Eastern Research Group, Inc.

FINAL

Evaluation of the Texas Vehicle Emissions Inspection and Maintenance Program in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas

Prepared for:

Texas Commission on Environmental Quality

Prepared by:

Eastern Research Group, Inc.

June 21, 2024

ERG No.: 0488.00.002.002

EVALUATION OF THE TEXAS VEHICLE EMISSIONS INSPECTION AND MAINTENANCE PROGRAM IN THE DALLAS-FORT WORTH AND HOUSTON-GALVESTON-BRAZORIA NONATTAINMENT AREAS

Prepared for:

Edgar Gilmore
Texas Commission on Environmental Quality
12100 Park 35 Circle
Austin, TX 78753

Prepared by:

Cindy Palacios
Jim Lindner
Sandeep Kishan

Eastern Research Group, Inc.
3508 Far West Blvd., Suite 210
Austin, TX 78731

Rob Klausmeier
dKC de la Torre Klausmeier Consulting
1401 Foxtail Cove
Austin, TX 78704

June 21, 2024

Plain Language Summary

Eastern Research performed this biennial program evaluation for Texas Commission on Environmental Quality to assess the effectiveness of the vehicle inspection and maintenance program in Dallas-Fort Worth and Houston-Galveston-Brazoria nonattainment areas. The methodology followed the recommended U.S. Environmental Protection Agency guidance procedures and found that the overall results were positive. Specific recommendations for improvements were also provided for some program elements that could be implemented in the future.

Table of Contents

List of Appendices

List of Tables

List of Tables (Continued)

List of Figures

Executive Summary

This report documents the evaluation of the Texas Vehicle Emissions Inspection and Maintenance (I/M) program for the 2022 and 2023 biennial period. Eastern Research Group (ERG) performed this evaluation for the Texas Commission on Environmental Quality (TCEQ) using the Texas Information Management System (TIMS) database and Remote Sensing (RS) data from January 1, 2022, through December 31, 2023.

This evaluation generally follows the U.S. Environmental Protection Agency (EPA) draft guidance on using in-program data for the evaluation of the Texas I/M program performance [EPA, 2001] and EPA guidance on the use of RS for the evaluation of I/M program performance [EPA, 2004].[1] This study focuses on program coverage, the inspection process, and the repair process.

Overall, the results for the Texas I/M program were positive. However, ERG found that improvements could be made in a few areas, and a list of specific recommendations for improvements in the program is provided in the last section of this Executive Summary. Some of the suggestions will be helpful for future biennial evaluations and will make the results more reflective of overall program performance.

A. COVERAGE

The results of the coverage analysis using out-of-program RS data revealed a consistent, high rate of participation in the Texas I/M program.

Participation Rates (Section II.A) – The program participation rates were estimated by determining the fraction of vehicles seen on the road during RS studies that had recent records in the TIMS. This analysis found that in the Dallas-Fort Worth (DFW) program area, the participation rate was 91.3% in 2022 and 93.9% in 2023. In the Houston-Galveston-Brazoria (HGB) program area, the 2022 and 2023 participation rates were 92.5% and 94.8%, respectively. The overall program participation rates were 91.9% in 2022 and 94.4% in 2023.

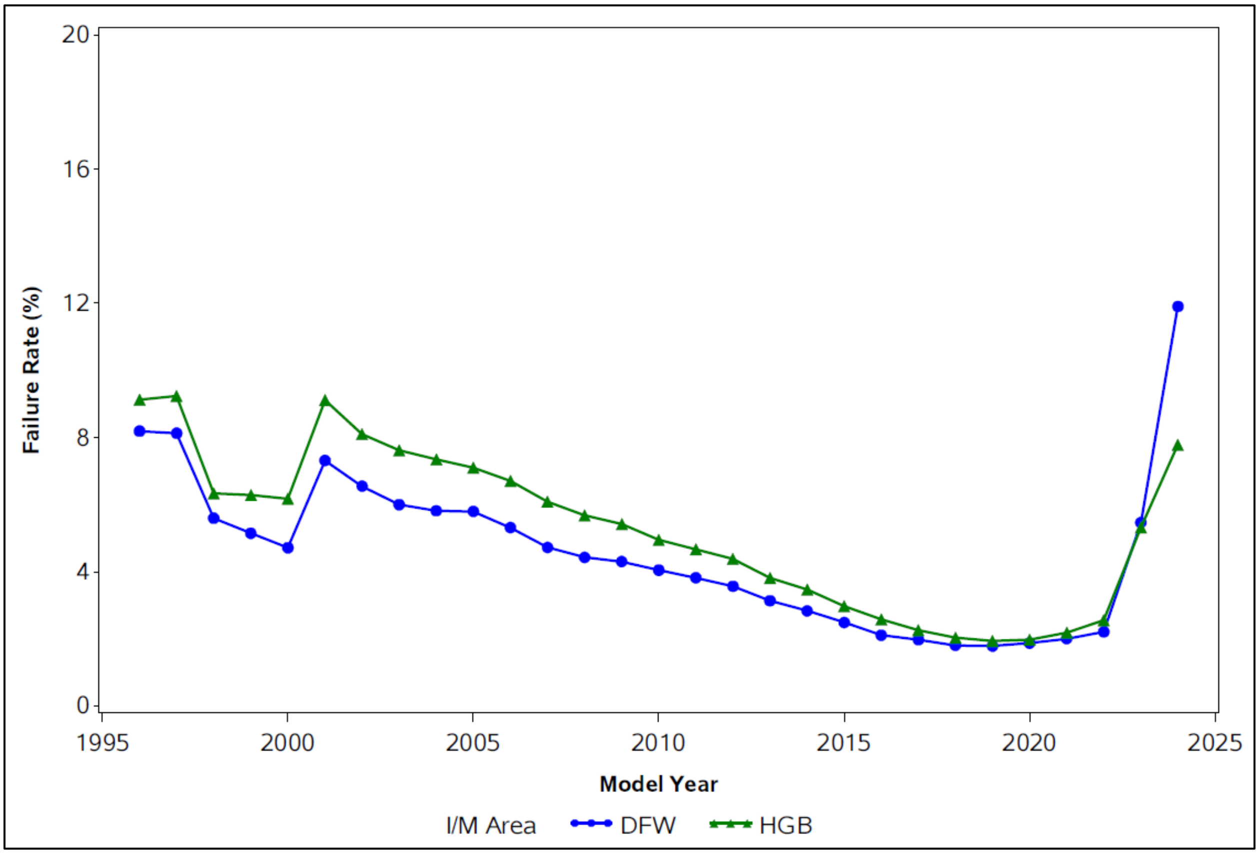
B. INSPECTION

Appropriateness of Major TIMS Fields (Section III.A) – The TIMS was used to document the Texas I/M program inspection process. This analysis checked the major fields in the TIMS using a series of basic data checks to demonstrate the accuracy and completeness of the data in the TIMS. ERG 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.

[1] Citations for references are given in Section 7.

Inspection Statistics (Section III.B) – Analysis of the TIMS data indicated that during the evaluation period, over 20.1 million On Board Diagnostic (OBD) tests were performed on 1996 and newer Model Year (MY) light-duty passenger cars and trucks, resulting in over eight million unique vehicle OBD tests. The DFW and HGB program areas initial inspection failure rates were similar and are illustrated in the figure below.

Figure ES-1. Initial Inspection Failure Rates by, MY and I/M Program Area



Repeat I/M Failure Patterns (Section III.C) – ERG examined the TIMS data to determine the relative frequencies of the I/M pass/fail patterns during each vehicle's inspection cycle.

In 99.5% of the test sequences, a verified initial test or an initial test that could reasonably be assumed to be a true initial test was confirmed, and a final test certified.

OBD Inspection Analyzer Communication Performance (Section III.D) – Overall, OBD communication rates between vehicle computers and program analyzers were 99.9%.

TIMS Handling of OBD Codes (Section III.E) – It appears that the OBD inspection logic used in Texas for light-duty gasoline-powered vehicles agrees with EPA policies. For the very few cases where this was found not to be true, ERG believes these instances were due solely to a minor oversight such as operator error or analyzers not having the latest software update for a brief period that resulted in a small percentage of errors.

C. REPAIR

Number and Types of Repairs (Section IV.A) – During the evaluation period, analysis of the TIMS data indicated that 94,372 repairs were made to vehicles to bring them into compliance with the Texas I/M program. The program requires reporting repair types according to five categories: fuel system, ignition electrical system, emissions system, engine mechanical, and miscellaneous. The fractions of total repairs in these five categories were approximately 46%, 7%, 12%, 2%, and 34%, respectively.

OBD Repair Effectiveness (Section IV.B) – ERG's analyses indicated approximately 85% of OBD tests that initially fail for an illuminated malfunction indicator light (MIL) with stored diagnostic trouble codes (DTCs) eventually receive a passing inspection. Within that cohort, 78.2% of the MIL-On failures passed with confirmed repairs and their monitors reset, and 14.2% passed after being repaired but without failure mode monitors reset. As seen in the earlier studies, when evaluating repairs by failure category (i.e., evaporative emissions control system, O_2 Sensor, Exhaust Gas Recirculation (EGR) System, air injection system, and catalytic converter), unset readiness monitors were seen to potentially "hide" malfunctions in 2% to 30% of "repaired" vehicles. This large range is consistent with the findings in previous program evaluation reports and reflects the uncertainty in identifying cases where unset readiness monitors are masking MIL illumination in repaired vehicles.

Average Repair Costs (Section IV.C) – The analysis of the TIMS repair cost data with repair costs of zero and greater than $2,000 removed indicate that Texas motorists spent approximately $5.4 million during this evaluation period performing 32,000 repairs so that they would be in compliance with the Texas I/M program. It should be noted that repair costs are hand-entered by the vehicle emissions inspectors, which can lead to transcription errors.

As in the previous studies, a large percentage (64.1%) of the repair costs in the TIMS were recorded as zero. Again, with zero repair costs and those over $2,000 removed, the median and mean repair costs ranged from $40 to $257 and $96 to $357.

D. I/M EMISSIONS BENEFITS

The annual emissions benefit of an I/M program (I/M benefit) 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 estimated by looking at before and after repair emissions and by pairing TIMS data with RS data.

Calculation of the Annual I/M Benefit using Comprehensive Method (Section V.B) – The analysis of RS data, which is out-of-program data, provides a different view of the annual I/M benefit of the Texas I/M program. The average RS emissions from 30 to 90 days before I/M inspections were compared to the average RS emissions from 1 to 90 days after the I/M inspections. About 96% of the vehicles measured by RS had I/M sequences produced by passing their initial inspections, while 3.5% had a Fail-Pass I/M test sequence. Initial pass vehicles showed an increase in RS emissions changes for hydrocarbon (HC), carbon monoxide (CO), and nitrogen oxides (NO_x). The Fail-Pass vehicles also had RS emissions increases for HC and NO_x, but a decrease in CO.

Remote Sensing Analysis of I/M and non-I/M Vehicles (Section V.C) – The vehicles observed by RS were divided into two groups: vehicles that have never been in the I/M program prior to the RS observation, and vehicles that have been in the I/M program prior to the RS observation. This provided a four-year period before the 2022/2023 analysis years, and a sufficiently large sample size to compare the I/M fleet to the no-I/M fleet. The no-I/M versus I/M averages were plotted and it could be seen that the emission averages for each pollutant were very dependent on vehicle MY. The one most obvious result was that the no-I/M fleet average NO_x emissions were substantially higher than the I/M fleet average.

E. MEASURES FOR EVALUATING STATION PERFORMANCE

(Section VI) – This section strives to consolidate the analyses performed that pertain to the evaluation of station performance. In past reports, these offenses were broken into two different levels: errors of commission: intentional breaking of rules to manipulate inspection results, and errors of omission: failure to routinely follow regulated procedures. However, errors of omission have become much less useful in detecting fraud now that only OBD testing is performed. Therefore, errors of omission are no longer included as a measure for evaluating station performance. An example of an error of commission would be a Vehicle Identification Number (VIN) mismatch, where the electronic VIN (eVIN) does not correspond to the hand-entered VIN. In the benign case, the discrepancies are basically random. In a highly suspicious case, the exact same eVIN may be found in a large number of tests, which seems to indicate a clear case of attempted clean-scanning. In all, there were nine error-of-commission metrics developed, and station rankings were developed for the error-of-commission category.

F. RECOMMENDATIONS

As a result of performing this biennial evaluation of Texas I/M program, ERG developed a list of recommendations TCEQ may consider implementing. As in the earlier reports, 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, ERG provided an importance rating of High **(***)**, Medium **(**)**, or Low **(*)**. These ratings are provided to assist TCEQ in prioritizing efforts to improve the Texas I/M program.

TIMS Recommendations

TIMS Recommendation 1 (***): Increase number of repair categories. The TIMS repair data includes only five different repair types, 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. "Miscellaneous" repairs make up roughly 34% of the reported repairs. It is recommended that TCEQ consider increasing the number of repair categories in the analyzer software and eliminating the "miscellaneous" category since that does not provide any useful information. Ideally, the repair choices that inspectors see and choose from would be only those that apply to the technology of the vehicle being inspected, although that does involve an increase in programming complexity. Another possible solution might be to redesign the repair tracking system so that it provides inspectors a list of the five to 10 most effective repairs for each vehicle technology. ERG performed a study in 2015 for the Maryland Department of the Environment that identified a list of legitimate repairs for a given OBD DTC [ERG 2015]. This approach would provide a convenient, short list of repairs for inspectors that would make the inspectors' task simpler while recording valuable repair information that is most important for the I/M program. Providing more standardized menu options would also help improve the accuracy of these data by standardizing the entries as well as making it more onerous for the technician to enter incorrect data than to enter real data. If it becomes more difficult to input false data than the real data, then technicians would be motivated to be more accurate when completing these electronic entry forms.

Another problem is that a large number of repairs with a cost of zero exist in the dataset, along with some extremely high (e.g., 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. It is possible that some zero cost repairs could be warranty repairs, so including a "Warranty" choice in the cost options could help track this. It might be worthwhile to consider a software change that would require the inspector to input repair information within set limits of price and from a menu selection of repair choices. For example, repair costs of zero would not be accepted, and any repairs above a certain threshold (e.g., $1,000), would have to be validated by re-entering the data. It is recommended that upper and lower cost limits be added to the software for each of the repair categories that would at least force the inspector to enter a value based on the historical range for each category. If the actual cost was below or above the set limits, it could be overridden, but as this would require more data entry than actually entering a realistic number the first time, ERG believes this would improve the repair cost data reporting.

TIMS Recommendation 2 (*): Testing MY96 and MY97 vehicles. Testing is no longer required for these vehicles; however, as can be seen in Section III a small number are still being tested.

OBD Recommendations

OBD Recommendation 1 (***): Interrupt OBD Tests on 2005 and newer vehicles with missing eVINs. Currently, the OBD inspection is not interrupted when the eVIN does not match the VIN for the Vehicle Under Test (VUT). This operation could greatly reduced the incidents of eVIN mismatches with the VIN for the VUT. TCEQ could also consider interrupting OBD tests on 2005 and newer vehicles that do not provide eVINs. By regulation, 2005 and newer vehicles are supposed to have eVINs available in the OBD data stream. Many tests on 2005 and newer vehicles do not report eVINs.

OBD Recommendation 2 (***): Investigate requiring a "set" status for certain monitors to prevent hiding malfunctions. Our analysis found that in 2% to 30% 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 the possibility that malfunctioning emissions control components could remain unrepaired even though the follow-up OBD test received a "pass." ERG recommends that TCEQ investigate implementing a software change that would require certain monitors to have a "set" readiness status on an OBD retest that follows certain types of initial failures. This software change was also recommended in the previous program evaluation report.

OBD Recommendation 3 (***): Review the OBD exemption list. Review the current list of vehicles on the OBD readiness exemption list to ensure it is up to date. This may have been done recently, but the document does not indicate when the last update was performed.

OBD Recommendation 4 (**): Switching Failed Light Duty Vehicle OBD test to Heavy Duty Vehicle. ERG investigated whether switching a vehicle from having a light-duty gross vehicle weight rating (GVWR less than or equal to 8,500 lbs.) to a heavy-duty GVWR was ever used to manipulate emissions inspection results. The vehicle GVWR is an inspector-entered field in the inspection record. Overall, it was found that only 0.25% of inspections (about 1,600 inspections) that were initially failed as a light-duty vehicle were followed by a passing retest as a heavy-duty vehicle. However, these inspections were clustered at a handful of stations, and at the 10 highest ranking stations this was done for about 12% of retests. ERG suggests adding a software check in the system that requires the inspector to verify the change in GVWR if it is greater than 10% of the value entered for the original test, or some other suitable flag to discourage this behavior.

OBD Recommendation 5 (*): Diesel OBD and Heavy-duty Gasoline OBD. Per EPA guidance, Texas does not perform testing on OBD heavy-duty vehicles. Furthermore, legislative action would be required to grant TCEQ the authority to test these vehicles. However, this topic continues to be discussed in the I/M community and California implemented a heavy-duty diesel I/M program in 2023. Other states are also exploring the possibility of adding a heavy-duty component to their I/M program; therefore, ERG suggests TCEQ stay abreast of any developments in this area.

OBD Recommendation 6 (*): Key-On-Engine-Running. The MIL Illumination Status appears to be well enforced as a condition for OBD failure as no inspections were recorded with a MIL Illumination Status of "N" and an overall OBD result of "P." However, the Key-On-Engine-Running (KOER) MIL Illumination Status is manually entered by the inspector, and the accuracy of this entry is not automatically enforced by the analyzer. In this analysis there were 243,982 inspections with a "pass" result that was manually entered when the downloaded MIL status indicated a "fail" result, and a "fail" result was entered 8,367 times when the MIL status indicated a "pass" result. Therefore, TCEQ may want to consider a specification change where passing MIL Status would result in a passing OBD result despite a KOER result of fail.

OBD Recommendation 7 (*): Collect Additional OBD Data. TCEQ may want to explore collecting additional OBD data that may now be available such as Permanent DTCs, Pending DTCs, Fuel Consumption, Run Time, and Traveled Distance.

RS Recommendations

Recommendation 2 (**): Collect RS data in San Antonio. In the 2009 Report [ERG 2009], ERG was able to use RS data from San Antonio to analyze the DFW/HGB RS fleet data using the Reference Method. The Reference Method for evaluating I/M programs compares RS readings from a non-I/M area like San Antonio to the RS readings from an I/M area to identify trends, benefits, and calculate effectiveness of implementing an I/M program. If possible, efforts should continue to obtain RS data from a non-I/M area for future evaluations.

Repair Tracking Recommendations

Regardless of how malfunctioning vehicle emission control systems are detected, improvements can be made to the system of recording 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. Because the Repair Tracking data are so integrated into the TIMS, all recommendations for this topic were included with the TIMS Recommendations above.

I. INTRODUCTION

The purpose of this report is to fulfill a federal requirement to evaluate the effectiveness of the state's I/M program operating in the DFW and HGB areas. Title 40 Code of Federal Regulations (CFR) §51.353 (c), Network Type and Program Evaluation, requires all states subject to an enhanced I/M program to evaluate the effectiveness of their program and submit a program evaluation report to EPA every two years. The last program evaluation report was issued on June 30, 2022. The DFW and HGB areas are evaluated because only the enhanced programs are required to be evaluated every two years. The Austin-Round Rock Area and El Paso County programs are not enhanced programs; therefore, those programs are not part of this study.

The DFW and HGB enhanced I/M programs were implemented on May 1, 2002, by TCEQ and DPS. These programs incorporated vehicle emissions inspections using OBD computer testing and Acceleration Simulation Mode (ASM) dynamometer testing in Collin, Dallas, Denton, and Tarrant Counties of the DFW area and Harris County of the HGB area. In May 2003, the enhanced I/M program was expanded to include Ellis, Johnson, Kaufman, Parker, and Rockwall Counties of the DFW area, and Brazoria, Fort Bend, Galveston, and Montgomery Counties of the HGB area. On January 1, 2020, the ASM test was eliminated from the program and now only OBD testing is performed on MY 1998 and newer vehicles.

Beginning in 2004, TCEQ contracted with ERG to research options for evaluating the DFW and HGB I/M programs, and ERG developed the Texas I/M Program Evaluation Plan [ERG, 2004]. This report detailed numerous potential methods and measures for evaluating the I/M program. Working closely with ERG, TCEQ selected a set of measures that provide qualitative and quantitative assessments of the four major evaluation elements as described in EPA's Guidance on Use of In-Program Data for Evaluation of I/M Program Performance, along with several measures that assess actual emissions benefits, as described in the Texas I/M Program Evaluation Plan and EPA's Guidance on Use of Remote Sensing for Evaluation of I/M Program Performance. This evaluation is required to be conducted in accordance with TCEQ-selected measures.

A. EVALUATION ANALYSIS APPROACH

The Clean Air Act requires that states evaluate their I/M programs every two years. The Sierra Method was initially used to evaluate the Texas I/M program in 2000 [ERG 2003], and later ERG used the updated EPA guidance [EPA 2001, EPA 2004] as a framework for an evaluation performed in 2006 [ERG 2006]. Since then, ERG performed evaluations in 2009 [ERG, 2009], 2012 [ERG 2012], 2014 [ERG 2014], 2016 [ERG 2016], 2018 [ERG 2018], 2020 [ERG 2020], and 2022 [ERG2022] using the same approach as the 2006 Report.

This 2024 report follows the same general methodology, analyzing and evaluating data to assess program coverage, the vehicle inspection process, the vehicle repair process, program air quality benefits, and station performance. These areas were chosen to provide the most useful information at a reasonable cost as well as an objective assessment on the overall status of the Texas I/M program, with the intent of identifying both areas that may be improved and those that are performing well.

B. STRUCTURE OF THE REPORT

As previously stated, this report follows the same outline as past reports. Section II investigates coverage by comparing vehicle license plates read during RS measurements with the vehicles seen in the Texas I/M program TIMS database.

Section III investigates the inspection process in various ways using the TIMS data for the evaluation period. For example, TIMS data fields were checked for appropriateness, the various failure patterns were counted, and OBD communication rates and test outcomes were examined.

In Section IV, the TIMS data were analyzed with a focus on the repair data to examine the types of repairs, the cost of repairs, and the success of these repairs by analyzing the reported OBD readiness and diagnostic data.

Section V provides emission benefits estimates based on the RS data, and Section VI is a detailed analysis of station performance based on TIMS data. It covers a variety of inspection details that could indicate that fraudulent inspections are being performed, such as “clean-scanning” with the eVIN missing or not matching the VIN of record, and other anomalous test results.

II. COVERAGE

An important component of an I/M program is the level of fleet coverage, or the vehicle compliance rate. In this section, coverage is evaluated by estimating the fraction of vehicles observed on the road using RS data that also have a current and valid Texas I/M program TIMS record.

Estimates of the participation rate of vehicles subject to I/M in the DFW program area and in the HGB program area were made through a comparison of RS data and TIMS data. The RS data provide a sample of vehicles that were driven on the road, and if these vehicles were eligible for I/M, they should have an I/M test record in the TIMS database.

To perform this analysis, ERG first created a dataset of I/M-eligible vehicles captured on the road by RS at least once. To create this dataset, RS data were merged with Texas registration records by license plate. This dataset does not include vehicles from out-of-state or registered in non-I/M counties. It only consists of I/M-eligible model years. Therefore, vehicles newer than two years and older than 24 years, at the time of the RS measurement, were excluded from the analysis. Table II-1 shows the counts of unique I/M-eligible vehicles from the DFW or HGB program areas that were measured by RS between January 1, 2022, and December 31, 2023.

Table II-1. Count of Unique I/M-Eligible RS Vehicles Registered in Texas I/M Program Areas by Calendar Year

I/M Registered Area at Time of RS	Unique RS-Captured Vehicles by Calendar Year		
	2022	**2023**	**Total**
DFW	137,441	122,299	259,740
HGB	153,349	156,035	309,384
Total	**290,790**	**278,334**	**569,124**

Next, the number of unique I/M-compliant vehicles (i.e., vehicles that were tested and ultimately passed or received a waiver) in each of the Texas I/M program areas during that same time frame was determined. Table II-2 shows the overall counts for the I/M tests in the DFW and HGB program areas.

Table II-2. Count of Unique I/M-Compliant Vehicles in Texas I/M Program Areas

I/M Area where Test Performed	Unique I/M-Tested Vehicles
DFW	6,077,185
HGB	5,160,924
Total	**11,238,109**

The I/M tests were then matched to the RS/registration dataset by VIN. If an I/M test occurred any time between January 1, 2022, and December 31, 2023, and was found to have a corresponding VIN with a RS measurement taken any time during the same period, this was a matched pair. Table II-3 summarizes these results for the DFW and HGB program areas. These I/M tested matched pair values were then divided by their respective I/M eligible values for each program area in Table II-1 to obtain an estimate for the Texas I/M program participation rate (e.g., in 2022, the DFW program area participation rate was calculated as 91.3% (125,418/137,441 x 100). Table II-3 shows that the participation rate did increase slightly overall from 2022 to 2023.

Table II-3. Count of Unique I/M Eligible RS Vehicles Paired with Unique I/M-Compliant Vehicles in Texas I/M Program Areas by Calendar Year

I/M Program Area where Test Performed	Paired RS and TIMS VIN Matches		Participation Rate	
	2022	**2023**	**2022**	**2023**
DFW	125,418	114,897	91.3%	93.9%
HGB	141,844	147,910	92.5%	94.8%
Total	**267,262**	**262,807**	**91.9%**	**94.4%**

III. INSPECTION

A. CHECK MAJOR DATA FIELDS FOR APPROPRIATENESS

The goal of this section was to analyze the ranges and values of the primary variables that make up the TIMS database. This analysis provides an indication of the ability of the Texas I/M program's analyzers and database system to accurately record the activities of the Texas I/M program. If any variables have values that are out of range or missing for unexplained reasons, it suggests that the Texas I/M program activities are not being conducted properly or monitored adequately. An iterative series of steps was used to evaluate the accuracy and completeness of the data in the database. Within the database, each record or row was a test entry that contained columns of variables or data fields. The first set of basic filters applied was to remove unusual or incomplete inspections from the dataset (e.g., aborted inspections, covert audits, etc.). Then, a frequency distribution was performed on nearly all database variables to evaluate the accuracy and completeness of data fields (excluding variables with unique information for each record, such as those for VIN, license plate, or test date, and excluding variables not relevant to this analysis such as TX96_STIK_COND, TX96_INSUR_CONFIRM, or TX96_SOFTWARE_VERSION). Additional records with obvious problems were tallied and removed from the dataset, such as invalid/undefined characters stored for a coded categorical variable. Finally, combinations of variables were evaluated for consistency. These steps are described in detail below.

Initial filters and frequency distributions

The following criteria were used to delete records from the full database containing approximately 28.8 million inspection records to get a set of successful inspections. This deletion covered:

- Out-of-area inspections (not from DFW or HGB areas);
- Aborted inspections (TX96_ABORT = "J", "A");
- Safety-only or visual-only inspections (TX96_TEST_TYPE="H", "P");
- Inspections that were covert audits (TX96_covert_FL not "N");
- Out-of-program model years, older than 1996 or newer than 2024;
- Inspections with invalid VINs, either fewer than 17 characters, including invalid characters (such as "!", "@", etc.), or flagged (TX96_VIN_FL= "B"); and
- Any remaining inspections with TX96_TEST_SEQUENCE less than 1.

In total, these deletions removed about 8.1 million records from the dataset (mostly for safety-only inspections and out-of-area inspections), leaving about 20.1 million potentially valid emissions inspections in the dataset.

Almost every database variable that stores a categorical result was checked for completeness and appropriateness of information. As mentioned above, variables such as TX96_STIK_COND, TX96_INSUR_CONFIRM, or TX96_SOFTWARE_VERSION that have little relevance to emissions inspection impacts are examples of those that were ignored. Most of the variables in the dataset contained the expected information, but after the record deletions described above, a few variables that still contained anomalous information included:

- 7,956 records with an overall inspection cost greater than $100 (TX96_OVERALL_COST>100);
- 201 records with a repair cost greater than $2,000 (TX96_REP_OVERALL_COST>2000); and
- Various other variables that had a small number of missing value results or otherwise odd results that did not appear to be significant.

The anomalous records described in the list above were counted and listed but were not deleted from the dataset. Most of the anomalies were investigated, and the results of those investigations are discussed in further detail in other areas of the report.

