	0.1054		0.0000	1896	99.8946	1898	0.0229
RST	Z3	0	0.0000		0.0000	100	100.0000	100	0.0012
RX3	RX300	3	0.0221		0.0000	13571	99.9779	13574	0.1634
RX7	MX5 Miata	0	0.0000		0.0000	1	100.0000	1	0.0000
S10	S10 P/U 2WD	42	0.1543	2	0.0073	27180	99.8384	27224	0.3278
S20	S2000	1	0.0835		0.0000	1197	99.9165	1198	0.0144
S22	Sable GS	0	0.0000		0.0000	1	100.0000	1	0.0000
S30	SC300	2	0.1350		0.0000	1479	99.8650	1481	0.0178
S40	S40 / V40	3	0.0902		0.0000	3324	99.9098	3327	0.0401
S70	S70 / V70	9	0.0992	2	0.0220	9063	99.8788	9074	0.1093
S80	S80	0	0.0000		0.0000	6023	100.0000	6023	0.0725
S90	S90 / V90	3	0.2757		0.0000	1085	99.7243	1088	0.0131
SAB	Sable GS	18	0.0651	5	0.0181	27618	99.9168	27641	0.3328
SAF	Safari 2WD	3	0.0678		0.0000	4424	99.9322	4427	0.0533
SAM	Vitara / Grand Vitar	0	0.0000		0.0000	1	100.0000	1	0.0000
SAV	Savanna 1500 2WD	6	0.7528	7	0.8783	784	98.3689	797	0.0096
SC	SC2 / SL1 / SW1	20	0.0828	5	0.0207	24133	99.8965	24158	0.2909
SCP	Tiburon	0	0.0000		0.0000	2	100.0000	2	0.0000
SDK	Sidekick 4dr 4WD	0	0.0000	1	0.1307	764	99.8693	765	0.0092
SE	P/U King Cab	0	0.0000		0.0000	31	100.0000	31	0.0004
SEB	Sebring LXi	29	0.0848	5	0.0146	34162	99.9006	34196	0.4118
SEN	Sentra / 200SX	89	0.1852	5	0.0104	47959	99.8044	48053	0.5786
SEP	Sephia	17	0.1590	1	0.0094	10675	99.8317	10693	0.1288
SER	Silver Dawn	0	0.0000		0.0000	25	100.0000	25	0.0003
SEV	SLS	4	0.0368	1	0.0092	10875	99.9540	10880	0.1310
SFT	Swift	0	0.0000		0.0000	187	100.0000	187	0.0023
SHA	300M	0	0.0000		0.0000	1	100.0000	1	0.0000
SID	Silver Dawn	0	0.0000		0.0000	3	100.0000	3	0.0000
SIL	Silhouette	2	0.0539		0.0000	3711	99.9461	3713	0.0447

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		Count	Percent	Count	Percent	Count	Percent		
SKH	Skylark Limited	0	0.0000		0.0000	1	100.0000	1	0.0000
SKY	Skylark	2	0.0510	2	0.0510	3919	99.8980	3923	0.0472
SL	SL2 / SW2	25	0.0536	6	0.0129	46636	99.9336	46667	0.5619
SL5	SL500	1	0.0699		0.0000	1430	99.9301	1431	0.0172
SL6	SL600	0	0.0000		0.0000	77	100.0000	77	0.0009
SLX	SLX 4WD	0	0.0000		0.0000	175	100.0000	175	0.0021
SNA	Sienna	0	0.0000		0.0000	13738	100.0000	13738	0.1654
SNF	Sunfire SE	27	0.0972	4	0.0144	27755	99.8884	27786	0.3346
SOL	Solara	0	0.0000		0.0000	1152	100.0000	1152	0.0139
SON	Sonata	21	0.1153	4	0.0220	18186	99.8627	18211	0.2193
SOV	S-Type	0	0.0000		0.0000	3	100.0000	3	0.0000
SPE	Escape XLT 2WD	0	0.0000		0.0000	15	100.0000	15	0.0002
SPI	Altima	0	0.0000		0.0000	1	100.0000	1	0.0000
SPO	S40 / V40	0	0.0000		0.0000	2	100.0000	2	0.0000
SPR	Geo Metro	0	0.0000		0.0000	17	100.0000	17	0.0002
SPT	Sportage	3	0.0446	1	0.0149	6716	99.9405	6720	0.0809
SPY		0	0.0000		0.0000	1	100.0000	1	0.0000
SR5	4Runner 2WD	0	0.0000		0.0000	3	100.0000	3	0.0000
SRA	Sierra 1500 2WD	1	0.0816	1	0.0816	1224	99.8369	1226	0.0148
SSE	SL2 / SW2	0	0.0000		0.0000	27	100.0000	27	0.0003
STA	Stratus	29	0.0915	6	0.0189	31674	99.8896	31709	0.3818
STE	Stealth ES	0	0.0000		0.0000	9	100.0000	9	0.0001
STO	Geo Metro LSi	0	0.0000		0.0000	3	100.0000	3	0.0000
STR	Stratus ES	0	0.0000		0.0000	2	100.0000	2	0.0000
STS	Seville Touring	0	0.0000		0.0000	214	100.0000	214	0.0026
STY	S-Type	0	0.0000		0.0000	152	100.0000	152	0.0018
SU1	Formula / Trans Am	0	0.0000		0.0000	4	100.0000	4	0.0000
SUB	C1500 Suburban 2WD	59	0.1737	70	0.2061	33835	99.6202	33964	0.4090
SUM		0	0.0000		0.0000	35	100.0000	35	0.0004
SUN	Sunfire SE	0	0.0000		0.0000	64	100.0000	64	0.0008