B. INSPECTION STATISTICS: NUMBER OF VEHICLES INSPECTED

As a basic summary of the emissions inspections being performed under the Texas I/M program, a number of inspection statistics were calculated. A single inspection type, the OBD inspection, is reported, since the ASM and two-speed idle (TSI) tailpipe inspections have been phased out of the Texas I/M program. Guidance from EPA's Office of Transportation and Air Quality (OTAQ) requires detailed reporting of inspection results by model year, vehicle type, and final inspection result, so the following tables are much larger than in 2020-and-earlier I/M evaluation reports. [2]

Table III-1 shows the inspection statistics for passenger cars in the DFW area. The table includes results for every vehicle tested, beginning with the initial inspection, and continuing through to report the breakdown in the disposition of the initial inspections, as either a passed inspection, a waiver, or a vehicle with no known final outcome. The first column on the left counts every inspection in the dataset for the two-year period. This will include two annual inspections for most of the vehicles, as well as any retests that are needed to pass the inspection after initially failing it. The total number of initial inspections is given in the second column. A vehicle may be in this column two times (once for an initial inspection in 2022, and once for an initial inspection in 2023), but only two times because retests are not included. The first two columns are provided for use by TCEQ; they are not required by OTAQ guidance. The information requested by OTAQ begins at the third column, the number of inspections

[2] "Guidance on Vehicle Inspection and Maintenance (I/M) Test Data Statistics as Part of Annual I/M Reporting Requirements", EPA OTAQ Transportation and Climate Division, May 2020, EPA-420-B-20-033.

of unique vehicles. This includes only one count per VIN, i.e., one count for every unique vehicle in the Texas I/M fleet. The columns to the right of that third column continue to subdivide the count of unique vehicles according to their test disposition.

Table III-2 shows the same information for light trucks in DFW. Table III-3 and Table III-4 show the same information for the HGB area. Overall, there were 20.1 million total inspections performed with over eight million total unique inspections.

Table III-1. Number of Inspections for DFW Passenger Cars

Model Year	Total Tests	Total Initial Tests	Total Tested Unique Vehicles	Divide Total Tested Vehicles into: Initial Pass	Initial Fail	Divide Initially Failing Unique Vehicles into: Initial Fail / Ultimate Pass Num.	Pct.	Initial Fail / Waiver Num.	Pct.	Initial Fail / No Final Outcome Num.	Pct.
1996	325	316	204	185	19	2	10.5%	0	0.0%	17	89.5%
1997	968	931	560	500	60	15	25.0%	0	0.0%	45	75.0%
1998	11,259	10,679	6,215	5,770	445	326	73.3%	0	0.0%	119	26.7%
1999	27,331	25,720	11,622	10,686	936	781	83.4%	2	0.2%	153	16.3%
2000	41,134	38,574	16,862	15,457	1,405	1,210	86.1%	1	0.1%	194	13.8%
2001	48,272	43,928	19,221	16,982	2,239	1,886	84.2%	7	0.3%	346	15.5%
2002	60,088	55,046	23,824	21,336	2,488	2,135	85.8%	5	0.2%	348	14.0%
2003	74,637	68,775	29,742	26,899	2,843	2,440	85.8%	4	0.1%	399	14.0%
2004	87,249	80,816	34,410	31,230	3,180	2,758	86.7%	7	0.2%	415	13.1%
2005	113,891	105,869	45,170	41,236	3,934	3,417	86.9%	5	0.1%	512	13.0%
2006	142,098	132,921	56,084	51,473	4,611	4,034	87.5%	6	0.1%	571	12.4%
2007	181,393	170,860	71,005	65,937	5,068	4,465	88.1%	4	0.1%	599	11.8%
2008	194,072	183,237	75,666	70,574	5,092	4,556	89.5%	4	0.1%	532	10.4%
2009	168,745	159,655	65,500	61,263	4,237	3,826	90.3%	3	0.1%	408	9.6%
2010	204,145	193,690	79,160	74,400	4,760	4,233	88.9%	6	0.1%	521	10.9%
2011	215,704	205,020	83,418	78,394	5,024	4,472	89.0%	4	0.1%	548	10.9%
2012	302,912	288,459	116,695	110,104	6,591	5,930	90.0%	4	0.1%	657	10.0%
2013	355,455	340,388	138,542	131,508	7,034	6,332	90.0%	5	0.1%	697	9.9%
2014	372,822	358,484	145,032	138,368	6,664	6,015	90.3%	3	0.0%	646	9.7%
2015	400,637	386,087	157,059	150,225	6,834	6,139	89.8%	2	0.0%	693	10.1%
2016	380,495	368,190	150,108	144,314	5,794	5,234	90.3%	1	0.0%	559	9.6%
2017	370,782	359,312	146,763	141,413	5,350	4,770	89.2%	4	0.1%	576	10.8%
2018	334,897	325,799	134,121	129,537	4,584	4,073	88.9%	3	0.1%	508	11.1%
2019	320,964	312,426	129,370	124,984	4,386	3,886	88.6%	0	0.0%	500	11.4%
2020	275,222	268,656	132,103	127,994	4,109	3,608	87.8%	2	0.0%	499	12.1%
2021	138,760	136,065	118,014	115,184	2,830	2,344	82.8%	0	0.0%	486	17.2%
2022	19,046	18,770	17,502	17,144	358	235	65.6%	0	0.0%	123	34.4%
2023	2,629	2,555	2,447	2,333	114	60	52.6%	0	0.0%	54	47.4%
2024	134	119	109	98	11	10	90.9%	0	0.0%	1	9.1%
Total	**4,846,066**	**4,641,347**	**2,006,528**	**1,905,528**	**101,000**	**89,192**	**88.3%**	**82**	**0.1%**	**11,726**	**11.6%**

Table III-2. Number of Inspections for DFW Light Trucks

Model Year	Total Tests	Total Initial Tests	Total Tested Unique Veh.	Divide Total Tested Vehicles into: Initial Pass	Initial Fail	Divide Initially Failing Unique Vehicles into: Initial Fail / Ultimate Pass Num.	Pct.	Initial Fail / Waiver Num.	Pct.	Initial Fail / No Final Outcome Num.	Pct.
1996	486	477	279	250	29	7	24.1%	0	0.0%	22	75.9%
1997	1,613	1,571	921	859	62	18	29.0%	0	0.0%	44	71.0%
1998	20,372	19,281	11,311	10,550	761	574	75.4%	0	0.0%	187	24.6%
1999	54,548	51,671	21,816	20,435	1,381	1,167	84.5%	2	0.1%	212	15.4%
2000	77,773	73,662	29,836	27,986	1,850	1,629	88.1%	2	0.1%	219	11.8%
2001	102,831	94,897	38,236	34,905	3,331	2,910	87.4%	5	0.2%	416	12.5%
2002	121,403	113,088	45,075	41,556	3,519	3,124	88.8%	1	0.0%	394	11.2%
2003	139,313	130,388	52,101	48,348	3,753	3,348	89.2%	6	0.2%	399	10.6%
2004	164,525	153,969	60,850	56,489	4,361	3,965	90.9%	4	0.1%	392	9.0%
2005	163,357	152,745	60,377	56,027	4,350	3,912	89.9%	5	0.1%	434	10.0%
2006	172,409	162,147	64,002	59,731	4,271	3,832	89.7%	4	0.1%	435	10.2%
2007	231,335	218,239	85,260	79,992	5,268	4,757	90.3%	3	0.1%	508	9.6%
2008	233,080	220,336	85,255	80,086	5,169	4,689	90.7%	7	0.1%	473	9.2%
2009	138,604	130,888	50,860	47,788	3,072	2,801	91.2%	3	0.1%	268	8.7%
2010	190,864	180,824	69,909	65,940	3,969	3,656	92.1%	4	0.1%	309	7.8%
2011	239,983	228,378	87,895	83,356	4,539	4,158	91.6%	5	0.1%	376	8.3%
2012	253,151	241,699	92,896	88,267	4,629	4,240	91.6%	5	0.1%	384	8.3%
2013	315,294	302,181	114,913	109,602	5,311	4,891	92.1%	2	0.0%	418	7.9%
2014	353,073	339,291	128,732	123,216	5,516	5,078	92.1%	3	0.1%	435	7.9%
2015	418,907	404,871	154,492	148,974	5,518	5,030	91.2%	0	0.0%	488	8.8%
2016	436,850	424,214	160,976	155,881	5,095	4,661	91.5%	5	0.1%	429	8.4%
2017	487,419	474,411	180,342	175,105	5,237	4,778	91.2%	2	0.0%	457	8.7%
2018	504,393	491,653	184,603	179,308	5,295	4,822	91.1%	0	0.0%	473	8.9%
2019	535,590	522,688	196,885	191,473	5,412	4,869	90.0%	0	0.0%	543	10.0%
2020	441,644	430,750	182,279	177,217	5,062	4,506	89.0%	1	0.0%	555	11.0%
2021	236,369	230,359	189,455	184,578	4,877	4,120	84.5%	1	0.0%	756	15.5%
2022	27,717	27,267	24,806	24,272	534	342	64.0%	0	0.0%	192	36.0%
2023	4,405	4,243	4,046	3,858	188	92	48.9%	0	0.0%	96	51.1%
2024	240	216	204	184	20	19	95.0%	0	0.0%	1	5.0%
Total	**6,067,548**	**5,826,404**	**2,378,612**	**2,276,233**	**102,379**	**91,995**	**89.9%**	**70**	**0.1%**	**10,315**	**10.1%**

Table III-3. Number of Inspections for HGB Passenger Cars

Model Year	Total Tests	Total Initial Tests	Total Tested Unique Veh.	Divide Total Tested Vehicles into: Initial Pass	Initial Fail	Divide Initially Failing Unique Vehicles into: Initial Fail / Ultimate Pass Num.	Pct.	Initial Fail / Waiver Num.	Pct.	Initial Fail / No Final Outcome Num.	Pct.
1996	331	320	185	153	32	8	25.0%	0	0.0%	24	75.0%
1997	798	780	453	413	40	7	17.5%	0	0.0%	33	82.5%
1998	8,536	7,979	4,611	4,196	415	315	75.9%	0	0.0%	100	24.1%
1999	19,453	17,995	8,288	7,501	787	641	81.4%	3	0.4%	143	18.2%
2000	29,232	26,986	11,797	10,644	1,153	972	84.3%	4	0.3%	177	15.4%
2001	35,210	31,431	14,082	12,172	1,910	1,601	83.8%	5	0.3%	304	15.9%
2002	43,876	39,652	17,441	15,275	2,166	1,832	84.6%	6	0.3%	328	15.1%
2003	54,577	49,416	21,661	19,037	2,624	2,269	86.5%	6	0.2%	349	13.3%
2004	63,096	57,407	24,779	21,931	2,848	2,497	87.7%	3	0.1%	348	12.2%
2005	85,119	77,856	33,227	29,659	3,568	3,123	87.5%	4	0.1%	441	12.4%
2006	107,709	98,993	42,030	37,723	4,307	3,754	87.2%	3	0.1%	550	12.8%

Model Year	Total Tests	Total Initial Tests	Total Tested Unique Veh.	Divide Total Tested Vehicles into:		Divide Initially Failing Unique Vehicles into:					
				Initial Pass	Initial Fail	Initial Fail / Ultimate Pass		Initial Fail / Waiver		Initial Fail / No Final Outcome	
						Num.	Pct.	Num.	Pct.	Num.	Pct.
2007	137,725	127,769	54,134	49,194	4,940	4,316	87.4%	4	0.1%	620	12.6%
2008	147,848	137,462	57,434	52,386	5,048	4,457	88.3%	5	0.1%	586	11.6%
2009	133,726	124,767	51,141	47,017	4,124	3,717	90.1%	1	0.0%	406	9.8%
2010	157,461	147,609	60,443	55,853	4,590	4,087	89.0%	3	0.1%	500	10.9%
2011	167,618	157,387	64,378	59,590	4,788	4,262	89.0%	4	0.1%	522	10.9%
2012	229,688	215,822	87,528	81,102	6,426	5,807	90.4%	3	0.0%	616	9.6%
2013	274,871	259,828	105,225	98,372	6,853	6,143	89.6%	3	0.0%	707	10.3%
2014	295,670	281,550	113,354	106,713	6,641	5,977	90.0%	3	0.0%	661	10.0%
2015	323,864	309,116	124,402	117,648	6,754	6,165	91.3%	4	0.1%	586	8.7%
2016	297,646	285,348	115,469	109,870	5,599	5,107	91.2%	1	0.0%	491	8.8%
2017	298,985	287,920	117,141	112,033	5,108	4,691	91.8%	0	0.0%	417	8.2%
2018	273,336	264,111	107,619	103,262	4,357	3,984	91.4%	1	0.0%	372	8.5%
2019	251,727	243,702	99,913	95,940	3,973	3,596	90.5%	0	0.0%	377	9.5%
2020	216,808	210,859	103,366	99,756	3,610	3,247	89.9%	1	0.0%	362	10.0%
2021	116,671	114,034	96,487	93,754	2,733	2,340	85.6%	0	0.0%	393	14.4%
2022	21,249	20,873	18,916	18,455	461	318	69.0%	0	0.0%	143	31.0%
2023	3,366	3,273	3,145	2,973	172	86	50.0%	0	0.0%	86	50.0%
2024	162	153	141	135	6	6	100.0%	0	0.0%	0	0.0%
Total	**3,796,358**	**3,600,398**	**1,558,790**	**1,462,757**	**96,033**	**85,325**	**88.8%**	**67**	**0.1%**	**10,642**	**11.1%**

Table III-4. Number of Inspections for HGB Light Trucks

Model Year	Total Tests	Total Initial Tests	Total Tested Unique Veh.	Divide Total Tested Vehicles into:		Divide Initially Failing Unique Vehicles into:					
				Initial Pass	Initial Fail	Initial Fail / Ultimate Pass		Initial Fail / Waiver		Initial Fail / No Final Outcome	
						Num.	Pct.	Num.	Pct.	Num.	Pct.
1996	358	349	206	190	16	3	18.8%	0	0.0%	13	81.3%
1997	1,286	1,240	710	629	81	22	27.2%	0	0.0%	59	72.8%
1998	16,989	15,943	9,182	8,420	762	565	74.1%	3	0.4%	194	25.5%
1999	41,940	39,148	16,768	15,418	1,350	1,141	84.5%	2	0.1%	207	15.3%
2000	62,116	57,885	23,866	22,045	1,821	1,633	89.7%	3	0.2%	185	10.2%
2001	82,219	74,745	31,173	27,840	3,333	2,907	87.2%	5	0.2%	421	12.6%
2002	99,677	91,292	37,462	33,882	3,580	3,162	88.3%	3	0.1%	415	11.6%
2003	112,187	103,250	42,521	38,455	4,066	3,604	88.6%	4	0.1%	458	11.3%
2004	131,245	121,134	49,346	45,087	4,259	3,762	88.3%	2	0.0%	495	11.6%
2005	135,249	125,080	50,957	46,439	4,518	4,029	89.2%	7	0.2%	482	10.7%
2006	153,833	142,633	57,038	52,344	4,694	4,208	89.6%	6	0.1%	480	10.2%
2007	198,524	184,722	73,970	68,074	5,896	5,288	89.7%	6	0.1%	602	10.2%
2008	206,789	193,019	75,673	69,940	5,733	5,192	90.6%	8	0.1%	533	9.3%
2009	125,269	116,800	45,934	42,441	3,493	3,161	90.5%	2	0.1%	330	9.4%
2010	166,617	156,196	60,496	56,292	4,204	3,872	92.1%	3	0.1%	329	7.8%
2011	214,932	202,291	77,774	72,697	5,077	4,644	91.5%	4	0.1%	429	8.4%
2012	228,407	215,904	82,084	77,012	5,072	4,658	91.8%	2	0.0%	412	8.1%
2013	287,318	273,325	103,143	97,565	5,578	5,114	91.7%	3	0.1%	461	8.3%
2014	327,608	311,998	117,435	111,263	6,172	5,681	92.0%	5	0.1%	486	7.9%
2015	394,323	378,260	142,714	136,526	6,188	5,757	93.0%	0	0.0%	431	7.0%
2016	386,289	372,253	139,876	134,384	5,492	5,123	93.3%	1	0.0%	368	6.7%
2017	444,547	430,177	162,592	156,874	5,718	5,350	93.6%	3	0.1%	365	6.4%
2018	471,173	457,084	169,379	163,758	5,621	5,248	93.4%	2	0.0%	371	6.6%
2019	478,451	465,297	173,886	168,660	5,226	4,840	92.6%	2	0.0%	384	7.3%

Model Year	Total Tests	Total Initial Tests	Total Tested Unique Veh.	Divide Total Tested Vehicles into: Initial Pass	Initial Fail	Divide Initially Failing Unique Vehicles into: Initial Fail / Ultimate Pass Num.	Pct.	Initial Fail / Waiver Num.	Pct.	Initial Fail / No Final Outcome Num.	Pct.
2020	389,449	379,049	160,208	155,565	4,643	4,240	91.3%	2	0.0%	401	8.6%
2021	216,928	210,520	168,355	163,388	4,967	4,305	86.7%	1	0.0%	662	13.3%
2022	34,790	34,056	29,994	29,231	763	532	69.7%	0	0.0%	231	30.3%
2023	6,214	6,050	5,704	5,463	241	129	53.5%	0	0.0%	112	46.5%
2024	304	302	274	270	4	2	50.0%	0	0.0%	2	50.0%
Total	**5,415,031**	**5,160,002**	**2,108,720**	**2,000,152**	**108,568**	**98,172**	**90.4%**	**79**	**0.1%**	**10,318**	**9.5%**

Inspection counts by model year are presented in the figures below. Figure III-1 shows the number of inspections by model year for the DFW and HGB program areas. The dip in the number of inspections for the 2009 and 2010 model years is due to the recession and has been seen in previous reports. The number of inspections by month of inspection is shown in Figure III-2. Finally, the failure rate by model year is shown in Figure III-3 for the DFW and HGB program areas. Only initial inspections are included, and retests are excluded. In general, the trends shown are as expected: more vehicles of newer model years are inspected than vehicles of older model years, and failure rates are considerably higher for older vehicles. The pass-fail rate jumps up for the 2022 and 2023 models; most of the failures for these models are for readiness. This happens because new vehicles usually have a readiness status of not ready for many non-continuous monitors.

Figure III-1. Number of Inspections by Model Year and I/M Program Area

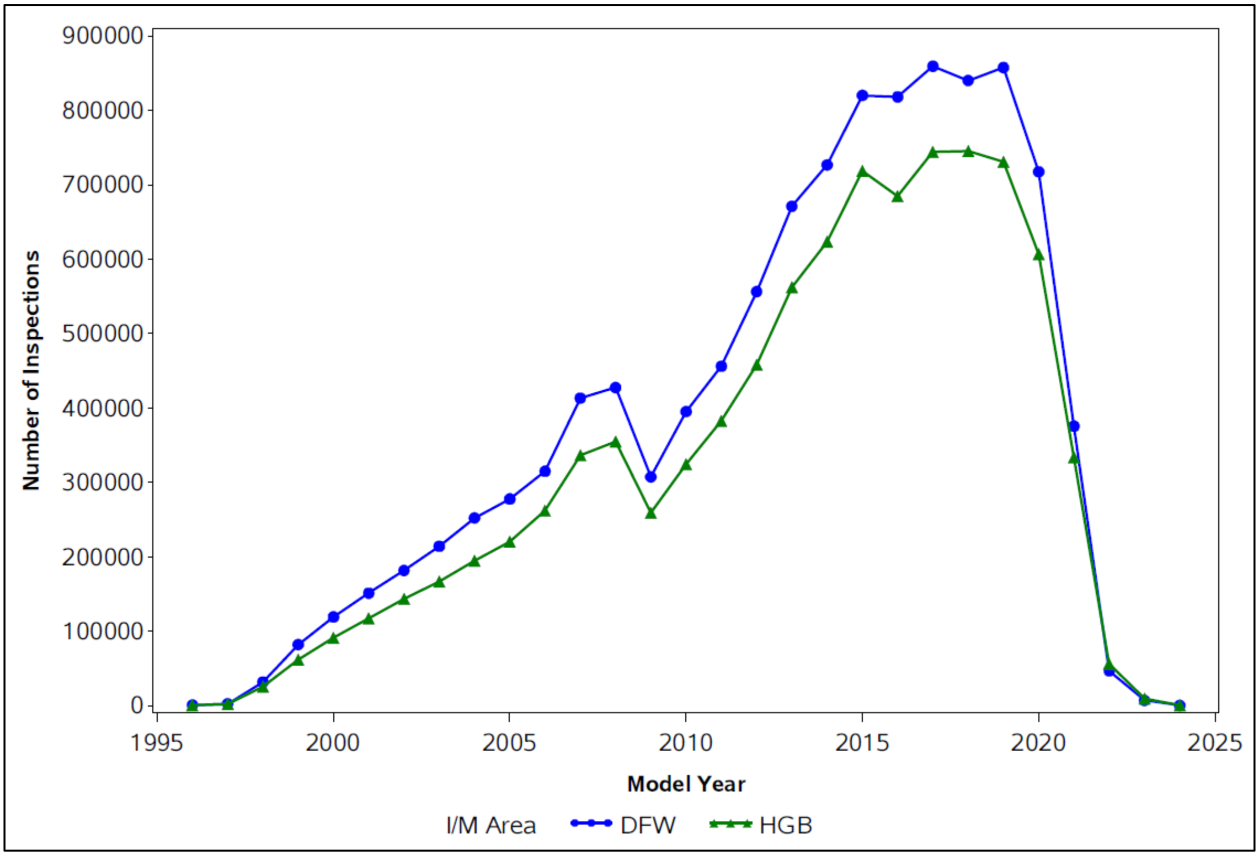


Figure III-2. Number of Inspections by Year and Month of Inspection

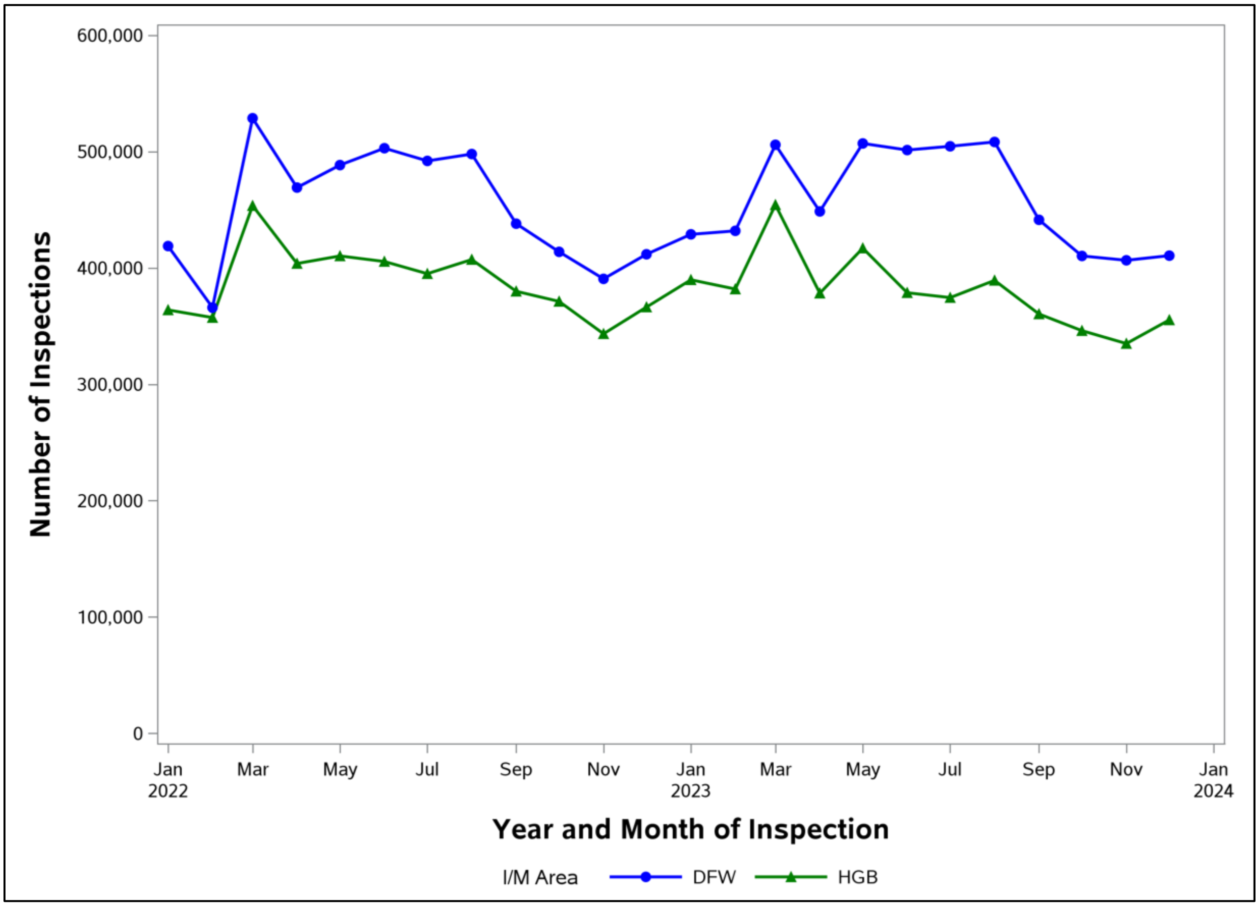
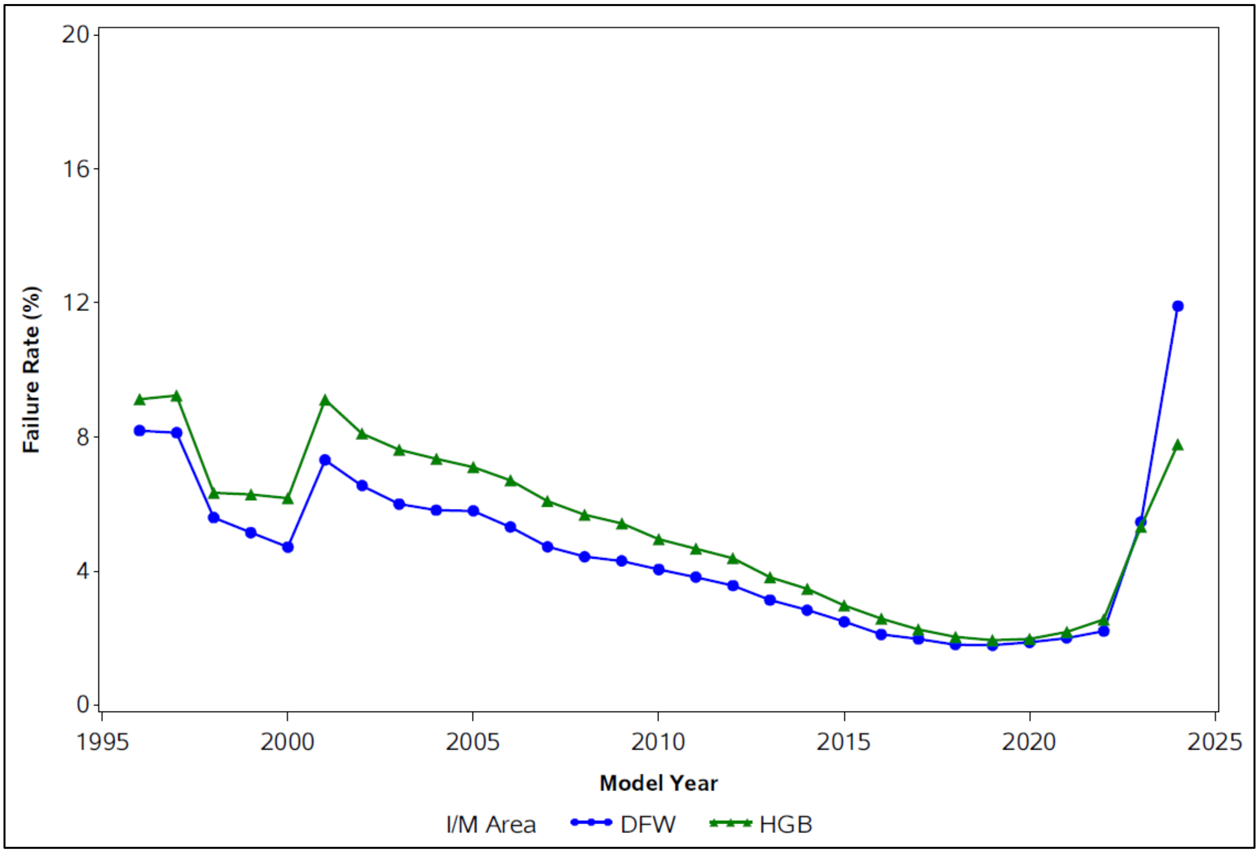


Figure III-3. Initial Inspection Failure Rate by Model Year and I/M Program Area



C. REPEAT I/M FAILURE PATTERNS

ERG examined the TIMS data to determine the patterns of repeat I/M failures. This illustrates the extent and characteristics of repairs related to the Texas I/M program. This analysis was based on the two-year evaluation period, including all of 2022 and 2023. Initial and retest inspections were not determined using the TX96_TEST_SEQUENCE or TX96_TEST_TYPE variables. These database variables are intended to store the number of inspections in an inspection sequence and indicate whether an inspection is an initial or a retest inspection. However, many factors can affect the information stored in these variables, such as the time span between an initial and a retest inspection, whether the motorist chose a different inspection station for the retest, or whether a safety-only inspection was performed at some point. For the purposes of this section and this report, ERG made new initial/retest assignments. The first inspection for a VIN was labeled an initial inspection. Additional inspections to that VIN were labeled as retests until an inspection was passed or a waiver was granted. The next inspection following a passed inspection or a waiver was labeled an initial inspection. For identifying initial inspections, inspection cycles that appeared to begin in the first four months of 2022 were excluded from the counts as they could have been preceded by additional inspections in 2021.[3] Also, for the purpose of identifying final inspections, any inspection cycles that appeared to end in the last four months of 2023 were excluded as there could be additional inspections in early 2024.

An "inspection sequence" is the series of inspections a vehicle receives as it moves through the Texas I/M program requirements. By far, the most common sequence is a single passed inspection. The second most common sequence is a failed inspection, followed by repair and a passed retest. Additional sequences might include additional failed inspections before the ultimately passed inspection. Sequences should not be found where additional retest inspections follow a passed inspection as these indicate that the measurements and efficacy of the repairs made to the vehicles in the program are less than ideal. For example, a sequence that is fail, fail, fail, fail, pass might indicate either that the motorist is "shopping around" for a passing result, that no repairs were made to the vehicle, that the repairs done to the vehicle were inadequate, or that the test was inaccurate.

Each vehicle was tested at an I/M inspection station on one or more occasions. The dataset contains 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). Failed inspections were designated with an "F" and passes with a "P." Inspections that resulted in a waiver were designated with a "W." For each unique VIN in the dataset, the designators were concatenated in chronological order to create a sequence that describes the test pattern that each vehicle experienced during an I/M testing cycle. For example, for a vehicle that initially failed and then passed on a retest, the test sequence would be "FP." The frequency distribution of the resulting test sequences is shown in Table III-5, with results for the DFW and HGB program areas shown separately. The infrequent waiver inspections are included in the "Other" category. In 99.5% of the test sequences, a verified initial test or an initial test that could reasonably be assumed to be a true initial test was confirmed, and a final test certified.

Table III-5. Frequency Distribution of Test Sequences

DFW			HGB		
Inspection Sequence	Number of Vehicles	Percent of Vehicles	Inspection Sequence	Number of Vehicles	Percent of Vehicles
P	8,375,883	95.65%	P	6,850,870	94.71%
FP	311,995	3.56%	FP	314,448	4.35%
F	34,710	0.40%	F	34,536	0.48%
FFP	24,577	0.28%	FFP	23,937	0.33%
FFFP	4,257	0.05%	FFFP	3,941	0.05%
FF	3,006	0.03%	FF	3,434	0.05%
FFFFP	941	0.01%	FFFFP	858	0.01%

[3] In previous years, ERG used a three-month period instead of four. However, the 2020 OTAQ guidance referred to in footnote 2 suggested a change to a four-month period, and ERG has made that change for this document.

DFW			HGB		
Inspection Sequence	Number of Vehicles	Percent of Vehicles	Inspection Sequence	Number of Vehicles	Percent of Vehicles
FFF	639	0.01%	FFF	649	0.01%
Other	976	0.01%	Other	888	0.01%

In Table III-5, the top two rows, which represent the two "ideal" inspection sequences, comprise about 99% of the total distribution, both in the DFW and HGB program areas. However, some of the other sequences raise questions, such as, what becomes of the vehicles that fail an inspection and do not receive a passing retest? One check that was performed for this set of vehicles was to make sure that they are not being affected by sequences that start near the end of the dataset and might have later retests. It was found that the sequences that end with a failed inspection are distributed fairly uniformly over all months of 2022 and 2023, although some increase is seen in the later months of the dataset. The vehicles that did not complete their inspection sequences and ended with no final passed inspection (NFP) may have moved (or have been re-registered) out of the I/M program area, and therefore may no longer be required to participate in the I/M program. However, some of the NFP vehicles were observed in the I/M program area by RS after their incomplete inspection cycle. These non-compliant vehicles were observed at approximately half the frequency as compliant vehicles. There were 34,710 NFP vehicles in the DFW area, accounting for 9.1% of all failing vehicles, and there were 34,536 NFP vehicles in the HGB area, accounting for 9.0% of all failing vehicles.

Several hundred less common sequences accounted for the remaining 0.01-0.02% of the tested fleets. Many of these remaining sequences seem to be unlikely, involving numerous failed inspections and/or multiple passed inspections. Some of these could be the result of resale vehicles, unidentified covert audit vehicles, or possibly test classification errors instead of real situations. While it might be possible to reduce the occurrence of these unlikely test sequences, the problem is relatively uncommon.

D. OBD INSPECTION ANALYZER COMMUNICATION PERFORMANCE

ERG analyzed TIMS OBD data to look for proper analyzer communication, as it is possible that certain models of analyzers cannot communicate with certain model year, make, and model vehicles when connected to the vehicle's Diagnostic Link Connector (DLC). The objective of this task was to analyze TIMS data to determine if certain manufacturers of OBD inspection analyzers appear to have communication problems with certain makes, models, or model year vehicles, which would result in elevated failure to communicate rates for those vehicle groups.

For this task, ERG reviewed OBD inspection records to identify all tests with a result other than "P" in the "OBD2_DLC_RES" field of the test record. For these records, analysis was performed to identify rates of failure to communicate by:

- vehicle model year;
- analyzer manufacturer;
- vehicle make; and
- vehicle model.

Results are presented for each of these four groups.

Three of the 20,146,563 OBD test records had no information stored in the OBD communication result field. These records all had null values for ready result, fault code result, downloaded MIL status, and OBD pass/fail result, and all three had an overall passing result (a "P" in the "OVERALL_RESULTS" field). There were also 568,563 records for vehicles of unknown gross vehicle weight rating (GVWR) or heavy-duty (HD) vehicles (i.e., >8,500 lbs. GVWR). All these records were excluded from the results, leaving 19,578,000 OBD records in the dataset.

Communication Rates by Vehicle Model Year – Table III-6 provides a summary of communication rates by model year of vehicles tested in the program.

The “MODEL_YEAR” field from the vehicle test result tables was used to determine model year. Values and percentages shown in the table are listed by model year. For example, 135,141 OBD tests were conducted on model year 1999 vehicles, and only 272 of these had an OBD fail to communicate status. Overall, very low numbers were seen for “failure to communicate” test results, and the overall “failure to communicate” rates were very low. In addition, most tests with a “failure to communicate” result were followed by a subsequent test of the same vehicle in which OBD communication was successfully established. The overall program-wide communication rate between vehicles and analyzers, excluding the inspections that were removed from the dataset as described in Section III.A, is 99.9%.

Communication Rates by Equipment Manufacturer – Table III-7 provides results of communication rates among the various analyzer manufacturers. Opus Inspection makes Environmental Systems Products (ESP)-branded analyzers. Records in the TIMS data from ESP analyzers are identified by their a two-letter designation, ES. Similarly, Worldwide Environmental Products makes self-branded analyzers whose records use WW as their two-letter designation.

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 two rightmost columns provide counts of tests and percentages of tests by each analyzer manufacturer relative to the total number of tests. For the most part, the rate of communication problems was consistently low for each manufacturer.

Table III-6. 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 Year
	Count	Percent	Count	Percent	Count	Percent	
1996	4	0.28%	5	0.34%	1,444	99.38%	1,453
1997	3	0.07%	6	0.13%	4,462	99.80%	4,471
1998	24	0.04%	104	0.19%	54,761	99.77%	54,889
1999	34	0.03%	272	0.20%	134,835	99.77%	135,141
2000	57	0.03%	327	0.16%	197,888	99.81%	198,272
2001	84	0.03%	447	0.18%	252,504	99.79%	253,035
2002	74	0.02%	493	0.16%	310,090	99.82%	310,657
2003	103	0.03%	626	0.17%	361,701	99.80%	362,430
2004	122	0.03%	657	0.15%	427,281	99.82%	428,060
2005	97	0.02%	667	0.14%	479,202	99.84%	479,966
2006	138	0.02%	694	0.13%	553,948	99.85%	554,780
2007	178	0.02%	833	0.11%	727,064	99.86%	728,075
2008	146	0.02%	734	0.10%	755,901	99.88%	756,781
2009	104	0.02%	509	0.09%	550,746	99.89%	551,359
2010	131	0.02%	748	0.11%	705,809	99.88%	706,688
2011	134	0.02%	830	0.10%	815,979	99.88%	816,943
2012	129	0.01%	1018	0.10%	988,589	99.88%	989,736
2013	160	0.01%	1101	0.09%	1,207,977	99.90%	1,209,238
2014	158	0.01%	1130	0.09%	1,324,642	99.90%	1,325,930
2015	150	0.01%	1353	0.09%	1,498,305	99.90%	1,499,808
2016	142	0.01%	1402	0.10%	1,463,740	99.89%	1,465,284
2017	166	0.01%	1627	0.10%	1,560,523	99.89%	1,562,316
2018	172	0.01%	1694	0.11%	1,548,302	99.88%	1,550,168
2019	212	0.01%	1835	0.12%	1,539,006	99.87%	1,541,053
2020	326	0.03%	4555	0.35%	1,283,379	99.62%	1,288,260
2021	251	0.04%	4131	0.60%	684,598	99.36%	688,980
2022	21	0.02%	198	0.20%	97,809	99.78%	98,028
2023	5	0.03%	27	0.17%	15,406	99.79%	15,438
2024	0	0.00%	2	0.26%	758	99.74%	760
Total	**3,325**	**0.02%**	**28,025**	**0.14%**	**19,546,649**	**99.84%**	**19,577,999**

Communication Rates by Vehicle Make - To assess communication rates by vehicle make, vehicle registration records were merged with vehicle test records by VIN. Makes that were represented by 100 or fewer vehicles were removed from the table since sample sizes would be too small to provide meaningful results.

Table III-8 provides a summary of communication rates among the various vehicle makes. The incident rates for “damaged, inaccessible, or cannot be found” or “no communication” were very low.

Communication Rates by Vehicle Model - To assess communication rates by vehicle models, the model codes and model names (series) as reported in the vehicle test results tables were used. Table III-9 lists communication rates for each vehicle model code. Records for the more uncommon series, i.e., less than 100 inspection records, were excluded. Because Table III-9 is very long, in the text below, only vehicle makes through Alfa are listed. The full table is provided in Appendix A.

It can be seen from the table that no model codes/vehicle series had "damaged, inaccessible, or cannot be found" or "no communication" rates that were greater than 1%, and all were below 0.5% except for Lotus.

Table III-7. 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	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
ESP	2,650	0.02%	21,397	0.14%	15,028,443	99.84%	15,052,490	76.88%
WW	675	0.01%	6,628	0.15%	4,518,206	99.84%	4,525,509	23.12%
Total	**3,325**	**0.02%**	**28,025**	**0.14%**	**19,546,649**	**99.84%**	**19,577,999**	**100.00%**

Table III-8. 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	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
ACURA	27	0.01%	240	0.09%	266,771	99.90%	267,038	1.37%
ALFA ROMEO	6	0.06%	20	0.19%	10,265	99.75%	10,291	0.05%
AUDI	32	0.02%	275	0.13%	207,624	99.85%	207,931	1.06%
BENTLEY	1	0.02%	8	0.18%	4,500	99.80%	4,509	0.02%
BMW	65	0.02%	662	0.17%	398,255	99.82%	398,982	2.04%
BUICK	30	0.02%	215	0.11%	194,228	99.87%	194,473	0.99%
CADILLAC	53	0.02%	325	0.10%	318,633	99.88%	319,011	1.63%
CHEVROLET	419	0.02%	2,705	0.11%	2,474,277	99.87%	2,477,401	12.66%
CHRYSLER	22	0.01%	211	0.10%	212,444	99.89%	212,677	1.09%
DODGE	160	0.02%	757	0.11%	715,835	99.87%	716,752	3.66%
FIAT	3	0.01%	35	0.16%	21,426	99.82%	21,464	0.11%
FORD	719	0.03%	8988	0.35%	2,548,033	99.62%	2,557,740	13.07%
GENS	1	0.01%	8	0.09%	9,070	99.90%	9,079	0.05%
GMC	79	0.01%	613	0.10%	632,722	99.89%	633,414	3.24%
HONDA	272	0.02%	1685	0.10%	1,743,663	99.89%	1,745,620	8.92%
HUMMER	6	0.05%	26	0.23%	11,179	99.71%	11,211	0.06%
HYUNDAI	83	0.01%	586	0.09%	656,458	99.90%	657,127	3.36%
INFINITI	35	0.01%	251	0.09%	280,022	99.90%	280,308	1.43%
ISUZU	1	0.02%	16	0.25%	6,320	99.73%	6,337	0.03%
JAGUAR	10	0.02%	60	0.15%	40,494	99.83%	40,564	0.21%
JEEP	115	0.02%	878	0.13%	674,234	99.85%	675,227	3.45%
KIA	48	0.01%	424	0.08%	542,017	99.91%	542,489	2.77%
LEXUS	71	0.01%	528	0.08%	675,890	99.91%	676,489	3.46%
LINCOLN	43	0.03%	632	0.41%	151,878	99.56%	152,553	0.78%
LAND ROVER	15	0.02%	96	0.10%	93,626	99.88%	93,737	0.48%
LOTUS	2	0.46%	4	0.92%	429	98.62%	435	0.00%

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	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
MASERATI	3	0.03%	27	0.24%	11,387	99.74%	11,417	0.06%
MAZDA	81	0.02%	743	0.22%	334,448	99.75%	335,272	1.71%
MERCEDES	6	0.01%	63	0.16%	40,533	99.83%	40,602	0.21%
MERCURY	76	0.02%	795	0.16%	482,180	99.82%	483,051	2.47%
MITSUBISHI	29	0.03%	226	0.20%	115,349	99.78%	115,604	0.59%
MINI	6	0.01%	68	0.14%	48,905	99.85%	48,979	0.25%
NISSAN	207	0.01%	1,500	0.09%	1,613,429	99.89%	1,615,136	8.26%
OLDSMOBILE	2	0.06%	5	0.15%	3,224	99.78%	3,231	0.02%
PONTIAC	8	0.02%	82	0.18%	44,363	99.80%	44,453	0.23%
PORSCHE	14	0.02%	218	0.28%	78,810	99.71%	79,042	0.40%
RAM	32	0.01%	296	0.11%	257,743	99.87%	258,071	1.32%
SAAB	2	0.06%	8	0.23%	3,457	99.71%	3,467	0.02%
SATURN	5	0.02%	45	0.16%	28,878	99.83%	28,928	0.15%
SCION	11	0.02%	67	0.11%	62,962	99.88%	63,040	0.32%
SUBARU	17	0.01%	261	0.11%	227,257	99.88%	227,535	1.16%
SUZUKI	3	0.03%	28	0.28%	9,924	99.69%	9,955	0.05%
TOYOTA	418	0.01%	2,548	0.09%	2,805,928	99.89%	2,808,894	14.36%
VOLKSWAGEN	47	0.02%	518	0.17%	305,906	99.82%	306,471	1.57%
VOLVO	9	0.01%	106	0.12%	91,610	99.87%	91,725	0.47%
OTHER	29	0.04%	143	0.19%	74,335	99.77%	74,507	0.38%
Total	**3,323**	**0.02%**	**27,995**	**0.14%**	**19,530,921**	**99.84%**	**19,562,239**	**100.00%**

Table III-9. OBD Communication Rates by Vehicle Model Code for Elevated Miscommunications

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
ACUR								
3.2TL	1	0.04%	5	0.18%	2,739	99.78%	2,745	0.02%
Integra	1	0.16%	4	0.65%	615	99.19%	620	0.00%
MDX	7	0.01%	70	0.09%	74,007	99.90%	74,084	0.47%
RDX	2	0.00%	56	0.09%	60,611	99.90%	60,669	0.38%
RL	2	0.12%	3	0.17%	1,734	99.71%	1,739	0.01%
RSX	1	0.04%	6	0.26%	2,324	99.70%	2,331	0.01%
TL	3	0.01%	35	0.11%	31,974	99.88%	32,012	0.20%
TLX	2	0.01%	12	0.05%	24,700	99.94%	24,714	0.16%
TSX	4	0.02%	11	0.05%	23,151	99.94%	23,166	0.15%
ALFA								
Giulia	1	0.05%	7	0.37%	1,869	99.57%	1,877	0.01%
Giulia Ti	2	0.08%	3	0.12%	2,551	99.80%	2,556	0.02%
Stelvio	1	0.05%	1	0.05%	2,082	99.90%	2,084	0.01%

E. TIMS HANDLING OF OBD CODES

ERG analyzed TIMS OBD data to evaluate the accuracy of OBD data collected in the Texas I/M program. This is a process-based measure for inspection effectiveness. The handling of OBD readiness, diagnostic trouble codes, and communication failures varies among I/M programs. The objective of this task was to analyze OBD inspection records to ensure OBD test results are appropriate for various OBD test dispositions, such as a vehicle with too many OBD monitors "not ready," a vehicle with "pending" DTCs, or a vehicle that fails to communicate with the analyzer.

Program Description and Results of Analysis

Proper handling of various OBD test scenarios is defined in Parts 85.2207 and 85.2222 of Title 40 of the CFR and also in various OBD implementation guidance documents issued by EPA. Appropriate responses to the various test scenarios are summarized here and serve as the basis for analysis in this task. The dataset for this analysis included records for OBD inspections between January 1, 2022, and December 31, 2023. Records for inspections that were aborted were excluded from the dataset, as were records for which either the OBD result, or the overall result was not "P" (pass) or "F" (fail). Because this analysis was performed with the goal of determining whether OBD inspection guidelines are enforced, only records for light-duty vehicles were used. Downloaded OBD test pass/fail results are not enforced for HD vehicles (i.e., vehicles with a GVWR greater than 8,500 pounds); therefore, these vehicles were removed from the dataset. HD vehicles were identified as those with the TX96_TYPE field equal to one and the TX96_GVW_ACTUAL field between zero and 8,501. Vehicles with no GVWR given were also removed since these might be HD vehicles. Following these removals, 19,571,314 records remained in the dataset.

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 the vehicle may be "rejected" for a DLC that is inaccessible or cannot be located. Failure to communicate with an OBD 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 III-10.

Table III-10 shows that 296 test records have a DLC communication status of "D", "I", "L", or "N," yet have an OBD test result of "pass." For these records, it was noted that no result was given for monitor readiness (which should have been a "pass" in order to pass the OBD inspection). It is not clear what led to the passing result for those records. In conclusion, the DLC failure to communicate was enforced on the vast majority of OBD tests conducted on light-duty vehicles during the period of evaluation.

Table III-10. Comparison of DLC Communication Status with Overall OBD Test Results

DLC Communication Status	Overall OBD Test Results	
	Fail	Pass
"D" (damaged)	1,190	0
"I" (DLC is inaccessible)	716	0
"L" (inspector cannot find DLC)	1,181	231
"N" (connected but will not communicate)	27,947	65
Sub-Total count of "D", "I", "L", and "N" Tests	**31,034**	**296**
"P" (communication successful)	726,040	18,813,944
Total	**757,074**	**18,814,240**

Because successful communication with the inspection analyzer is critical for all other OBD results, the OBD records with OBD2_DLC_RES results other than "P" were removed from the dataset for the other analyses that comprise the remainder of this section. This left 19,539,984 records in the dataset.

Agreement between OBD test result and overall test result – A vehicle that fails the OBD inspection should fail the overall inspection. To determine if OBD failures were properly recorded in the overall inspection disposition, a query was performed to quantify the number of vehicles that failed the OBD portion of the test ("F" in the "OBD2_PF_FLAG" field) but passed the overall OBD test ("P" in the "OVERALL_RESULTS" field). Table III-11 shows that no tests were recorded with a "fail" in the OBD portion of the test and a "pass" for the overall test.

Table III-11. Comparison of OBD Test Result with Overall Test Result

Result of OBD Test	Overall Test Result				Total	
	Fail		Pass			
Fail	726,040	100.00%	0	0.00%	726,040	3.72%
Pass	256,068	1.36%	18,557,876	98.64%	18,813,944	96.28%
Total	**982,108**	**5.03%**	**18,557,876**	**94.97%**	**19,539,984**	**100.00%**

Inspector-Entered MIL bulb check – This is also referred to as the Key On / Engine Off (KOEO) check. The inspector is instructed to turn the vehicle's ignition key to the "on" position, but not start the vehicle, 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 OBD 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 OBD test result ("OBD2_PF_FLAG" field), to ensure that a MIL bulb check failure always results in an OBD test failure. The "OBD2_MIL_CHECK" results are "Y" or "K", which is a pass (yes, the MIL did illuminate or keyless ignition), and "N", which is a fail (no, the MIL did not illuminate). There were no records where a KOEO MIL result of "N" (fail) did not receive a failing OBD result. This is a new and positive result as prior I/M evaluation reports had observed at least a few dozen records where the "N" result did not receive a failing OBD result. The three inspections for which no KOEO result was available also received a failing result. The results are presented in Table III-12 below.

Table III-12. Comparison of KOEO MIL Bulb Check Result with Overall OBD Test Result

Result of KOEO MIL Bulb Check	Overall OBD Test Result		Total
	Fail	Pass	
Missing result	3	0	3
N (fail)	14,360	0	14,360
K (pass)	84,643	3,644,856	3,729,499
Y (pass)	627,034	15,169,088	15,796,122
Total	**726,040**	**18,813,944**	**19,539,984**

Inspector-Entered Engine-Running MIL Illumination Status – The KOER 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 OBD 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 III-13 shows that the MIL Illumination Status appears to be enforced as a condition for OBD failure: no inspections were recorded with a MIL Illumination status of “N” and an overall OBD result of “P.” However, since the KOER MIL Illumination Status is manually entered by the inspector, accuracy of this entry is not automatically enforced by the analyzer. As shown in Table III-14, in 243,982 inspections a “pass” result was manually entered when the downloaded MIL status indicated a “fail” result, and a “fail” result was entered 8,367 times when the MIL status indicated a “pass” result. These latter cases are possible false failures.

Table III-13. Comparison of Inspector-Entered MIL Illumination Status (Engine Running, KOER) with Overall OBD Test Result

Result of MIL Illumination Status	Overall OBD Test Result		Total
	Fail	Pass	
Missing result	3	0	3
N (Fail)	28,524	0	28,524
Y (Pass)	697,513	18,813,944	19,511,457
Total	**726,040**	**18,813,944**	**19,539,984**

Table III-14. Comparison of Downloaded MIL Command Status with Inspector-Entered MIL Illumination Status (Engine Running, KOER)

Result of Downloaded MIL Status	Result of MIL Illumination Status			Total
	(missing result)	Fail	Pass	
Missing result	3	0	0	3
Fail	0	20,157	243,982	264,139
Pass	0	8,367	19,267,475	19,275,842
Total	**3**	**28,524**	**19,511,457**	**19,539,984**

MIL Commanded On – A vehicle with the MIL commanded on and with stored emissions-related DTCs should fail the OBD inspection, regardless of readiness status. The TIMS software ignores manufacturer-specific (non-generic) DTCs in this pass/fail determination. To perform this analysis, all OBD test records were reviewed to determine the overall OBD 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 III-15 provides the results of this review.

Table III-15. Comparison of Downloaded MIL Command Status with Overall OBD Test Result

Result of Downloaded MIL Status	Overall OBD Test Result					
	Fail		Pass		Total	
Missing result	3	0.0%	0	0.0%	3	0.0%
Fail	143,476	19.8%	120,663	0.6%	264,139	1.4%
Pass	582,561	80.2%	18,693,281	99.4%	19,275,842	98.6%
Total	**726,040**	**100.0%**	**18,813,944**	**100.0%**	**19,539,**984	**100.0%**

The results in Table III-15 show that 120,663 test records (0.6% of all OBD "pass" test records) have a MIL commanded on status yet receive an overall OBD pass result. However, 120,421 of the 120,663 tests had no stored DTCs, in which case it is appropriate to pass the test. The 242 remaining inspections had one or more DTCs stored, and should have resulted in a failed OBD result, since the MIL was commanded on. In conclusion, the downloaded OBD MIL command status was enforced for almost all OBD tests conducted on light-duty vehicles (≤ 8500 lbs. GVWR) with stored DTCs during the period of evaluation.

Readiness Evaluation – Federal guidelines recommend two or fewer unset non-continuous monitors be allowed for MY 1996 through 2000 vehicles and only one (or none) unset non-continuous monitors be allowed for MY 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 based on the OBD system's readiness status.

To perform this analysis, the OBD readiness status of test records was compared on a model-year basis to evaluate conformance with the readiness guidelines. Vehicles of model years 1996 through 2000 with three or more "not ready" non-continuous monitors should have an OBD readiness failure ("F" in the "OBD2_READY_RES" field of the test record) and an OBD test result of fail ("F" in the "OBD2_PF_FLAG" field of the test record). Vehicles with two or fewer "not ready" non-continuous monitors should have an OBD readiness result of pass ("P" in the "OBD2_READY_RES" of the test record). The 2001 and newer vehicles with two or more "not ready" non-continuous monitors should have an OBD readiness failure ("F" in the "OBD2_READY_RES" of the test record) and an OBD test record result of fail ("F" in the "OBD2_PF_FLAG" field of the test record), while 2001 and newer vehicles with one or fewer "not ready" non-continuous monitors should have an OBD readiness result of pass ("P" in the "OBD2_READY_RES" field of the test record).

Table III-16 compares OBD readiness status with the number of unset monitors for all OBD tests. Only non-continuous and "enabled" monitors are presented in this comparison.

Table III-16. Unset Monitors vs. Test Readiness Status for Inspections

Count of Unset Non-Continuous Monitors	Counts of Tests of Vehicles Model Year 1998 through 2000		Counts of Tests of Vehicles Model Year 2001 and newer	
	OBD "Not Ready"	OBD "Ready"	OBD "Not Ready"	OBD "Ready"
0	0	228,795	3	16,383,697
1	0	111,905	1	2,183,163
2	19	30,267	248,453	515
3	7,934	0	164,407	2
4	4,663	0	124,051	0
5	3,450	0	44,132	0
6	123	0	1,786	0
8	0	0	1	0
Total	**16,189**	**370,967**	**582,834**	**18,567,377**

Results in Table III-16 show that a small number of tests (a total of 3) appear to have received an OBD "not ready" status despite having no unset monitors and another 20 not ready (19 for MY98-00 and 1 for MY01 and newer) despite fewer monitors below the limit. Also, 517 vehicles of model year 2001 or newer with two or more unset readiness monitors still received a readiness result of "pass." The majority of these were tested using the ESP equipment.

Table III-17 shows these data in greater detail, separated by model year.