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		Count	Percent	Count	Percent	Count	Percent		
SUP	Supra	1	0.3472		0.0000	287	99.6528	288	0.0035
SVX	XT/XT6	0	0.0000		0.0000	7	100.0000	7	0.0001
SW	SL2 / SW2	0	0.0000	2	0.0803	2490	99.9197	2492	0.0300
SWA	SC1 Manual / SW2 Aut	0	0.0000		0.0000	6	100.0000	6	0.0001
SWI	Geo Metro LSi	0	0.0000		0.0000	298	100.0000	298	0.0036
T10	T100 XTRACAB 2WD	2	0.0809		0.0000	2471	99.9191	2473	0.0298
TAC	Tacoma Deluxe	5	0.0186	3	0.0112	26892	99.9703	26900	0.3239
TAH	Tahoe 2WD	17	0.0327	2	0.0038	52044	99.9635	52063	0.6269
TAL	Talon ESi	1	0.1178		0.0000	848	99.8822	849	0.0102
TAM	Formula / Trans Am	0	0.0000		0.0000	549	100.0000	549	0.0066
TAU	Taurus SE	113	0.0847	16	0.0120	133341	99.9033	133470	1.6071
TBR	Turbo RL LWB	0	0.0000		0.0000	5	100.0000	5	0.0001
TC	PT Cruiser LHD	0	0.0000		0.0000	1	100.0000	1	0.0000
TEM	Escort LX	0	0.0000		0.0000	1	100.0000	1	0.0000
TER	Tercel	1	0.0214		0.0000	4680	99.9786	4681	0.0564
TGA	911	0	0.0000		0.0000	6	100.0000	6	0.0001
THU	Thunderbird LX	27	0.2369	4	0.0351	11366	99.7280	11397	0.1372
TIB	Elantra	7	0.1790	1	0.0256	3903	99.7954	3911	0.0471
TNC	Town & Country	0	0.0000		0.0000	65	100.0000	65	0.0008
TOW	Town Car Signature	52	0.1031	5	0.0099	50383	99.8870	50440	0.6074
TRA	Tracer LS	8	0.1560	6	0.1170	5113	99.7269	5127	0.0617
TRK	Tracker	4	0.1221	1	0.0305	3270	99.8473	3275	0.0394
TRP	Trooper 4WD	5	0.1014		0.0000	4924	99.8986	4929	0.0594
TRS	SLS	0	0.0000		0.0000	2	100.0000	2	0.0000
TSP	Transport	2	0.1188	1	0.0594	1681	99.8219	1684	0.0203
TUN	Tundra SR5	2	0.0199		0.0000	10041	99.9801	10043	0.1209
V15	Ram P/U 2WD	35	0.1313	9	0.0338	26609	99.8349	26653	0.3209
V25	Ram P/U 2WD	36	**1.6327**	43	**1.9501**	2126	96.4172	2205	0.0266
V35	Ram Wgn Bus	59	**2.4989**	53	**2.2448**	2249	95.2562	2361	0.0284
V40	S40 / V40	0	0.0000		0.0000	227	100.0000	227	0.0027

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V70	S70 / V70	4	0.1519	1	0.0380	2628	99.8101	2633	0.0317
V90	S90 / V90	0	0.0000		0.0000	79	100.0000	79	0.0010
VAN	Vandenplas LWB	2	0.1094		0.0000	1826	99.8906	1828	0.0220
VCS		0	0.0000		0.0000	111	100.0000	111	0.0013
VEN	Venture 2WD Extended	8	0.1063	1	0.0133	7518	99.8804	7527	0.0906
VER	Town Car Executive	0	N/A		N/A		N/A	0	0.0000
VGR	Villager Wgn	3	0.0553	1	0.0184	5417	99.9262	5421	0.0653
VIC	LTD Crown Victoria	0	0.0000		0.0000	12	100.0000	12	0.0001
VIG	TL	0	0.0000		0.0000	5	100.0000	5	0.0001
VIL	Villager Wgn	4	0.1739		0.0000	2296	99.8261	2300	0.0277
VIP	Viper	1	0.1524		0.0000	655	99.8476	656	0.0079
VIS	Vision ESi	1	0.2513		0.0000	397	99.7487	398	0.0048
VIT	Vitara / Grand Vitar	0	0.0000		0.0000	647	100.0000	647	0.0078
VOY	Voyager	14	0.0718	1	0.0051	19496	99.9231	19511	0.2349
WAG	Wrangler 4WD	1	**10.0000**		0.0000	9	90.0000	10	0.0001
WIL	Park Avenue Ultra	10	**90.9091**		0.0000	1	9.0909	11	0.0001
WIN	Windstar GL Wgn	19	0.0597	10	0.0314	31777	99.9088	31806	0.3830
WRG	Wrangler 4WD	7	0.0648	1	0.0093	10791	99.9259	10799	0.1300
X5	X5 3.0i	0	0.0000		0.0000	201	100.0000	201	0.0024
X90	X90 2WD	0	0.0000		0.0000	24	100.0000	24	0.0003
XE	Truck Regular Bed	0	0.0000		0.0000	358	100.0000	358	0.0043
XJ	XJ Sport	0	0.0000		0.0000	99	100.0000	99	0.0012
XJ6	XJ6 (USA) / Sovereig	1	0.0607		0.0000	1647	99.9393	1648	0.0198
XJ8	XJ8 / XJ8L	7	0.1706	1	0.0244	4094	99.8050	4102	0.0494
XJR	XJR Sport SWB	0	0.0000		0.0000	772	100.0000	772	0.0093
XJS	XJS	0	0.0000		0.0000	185	100.0000	185	0.0022
XK	XK8 / XKR	0	0.0000		0.0000	39	100.0000	39	0.0005
XK8	XK8	0	0.0000		0.0000	1053	100.0000	1053	0.0127
XKE	X-Type	0	0.0000		0.0000	1	100.0000	1	0.0000
XPL	Explorer XL	92	0.0827	20	0.0180	111195	99.8994	111307	1.3403

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XTE	Xterra	2	0.0217		0.0000	9228	99.9783	9230	0.1111
XXX	Wrangler 4WD	181	0.4313	385	0.9174	41400	98.6513	41966	0.5053
YUK	Yukon 2WD	4	0.0229	1	0.0057	17490	99.9714	17495	0.2107
Z3	Z3	3	0.0880		0.0000	3406	99.9120	3409	0.0410
Z3C	Z3	0	0.0000		0.0000	535	100.0000	535	0.0064
Z3R	Z3	3	0.4138		0.0000	722	99.5862	725	0.0087
Z8	Z8	0	0.0000		0.0000	55	100.0000	55	0.0007
hom	Sonoma P/U 2WD	0	0.0000		0.0000	977	100.0000	977	0.0118
	Total	23909	0.2879	10072	0.1213	8270883	99.5908	8304864	100.00