Table III-17. Unset Monitors vs. Test Readiness Status for Inspections by Model Year

Model Year	Count of Unset Non-Continuous Monitors							
	0		1		2		3 or more	
	OBD Not Ready	OBD Ready	OBD Not Ready	OBD Ready	OBD Not Ready	OBD Ready	OBD Not Ready	OBD Ready
1996	0	31,845	0	16,408	0	4,040	2,258	0
1997	0	78,462	0	39,952	1	10,508	5,853	0
1998	0	118,488	0	55,545	18	15,719	8,059	0
1999	0	155,980	0	76,923	10128	26	9,346	0
2000	0	200,374	0	88,804	10277	32	10,500	0
2001	0	232,807	0	106,516	11,228	49	10,958	0
2002	0	286,072	1	115,876	12,377	48	12,749	2
2003	0	334,587	0	116,788	12,768	58	14,868	0

Model Year	Count of Unset Non-Continuous Monitors							
	0		1		2		3 or more	
	OBD Not Ready	OBD Ready	OBD Not Ready	OBD Ready	OBD Not Ready	OBD Ready	OBD Not Ready	OBD Ready
2004	0	395,580	0	129,046	13,282	49	15,831	0
2005	0	538,742	0	154,079	14,422	56	19,594	0
2006	1	582,631	0	139,625	14,735	40	18,675	0
2007	1	437,836	0	89,261	10,230	22	13,278	0
2008	0	577,288	0	100,674	11,312	26	16,382	0
2009	0	675,234	0	110,056	12,683	24	17,870	0
2010	0	835,709	0	117,917	13,683	31	21,106	0
2011	0	1,048,407	0	122,491	13,699	15	23,240	0
2012	0	1,165,520	0	122652	12,992	16	23,340	0
2013	0	1,342,693	0	119711	13,578	12	22,207	0
2014	0	1,335,936	0	98,209	11,306	4	18,196	0
2015	0	1,438,013	0	93,359	12,350	6	16,736	0
2016	1	1,442,281	0	79,990	11,023	1	14,945	0
2017	0	1,416,823	0	95,801	11,728	0	14,617	0
2018	0	1,193,641	0	69,230	8,896	0	11,583	0
2019	0	31,845	0	16,408	0	4,040	2,258	0
2020	0	78,462	0	39,952	1	10,508	5,853	0
2021	0	644,373	0	29,306	4,402	0	6,516	0
2022	0	89,908	0	5,632	974	0	1,294	0
2023	0	13,262	0	1,217	380	0	546	0
Total	**3**	**16,612,492**	**1**	**2,295,068**	**248,472**	**30,782**	**350,547**	**2**

Comparison of readiness result with overall pass/fail result – The pass/fail disposition of the readiness result field of the test record was compared with the overall OBD test disposition to see if any vehicles with a "not ready" status (as determined automatically by the analyzer) received an overall OBD test result of "pass." To perform this analysis, the "OBD2_READY_RES" field was compared to the "OBD2_PF_FLAG" fields in the analyzer OBD test records. These records with transitional vehicles were excluded from this analysis of readiness to prevent any confusion in the results, leaving 19,539,976 records in the dataset for this analysis. The results are shown in Table III-18.

Table III-18. Comparison of Readiness Status Field with Overall OBD Test Result

Readiness Status Check	Overall OBD Test Result				Total	
	Fail		Pass			
Missing result	14	0.0%	2,415	0.0%	2,429	0.0%
Fail (Not Ready)	593,641	81.8%	5,382	0.0%	599,023	3.1%
Pass (Ready)	132,369	18.2%	18,805,975	100.0%	18,938,344	96.9%
Total	**726,024**	**100.0%**	**18,813,772**	**100.0%**	**19,539,796**	**100.0%**

Table III-18 indicates that 2,415 of the vehicles with a “not ready” status received an overall “pass” result for the OBD portion of the test. This represents less than 0.013%; therefore, the value in Table III-18 is shown as 0.0%. This indicates that the OBD readiness status (as determined by the analyzer and stored in the OBD2_READY_RES” field of the test record) was almost always enforced for OBD tests formed during the period of evaluation. Note that the first row of the table, for 2,429 records with a missing result for the readiness status check, is a new addition that began with the 2022 report [ERG 2022] per EPA guidance. However, it is not clear why the few thousand records with the missing readiness result were able to receive mostly passing inspections.

IV. REPAIR

ERG used TIMS data from January 1, 2022, through December 31, 2023, to analyze repair activities to demonstrate the extent and effectiveness of repairs directed by the Texas I/M program. This task will cover process-based measures for repair effectiveness.

There are several issues with the repair data contained in the TIMS dataset that make analysis difficult. Future changes in the way data are collected and stored may alleviate many of these issues. These issues are described below and are very similar to those listed in previous reports.

Repair data in the TIMS are entered by the inspector performing the inspection; however, the motorist often does not bring the vehicle repair form for the re-inspection, and this leads to the inspector leaving this information blank. Most repair entries in the TIMS are made by inspectors who either work in the same facility where the re-inspection takes place or make the repairs themselves.

The TIMS repair data include only five different repair types, 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 IV-2, below, "miscellaneous" repairs make up almost 35% 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 that been used for many years. Accuracy and completeness of repair data are common issues in I/M programs that attempt to collect repair data.

It is recommended that TCEQ consider increasing the number of repair categories in the analyzer software and eliminating the "Miscellaneous" category since that does not provide any useful information. Ideally, the repair choices that inspectors see and choose from would be only those that apply to the technology of the vehicle being inspected, although that does involve an increase in program complexity.

Another problem, described in the costs section below, exists in the reported values of repair costs. Many repairs with a cost of zero exist in the dataset, along with some extremely high (e.g., greater than $2,000) costs as well. The source of these zero cost entries is not clear, but their presence makes it difficult to comprehensively assess costs across the entire dataset because they skew the results downward.

A. NUMBER AND TYPES OF REPAIRS

ERG performed analysis on the number and types of repairs for the two years of TIMS data. The inspectors at Texas I/M stations have an opportunity to enter vehicle repair information into the inspection analyzer prior to conducting an emissions retest. A simple count of the number of repairs entered and stored in the TIMS and a distribution of the repair types suggests the Texas I/M program is resulting in vehicles being repaired.

General I/M Repairs

As noted above, the TIMS database, provided by TCEQ for this analysis, contained many repair entries but relatively little detail on the nature of repairs performed. The five repair categories listed in the TIMS, along with the corresponding number of performed repairs, are presented in Table IV-1 by model year group.

Table IV-1. Repairs Listed in the TIMS

Repair Type	Model Year	Number of Repairs	% of Repair Type	% of Total
Fuel System	1998-2006	14,211	32.7%	15.1%
	2007-2012	15,121	34.8%	16.0%
	post-2013	14,083	32.4%	14.9%
	Total	*43,415*	*100.0%*	*46.0%*
Ignition / Electrical System	1998-2006	2,116	33.0%	2.2%
	2007-2012	2,124	33.2%	2.3%
	post-2013	2,165	33.8%	2.3%
	Total	*6,405*	*100.0%*	*6.8%*
Emissions System	1998-2006	3,759	33.9%	4.0%
	2007-2012	3,833	34.5%	4.1%
	post-2013	3,505	31.6%	3.7%
	Total	*11,097*	*100.0%*	*11.8%*
Engine Mechanical	1998-2006	596	35.2%	0.6%
	2007-2012	577	34.1%	0.6%
	post-2013	518	30.6%	0.5%
	Total	*1,691*	*100.0%*	*1.8%*
Miscellaneous	1998-2006	10,311	32.5%	10.9%
	2007-2012	10,410	32.8%	11.0%
	post-2013	11,043	34.8%	11.7%
	Total	*31,764*	*100.0%*	*33.7%*
	Grand Total	**94,372**		**100.0%**

B. SUCCESS OF REPAIRS TO VEHICLES FAILING OBD

The objective of this task was to determine whether vehicles failing the OBD inspection were being properly repaired. ERG performed an analysis of the TIMS data for OBD failures and the presence of an illuminated MIL and DTCs followed by an OBD pass (readiness criteria met, MIL commanded off and no DTCs) as an indicator that the I/M program is resulting in OBD repairs. In this analysis, it is assumed that an OBD fail result followed by an OBD pass result is due to vehicle repairs, although it is possible that some of the OBD fails followed by an OBD pass could result from intermittent problems, self-correcting problems (such as a loose gas cap that is tightened upon a vehicle refuel) or an OBD problem that is masked by unset readiness monitors (e.g., through a battery disconnect) on a subsequent passing retest. For example, after DTCs are cleared, it might be possible to pass a retest if the monitor associated with the DTC has not reset to ready. This “masking” issue is analyzed later in this section.

Since the electronic OBD information is not used to determine the pass or fail status of HD vehicles during OBD inspections, the records from their inspections were excluded from this analysis. This left a dataset of 19,540,639 OBD inspection records available for the analysis.

Overall Success of Repairs to Vehicles Failing OBD

For this task, ERG analyzed vehicle inspection records to identify tests with OBD failures and then determined how many of those failures were subsequently corrected. In addition, ERG created very specific definitions of OBD “fail” and “pass” to exclude initial test failures associated with readiness, failures due to OBD/analyzer communication problems, OBD test failures associated with inspector-entry, and bulb-illumination checks. An OBD test failure was defined to be any test record with one or more stored DTCs, coinciding with the OBD MIL command status of “on.” A passing result for an OBD test was defined as a downloaded OBD MIL commanded status of “off.” These definitions were needed in order to fully control the analysis of MIL status, but they did leave some inspections that did not qualify as either a full “fail” or a full “pass” (i.e., OBD test was passed but overall, I/M test was failed, etc.).

Next, all individual vehicle I/M cycles that contained at least one failed OBD 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 either passed the overall inspection or received a waiver. 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 or received a waiver, or the evaluation period ended. Once the vehicle passed its inspection, its next test (most likely for the following year’s I/M inspection) would be a new I/M cycle. Any I/M cycles that began on or after September 1, 2023, were excluded from the analysis, since it would be possible that cycles starting so near the end of the date range of the dataset could have included additional re-inspections after December 31, 2023, and there would be no information for those inspections. Using these criteria, the dataset contained 15,196,382 OBD I/M cycles (including single-OBD-test passes) that started before September 1, 2023.

After grouping by I/M cycle for vehicles with OBD failures (as previously defined), 529,833 I/M cycles were seen to include at least one failed OBD test. Of these cycles, 450,310 (85%) had a final OBD test disposition of “pass,” which for purposes of this analysis was defined as a test with a commanded MIL status of “pass” (MIL commanded off) and an OBD test disposition of “pass.” Of the remaining vehicles that never passed a subsequent OBD test, 626 received waivers, but the majority simply failed to report for additional inspections to complete the program requirements, although additional re-inspections may have occurred after December 31, 2023, which would increase the overall "repaired" numbers. Note that this indicates a higher "no-final-pass" rate than that reported above in Section III. The results here are using stricter criteria for passing the test and are therefore different than the results in Section III that were simply based on the recorded pass/fail result.

It should be noted that the two allowed unset monitors could mask existing malfunctions in some of these repaired outcomes. The influence of this masking is explored later in this section.

Success of Repairs to Specific Emission Control Systems Failing OBD

For this analysis, DTCs were categorized based on the type of monitored system, and using this categorization, ERG performed an analysis of repairs based on component categories to determine if the program was resulting in effective emission control system repairs. This task was performed as a continuation of the analysis in Section C. It uses combinations of vehicles and I/M cycles defined in that section. However, for this task, failure modes were assigned based on the DTCs contained in the failed test records.

Specifically, the analysis was performed on vehicles with DTC failures associated with oxygen sensors (O_2 Sensor), exhaust gas recirculation systems (EGR System), secondary air injection systems (AI System), catalytic converter efficiency (Catalyst), and evaporative emissions control system (Evap System) components.[4] The O_2 Sensor, EGR System, AI System, and Catalyst were included with this analysis because the readiness status of these systems, as well as the evaporative system, are specifically monitored by non-continuous monitors, and therefore the extent to which malfunctions may be masked by 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 as indicated by a "fail" test followed by a "pass" test.

For each of the failure categories, a failed inspection is defined as any inspection that contains at least one test record with stored DTCs, a downloaded OBD MIL commanded status of "on," an OBD test disposition of "fail," and an overall test disposition of "fail." Passed inspections were those that had a final test in that I/M cycle with a downloaded MIL status of "pass" (not commanded on) and an OBD test disposition of "pass."

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

[4] A list of DTCs that were included in each of these groups is given in Appendix B.

- 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 evaporative system malfunction, then the evaporative system monitor is unset on the final "pass" test for this vehicle, thereby possibly masking an unrepaired evaporative system malfunction. Once this monitor becomes "ready," any unrepaired malfunction would result in a stored evaporative system DTC and MIL re-illumination.
- Confirmed Repaired – These are the vehicles whose monitors for which the initial failure occurred are "ready" in the final test, indicating that specific type of failure is not being masked by a "not-ready" monitor. Therefore, there is 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 might have been due to DTCs being generated by a continuous monitor; however, by definition, this should not be possible since a system with a stored code must be monitored. Therefore, this subset of results was classified as "ready." Because this subset of inspections was failed, it seems that incorrect reporting of monitor status is truly the cause as opposed to potential inspection fraud through "clean-scanning."

Regarding criteria used for categorizing "pass" and "fail" tests, it should also be noted that historical or permanent DTCs without MIL illumination are trouble codes for previous malfunctions that do not necessarily indicate a current malfunction. In accordance with EPA guidance, vehicles are not failed for historical or non-MIL permanent DTCs, that is, stored DTCs but no MIL. Pending DTCs or permanent DTCs are not collected in the Texas I/M program.[5] Results from this repair analysis, 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 is worthwhile to note that a failed OBD test record could contain more than one DTC. In the Texas I/M program, up to 10 DTCs may be stored in the test record, and all stored DTCs were used for this analysis. Therefore, some vehicles were included in more than one set of results. For example, repair results for vehicles with both oxygen sensor DTCs and catalytic converter DTCs were included in both the oxygen sensor repair analysis and the catalytic converter repair analysis. Because of

[5] To ERG's knowledge, no state I/M program collects pending DTC data per Mode $07 or permanent DTC data per Mode $0A of SAE J1979. States typically only use Mode $03 and DTCs read via Mode $03 are associated to MIL status, i.e., a DTC + MIL commanded on with a confirmed DTC.

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 OBD-fail records. Rather, vehicles were categorized as "repaired" when the MIL was extinguished and the analyzer assigned an overall OBD "pass" result, regardless of the number or type of DTCs seen in the initial test failure.

Table IV-2 provides a summary of vehicle repairs (as indicated by OBD-fails followed by OBD-passes) performed over the period of evaluation. Since this analysis was performed on I/M data collected from January 1, 2022, through December 31, 2023, it is possible that some of the unrepaired vehicles were repaired in 2024. This would increase the "repaired" counts from the numbers shown in this table.

These data show that roughly 80% of vehicles that failed an OBD test received a passing OBD test. As previously indicated, many vehicles were failed with more than one DTC. Therefore, Table IV-2 may contain vehicles included in more than one DTC category. Also, only categories directly monitored with non-continuous monitors are tabulated in Table IV-2. Other failure categories for which readiness status would be more difficult to assess are excluded from the table. Table IV-2 indicates that readiness status may be masking malfunctions of 2% to 30% of vehicles that pass OBD 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 to "ready" 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.

A comparison was also made between OBD evaporative system results and gas cap test results, on a by-test basis, for all OBD tests conducted during the period of evaluation. Table IV-3 presents a summary of these results.

Table IV-2. 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	31,439	24,983	79.5%	9,480	30.2%	15,503	49.3%
O_2 Sensor	18,072	13,917	77.0%	367	2.0%	13,550	75.0%
EGR System	3,811	2,801	73.5%	96	2.5%	2,705	71.0%
AI System	908	658	72.5%	55	6.1%	603	66.4%
Catalyst	28,818	22,590	78.4%	1,783	6.2%	20,807	72.2%
Totals	**83,048**	**64,949**	**78.2%**	**11,781**	**14.2%**	**53,168**	**64.0%**

Table IV-3. Comparison of OBD Evaporative Emission Control System Test Results with Gas Cap Test Results

OBD Evap System Test Results	Gas Cap Test Result				Total
	Pass		Fail		
Pass	16,326,052	98.78%	57,928	0.35%	16,383,980
Fail	142,284	0.86%	1,645	0.01%	143,929
Total	**16,468,336**	**99.64%**	**59,573**	**0.36%**	**16,527,909**

Table IV-3 shows that approximately 0.86% of the tests had failed the OBD portion of the test with evaporative system DTCs, and approximately 0.36% of the tests failed the gas cap portion of the test. The OBD evaporative system monitoring is designed to be a more comprehensive test since it assesses the integrity of the entire evaporative control system, but the OBD evaporative emissions control system fail rate may be lowered in part by unset evaporative system readiness monitors. Evaporative emissions control systems generally require a complex series of vehicle operating conditions before this monitor is set. Although most vehicles passed both tests, very few vehicles, less than 1%, failed both tests. Allowable pressure decay limits and enhanced OBD evaporative emissions control system test criteria may contribute to differences in fail rates of the two tests and the slight discrepancy in overlap between the two tests.

Overall OBD Repair Slates

The most common repair slates for vehicles receiving OBD inspections were also identified. The top 10 slates are listed in Table IV-4. The table also gives the total number of vehicles that received repairs, i.e., received one of the top 10 repairs or some other repair.

Table IV-4. 10 Most Common Repair Slates

Repair Description	OBD	
	Count	Percent
Fuel System	33,652	44.2%
Miscellaneous	25,725	33.8%
Emissions System	9,103	11.9%
Ignition/Electrical System	5,335	7.0%
Engine/Mechanical	1,518	2.0%
Fuel System & Miscellaneous	436	0.6%
Emissions & Fuel Systems	149	0.2%
Emissions System & Miscellaneous	88	0.1%
Fuel System & Ignition/Electrical	88	0.1%
Ignition/Electrical & Emissions Systems	40	0.1%
Other	86	0.1%
Total	**76,220**	**100.0%**

For OBD inspections, a failed inspection includes one or more DTCs that are set and the DTCs give information about what type of problem(s) the vehicle has that may necessitate repairs. When an OBD inspection is passed, no DTCs will be set. Therefore, the DTCs that are initially set and then finally unset (turned off) were compared to the repairs for OBD vehicles. Since there are far too many possible combinations of DTCs to create a "DTC slate" analogous to the repair slates, where all DTCs that were turned on during an inspection sequence are considered as a group, and the analysis is done on these groups, repairs were correlated with DTCs on an individual basis rather than as slates for the OBD repair analysis.

In Table IV-5, the five repair types are listed horizontally across the header row and each row of the table represents one DTC. The number of times that each DTC was "turned off" in the same inspection cycle as each repair is given in the cells of the table. For example, in row one of the table, DTC P0420 (a catalyst system DTC) was turned off most frequently by "Fuel System" repairs (1,554 times), followed by "Emissions System" repairs (702 times), and then by "Miscellaneous" repairs (719 times). Rows with DTCs that relate to similar components or problems are grouped together in the table. The DTCs listed in Table IV-5 are the most commonly recorded DTCs, representing about two-thirds of the total DTC repair counts. In some cases, the inspectors are not choosing the correct repair type. For example, most misfire DTCs should involve ignition system repairs.

Table IV-5. Most Common OBD DTCs and Associated Repairs

DTC Name	DTC Description	Repair Type										Total
		Fuel System		Ignition/ Electrical System		Emissions System		Engine Mechanical		Miscellaneous		
		Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count
P0420	Catalyst System Efficiency Below Threshold (Bank 1)	1,554	49%	100	3%	702	22%	89	3%	719	23%	3,164
P0430	Catalyst System Efficiency Below Threshold (Bank 2)	618	47%	55	4%	267	20%	36	3%	338	26%	1,314
P0300	Random/Multiple Cylinder Misfire Detected	517	49%	145	14%	144	14%	25	2%	229	22%	1,060
P0301	Cylinder 1 Misfire Detected	253	48%	76	14%	66	13%	19	4%	114	22%	528
P0302	Cylinder 2 Misfire Detected	246	48%	86	17%	53	10%	19	4%	106	21%	510
P0303	Cylinder 3 Misfire Detected	197	44%	70	16%	66	15%	19	4%	93	21%	445
P0304	Cylinder 4 Misfire Detected	229	44%	76	15%	55	11%	18	3%	140	27%	518
P0305	Cylinder 5 Misfire Detected	122	46%	37	14%	38	14%	12	5%	56	21%	265
P0306	Cylinder 6 Misfire Detected	124	44%	42	15%	46	16%	15	5%	56	20%	283
P0441	Evaporative Emission Control System Incorrect Purge Flow	243	44%	32	6%	118	21%	13	2%	144	26%	550
P0442	Evaporative Emission Control System Leak Detected (small leak)	356	44%	40	5%	179	22%	21	3%	221	27%	817
P0446	Evap Emiss Control Sys. Vent Control Circuit Malfunction	231	47%	19	4%	108	22%	10	2%	119	24%	487
P0455	Evaporative Emiss Control Sys. Leak Detected (gross leak)	559	47%	55	5%	243	20%	36	3%	308	26%	1,201

DTC Name	DTC Description	Repair Type										Total
		Fuel System		Ignition/ Electrical System		Emissions System		Engine Mechanical		Miscellaneous		
		Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count
P0456	Evaporative Emission System Leak Detected (very small leak)	413	43%	42	4%	238	25%	24	2%	249	26%	966
P0457	Evaporative Emission System Leak Detected (fuel cap loose/off)	148	46%	16	5%	65	20%	9	3%	86	27%	324
P0171	Fuel System too Lean (Bank 1)	785	51%	93	6%	232	15%	52	3%	383	25%	1,545
P0172	Fuel System too Rich (Bank 1)	115	48%	12	5%	46	19%	15	6%	53	22%	241
P0174	Fuel System too Lean (Bank 2)	415	50%	48	6%	123	15%	28	3%	218	26%	832
P0101	Mass Air Flow (MAF) Circuit Range/Performance	213	49%	21	5%	72	17%	14	3%	114	26%	434
P0102	Mass or Volume Air Flow Circuit Low Input	109	50%	5	2%	30	14%	9	4%	65	30%	218
P0325	Knock Sensor 1 Circuit Malfunction (Bank 1 or Single Sensor2)	111	52%	20	9%	33	15%	15	7%	35	16%	214
P0335	Crankshaft Position Sensor A Circuit Malfunction	47	48%	6	6%	13	13%	4	4%	27	28%	97
P0011	Camshaft Position Timing Over-Advanced (Bank 1)	92	50%	9	5%	22	12%	13	7%	48	26%	184
P0014	Exhaust Camshaft Timing Over-Advanced (Bank 1)	98	55%	8	5%	26	15%	14	8%	31	18%	177

DTC Name	DTC Description	Repair Type										Total
		Fuel System		Ignition/ Electrical System		Emissions System		Engine Mechanical		Miscellaneous		
		Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count
P0106	Manifold Absolute Pressure/Barometric Sensor Range/Performance	60	49%	5	4%	13	11%	5	4%	40	33%	123
P0113	Intake Air Temperature Sensor 1 Circuit High Input	106	44%	15	6%	38	16%	11	5%	72	30%	242
P0115	Engine Coolant Temperature Circuit Malfunction	10	59%	2	12%	2	12%	1	6%	2	12%	17
P0121	Throttle Position Sensor/Switch A Circuit Malfunction	93	43%	20	9%	36	17%	11	5%	58	27%	218
P0128	Coolant Temperature Below Thermostat Regulating Temp.	383	42%	48	5%	116	13%	29	3%	339	37%	915
P0700	Transmission Control System Malfunction	113	43%	12	5%	23	9%	10	4%	103	39%	261

C. AVERAGE REPAIR COSTS

The TIMS dataset contains manually entered costs for I/M program repairs. This information was analyzed to provide a rough estimate of the cost of vehicle repairs because of the Texas I/M program.

To estimate repair costs based on type of repair, repair categories were developed for each vehicle for a given I/M cycle. A repair category is a concatenation of the set of repair types performed in a repair event. The five different repair types listed in Table IV-1 were combined to produce the seven most common repair categories, which account for approximately 99.6% of all vehicle and I/M cycle combinations. These categories are presented in Table IV-6.

Table IV-6. TIMS Records with a Repair Cost of Zero by Category

Repair Category	Cost > $0	Cost = $0	Total	% of Cost = $0
Fuel System and Emissions System	105	71	176	40.3%
Emissions System & Miscellaneous	237	261	498	52.4%
Engine Mechanical	1,324	309	1,633	18.9%
Ignition / Electrical System	3,912	2,149	6,061	35.5%
Fuel System	5,560	4,895	10,455	46.8%
Miscellaneous	9,064	20,923	29,987	69.8%
Emissions System	12,291	29,441	41,732	70.5%
Total	**32,493**	**58,049**	**90,542**	**64.1%**

Almost two-thirds (64.1%) of the repair costs in the TIMS were recorded as zero. There are several possible reasons for this, including repairs under warranty, inaccurate repair data entry during a vehicle re-inspection; motorists performing their own repairs; lack of repair data available during a vehicle re-inspection; or vehicles receiving a retest without receiving repairs, such as vehicles that fail due to a readiness monitor and need to simply be driven until the monitors pass their readiness tests. 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 zero significantly affected the average and median repair values calculated. Table IV-6 presents the number of records with a cost of zero by repair category. It was observed that some categories listed contained about 20–40% with zero repair costs, but the most common repair types of emissions system, fuel system, and miscellaneous repairs contained a much higher percentage, at 50% or more. However, all these percentages are comparable to those in the 2014, 2016, 2018, 2020 and 2022 reports.

It was also noted than many of the repair costs seemed to be unusually large; many records were more than $2,000, with some as high as $95,000. It is suspected that these repair costs reflect invalid data entry by inspectors during vehicle re-inspections. Figure IV-1 presents a histogram of repairs that cost $2,000 or more.

Figure IV-1. Repairs with Cost Greater than or Equal $2,000

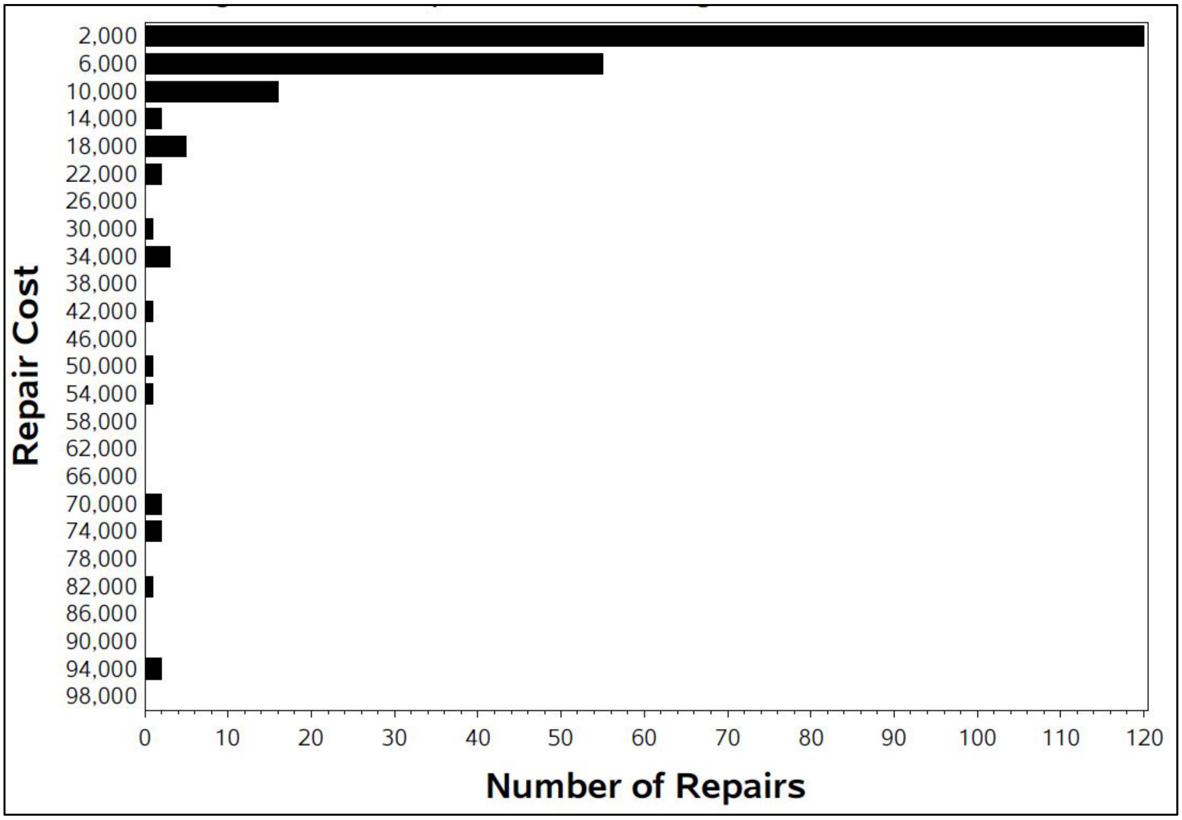


Table IV-7 presents median and mean repair costs for each of the repair types specified in the TIMS. Mean and median are calculated twice – once including the zero-dollar amount and >$2,000 repair costs found in the dataset (unedited), and once without (edited). According to the unedited dataset, vehicle owners performed 90,000 repairs while spending approximately $7.2 million. According to the edited dataset, which leaves out zero cost and greater than $2,000 cost observations, vehicle owners performed 32,000 repairs while spending approximately $5.4 million. These numbers are notably lower than the numbers for previous I/M evaluations, both for the numbers of repairs, and the total costs.