Appendix C

Counts of Vehicle Models Achieving Readiness With More Than Three Unset Monitors

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
150	1	(TOYOTA) COROLLA	1
1500	3	6	1
1500 LS	1	1500	3
1500 SUBURBAN	1	2500EXPRESSVAN	1
1500 VAN	1	3-SERIES	1
1MPALA	1	3.2CL	1
2+2	1	300M	1
2.2CL	1	320 SERIES	1
2.3 CL	1	4RUNNER	1
2.3CL	3	4RUNNER 2WD	1
2000 CARAVAN	1	5	1
2000 CHEVROLET 1500	1	500 SERIES	1
2000 HONDA ACCORD	1	626	4
200SX	11	3-Sep	6
230 SERIES	1	93	1
240SX	4	93A	4
2500	3	93L	9
3-SERIES	7	95	1
3.0 CL	1	A4	2
3.0C	1	ABS	2
3.0CL	3	ACCORD	9
3.2TL	3	ACCORD V6	2
3.5 RL	2	ACURA RSX	1
¾ TON TRUCK	2	AERIO	1
300 M	1	AERO	1
318I	2	AEX	2
323I	1	AGL	1
328I	2	ALERO	5
350	1	ALTIMA	5
3500	3	ARMADA	1
3500 FLATBED 4X4	1	ASG AERI0	1
4 RUNNER	2	AST	1
4-RUNNER	1	ASTRO 2WD	1
4RUNNER	17	ASVE PU	1
4RUNNER 2WD	6	ATQ	1
4RUNNER 4WD	1	AVA	3
5-SERIES	6	AVALANCH	1
528I	1	AVALANCHE	1
626	72	AXM	1
7-SERIES	1	AZTEC	1
850	9	AZTEK	3
850 SERIES	1	B3500	1
960	5	B40	1
A4 QUATTRO	1	BEETLE	1
A6	2	BLAZER	4
A6 QUATTRO	1	BLAZER 2WD	2
ABL	1	BLAZER 4WD	3
ACC HONDA	1	BOXSTER	1
ACC0RD/HONDA	1	BUICK	1
ACCENT	18	BUICK CENTRY	1
ACCORD	144	BUICK CENTURY CUSTOM	1

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
ACCTN	2	BUICK RENDEVOUS	1
ACHIEVA	5	BUICK RENDEZVOUS	1
ACURA INTEGRA	1	BUICK RENEVOUS	1
AEROSTAR	18	BZR	2
AGS	1	C/K 1500 (K/R10)	4
ALERO	8	C/K 2500 (C/K/R20)	4
ALTIMA	57	C/K10 (R10 OR 1500)	3
AMI	1	C/T	1
AMIGO	2	C15	7
ARNAGE	1	C1500	26
ASPIRE	8	C1500 CHEVROLET	1
AST	5	C1500 SUB	1
ASTRO	39	C1500SUB	1
ASTRO 2WD	11	C24	1
ASTRO AWD	1	C240	3
AUR	1	C2500	2
AURORA	11	CADILLAC ESC	1
AVALON	11	CADILLAC SEVILLE	1
AVENGER	15	CAMARO	3
B SERIES	2	CAMRY	3
B-SERIES	8	CAR	2
B150 VAN (& 1500)	1	CARAVAN	8
B1500	2	CARAVAN 2WD	9
B2300	4	CARAVAN AWD	2
B250 VAN (& 2500)	3	CASCHEVROLETCAVALIER	1
B2500 VAN	1	CAV	3
B3000	6	CAVALIER	13
B3500 VAN	1	CAVALIR	1
B4000	1	CAYENNE	2
BERETTA	3	CENTURY	4
BLAZER	26	CHEROKEE	1
BLAZER 2WD	5	CHEROKEE (1971-)	1
BONNEVILLE	6	CHEROKEE 2WD	4
BOXSTER	1	CHEROKEE 4WD	1
BRAVADA	4	CHEV BLAZER	1
BRE	1	CHEV CAVALIER	1
BREEZE	21	CHEV PU 2500	1
BVS	1	CHEV TAHOE	1
C-1	1	CHEV. S10	1
C-1500	3	CHEVROLET 1500	1
C/K 1500 (K/R10)	16	CHEVROLET AVALANCHE	1
C/K 1500 (K/R10)CHEV	1	CHEVROLET CAVALIER	2
C/K 1500 PICKUP	1	CHEVROLET MALIBU	1
C/K 2500 (C/K/R20)	8	CHEVROLET MONTE CARL	1
C/K 3500 (C/K/R30)	4	CHEVROLET SILVERADO	1
C/K10 (R10 OR 1500)	20	CHEVROLET SUBURBAN	2
C/K20 (R20 OR 2500)	4	CHEVROLET TAHOE	3
C/K30 (R30 OR 3500)	4	CHEVROLET TRACKER	1
C15	6	CHEVROLET TRAILBLAZE	1
C15 SUBURBAN	1	CHEVY	2
C1500	150	CHEVY 1500	1

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
C1500 PICKUP	34	CHEVY CAVALIER	1
C1500 SIERRA	13	CHEVY SILVERADO	1
C1500 SUBURBAN	15	CHEVY TRACKER	1
C1500 TAHOE	1	CHEVY TRK SILVERRADO	1
C1500 YUKON	4	CHRYSLER PACIFICA	1
C1500SUBURBAN	1	CHRYSLER SEBRING	1
C220	3	CHRYSLER T&C	1
C230	2	CHRYSLER TOWN AND CO	1
C230 KOMPRESSOR	1	CHY	1
C2500	14	CIVIC	8
C2500 PICKUP	1	CIVIC HYBRID	1
C2500 SIERRA	1	CL500	1
C2500.CHEV	1	CLK320	1
C280	1	CLS 500	1
C3500	3	CLUB WAGON E350	1
C3500 PICKUP	1	CONCORDE	1
C70	1	CONTOUR	1
CABRIO	2	COR	2
CAMARO	41	COROLLA	20
CAMERO	2	COROLLO	1
CAMRY	76	CORROLLA	1
CAMRY SOLARA	1	CORVETTE	3
CAPRICE	1	COUGAR	2
CAR	2	CR-V	2
CARAVAN	66	CRF	1
CARAVAN 2WD	17	CROWN VICTORIA POLIC	3
CARAVAN DODGE	1	CRUISER	1
CATERA	8	CRV	1
CAV	3	CTA	5
CAVALIER	74	CTS	5
CC1	1	CVI	1
CELICA	8	CVT	3
CENTURY	7	D150 TRUCK (& 1500)	4
CEVY SUBURBAN	1	DAK	1
CGL	1	DAKOTA	3
CHEROKEE	3	DAKOTA 2WD	2
CHEROKEE (-1970)	1	DB7 VOLANTE	1
CHEROKEE (1971-)	1	DEVILLE	2
CHEROKEE 2WD	2	DIS	2
CHEV ASTR0	1	DISCOVERY	9
CHEV PRIZM	1	DODG	1
CHEV SILVERADO	1	DODGE	1
CHEV SUBURB	1	DODGE RAM 1500	1
CHEV SUBURBAN	1	DODGE DURANG0	1
CHEVE 3500	1	DODGE NEON	1
CHEVROLET C-1500	1	DODGE RA 1500	1
CHEVROLET CAMARO Z28	1	DODGE RAM	3
CHEVROLET CAVALIER	1	DODGE RAM 1500	4
CHEVROLET G VAN	1	DODGE RAM150	1
CHEVROLET IMPALA	1	DODGE-1500	1
CHEVROLET MALIBU	1	DODGERAM1500	1