Table IV-7. Average Repair Costs

Year of Inspection	Repair Category	Original Dataset			Costs Between $0 and $2,000		
		Number of Repairs	Median Repair Cost	Mean Repair Cost	Number of Repairs	Median Repair Cost	Mean Repair Cost
2022	Fuel System and Emissions System	83	$7	$225	44	$242	$357
2022	Emissions System & Miscellaneous	51	$123	$298	37	$216	$345
2022	Engine Mechanical	796	$216	$292	627	$257	$293
2022	Ignition / Electrical System	3,233	$100	$143	2,075	$150	$201
2022	Fuel System	5,457	$45	$210	3,102	$225	$300
2022	Emissions System	18,624	$0	$49	5,372	$100	$140
2022	Miscellaneous	14,950	$0	$41	4,621	$40	$104
2023	Fuel System and Emissions System	93	$55	$256	58	$200	$311
2023	Emissions System & Miscellaneous	50	$5	$87	25	$118	$173
2023	Engine Mechanical	837	$198	$311	668	$199	$278
2023	Ignition / Electrical System	2,828	$100	$186	1,824	$175	$209
2023	Fuel System	4,998	$0	$194	2,380	$200	$312
2023	Emissions System	23,108	$0	$54	6,884	$87	$124
2023	Miscellaneous	15,037	$0	$40	4,396	$45	$96

Figure IV-2 and Figure IV-3 present mean repair costs by inspection year and model year, for both the unedited and edited TIMS datasets. There is a significant amount of variability in the unedited data when compared to the edited data. As shown by these plots, entered repair costs have not increased from year to year. Due to the limited control in repair data entry and the large number of suspect values in the TIMS repair data, these results may be significantly different from true repair costs resulting from the Texas I/M program.

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

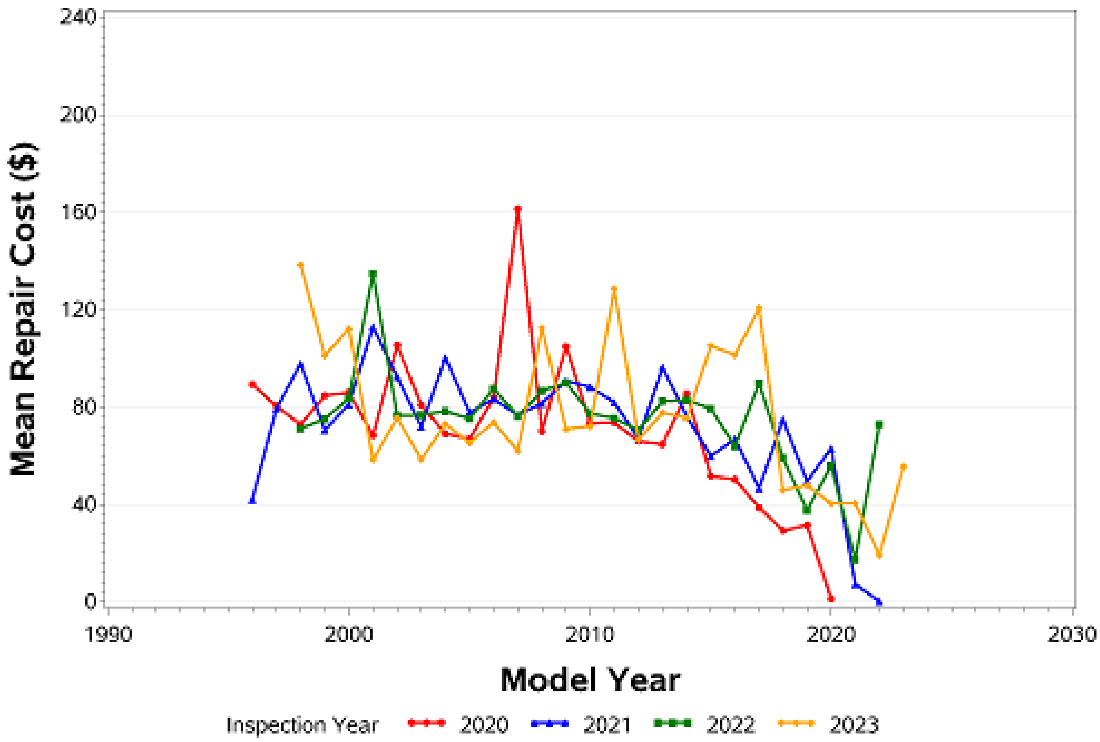


Figure IV-3. Mean Repair Costs by Model Year and Inspection Year (Edited Dataset)

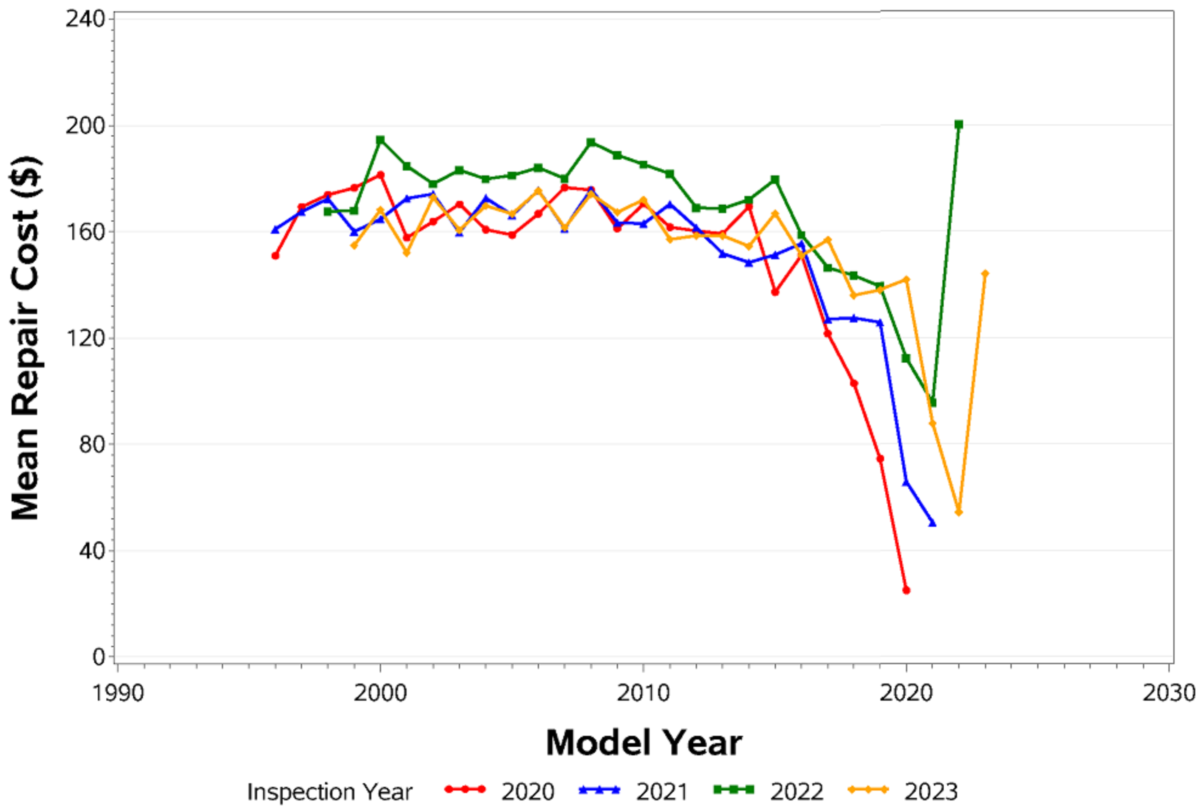


Figure IV-4 and Figure IV-5 present the percentile distribution of repair costs for the most common TIMS repair categories, for both the unedited and edited datasets. The unedited dataset contains repairs with an average cost of zero for all repair slates, but miscellaneous repairs costing zero extend close to the 70th percentile, which is considerably more than the other categories.

Figure IV-4. Distribution of Repair Costs by Category (Unedited Dataset)

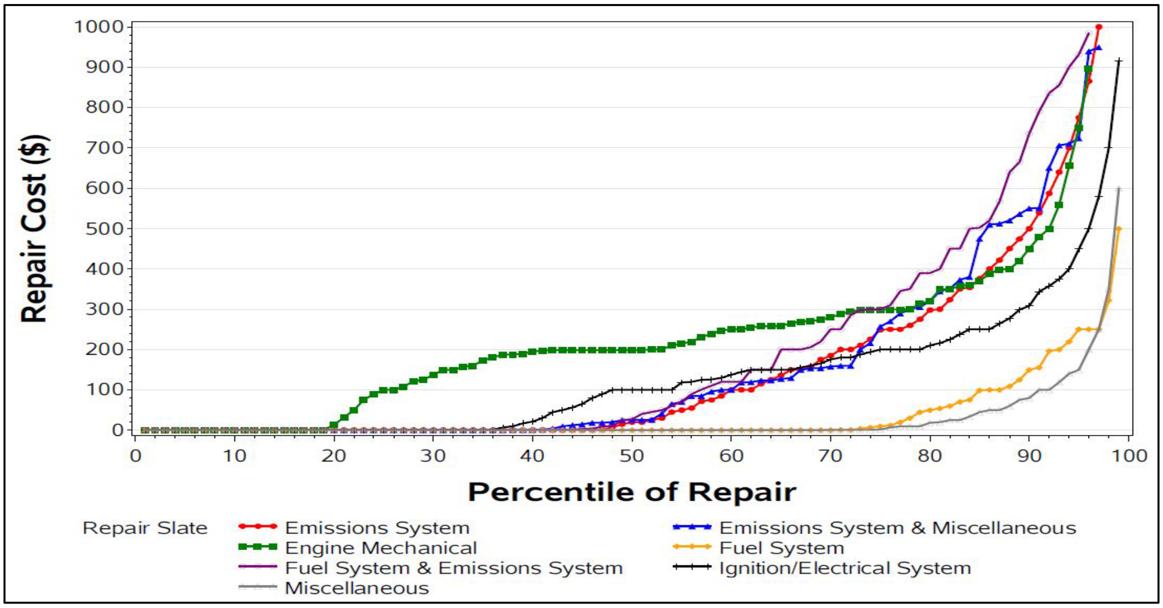
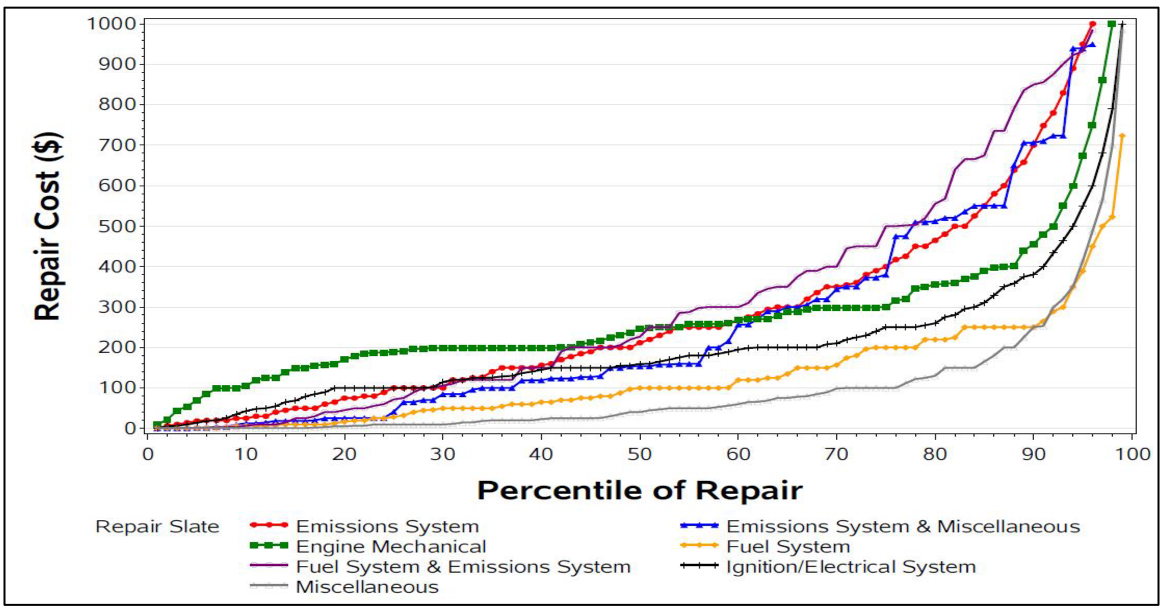


Figure IV-5. Distribution of Repair Costs by Category (Edited Dataset)



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.

V. ESTIMATES OF I/M BENEFITS

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 repair and then upward from emissions degradation before the next I/M cycle. In previous versions of this I/M Program Evaluation Report, ERG used tailpipe inspection data (ASM and TSI) to calculate emissions reductions for vehicles inspected under the program requirements. However, the tailpipe testing program ended on December 31, 2019, and all inspections are now OBD inspections. Since tailpipe emissions results are no longer available for evaluation, ERG has expanded the analysis of the paired RS/TIMS data.

Four I/M sequence categories were considered in this analysis. All the various failure patterns described in Section III.C were combined into these four categories for the purposes of calculating the annual I/M benefit. 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, which it fails. 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. Waivers are flagged separately but are not removed from these calculations.
- 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 OBD inspection each year. The 1Ps make up about 91% of all sequences. The FP sequences are the next most common and make up almost 9% of all sequences. The 1F and FF sequences make up the remaining fractional percentage of the sequences, but because they are so infrequent and because they do not result in a passed inspection, they do not contribute to the calculated annual I/M benefit.

A. ESTIMATE OF THE ANNUAL I/M BENEFIT FROM PAIRED I/M AND RS DATA

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 period before the next I/M cycle. The analysis presented in this section estimates annual benefits based on pairing the TIMS data with RS data.

Although the effect of the Texas I/M program is to reduce emissions by repairing vehicles that fail an emissions test, these vehicles will then likely have increasing emissions until their next I/M test, and this is also true for passing vehicles. RS data allow this slow increase in emissions to be observed as initially passing vehicles (95% of the fleet) go through the Texas I/M program and their emissions gradually increase each year. This is often called emission creep or deterioration. Eventually, when their emissions have increased over the years to a high enough level, the vehicle fails the I/M inspection, repairs are performed, and emissions should be reduced. During those previous years, the emissions of initially passing vehicles have gradually increased.

ERG used RS data taken in the I/M program areas to determine the annual I/M benefit produced by the Texas I/M program. This was done by pairing RS data with the TIMS inspection data by vehicle license plate and comparing the before-I/M and after-I/M RS levels.

A vehicle can be measured by RS at any time before or after its annual I/M inspection. By aligning all the RS measurements with respect to the time of I/M test with the assumption that failing vehicles receive any necessary repairs, the average of the RS measurements will reveal the change in emissions produced by the Texas 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 RS measurements before the I/M inspection does not contain the same vehicles as those with RS measurements after the I/M inspection. Because of the large emissions variability of RS emissions measurements, the average RS emissions versus time before and after I/M inspection will have a considerable amount of variability even when millions of RS observations are used. Nevertheless, the calculation provides an estimate of the benefits of the Texas I/M program that is independent of the program itself.

Preparation of RS Data

In this task, the RS data were collected in the DFW and HGB program areas to evaluate the annual I/M benefit. The goal was to use the RS data already being collected by DPS as an independent means of measuring the benefit. The RS data provided by DPS started with about 2.4 million records, collected between July 1, 2021, and February 28, 2024, with about 1.0 million records coming from the DFW area and about 1.4 million records coming from the HGB area.

The RS contractor matched the RS records to registration records in the weeks after they were collected, so that matching process did not have to be performed for this analysis. This match of RS records to registration records allowed ERG to then match the record to the I/M test in the TIMS dataset whenever a successful match was made. The RS records provided to ERG also contained vehicle information from the match to the registration dataset, including model year, make, and model. This information, in addition to the vehicle information in the TIMS dataset, can be used to characterize the on-road fleet for the Comprehensive Method [EPA, 2004] calculations.

The RS records provided to ERG by DPS were already checked for validity by the RS data collection contractor. Therefore, there was no additional check made here for the validity of the values within each of the RS data fields. However, a filter on the vehicle specific power (VSP) was applied to remove vehicles that happened to be observed while under very high or very low loads. Any records with a VSP outside the range of 0-35 kilowatt per ton were removed from the dataset. This left approximately 1.6 million records in the dataset: 750,000 records in the DFW program area and 880,000 records in the HGB program area.

The counts of available RS records vary every year; for this evaluation, the dataset includes a somewhat larger number of records than in previous evaluation years.

B. CALCULATION OF THE ANNUAL I/M BENEFIT USING THE COMPREHENSIVE METHOD

The calculation of the annual I/M benefit was done using the Comprehensive Method outlined by EPA [EPA, 2004]. In this method, RS data taken in the I/M area is paired with I/M inspections, by vehicle.

ERG calculated the time between the RS reading and the I/M test and placed each observation into a month bin. For example, one month before the initial test, two months before the initial test, three months before the initial test, one month after the final test, two months after the final test, three months after the final test, etc. Any RS readings that occurred within the I/M cycle, that is, between the initial test and the final test, were removed from the analysis, because for these mid-cycle observations it was not possible to assume the state of repair of the vehicle at the time of the RS measurement.

ERG also created a variable to describe the sequence of I/M inspection results for each vehicle inspected. There were four I/M sequence categories outlined in EPA's description of the Comprehensive Method calculations:

1. Vehicles that passed their initial I/M tests (1P);
2. Vehicles that failed their initial I/M test and then eventually passed (FP);
3. Vehicles that failed their I/M test and did not come back for another test (1F); and
4. Vehicles that failed their I/M test and failed all other subsequent I/M tests (FF).

The average RS concentrations for HC, CO, and NO_x by month bin, by I/M sequence category, and by model year group were examined. Because the Texas I/M program is an annual program, the plots were limited to only the RS matches that happened up to six months before and six months after the I/M test. The HC, CO, and NO_x plots for the entire dataset are shown in Figure V-1 through Figure V-3 for the DFW program area and in Figure V-4 through Figure V-6 for the HGB program area. These figures show the RS averages (indicated by the dots) and the uncertainties associated with these averages at a 95% confidence level (indicated by the lines).

Figure V-1. Average RS HC vs. Month from the I/M Test RS Readings from the DFW Program Area

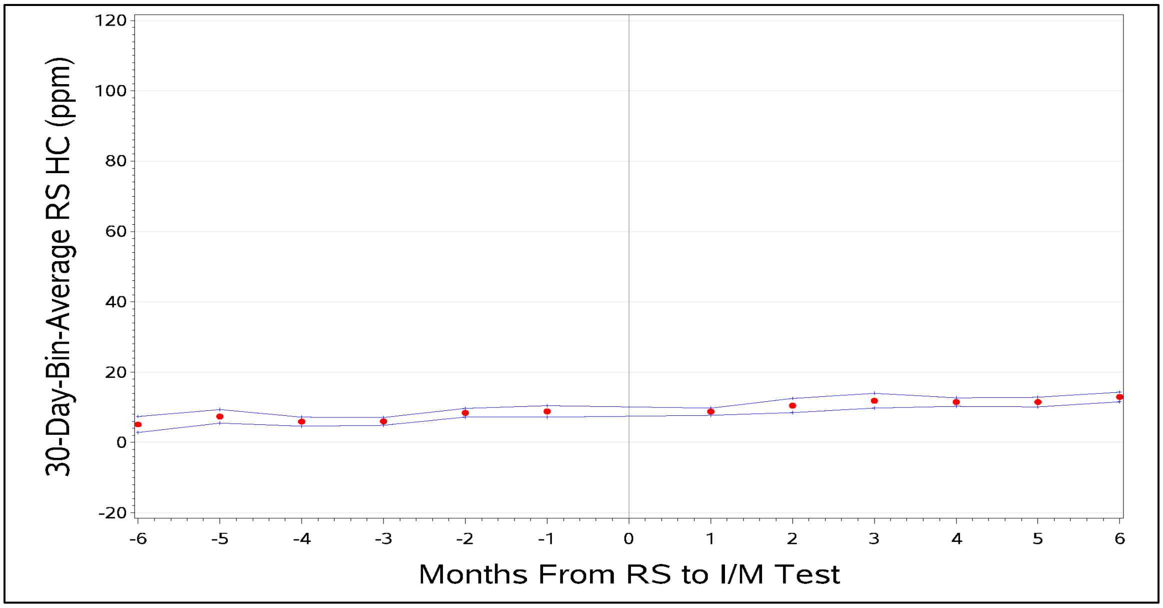


Figure V-2. Average RS CO vs. Month from the I/M Test RS Readings from the DFW Program Area

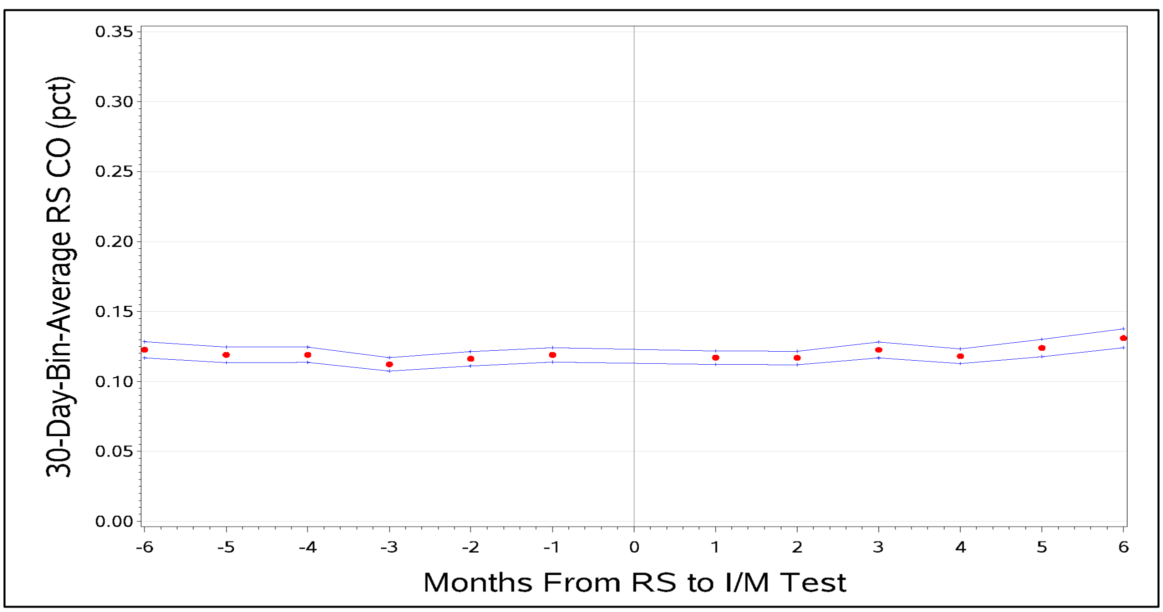


Figure V-3. Average RS NO_X vs. Month from the I/M Test RS Readings from the DFW Program Area

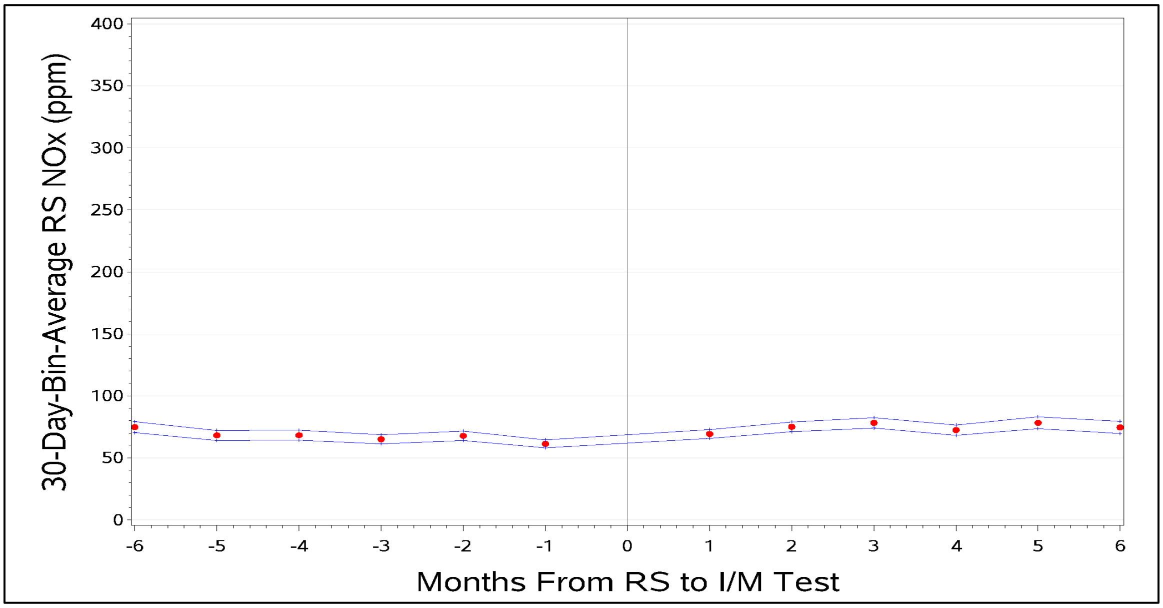


Figure V-4. Average RS HC vs. Month from the I/M Test RS Readings from the HGB Program Area

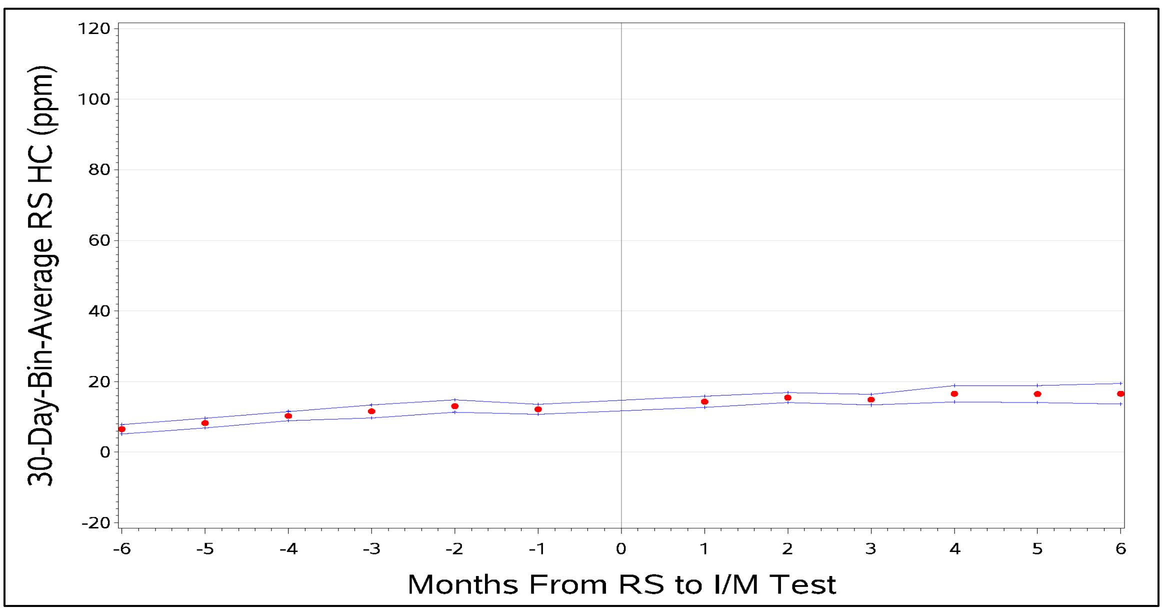


Figure V-5. Average RS CO vs. Month from the I/M Test RS Readings from the HGB Program Area