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
CHEVROLET VENTURE	1	DUR	3
CHEVY	1	DURANGO	2
CHEVY MALIBU	1	DURANGO 2WD	3
CHEVY 1500	1	E150 ECONOLINE	2
CHEVY 3500	1	E250 ECONOLINE	1
CHEVY CAMARO	1	E320	2
CHEVY CAVALIER	1	E350	1
CHEVY EXPRESS	1	ECH	1
CHEVY SIERRA	1	ECLIPSE	3
CHEVY SILVERADO	1	ECLIPSE GT	1
CHEVYCAVALIER	1	ECO	1
CHEY IMPALA	1	ECONOLINE E150	2
CHEYENE	1	ECONOLINE E250	2
CHRYSLER	1	ELANTRA	2
CHRYSLER T&CONTRY	1	ELE	1
CIERA	3	ELX	1
CIRRUS	22	ENV	2
CIVIC	82	EPR	6
CIVIC DEL SOL	1	EPT	9
CIVIC HONDA	1	EQUIN	1
CK-	1	ERS	1
CL230	1	ES300	2
CLI	1	ES330	2
CLK320	1	ESCALADE	1
CLM	1	ESCALADE AWD	1
CLUB WAGON E150	1	ESCALADE CAD.	1
CLUB WAGON E250	2	ESCALADE EXT	2
CLUB WAGON E350	2	ESCAPE	9
COMM. VAN-P10/20/30	2	ESCORT	5
CONCORDE	9	ESCORT 4DR	1
CONTINENTAL	2	ESTEEM	1
CONTOUR	66	EXP	5
COROLLA	59	EXP SPORT	1
CORSICA	7	EXPEDETION	1
CORVETTE	2	EXPEDITION	16
COU	1	EXPEDITION FORD	1
COUGAR	23	EXPEDTION	1
CR-V	2	EXPLORE	1
CROWN VICTORIA	29	EXPLORER	18
CROWN VICTORIA POLIC	7	EXPLORER 2-DR	6
CROWN VICTORIAFORD	1	EXPLORER 4 DR	18
CRUISE MASTER	1	EXPLORER 4-DR	7
CSS	1	EXPLORER 4DR	1
CST	1	EXPLORER FORD	1
CU6	1	EXPLORER SPORT TRAC	2
CUTLASS	6	EXPLORER SPORT TRACK	1
CUTLASS SUPREME	3	EXPOL	1
CUTLASS/CIERA	4	F 150	2
CXI	1	F-1	1
CXL	1	F-150	2
D0DGE TRUCK	1	F-150 FORD	1

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
D150 TRUCK (& 1500)	6	F0CUS	1
DAEWOO LANOS	1	F15	8
DAEWOO LEGANZA	2	F150	45
DAKOTA	5	F150 FORD	1
DAKOTA 2WD	4	F150 REG CAB LONG	2
DELTA 88	2	F150 REG CAB SHORT	1
DEV	1	F150 REGULAR CAB LON	13
DEVILLE	12	F150 REGULAR CAB SHO	5
DIAMANTE	1	F150 SUPER CAB HD SH	1
DISCOVERY	2	F150 SUPER CAB LONG	7
DLS	1	F150 SUPER CAB SHORT	20
DODG RAM 1500	2	F150 SUPER CREW	1
DODGE RAM	1	F150 SUPER CREWCAB S	1
DODGE 1500	1	F150 SUPERCAB HEAVY	1
DODGE CARVAN	1	F150 SUPERCAB LONG	2
DODGE RAM 1500	1	F150 SUPERCAB SHORT	1
DODGE STRATUS	1	F150.	1
DODGE-NEON	1	FIREBID	1
DUR	1	FIREBIRD	2
DURANGO	8	FIREHAWK	1
DURANGO 2WD	3	FOC	1
DURANGO 4WD	3	FOCUS	20
E 350	1	FOCUS 4 DR SEDAN	5
E-350 WINNEBAGO	1	FOCUS WAGON	1
E150 CLUB WAGON	8	FOCUS ZX3	2
E150 ECONOLINE	22	FOCUZ	1
E250	2	FORD	1
E250 ECONOLINE	17	FORD ESCAPE	1
E250 ECONOLINE NGV	1	FORD F150	1
E250 SUPER VAN	5	FORD E-150	1
E320	8	FORD EC0150	1
E430	1	FORD EXPEDITION	1
ECHO	2	FORD EXPLORER	1
ECLIPSE	47	FORD F-150	1
ECLIPSE SPYDER	2	FORD F150	11
ECLIPSE TC 2WD	2	FORD FOCUS	9
ECO	2	FORD MUSTANG	1
ECONOLINE	2	FORD TAURUS	2
ECONOLINE E150	2	FORD/TAURUS	1
ECONOLINE E250	17	FOUCOS	1
ECONOLINE E350	6	FOUCS	1
EGS	1	FOX	1
EIGHTY EIGHT	1	FOXUS	1
EIGHTY-EIGHT	1	FREELANDER	3
ELANTRA	15	FRONTIER	4
ELDORADO	2	FRONTIER 2WD	4
ENDEAVOR	1	FRONTIER PU	1
EPR	8	FSC	1
EPT	5	FSF	1
ES300	10	FSS	1
ESC0RT	1	FZT	2

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
ESCALADE	3	FZX	3
ESCORT	92	G1500/2500 VAN	1
ESS	1	GAG	1
ESTEEM	3	GALANT	4
EX	1	GEO PRIZM	1
EXCURSION	1	GES	1
EXP	1	GMC SIERRA	1
EXPEDITION	112	GMC SUBURBAN	1
EXPEDITION SW	1	GMC YUKON	3
EXPLORER	117	GMC YUKON DENALI	1
EXPLORER 2-DR	6	GMC YUKON XL	1
EXPLORER 2-DR.	15	GMC/JIMMY	1
EXPLORER 2DR	3	GMG	1
EXPLORER 4-DR	14	GPG	2
EXPLORER 4-DR.	48	GRA	1
EXPLORER 4DR	6	GRAND AM	9
F 150	2	GRAND CARAVAN	1
F-150	1	GRAND CHEROKEE	1
F15	4	GRAND CHEROKEE 2WD	2
F150	89	GRAND CHEROKEE 4WD	1
F150 REG CAB HD LONG	1	GRAND MARQUIS	2
F150 REG CAB LONG	9	GRAND PRIX	7
F150 REG CAB SHORT	8	GRAND-CHEROKEE	1
F150 REG. CAB LONG	96	GRANDCHEROKEE	1
F150 REG. CAB SHORT	62	GRANDPRIX	1
F150 REGULAR CAB LON	22	GS300	2
F150 REGULAR CAB SHO	19	GT	1
F150 SUPER CAB HD SH	1	GTI	2
F150 SUPER CAB LONG	44	GTI GLX	1
F150 SUPER CAB SHORT	87	GTP	1
F250	8	GVT	1
F250 REG. CAB LONG	4	GX470	1
F250 REGULAR CAB LON	4	H2	1
F250 SUPER CAB SHORT	4	HARLEYDAVIDSON	1
F250 SUPERCAB(TRUCK)	2	HONDA	1
F350	2	HONDA ACCORD	1
F450	1	HONDA CIVIC	4
FBD	1	HONDA/ACCORD	1
FIREBIRD	16	HUMMER	1
FIREBIRD (TRANS AM)	4	IMP	5
FOC	1	IMPALA	11
FOCUS	12	IMPREZA	1
FOCUS 4 DR SEDAN	1	INTREPID	7
FOCUS 4DR SEDAN	1	INTRIGUE	1
FORD	1	ION	2
FORD CONTOUR	1	IPL	2
FORD EXPEDITION	2	IS300	5
FORD EXPLORER	1	ISUZU TROPER	1
FORD F150	1	JAGUAR S-TYPE	1
FORD FOCUS	1	JAGUARXTYPE	1
FORD MUSTANG	2	JEEP LIBERTY	1