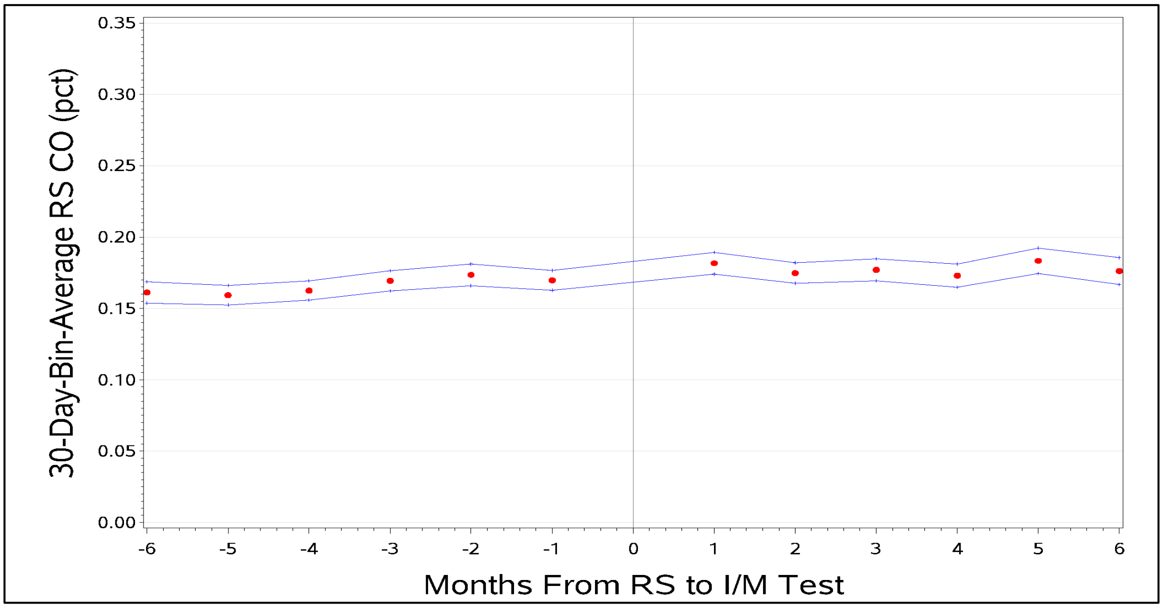
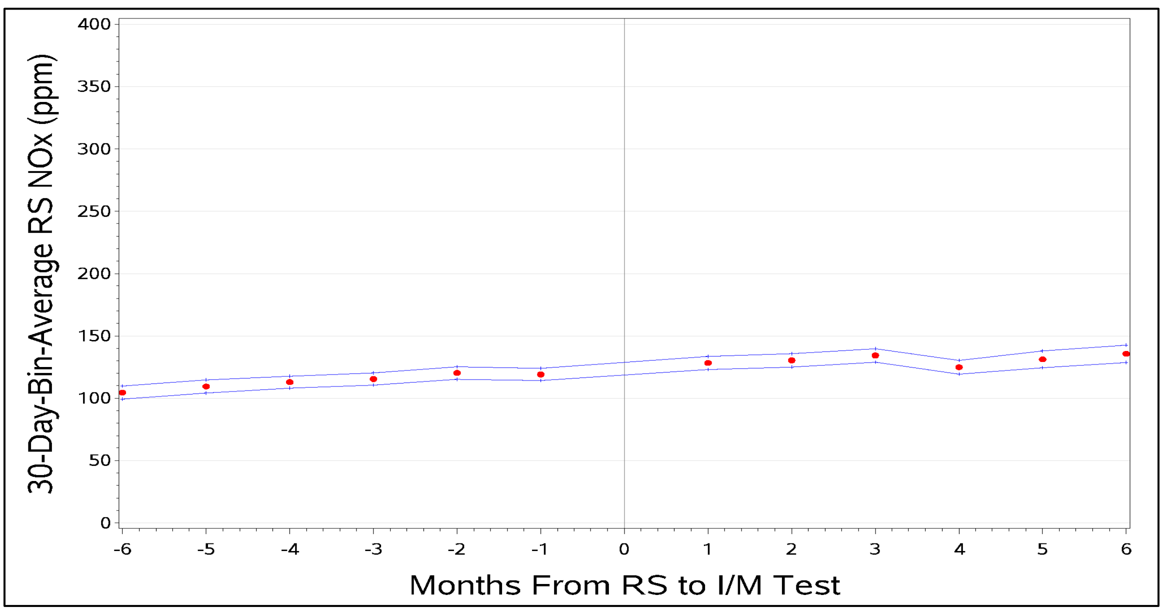


Figure V-6. Average RS NO_X vs. Month from the I/M Test RS Readings from the HGB Program Area



It is difficult to assess the impact of I/M testing from these figures as the RS values do not show substantial trends with respect to I/M test timing. The HC readings are relatively constant around 15 parts per million (ppm) for both program areas. For the CO readings, the DFW values that average around 0.18% are somewhat higher than the HGB values, which are closer to 0.13%. The DFW values for NO_x values are also higher than for HGB, at 120 and 80 ppm, respectively. This trend of the DFW RS results being higher than the HGB results was also visible in the 2022 I/M Evaluation, although the differences were not as large as they are in this 2024 Evaluation.

Figure V-1 through V-6 showed greater differences between DFW and HGB than the differences by RS measurement versus timing of I/M inspection. However, when the plots are done on a dataset that has been stratified by the I/M sequence category, some I/M benefits start to become evident.

Table V-1 shows the number of records in the RS-matched-with-TIMS dataset for both DFW and HGB program areas that fall into each I/M sequence category. The sample sizes are for the total number of I/M vehicles matched to RS records, but they are not necessarily the same vehicle before and after the I/M test. The table clearly demonstrates that the 1P and FP I/M sequence categories dominate the Texas I/M program vehicles that are observed on the road. Few vehicles that fail and never pass (1F and FF) are observed by remote sensing.

Table V-1. Number of Vehicles in Each I/M Sequence Category for the Dataset of RS Events Matched with I/M Tests

I/M Sequence Category	DFW		HGB	
	Number of Vehicles	Percent	Number of Vehicles	Percent
Pass Initial (1P)	187,279	96.1%	194,061	95.4%
Fail Initial (1F)	658	0.3%	669	0.3%
Fail Initial, Fail Final (FF)	63	0.0%	74	0.0%
Fail Initial, Pass Final (FP)	6,842	3.5%	8,508	4.2%
Other Misc. Sequences	6	0.0%	11	0.0%
Total	**194,848**	**100.0%**	**203,323**	**100.0%**

The plots of mean RS concentrations versus time from I/M inspection were repeated, this time separately for the 1P and FP categories. Figure V-7, Figure V-9, and Figure V-11 show the time trend of the monthly average RS HC, CO, and NO_x for the DFW program area for vehicles that passed initially (1P). Below these figures are Figure V-8, Figure V-10, and Figure V-12 for the corresponding vehicles that failed initially and then ultimately passed (FP).

The 1P plots, which describe 96.1% of the vehicles in the DFW program 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 may be attributed to the general long-term emissions deterioration of these vehicles.

The FP plots, which describe 3.5% of the vehicles in the DFW program area, show downward jogs in the emissions at the time of the I/M inspection, or just following the inspection. Examining the overall trend of each plot shows that downward jogs at the I/M inspection interrupts the generally upward trend of emissions creep, which is what the Texas I/M program is designed to do.

Grouping vehicles of all I/M sequence categories results in a slightly increasing trend from before to after I/M as was seen in Figure V-2 and Figure V-3. This is because although the FP vehicles show substantial emissions decreases, they make up only 3.5% of the DFW fleet. An additional 96.1% of the fleet is made up of 1P vehicles that have slight emissions increases, as an expected result of general long-term emission creep. There was no discernible difference in the plots for the emissions in the HGB program area; therefore, they were not included here to conserve space.

Figure V-7. Average RS HC vs. Month After the I/M Test for DFW Vehicles with I/M Sequence Category = 1P

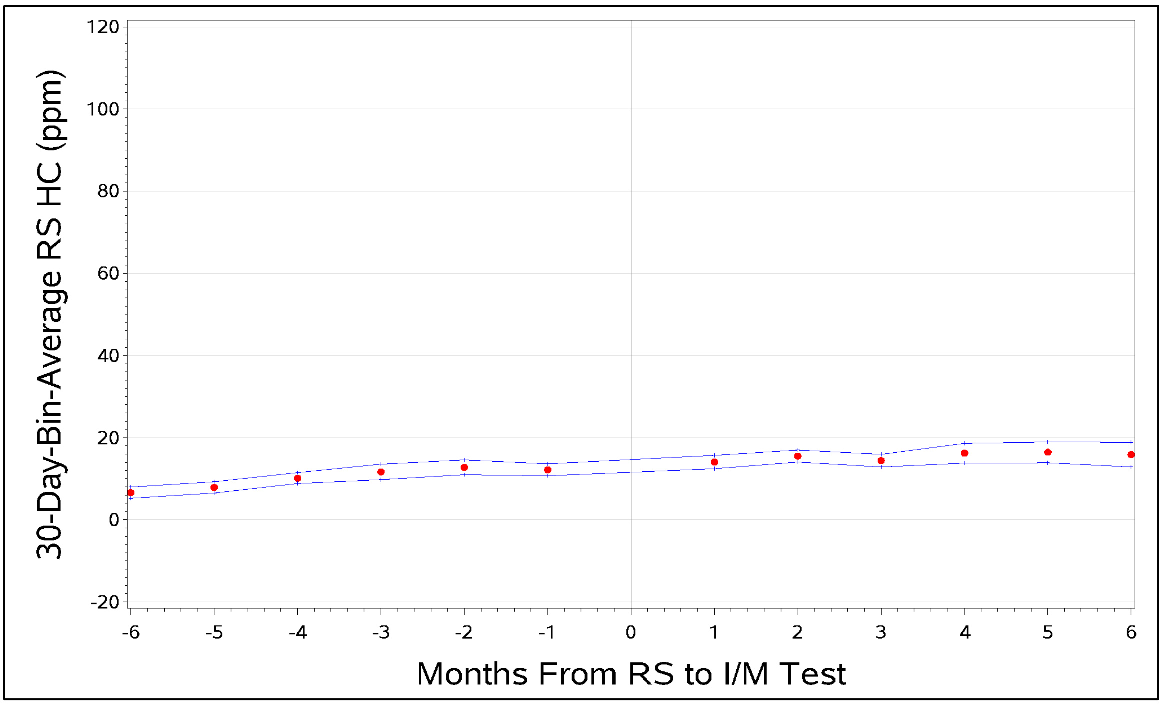


Figure V-8. Average RS HC vs. Month After the I/M Test for DFW Vehicles with I/M Sequence Category = FP

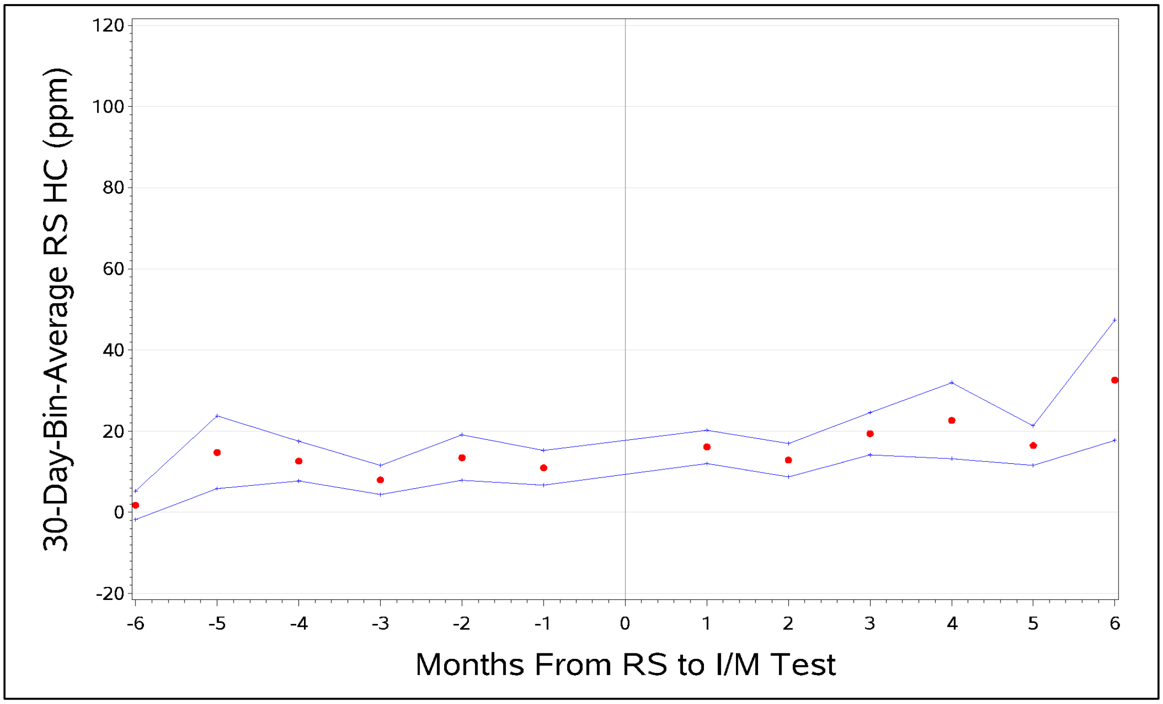


Figure V-9. Average RS CO vs. Month After the I/M Test for DFW Vehicles with I/M Sequence Category = 1P

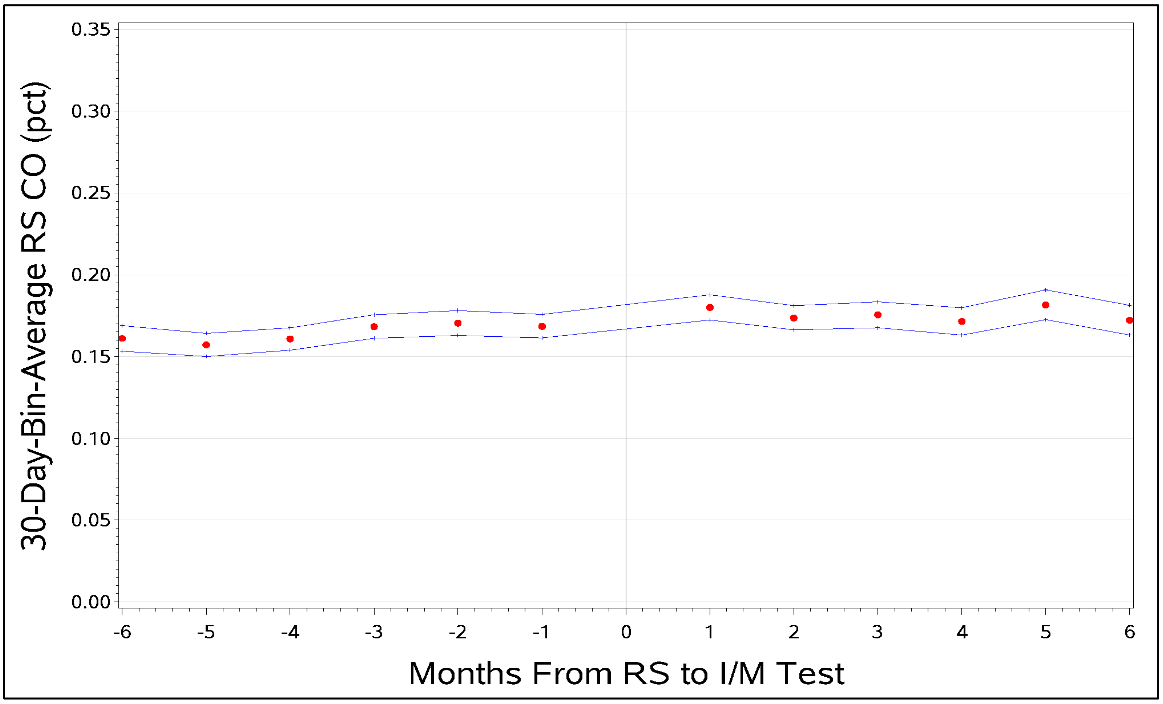


Figure V-10. Average RS CO vs. Month After the I/M Test for DFW Vehicles with I/M Sequence Category = FP

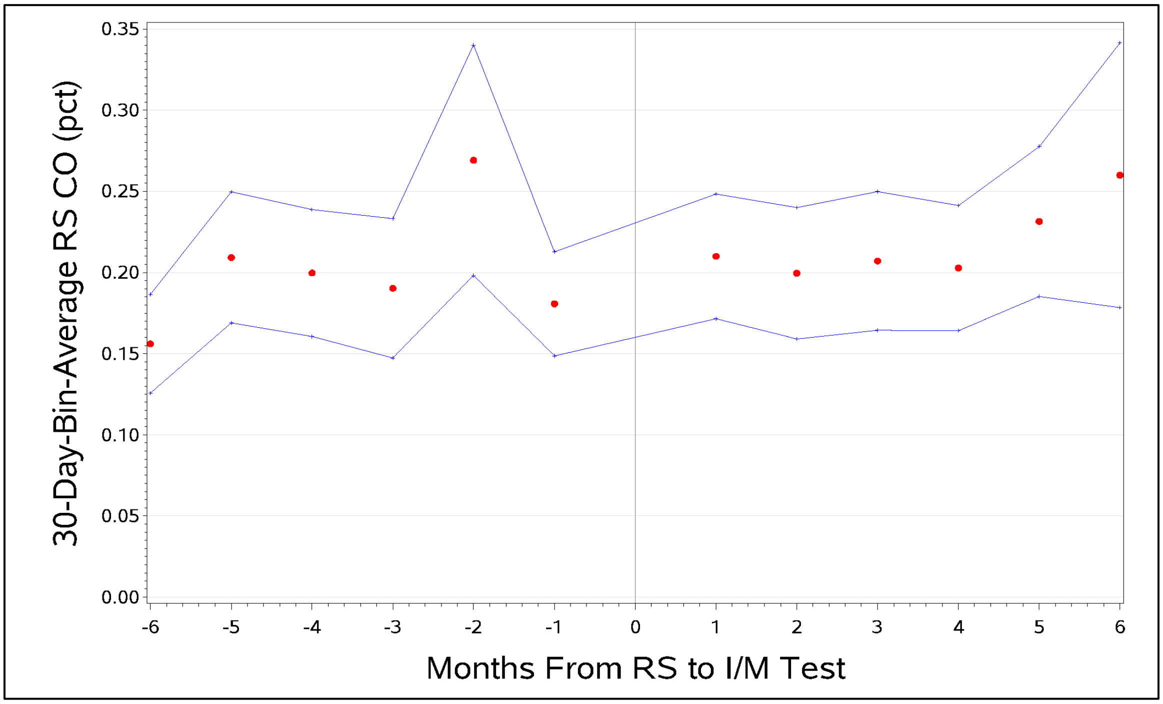


Figure V-11. Average RS NO_X vs. Month After the I/M Test for DFW Vehicles with I/M Sequence Category = 1P

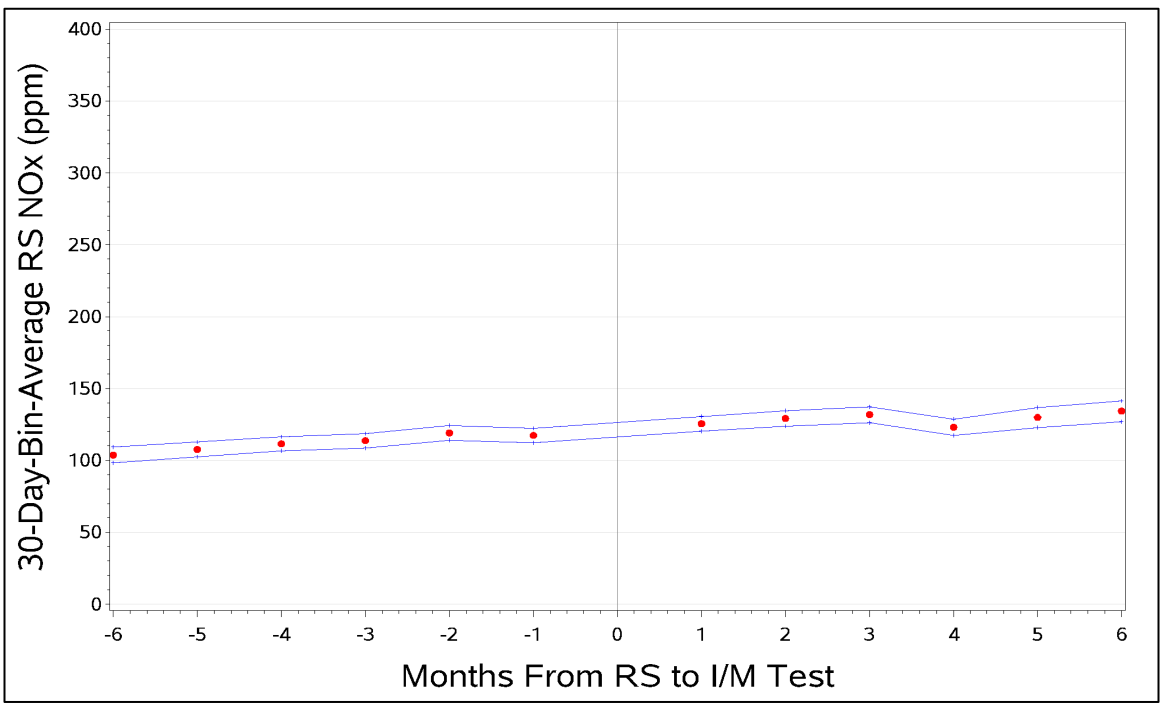
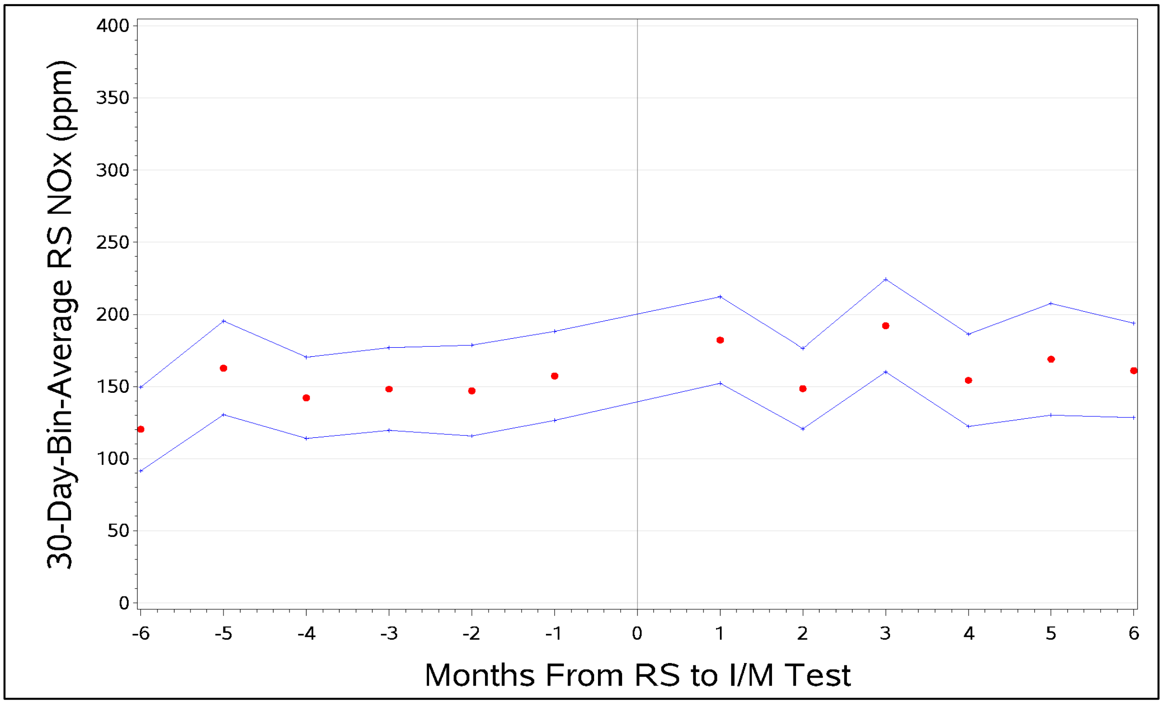


Figure V-12. Average RS NO_X vs. Month After the I/M Test for DFW Vehicles with I/M Sequence Category = FP



To quantify the annual I/M benefit, the month bins were combined to obtain a single average RS concentration before the I/M test and another average RS concentration after the I/M test. The 'before' bin consists of all RS measurements that happened between 31 and 120 days prior to the initial I/M test. The RS measurements that happened from one to 30 days prior to the I/M test 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 RS tests that happened between one and 120 days following the final I/M test.

The calculations for the before and after I/M RS averages were done for the entire RS-matched TIMS dataset for each of the two major I/M sequence categories, FP and 1P, and averages were calculated separately by model year group. At the beginning of this analysis, when the fleet characteristics of the I/M fleet were compared to the fleet characteristics of the matched set of RS vehicles, the RS-matched fleet was found to contain a larger percentage of new vehicles. Therefore, each of the I/M category bins was also separated by model year group. 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 translate the benefits observed in the RS-matched fleet to the I/M fleet.

These before and after I/M average RS measurements for the FP vehicles and the 1P vehicles were plotted for both the DFW and HGB program areas in Figure V-13 through Figure V-24. The graphs show the mean emissions levels, and the error bars show the

95% confidence level uncertainties for the respective averages, with the number of observations. There are two groups of vehicles shown on each plot. The first labeled "RS Before I/M" is comprised of vehicles that were observed by RS prior to their I/M inspection, and the second, "RS After I/M" is comprised of those vehicles that were observed by RS after their I/M inspection.

The plots for the FP vehicles show that in most cases the emissions of FP vehicles decrease, especially for the older model year groups; however, in many cases the decrease is not statistically significant even with thousands of RS observations in the FP category. The plots for the 1P vehicles show that in some cases the emissions of 1P vehicles increase across the I/M inspections; however, in many cases the increase is not statistically significant even with tens of thousands of RS observations in the 1P category.