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
FORD RANGER	3	JETTA	4
FORD TAUROS	1	JIMMY	1
FORD TAURUS	2	K15	1
FORD TAURUS SE	1	K1500	1
FORD	2	L300	1
FORESTER	1	LCF	1
FOX	2	LE SABRE	1
FRONTIER	19	LESABRE	1
FRONTIER 2WD	5	LEXUS SC430	1
FRONTIER CREW CAB	1	LHS	1
FSS	1	LIBERTY 4WD	1
G AM	1	LINCOLN	1
G-VAN	1	LINCOLN NAVIGATOR	2
G15	1	LS4	1
G1500	3	LS430	3
G20	2	LUMINA	2
G30 CHEVY VAN	2	LX 470	1
G3500	2	LX470	6
GAG	1	M/L	1
GALANT	56	M6I	1
GAS	1	M6S	1
GC2	1	MAGNUM	2
GEO	1	MAGNUM PICKUP	1
GEO METRO	3	MAL	1
GEO PRIZM	1	MALIBU	20
GEP	1	MAXIMA	2
GMC SONO	1	MAXIMA (NISSAN)	1
GMC 1500	2	MAZDA	1
GMC SONOMA	1	MAZDA 3	1
GOLF	1	MAZDA 3S	1
GOLF III	1	MAZDA 6	2
GRAND AM	63	MAZDA PROTEGE	2
GRAND CARAVAN	3	MAZDA6	3
GRAND CHEROKEE	15	MERCEDES E320	1
GRAND MARQUIS	11	MERCURY COUGAR	1
GRAND PRIX	26	MERCURY	1
GRAND VITARA	1	MGT	2
GRAND VITARA 2WD	1	MIL	1
GRAND VITARA 4WD	1	MIRAGE	2
GRAND VOYAGER	6	MIS	1
GS300	2	MITS	1
GS400	1	MITS GALANT	2
GTI	2	MITSU GALANT	1
HOMBRE	7	MITSUBISHI LANCER	1
HYUNDAI SONATA	1	MITSUBISHIES	1
I30	5	ML320	1
ILS	1	ML320SPORT UTILITY	1
IMPALA	10	ML350	1
IMPALA SS	2	ML500	1
INT	9	MLS	1
INTEGRA	7	MONTE CARLO	3

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
INTREPID	59	MONTE CARLO/DALE E	1
INTRIGUE	3	MONTECARLO	2
J30	4	MONTERO	3
JEEPSTER (1971-)	1	MONTERO SPORT	2
JETTA	15	MOUNT	1
JETTA GL	1	MPV	2
JETTA III	1	MR2	1
JGS	1	MUS	2
JIMMY	12	MUSTAN	1
JIMMY 4WD	1	MUSTANG	9
JIMMY SLT	1	MUSTANG CONVERTIBLE	2
K1500	11	MUSTANG COUPE	10
K1500 PICKUP	3	MZ6	1
K1500 SIERRA	1	NAV	6
K1500 SUBURBAN	3	NAVIGATOR	6
K1500 TAHOE	1	NEON	8
K2500	4	NEW BEETLE	1
KIA SEPHIA	1	NEW BEETLE CABRIOLET	1
KIA/SEPHIA	1	NEW JETTA	2
KINGCAB13	1	NEWBEETLE	1
L SERIES	1	NISSAN ALTIMA	2
L20	1	NISSAN FRONTIER	1
LAN	1	NSE	1
LANCASTER POLICE DPT	1	NSS	1
LANOS	3	NUBIRA	2
LE SABRE	2	ODYSSEY	1
LEGACY	9	OLDS ALERO	1
LEGANZA	3	OPTIMA	2
LESABRE	6	OPTIMAL	1
LHS	6	OTHER	1
LINCOLN NAVIGATOR...	1	OUTBACK	1
LS	1	PASSPORT	1
LS2	1	PATHFINDER	1
LS400	4	PATHFINDER 2WD	1
LSS	1	PDL	1
LUMINA	44	PIF	1
M P 3	1	PLS	1
M/L	1	PLYMONTH NEON	1
MAL	3	PLYMOUTH NEON	1
MALIBU	62	POLICE	1
MARK VIII	3	PONT	1
MARQUIS	2	PONTIAC SUNFIRE	2
MAXIMA	42	PRIZM	1
MAXIMA (NISSAN)	6	PROTEGE	6
MAZDA 626	1	PT	1
MAZDA REGULAR CAB SH	3	PT CRUISER	7
MDE	2	PTC	3
MEL	1	RAM	7
MERCURY COUGAR	1	RAM 150	1
MERCURY VILLAGER	1	RAM 1500	3
MET	3	RAM 1500 2WD	11

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
METRO	31	RAM 1500 4WD	1
MGE	1	RAM 1500 PU (D150)	1
MGS	2	RAM 2500	1
MIATA	3	RAM 2500 PU (D250)	4
MILLENIA	23	RAM 3500 PU (D350)	1
MIRAGE	58	RAM VAN 1500	1
MITSUBISHI MONTERO	1	RAM1500	7
ML320	2	RAM2500	1
ML320SPORT UTILITY	1	RAN	1
MLL	1	RANGE ROVER	5
MLS	1	RANGER	7
MONTANA	2	RANGER REG CAB LONG	2
MONTE CARLO	16	RANGER REGULAR CAB L	1
MONTERO	6	RANGER SUPER CAB SHO	2
MONTERO MITS	1	RANGER SUPERCAB 2DR	1
MONTERO SPORT	8	RAV4	1
MONTERO SPORT 2WD	1	RAV4 2WD	1
MONTERO SPORT 4WD	6	REGAL	3
MOUNTAINEER	9	RENDEZVOUS	2
MPV	6	RENDEZVOUS AWD	1
MUS	5	RIO	9
MUSTANG	66	RLS	1
MUSTANG CONVERTIBLE	4	ROD	1
MUSTANG COUPE	16	RODEO	3
MX-6	3	RODEO 2WD	1
MX6	1	RSX	1
MYSTIQUE	20	RV4	1
MYSTIQUE MERC	1	RX 330	1
NAV	2	RX-330	1
NAVIGATOR	14	RX3	1
NEH	1	RX300	1
NEON	116	RX330	3
NEON D0DGE	1	RX8	5
NEON EXPRESSO	1	RZV	1
NEW BEETLE	3	S-10	1
NISSAN	1	S-10 BLAZER	1
NISSAN FR0NT	1	S-10 P/U 4X4	1
NISSAN FRONTEER	1	S-TYPE	2
NISSAN FRONTIER	3	S10	2
NISSAN/SENTRA	1	S10 2WD	3
NLX	2	S420	1
NSX	1	S500	1
NUBIRA	2	SAAB 93	1
ODYSSEY	4	SABLE	5
OLDS	1	SANTA FE	1
OLDSMOBILE ALERO	1	SANTAFE	2
OTHER	3	SATURN ION	1
OUT BACK	1	SATURN VUE	1
OUTBACK	1	SC	2
P UP	1	SEABRING	1
PARK AVENUE	2	SEBRING	7

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
PAS	1	SEDONA	2
PASSAT	5	SENTRA	3
PASSPORT	9	SEPHIA	2
PATHFINDER	17	SEQ	2
PATHFINDER 2WD	2	SEQUOIA	1
PIC	1	SEVILLE	1
PICKUP	1	SFR	1
PICKUP 2WD	64	SI3	1
PICKUP 4WD	4	SIE	2
PK	2	SIENNA	3
PKA	1	SIL	3
PLS	1	SIL2500HD	1
POLICE	1	SILHOUETTE	1
PONTIAC GRAND AM SE	1	SILVERADO	5
PREL	1	SILVERADO C1500	1
PRELUDE	6	SILVERADO SS	1
PRELUDE HONDA	1	SL	1
PREVIA	1	SL1	1
PRIZM	10	SL55	1
PROBE	8	SLK230 KOMPRESSOR	1
PROTEGE	65	SLS	2
PRZ	1	SLX	1
Q45	2	SOLAR	1
QUEST	16	SON	1
R10 PICKUP	1	SONATA	6
RALLYE	1	SONOMA	1
RAM	2	SPE	2
RAM 1500	49	SPECTRA	5
RAM 1500 2WD	12	SRX	1
RAM 1500 4WD	1	SSE	1
RAM 1500 PU (D150)	5	SSR	1
RAM 1500 VAN (B150)	1	SSX	1
RAM 2500	2	STL	1
RAM 2500 PU (D250)	2	STRATUS	7
RAM CHARGER (W150)	1	SUB	1
RAM VAN	2	SUBURBAN	12
RAM1500	4	SUNFIRE	7
RAM2500	1	SURBURBAN Z-71	1
RAM2500 VAN	1	TAC	2
RAN	3	TACOMA	3
RANGER	31	TACOMA 2WD	4
RANGER FORD	1	TAHOE	8
RANGER REG CAB LONG	6	TAURUS	25
RANGER REG CAB SHORT	7	TIB	1
RANGER REG. CAB LONG	25	TIBURON	2
RANGER REG. CAB SHOR	35	TIBURON HYUNDAI	1
RANGER REGULAR CAB L	12	TKR	1
RANGER REGULAR CAB S	10	TOUAREG	1
RANGER SUPER CAB	15	TOUAREG.	1
RANGER SUPER CAB 2DR	14	TOUREG	1
RANGER SUPER CAB SHO	13	TOWN & COUNTRY 2WD	4

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
RANGERSUPERCABSHORT	1	TOWN AND COUNTRY	1
RAV4	4	TOWN CAR	2
RAV4 2WD	1	TOYO CORROLLA	1
REGAL	7	TOYOTA 4 RUNNER	1
RGC	1	TOYOTA COROLA	1
RIVIERA	2	TOYOTA COROLLA	8
RNG	1	TOYOTA ECHO	1
ROADMASTER	1	TOYOTA PK	1
ROD	2	TOYOTA TACOMA	1
RODEO	27	TOYOTA TUNDRA	1
RX 300	2	TRACKER	1
RX300	4	TRAILBLAZER	3
S TYPE	1	TRAILBLAZER 2WD	1
S TYPE 4.0	1	TRAKER	1
S-10	13	TRAN AM	1
S-TYPE	1	TRANS AM	1
S10	38	TRIBUTE	1
S10 2WD	18	TRL	3
S10 BLAZER	4	TROOPER	2
S10 PICKUP	19	TSE	4
S15 JIMMY	3	TSS	1
S15 SONOMA	3	TSX	1
S320	1	TUN	4
S430	1	TUNDRA	7
S50	1	TUNDRA 2WD	2
S500	3	TWC	1
S70	10	U6X MAZDA	1
S80	2	UAX	1
S90	3	UCS	1
SABLE	40	UEX	1
SAFARI	10	V93	1
SATURN	1	VAN	1
SATURN LS2	1	VDP	1
SAVANA	2	VENTURE	2
SAVANA G1500	1	VENTURE 2WD	1
SAVANNA VAN	1	VIBE	3
SC	23	VOLVO XC90 T6AWD	1
SCS	1	VOV	1
SE TRUCK (& SE-V6)	2	VOYAGER	1
SE1	1	VOYGER	1
SEBRING	48	VOYOGER	1
SEDAN	2	VUE	1
SENTRA	56	WIN	2
SEPHIA	31	WINDSTAR	3
SEVILLE	6	WINDSTAR 4 DR	3
SFS	2	WRA	1
SGS	1	WRANGLER	2
SHO	1	WRANGLER (1971-)	1
SIDEKICK	3	WRX	1
SIENNA	3	X TERRA	1
SIERRA C/K 15	9	X-TYPE	1

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
SIERRA C/K 15	1	XC90	3
SIERRA C/K 35	1	XE TRUCK (& E)	2
SIL	1	XE TRUCK (& E).	1
SILHOUETTE	6	XG 350L	1
SILVERADO	1	XG350	1
SKYLARK	9	XGX	1
SL	33	XJ8	4
SL1	2	XJR	1
SL2	4	XTERRA	3
SLK230 KOMPRESSOR	1	XTERRA NISSAN	1
SOL	1	XTYPE	1
SOLAR	1	YKN	1
SOLARA	1	YUK	1
SONATA	22	YUK0N DENALI	1
SONOMA	13	YUKON	5
SOUTHWIND 34L	1	YUKON DENALI	1
SPORTAGE	16		
STEP VAN	1		
STRATUS	43		
STRTUS	1		
STS	1		
STYPE	1		
SUB	3		
SUBARU IMPREZA	1		
SUBURBAN	35		
SUBURBAN CHEEV	1		
SUBURBAN 1500	2		
SUBURBUN	1		
SUNFIRE	26		
SURBURBAN C1500	2		
SW	2		
SWIFT	1		
T-100	1		
T10 BLAZER	2		
T100	1		
T15 JIMMY	1		
TAC	1		
TACOMA	8		
TACOMA 2WD	23		
TACOMA 4WD	4		
TAG	2		
TAHOE	28		
TALON	3		
TAURAS	3		
TAURUS	153		
TEI	2		
TERCEL	5		
TG2	1		
THOE	1		
THUNDERBIRD	11		
TIBURON	4		