Figure V-13. Average 1P RS HC by Model Year Group Before and After I/M Test for DFW Vehicles

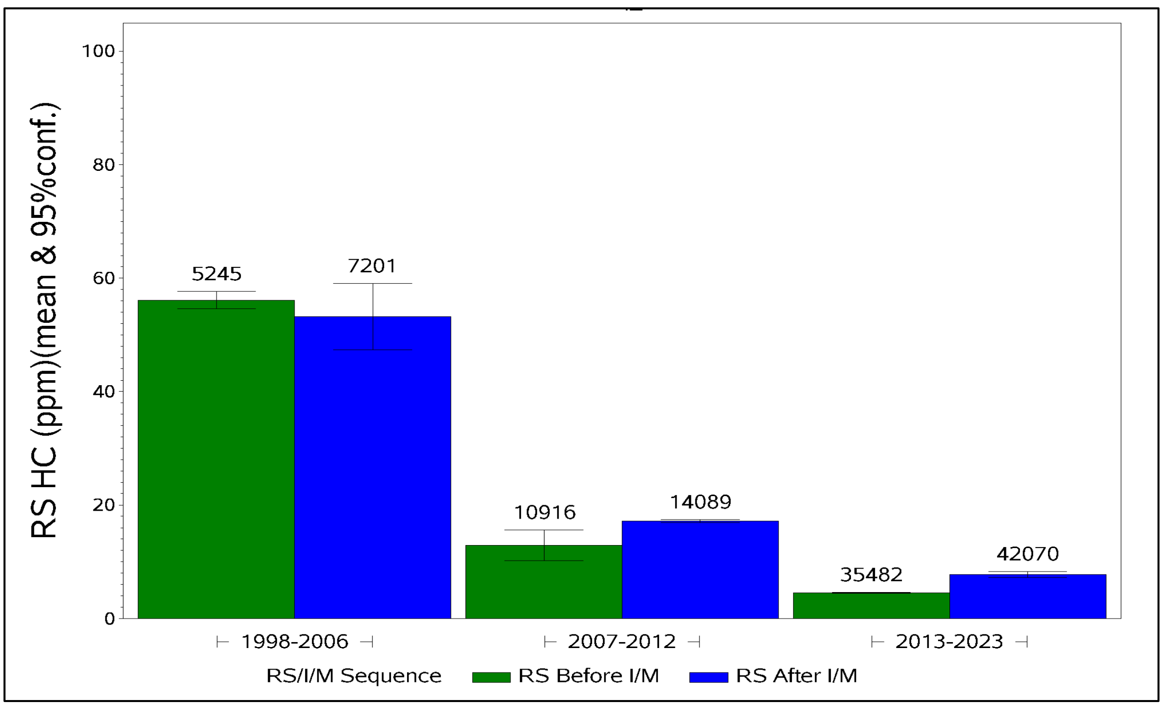


Figure V-14. Average FP RS HC by Model Year Group Before and After I/M Test for DFW Vehicles

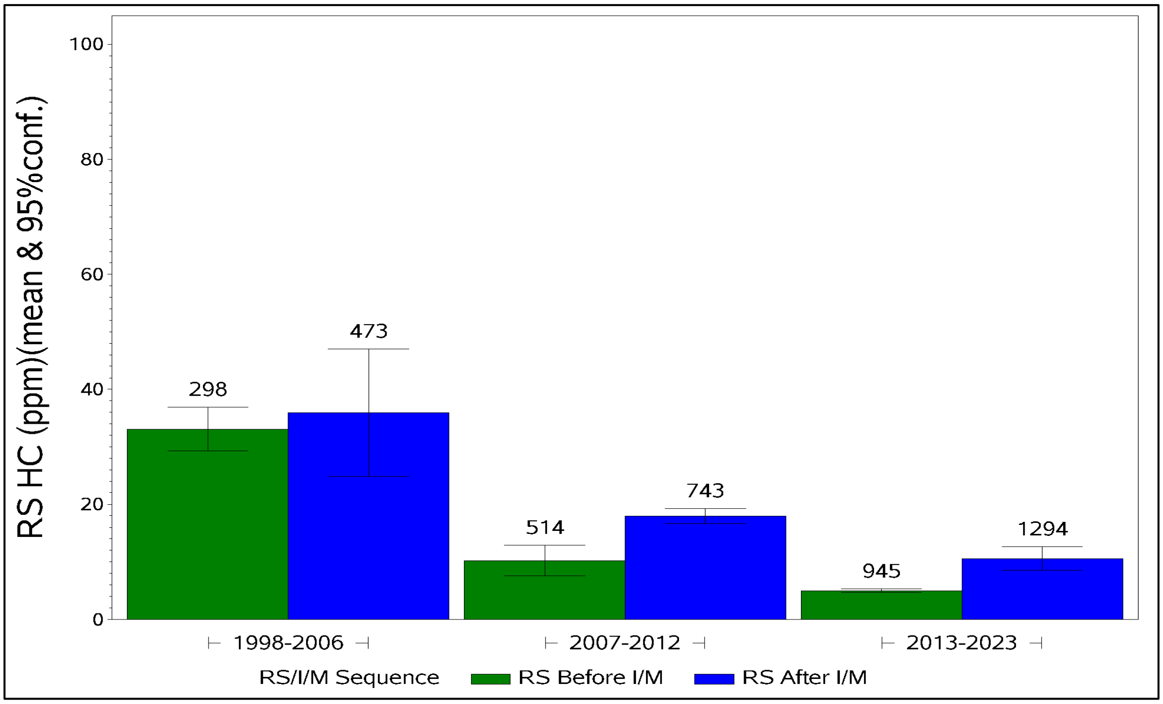


Figure V-15. Average 1P RS HC by Model Year Group Before and After I/M Test for HGB Vehicles

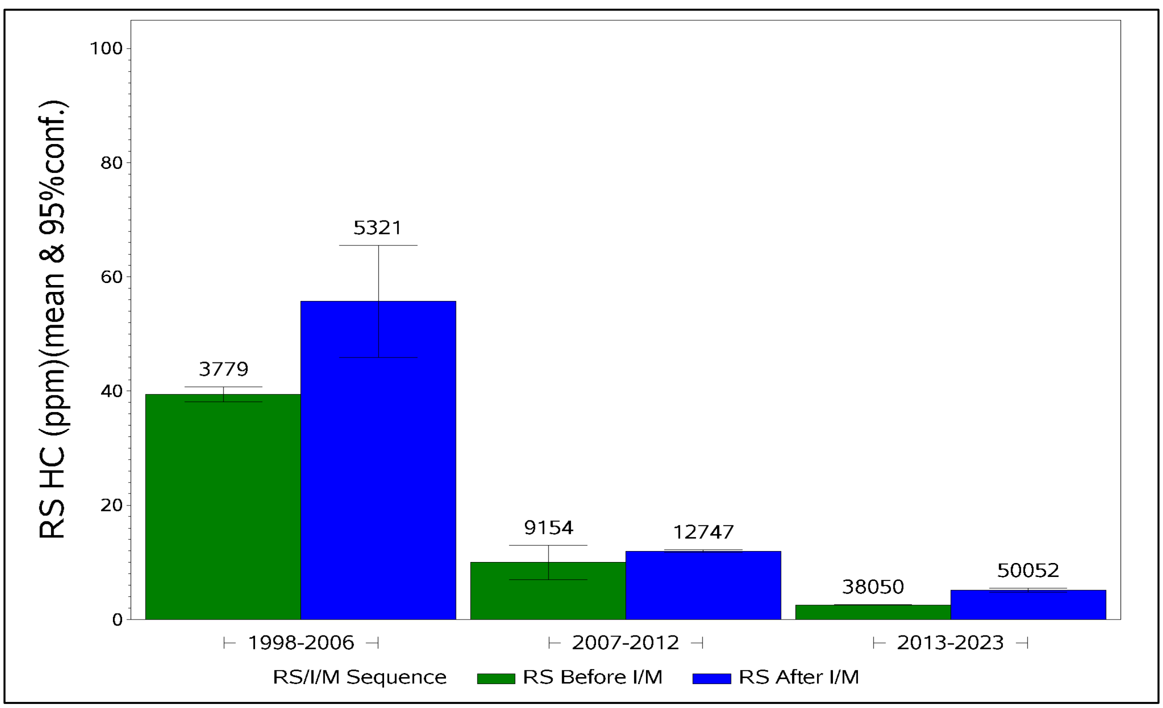


Figure V-16. Average FP RS HC by Model Year Group Before and After I/M Test for HGB Vehicles

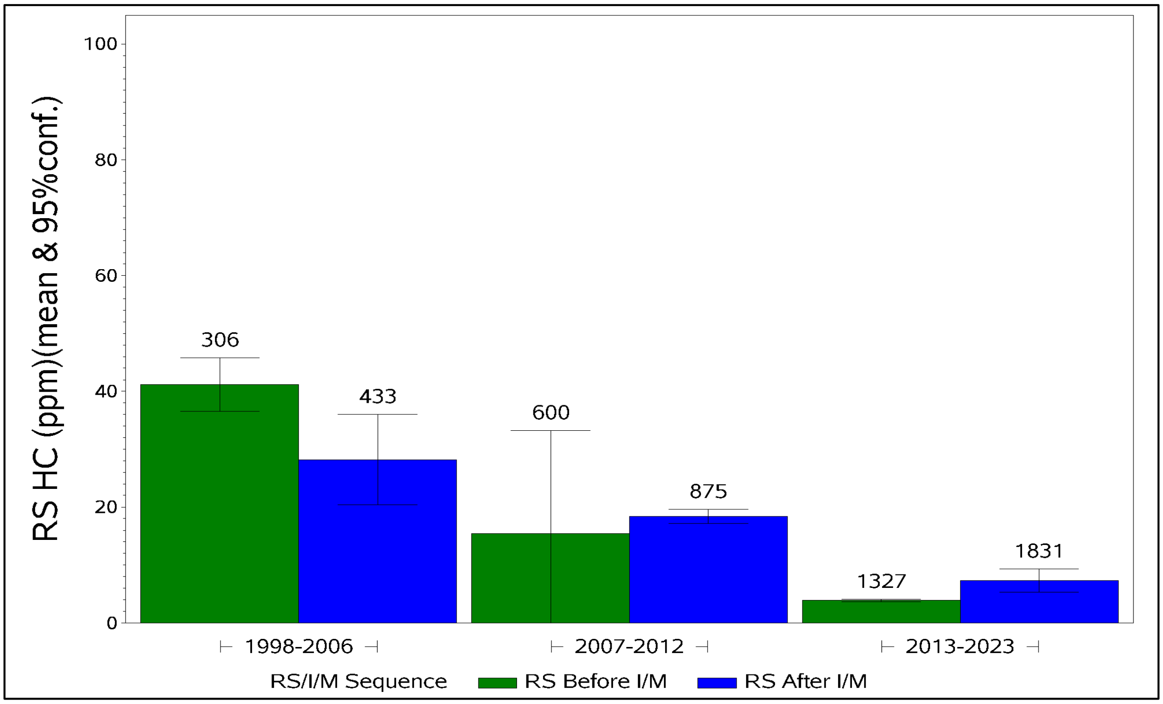


Figure V-17. Average 1P RS CO by Model Year Group Before and After I/M Test for DFW Vehicles

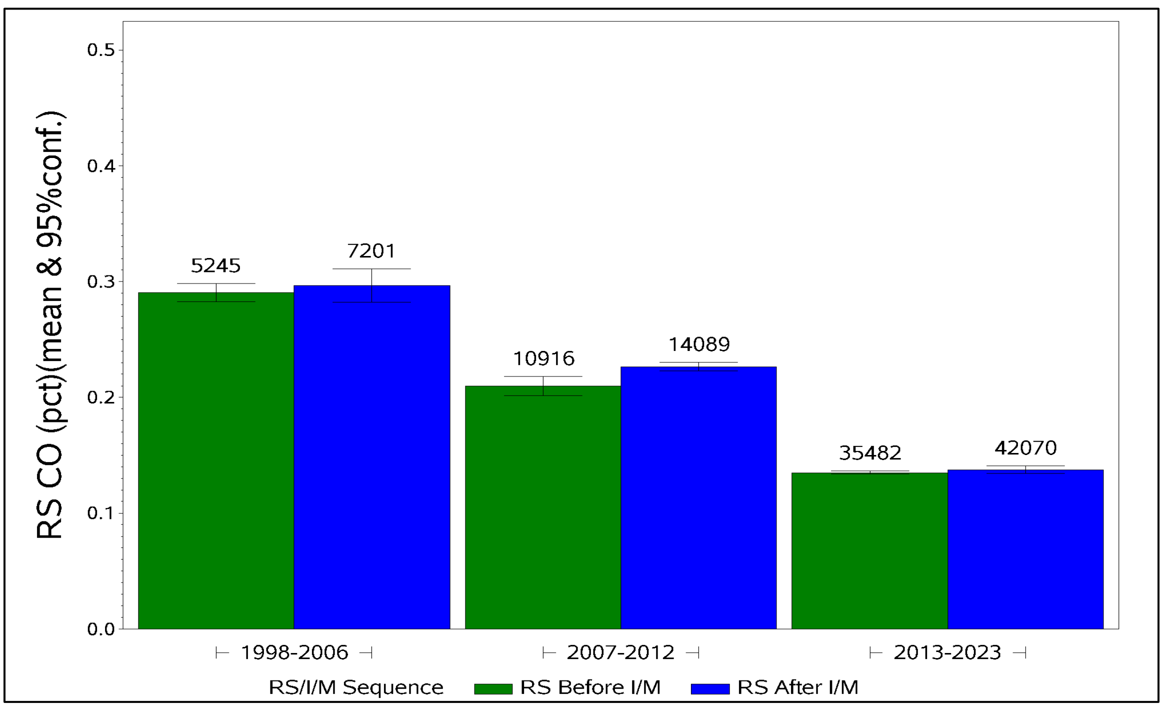


Figure V-18. Average FP RS CO by Model Year Group Before and After I/M Test for DFW Vehicles

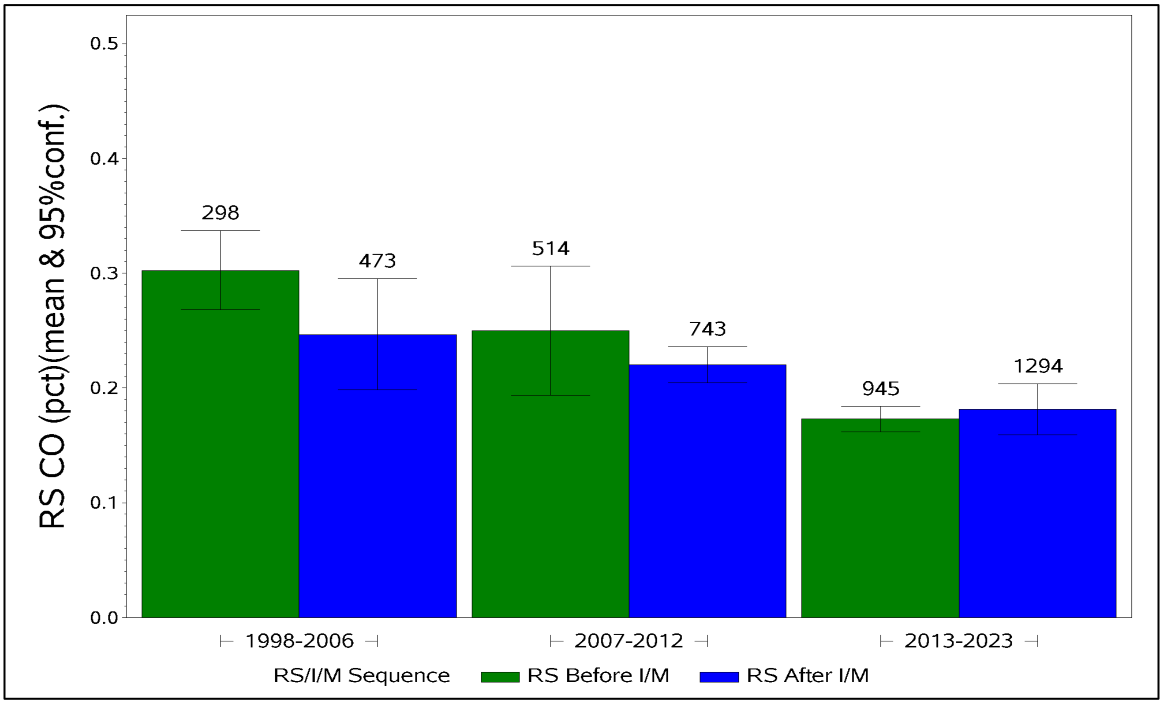


Figure V-19. Average 1P RS CO by Model Year Group Before and After I/M Test for HGB Vehicles

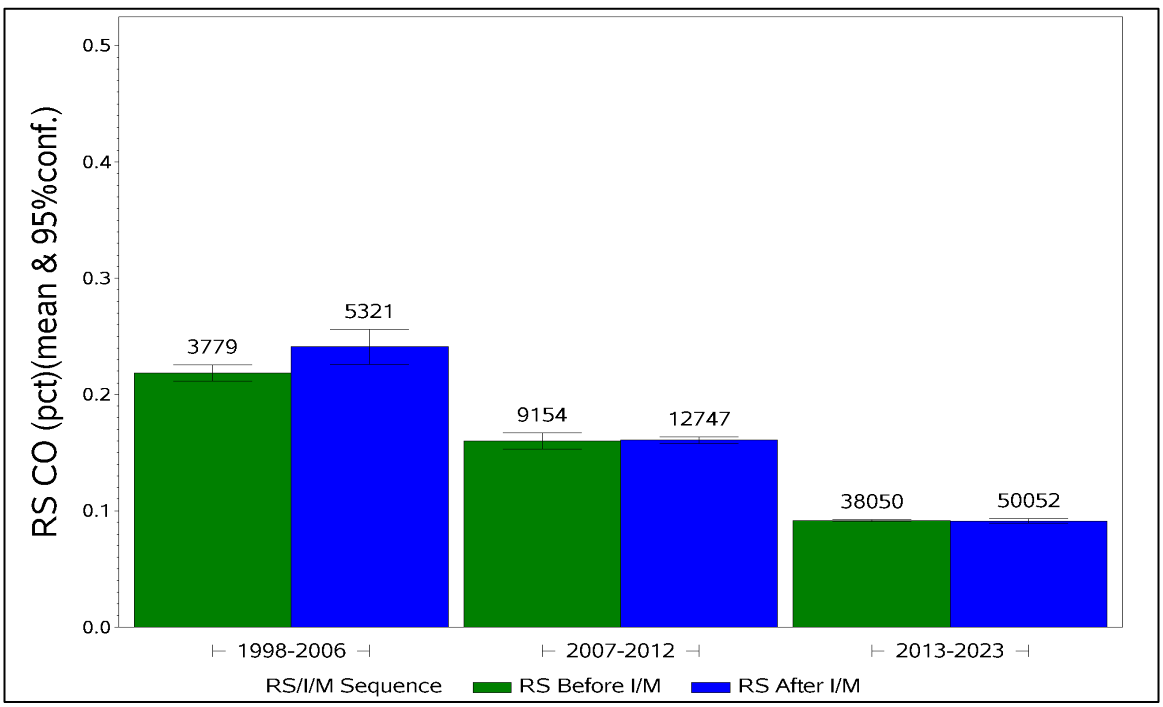


Figure V-20. Average FP RS CO by Model Year Group Before and After I/M Test for HGB Vehicles

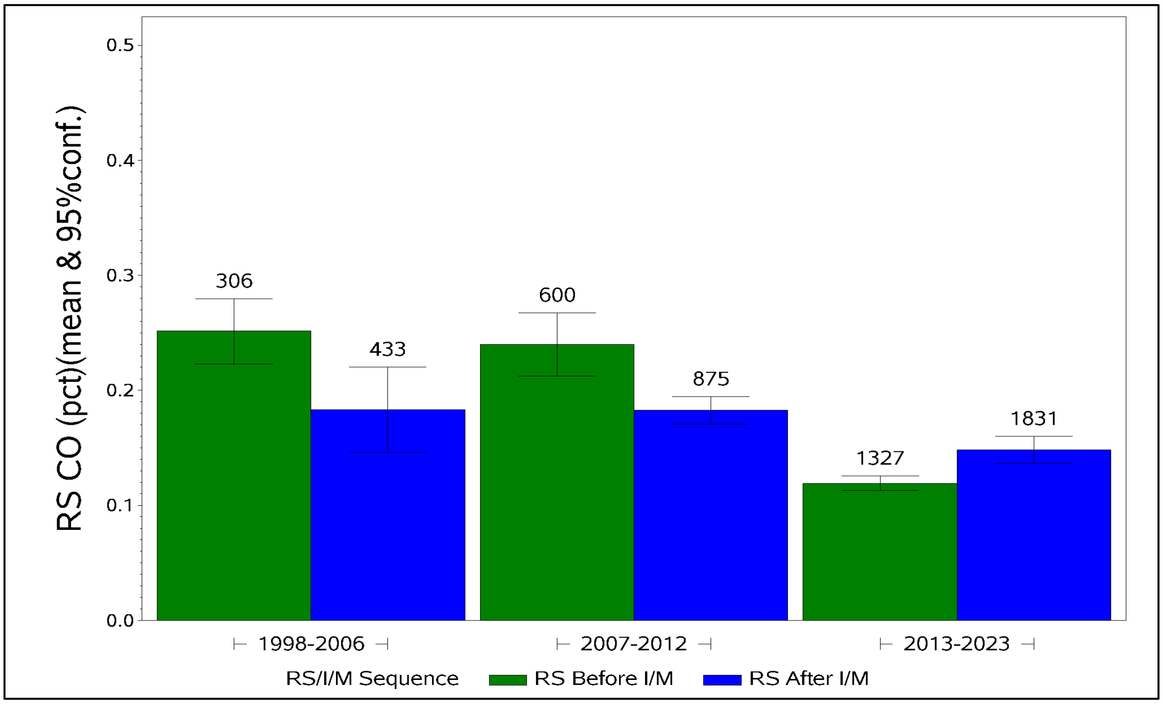


Figure V-21. Average 1P RS NO_X by Model Year Group Before and After I/M Test for DFW Vehicles

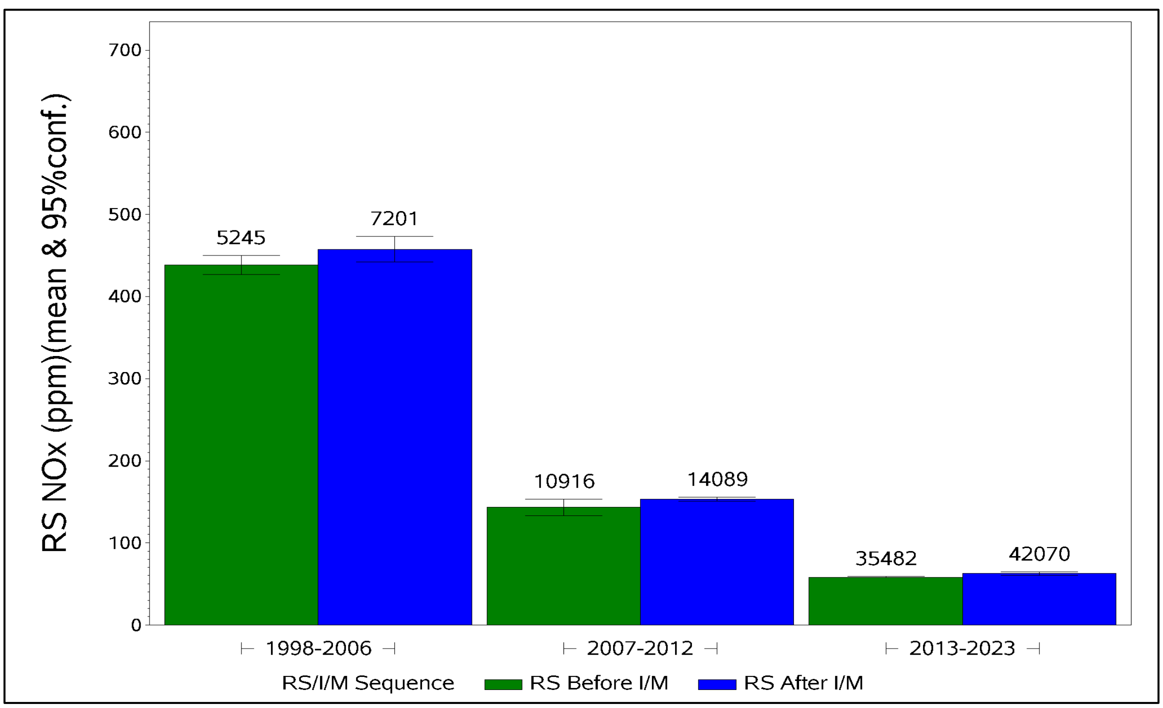


Figure V-22. Average FP RS NO_X by Model Year Group Before and After I/M Test for DFW Vehicles

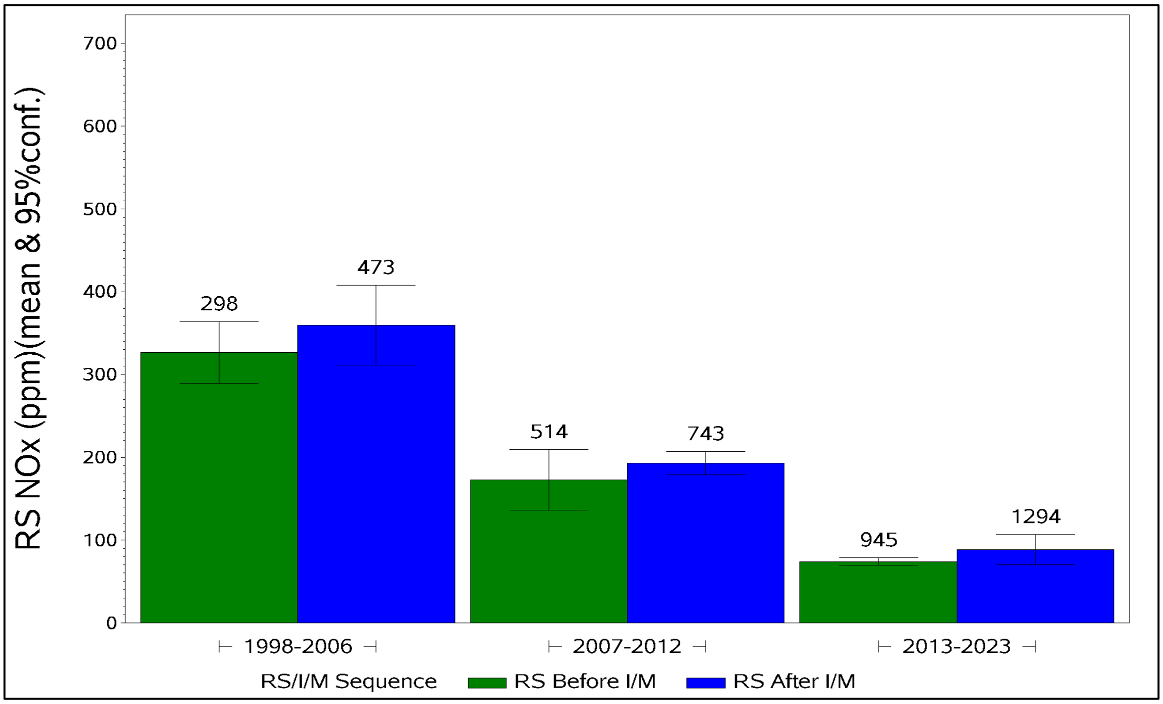


Figure V-23. Average 1P RS NO_X by Model Year Group Before and After I/M Test for HGB Vehicles

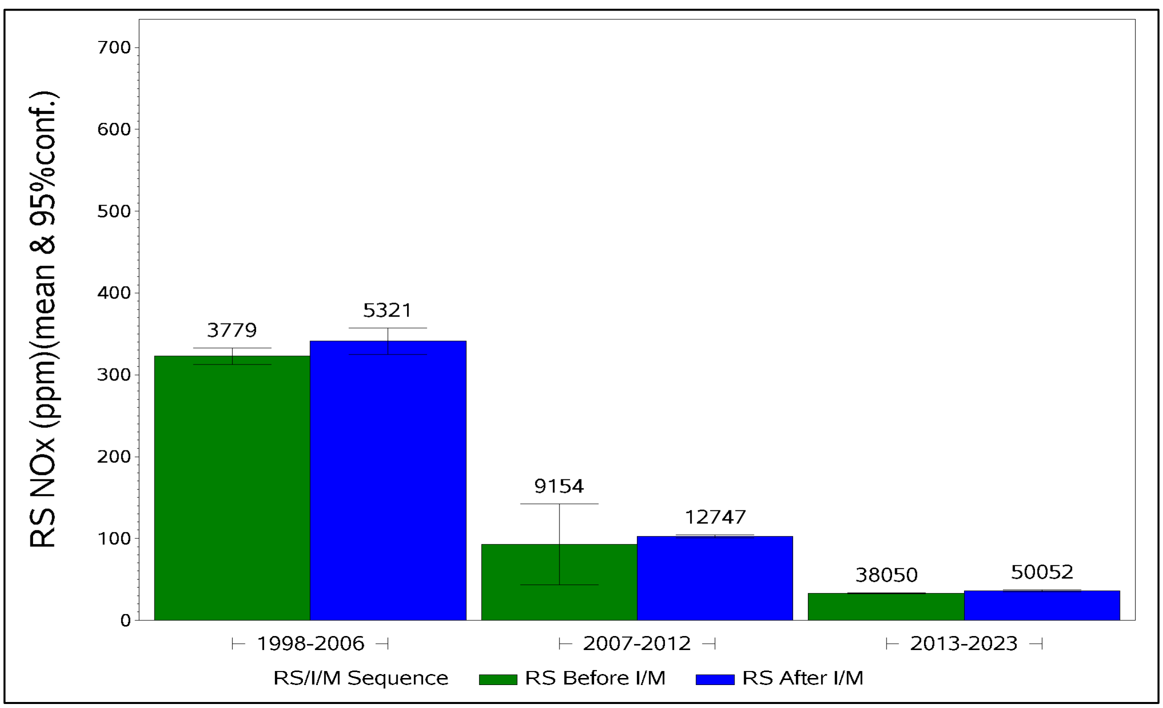
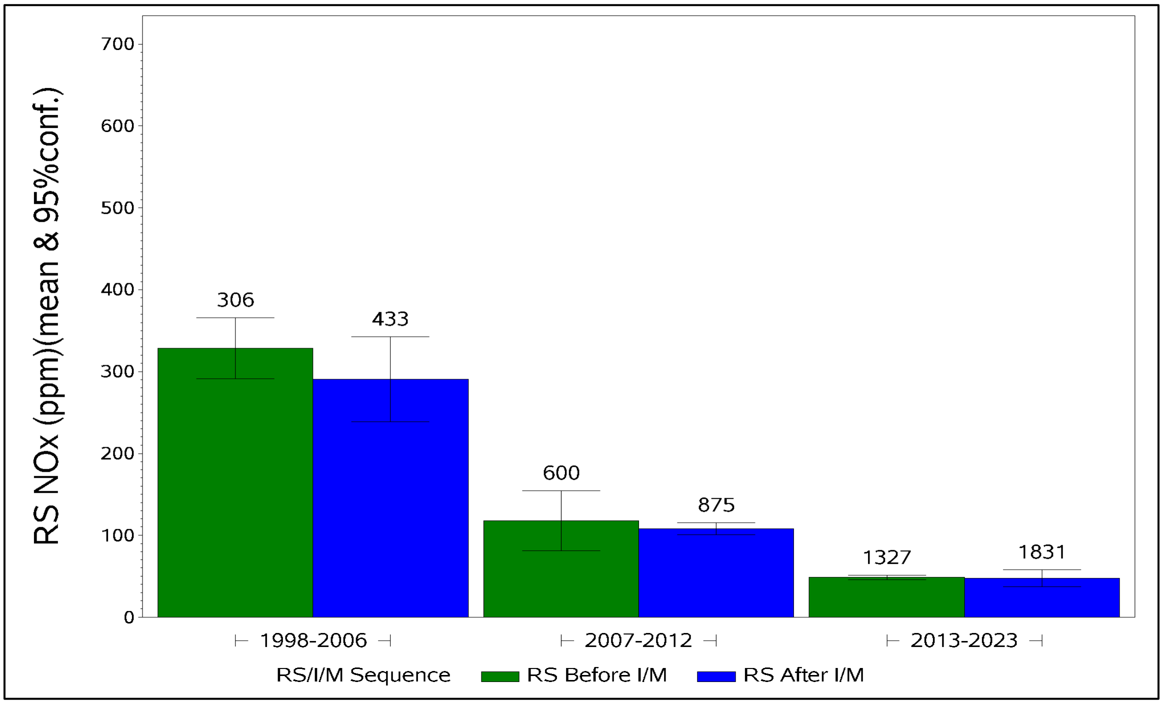


Figure V-24. Average FP RS NO_X by Model Year Group Before and After I/M Test for HGB Vehicles



The RS average concentrations shown in the figures above are summarized in Table V-2 and Table V-3. The values in Table V-2 show that for vehicles that failed and then passed, HC, CO, and NO_X emissions were substantially reduced for some model year groups, while other model year groups remained constant from before to after the I/M inspection. Table V-3 shows that for 1P vehicles, there was some variability of increases or decreases in RS average concentrations. However, looking back at Figure V-13 through Figure V-18, the changes are almost always within the error bars, and therefore, not statistically significant.