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
TKR	2		
TL 2.5	2		
TL 3.2	1		
TOWN & COUNTRY	13		
TOWN & COUNTRY 2WD	2		
TOWN CAR	14		
TOY CAM	1		
TOYOTA CAMRY	1		
TOYOTA TUNDRA	1		
TRACER	18		
TRACKER	19		
TRANS AM	5		
TRANS SPORT	3		
TRANSAM	3		
TROOPER	8		
TRUCK (MD	1		
TSE	1		
TUN	2		
TUNDA	1		
TUNDRA	5		
TWC	1		
UCD	2		
UCL	1		
UEL	2		
UEX	2		
UEX ACCORD	1		
USG	1		
UTL4X2	1		
UVL	1		
V70	2		
V90	1		
VAN	4		
VAN 10(G10)	1		
VAN 15	1		
VAN 20(G20)	1		
VAN 30(G30)	1		
VAN1500	1		
VENTURE	13		
VILLAGER	21		
VILLAGER MINIVAN	1		
VIPER	1		
VITARA	1		
VOYAGER	61		
VTR	2		
VW PASSAT	1		
W-4	1		
WIN	2		
WINDSTAR	97		
WINSTAR	1		
WINSTAR.	1		
WORKHORSE	1		

1996 – 2000 Vehicle		2001 + Vehicle	
Model	**Count**	**Model**	**Count**
X-TERA	1		
X200	1		
XE TRUCK (& E)	13		
XGX	1		
XJ8	1		
XTERA	1		
XTERRA	1		
XTERRA 2WD	1		
YUKON	11		
YUNDIY	1		
Z28	2		
ZCH	1		

Appendix D

Example Registration Denial Letter

Date letter sent, 2006

«OWNER»
«ADDRESS» «address1»
«CITY» «STATE» «ZIP»

Dear «OWNER»:

Based on Texas vehicle registration records, you are the registered owner of a:

«VEHYEAR» «MAKE» «MODEL»
License Plate Number: «LICENSE»
County of Registration: «county»

Our vehicle testing records show this vehicle failed its annual emissions test and has not passed an emissions re-test in the last twelve months. State law requires that the Texas Commission on Environmental Quality (TCEQ) share this vehicle's information with the Texas Department of Transportation (TxDOT). TxDOT may deny this vehicle's registration if one of the following forms of compliance is not shown before or when the vehicle registration is due:

- Passing Vehicle Inspection Report*
- DPS Affidavit (Form VIE-12)*
- DPS Low Mileage Waiver (Form VIE-5)*
- DPS Low Income Time Extension (Form VIE-5)*
- DPS Individual Vehicle Waiver (Form VIE-5)*
- DPS Parts Availability Time Extension (Form VIE-9)*

*descriptions of each form are listed on the back of this letter.

Vehicles registered in the following counties must pass an emissions test as part of the annual vehicle inspection to be driven legally on public roads:

Brazoria, Fort Bend, Galveston, Harris, Montgomery, El Paso, Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, Travis, and Williamson counties.

The vehicle emissions testing program, called AirCheckTexas, is managed by the TCEQ and the Texas Department of Public Safety (DPS). Vehicle emissions testing is part of an overall effort to improve air quality in Texas.

If you no longer own the vehicle, the vehicle is no longer in operation or the vehicle has recently passed an emissions test, we apologize for the inconvenience and ask that you call us toll free at 1-888-295-0141. We appreciate your assistance and cooperation.

Sincerely,

Marivel Rodriguez

Marivel Rodriguez
Program Specialist, Inspection and Maintenance Team

Vehicle Inspection Report (VIR) issued by Vehicle Inspection Station

Certified Vehicle Inspection Stations use an emissions analyzer to conduct vehicle emissions testing. At the conclusion of a safety and emissions inspection or an emissions-only inspection, the analyzer prints the results of the inspection on a Vehicle Inspection Report (VIR) which indicates whether the vehicle passed or failed the inspection. The VIR can be obtained from any inspection station within 13 months of the inspection.

Department of Public Safety (DPS) Assistance

Affidavit (Form VIE-12) An owner of a vehicle registered in Brazoria, Fort Bend, Galveston, Harris, Montgomery, El Paso, Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, or Tarrant counties may obtain an affidavit (Form VIE-12) and have a vehicle safety inspection in a county where the emissions test is not required, if one of the following conditions is true:

1) The vehicle is not an affected vehicle and is not and will not be primarily operated (driven, parked or stored less than 60 days per year) in one of the affected counties listed above. (e.g., certain company fleet vehicles, hunting vehicles, etc.)

2) The vehicle is no longer an affected vehicle and will no longer be primarily operated for 60 calendar days per testing cycle in one of the counties listed above. (e.g., someone who moved from an affected county.)

3) The vehicle will not return to an affected county prior to the expiration of the current inspection certificate. (e.g., student , vacationer, extended out -of- town business.)

4) The vehicle is inoperable and will not be operated in an affected county.

Low Mileage Waiver (VIE-5) The DPS Waiver stations may issue a Low Mileage Waiver to a vehicle owner whose vehicle has failed both its initial emissions inspection and re-test, and in which at least $100.00 in emissions-related repairs have been performed. The vehicle should have been driven less than 5,000 miles in the previous inspection cycle and is expected to be driven fewer than 5,000 miles before the next safety inspection is required.

Low-Income Time Extension (VIE-5) The DPS Waiver stations may issue a Low-Income Time Extension to a vehicle owner whose vehicle fails the initial emissions inspection if the vehicle owner meets the income eligibility requirements.

DPS Parts Availability Time Extension (Form VIE-9) The DPS Waiver stations may issue a Parts Availability Time Extension for 30, 60, or 90 days to a motorist whose vehicle fails

the initial emissions inspection and needs time to receive necessary vehicle emissions control parts which have been ordered.

Individual Vehicle Waiver (VIE-5) The DPS Waiver stations may issue an Individual Vehicle Waiver to a vehicle owner whose vehicle has failed both its initial emissions inspection and re-test, and in which at least $600.00 ($450.00 in El Paso County) in emissions-related repairs have been performed by a Recognized Repair Facility. When repairs are not performed at a Recognized Repair Facility, only the purchase price of emission-related parts may qualify as a repair expenditure.

For eligibility requirements, conditions, or information about affidavits, waivers, and time extensions, or to make an appointment for a waiver or time extension, contact one of the local DPS stations listed below.				
DALLAS-FT WORTH AREA		EL PASO COUNTY	HOUSTON-GALVESTON AREA	
1613 W Irving Blvd. Irving, TX 75061 (972)251-2404	830 Central Parkway E Suite 325 Plano, Tx 75054 (972) 251-2404	11612 Scott Simpson El Paso, TX 79936 (915) 849-4053	11222 N Houston Rosslyn Houston, Texas 77088 (281) 272-1150	3224 S. Main Pearland, TX 77581 (281) 412-4552
TRAVIS and WILLIAMSON COUNTIES: 108 B Denson Drive, Austin, Tx 78752 (512)424-2222				

AirCheck Texas Repair & Replacement Assistance Program

You may be eligible for assistance through the AirCheckTexas Repair & Replacement Program. The program offers financial assistance for low-income owners of vehicles that fail an emissions test. Please call:

In the Houston/Galveston area:	1-866-237-9392 (Toll Free).
In the Dallas/ Fort Worth area:	1-800-898-9103 (Toll Free).
In Travis County:	(512)267-0301.
In Williamson County:	1-800-978-1766 (Toll Free).

Appendix E

Summary of Texas Department of Public Safety “Gas Audit Procedures” Video

The target audience for this 15 minute video is DPS officers. The video begins with an introduction into why gas audits are important (accuracy, obligation to motorists and inspection stations).

The video then goes into describing the gas audit procedures.

1) Ask operator to do the 3-day calibration and leak check, then

2) Do the gas audit itself.

Talks about how to begin the 3-day calibration, scanning bottles (internal cal bottles) into analyzer software or manually enter. Describes barcodes and scanning process for 3-day calibration.

Video provides Tips for reducing audit failures:

1) Ensure internal cal bottle values are entered correctly. Explained how they found bottles in the field that had been changed but new bottle values never entered, which caused the analyzers to fail the gas audit.

2) Change bottle with low pressure (<50 psi), video explained low press had also been shown to cause gas audit failures.

Discuss leak check (have owner/operator perform it) – why it's done, how to do it,

- Then video discusses how to perform the actual gas audit
- Says auditors are provided with a gas audit procedure card

Discusses how to determine audit gas concentration values, how to distinguish between high/low, information presented on concentrations, how to remove the concentration cards, entering audit values into analyzer, differences among analyzer software sequences for this process, how to attach regulator, how to plumb the hose and manipulate the regulator/bottle valves for appropriate flow, how long to flow the gas, how to determine stable readings. After audit, how to turn gas off, close valves, bleed of excess gas, remove regulator, put on bottle cap.

- Discusses low bottle first, then high. Same procedure for high as for low.

The video then gives a summary of steps necessary to conduct a high gas audit:

- Connect regulator
- Connect sample probe
- Initial gas flow
- Stabilize gas flow
- Run the high gas audit

Then, after high gas audit, analyzer may prompt for a gas cap test (Worldwide and Snap-On require gas-cap calibration)

After this is done, go to “Station Performance Report”, discusses lockout procedure as necessary for failure, and info to enter in analyzer screen. Print minimum of two copies (station/self).

After print, do a communication refresh to upload to VID.

- The video then reviews all the steps in the gas audit procedure
- Owner/operator perform a 3-day calibration and leak check procedure
- Perform low gas audit
- Perform high gas audit
- Perform gas cap test (if prompted by analyzer)
- Complete station performance report
- Lockout analyzer (for low or high audit failures)
- Remind owner/operator to contact DPS for a reaudit after repairs are made
- Perform communications refresh

Video then starts with “Safety Precautions” for gas audits:

1) Use precautions when transporting bottles between gas audits (valve, attachment to transport board/pad. Use precautions in the area where bottles will be transported (secure bottles, etc.).

2) Use precautions when using gas bottles for the audit itself – safety glasses/goggles and gloves.

3) Use gas audit procedure card to assist in performing the gas audit.

Appendix F

Summary of Federal and State Covert and Overt Auditing Requirements

This is a summary based on federal requirements as listed in 40 CFR 51 and also included in the Tx I/M SIP, unless specifically identified otherwise. SIP language generally very closely follows that included in the Code of Federal Regulations.

Overt auditing:
2x per year **per analyzer**
Appropriate document security;
A check to see that required record keeping practices are being followed;
A check for licenses or certificates and other required display information; and

Observation and written evaluation of each inspector's ability to properly perform an inspection;

A gas audit of known concentration at least as accurate as those used for routine QC checks (calibration gases with a 2% certainty)

A check for analyzer tampering and condition

A check for the optimization of the Flame Ionization Detection fuel-air ratio using methane (not applicable in Texas)

A leak check;

A check that station cal gas bottles are properly labeled and within the appropriate range

Functional dynamometer checks (coast-down, roll speed, roll distance, inertia weight selection, and power absorption) (SIP states "Functional checks of any loaded mode equipment which may be in use.")

A check of the pressure monitoring devices used to perform the evaporative canister pressure test(s) (SIP states "A check to determine that the gas cap pressure test equipment is within specifications" which is fine)

A check of the system's ability to accurately detect background pollutant concentrations; (Not in SIP)

A check of the purge flow metering system (Not in SIP).

Auditor requirements: (Assessed during interview with Tx DPS)
Knows hot to use test equipment and/or procedures;
Knows program rules and regulations;

Knows the basics of air pollution control;
Knows basic principles of motor vehicle engine repair, related to emission performance;
Knows emission control systems;
Knowledgeable and proficient in evidence gathering;
Knowledgeable of state administrative procedures laws;
Knowledgeable of quality assurance practices; and
Knowledgeable of covert audit procedures.
Auditors shall themselves be audited at least once annually. (Not in SIP)

Covert audit requirements:

Remote visual observation 1x per year in high-volume stations (> 4000 tests/yr)

Site visits 1x per year [times number of full-time inspectors] with induced-fail covert vehicle, and if the facility is test and repair, the 1x per year visit must include the purchase of repairs and subsequent retesting if the vehicle is initially failed for tailpipe emissions (note: Chapter 13 of the SIP outlines how "full-time" inspectors are calculated)

Audit documentation (including inducements and condition)

Covert vehicles must cover the range of vehicle technology groups (e.g., carbureted and fuel-injected vehicles)

Full range of inducements covering the emission test, evap test, and visual checks must be used) Adequate covert vehicles and auditors to allow for frequent rotation of both

Access to on-line inspection databases by to permit the creation and maintenance of covert vehicle records.

Record audit requirements (assessed in Task 3, Element 1D**).**

Station & inspector records screened monthly, including

- Automated statistical record analysis (i.e., triggers)
- In-person review of any records at stations that have not been reviewed electronically
- Accounting of official program forms