Table V-2. RS Averages Before and After an I/M Test for DFW and HGB for I/M Sequence Category = FP

MY Group	RS HC (ppm)		RS CO (%)		RS NO_X (ppm)	
	Before I/M	After I/M	Before I/M	After I/M	Before I/M	After I/M
DFW Program Area						
1998–2006	33.1	35.9	0.30	0.25	327	360
2007–2012	10.2	18.0	0.25	0.22	173	193
2013–2023	5.0	10.6	0.17	0.18	74	89
HGB Program Area						
1998–2006	41.2	28.2	0.25	0.18	329	291
2007–2012	15.4	18.3	0.24	0.18	118	108
2013–2023	3.9	7.3	0.12	0.15	49	47

Table V-3. RS Averages Before and After an I/M Test for DFW and HGB for I/M Sequence Category = 1P

DFW Program Area						
	RS HC (ppm)		RS CO (%)		RS NO_x (ppm)	
MY Group	Before I/M	After I/M	Before I/M	After I/M	Before I/M	After I/M
1998–2006	56.1	53.2	0.29	0.30	438	458
2007–2012	12.9	17.2	0.21	0.23	143	153
2013–2023	4.5	7.7	0.13	0.14	58	62
HGB Program Area						
	RS HC (ppm)		**RS CO (%)**		**RS NO_x (ppm)**	
MY Group	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**	**Before I/M**	**After I/M**
1998–2006	39.4	55.7	0.22	0.24	323	341
2007–2012	10.0	12.0	0.16	0.16	93	103
2013–2023	2.6	5.1	0.09	0.09	33	36

The results in Table V-2 and Table V-3 show the difference in average RS concentrations between before and after I/M observations for different model year groups. These results are then combined to calculate the net overall effect on emissions of the I/M program. Because RS measurements are primarily taken on freeway on-ramps, it is generally assumed newer vehicles are driven on the highways; therefore, the average vehicle observed by RS is somewhat newer than the average vehicle in the I/M fleet. This difference is shown in Table V-4, which contains the distribution of vehicles among the model year groups for the RS measurements-matched-to-I/M fleet, and for the I/M fleet. The fact that this difference exists (i.e., that the RS measurements-matched-to-I/M fleet is somewhat newer than the I/M fleet) should be kept in mind when considering overall fleet results. The overall fleet results for the annual I/M benefit are shown in Table V-5. It should be noted that in the absence of an I/M program, fleet emissions are expected to increase as motorists are less likely to make emission repairs to pass an upcoming I/M test; therefore, the actual emission reductions are likely greater than those reported below.

Table V-4. Model Year Distributions for RS-Matched-to-I/M Fleet and I/M Tested Fleet

Model Year Group	DFW				HGB			
	RS-Matched-to-I/M Fleet		I/M Tested Fleet		RS-Matched-to-I/M Fleet		I/M Tested Fleet	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1998-2006	21,485	11.0%	1,321,848	14.5%	16,007	7.9%	1,018,332	13.4%
2007–2012	42,381	21.8%	2,105,872	23.1%	38,346	18.9%	1,715,977	22.5%
2013–2023	130,982	67.2%	5,702,949	62.5%	148,970	73.3%	4,892,571	64.1%
Total	**194,848**	**100.0%**	**9,130,669**	**100.0%**	**203,323**	**100.0%**	**7,626,880**	**100.0%**

Table V-5. RS Average Concentrations to Evaluate the Annual I/M Benefit

I/M Program Area	I/M Sequence	RS with respect to I/M	Number of Observations	RS HC (ppm) Mean	RS HC UCLM*	RS HC LCLM***	RS HC Change (%)	RS CO (%) Mean	RS CO UCLM***	RS CO LCLM***	RS CO Change (%)	RS NO_X (ppm) Mean	RS NO_X UCLM***	RS NO_X LCLM***	RS NO_X Change (%)
DFW+HGB	1P+FP	Before	106,616	9.2	9.8	8.6		0.14	0.14	0.14		91	93	89	
	1P+FP	After	137,129	12.7	13.3	12.1	38.2%	0.15	0.15	0.14	2.9%	100	102	98	9.7%
	1P	Before	102,626	9.1	9.7	8.5		0.14	0.14	0.14		90	92	88	
	1P	After	131,480	12.6	13.2	12.0	38.5%	0.14	0.15	0.14	3.2%	99	100	97	9.7%
	FP	Before	3,990	11.7	15.0	8.4		0.19	0.21	0.17		123	134	113	
	FP	After	5,649	15.2	16.9	13.4	29.3%	0.18	0.19	0.17	-4.8%	130	139	121	5.6%
DFW	1P+FP	Before	53,400	11.5	12.5	10.6		0.17	0.17	0.16		116	119	113	
	1P+FP	After	65,870	15.1	15.9	14.3	30.9%	0.18	0.18	0.17	4.9%	129	132	126	11.5%
HGB	1P+FP	Before	53,216	6.8	7.5	6.1		0.12	0.12	0.11		67	69	64	
	1P+FP	After	71,259	10.5	11.3	9.7	53.2%	0.12	0.12	0.12	2.0%	73	75	71	9.8%
DFW	1P	Before	51,643	11.5	12.5	10.6		0.17	0.17	0.16		115	118	112	
	1P	After	63,360	15.0	15.9	14.1	30.0%	0.18	0.18	0.17	5.3%	128	130	125	11.1%
	FP	Before	1,757	11.3	14.0	8.6		0.22	0.25	0.19		146	163	129	
	FP	After	2,510	17.5	20.4	14.7	55.4%	0.21	0.23	0.19	-5.7%	171	186	155	17.1%
HGB	1P	Before	50,983	6.6	7.3	5.9		0.11	0.12	0.11		65	67	63	
	1P	After	68,120	10.4	11.2	9.5	56.6%	0.12	0.12	0.11	2.3%	72	74	70	10.9%
	FP	Before	2,233	12.1	17.6	6.6		0.17	0.19	0.15		106	119	92	
	FP	After	3,139	13.3	15.4	11.2	9.8%	0.16	0.18	0.15	-4.2%	98	109	87	-7.3%

*** - UCLM/LCLM- upper/lower confidence limit

C. CALCULATION OF THE ANNUAL I/M BENEFIT- REFERENCE METHOD

The RS data used for this analysis were collected in the DFW and HGB areas. Most vehicles in these areas are participating in the I/M program. However, commuter vehicles that drive into the I/M area but are not registered in the I/M area may not be required to participate, as well as very new vehicles in their two-year exemption period, or vehicles that are otherwise avoiding program compliance. Unregistered vehicles cannot be included in the RS dataset, because if the observed license plate is not linked to a registered vehicle, then the RS record does not contain any vehicle information and isn't used for any analysis.

For this analysis, the vehicles observed by RS are divided into two groups: vehicles that have never been in the I/M program prior to the RS observation and vehicles that have been in the I/M program prior to the RS observation. (The cutoff point for looking back in time for prior I/M inspections was January 1, 2018. This provides a four-year period before the 2022/2023 analysis years begin, and it should be sufficient to identify vehicles that are essentially in a no-I/M condition at the beginning of 2022.)

The number of vehicles available for the analysis is shown in Figure V-25, and again in Figure V-26. The first figure uses a linear scale for the vertical axis, while the second figure uses a logarithmic scale, to allow the smaller counts to be seen. The figures show that the group of no-I/M vehicles (red) is dominated by vehicles in their new-vehicle exemption period. However, for all model years 2001 and newer, there are at least 1,000 no-I/M vehicles, and that will provide a large enough sample for this analysis.

Figure V-25. Number of RS Vehicles (linear scale) by Model Year and I/M Area

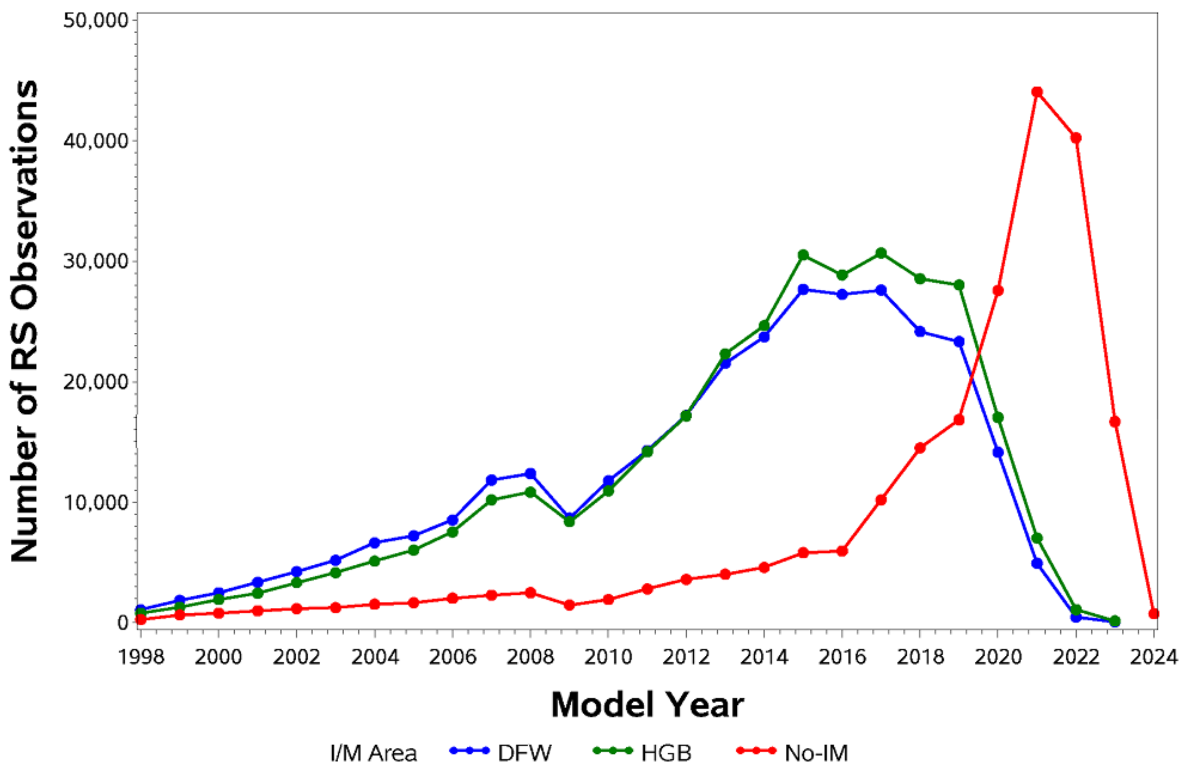


Figure V-26. Number of RS Vehicles (log scale) by Model Year and I/M Area

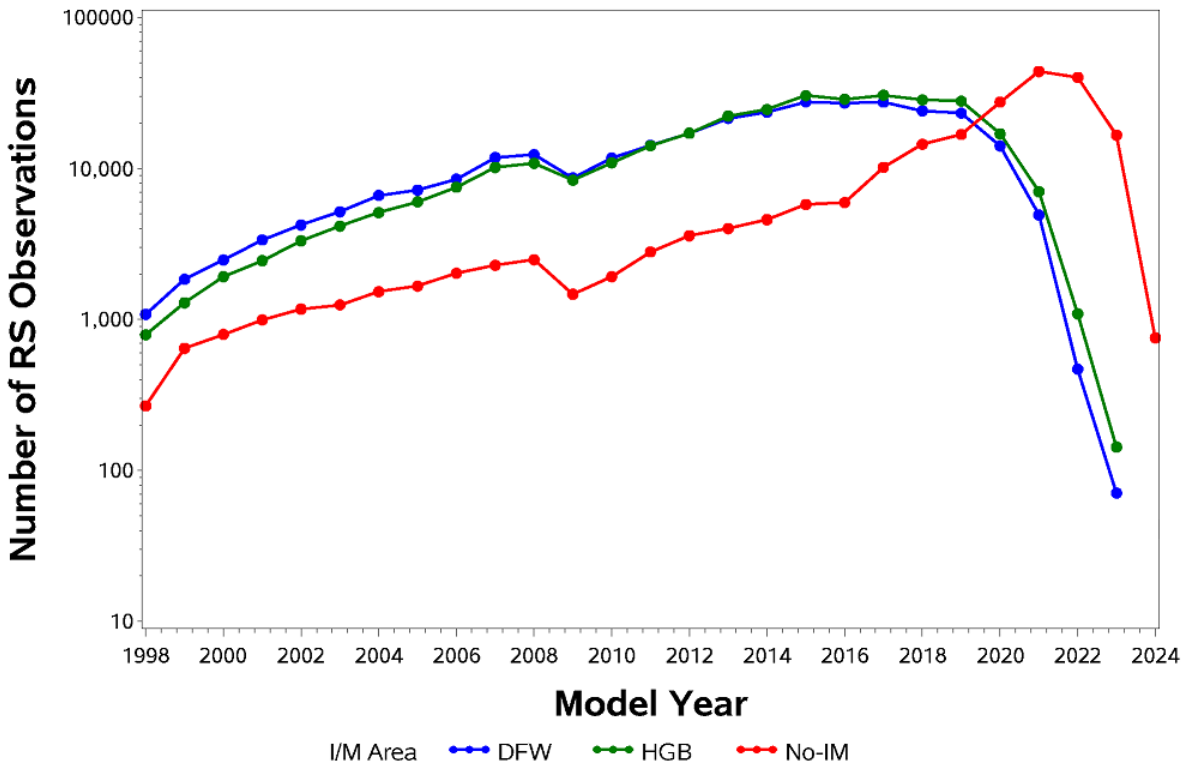


Figure V-27, Figure V-28, and Figure V-29 show the average RS HC, CO, and NO_x, for the DFW, HGB, and no-I/M areas.[6] In Figure V-27, the no-I/M HC averages are higher than the DFW or HGB HC averages for model years 2004-2017. For model years older and newer than that range, the no-I/M HC averages are very similar to the DFW and HGB averages. The no-I/M CO averages shown in the Figure V-28 are lower than the DFW and HGB averages for model years 2012 and older. The no-I/M CO averages are similar to those for DFW and HGB for model years newer than 2012. Finally, Figure V-29 shows that the NO_x averages for the no-I/M fleet are substantially higher than the averages for the DFW and HGB areas. This figure indicates that the I/M program's most significant impact is on NO_x emissions. This is important since NO_x plays a major role in ozone formation.

[6] These figures were also examined as bar charts with confidence intervals. Due to the large sample sizes in the dataset, the confidence intervals were very small. Therefore, since the overall trends are much easier to see in the line plots, the bar charts are not used here.

Figure V-27. Average RS HC by Model Year and I/M Area

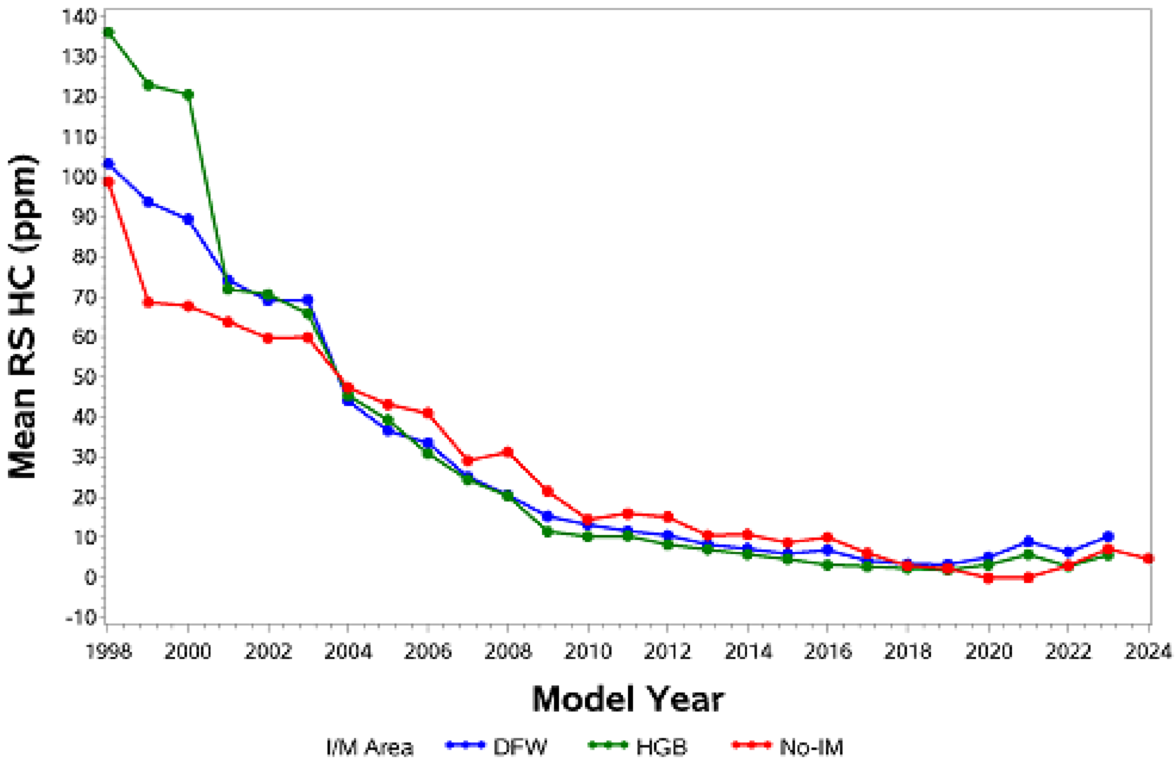


Figure V-28. Average RS CO by Model Year and I/M Area

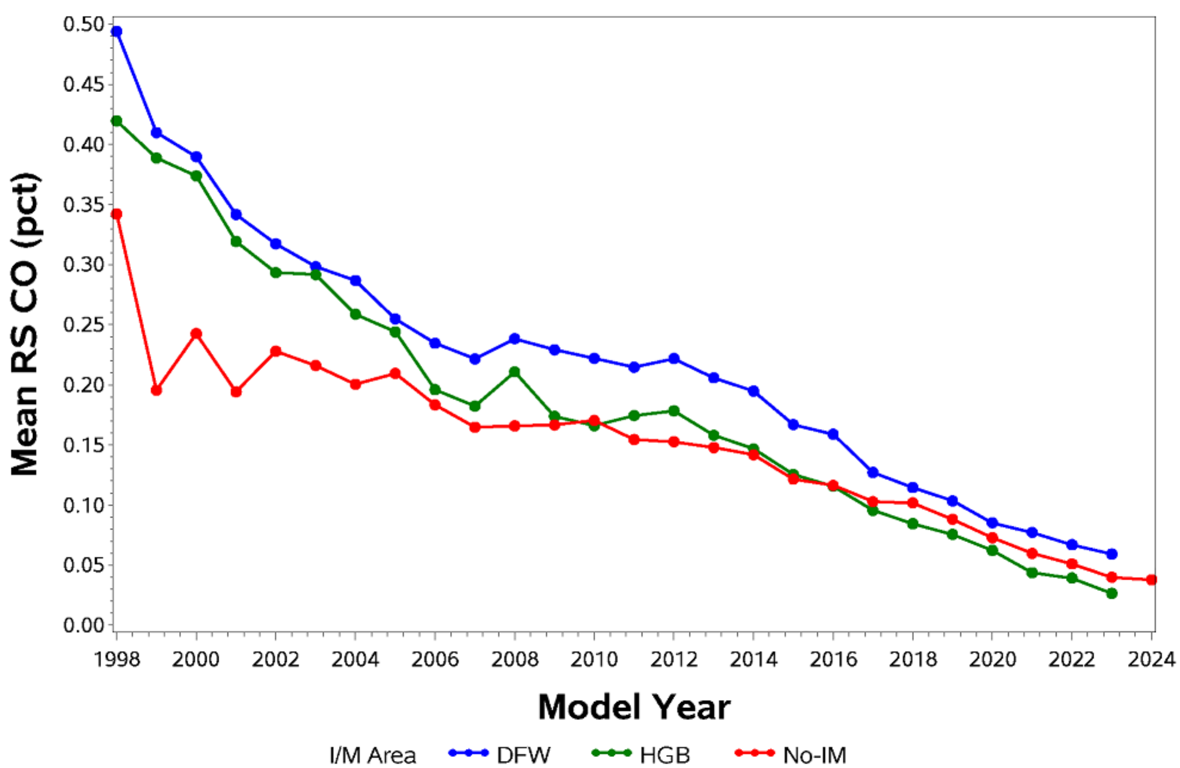
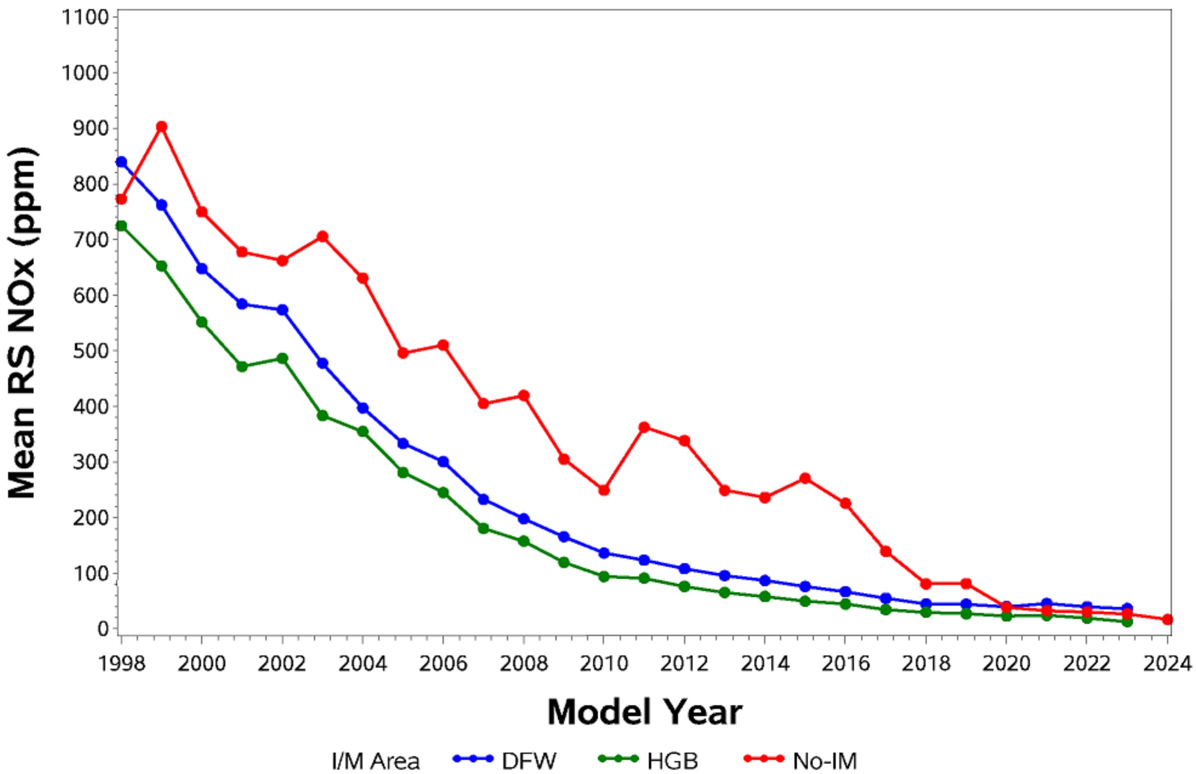


Figure V-29. Average RS NO_x by Model Year and I/M Area



VI. MEASURES FOR EVALUATING STATION PERFORMANCE

For an I/M program to function as designed, it is critical that each I/M inspection station follow the procedures and regulations that have been created to ensure that inspections are consistently performed properly. In this section, data from the TIMS database were used to explore a range of ways in which individual I/M stations and inspectors may be circumventing procedures or regulations. In past reports, these offenses were broken into two different levels: errors of commission: intentional breaking of rules to manipulate inspection results, and errors of omission: failure to routinely follow regulated procedures. However, errors of omission have become much less useful in detecting fraud now that only OBD testing is performed. Therefore, errors of omission are no longer included as a measure for evaluating station performance. The error of commission items are now broken into two different levels: a tampering with the conduct of the OBD inspection (Section VI.A), and a tampering with the overall inspection process (Section VI.B).

- Tampering with the OBD Inspection: fraud checks for potential clean-scanning (Section VI.A)
  - VIN from vehicle does not match eVIN (VI.A.1)
  - eVIN is missing (VI.A.2)
  - Powertrain Control Module (PCM), Parameter ID (PID), VIN, and/or not ready status changes between inspections (VI.A.3)
  - Communications Protocol differs from expected (VI.A.4)
- Additional Inspection Manipulation (Section VI.B) Tampering with the Overall Inspection: Additional Inspection Manipulation (Section VI.B)
  - Retest too soon to have performed repairs: a passing retest follows a failed inspection within only a few minutes (VI.B.1)
  - Stations with very high safety-only inspection rates (VI.B.2)
  - Switching from light-duty (LD) (<8,500 GVWR) to HD (≥8,500 GVWR) in order to pass inspection (VI.B.3)
  - Stations with an average very high or very low fail rates relative to peers (VI.B.4)

Obviously, many stations will have the occasional inspection where the VIN was accidentally entered incorrectly and did not match the eVIN. However, the goal of this section is to identify those stations where these events are frequent (search for statistical outliers), suggesting that their occurrence is not accidental, and these events are much more common than at other stations.

A percentile rank was assigned to each station for its performance on each bullet in the previous list. Using a ranking of the stations for each measure permits the comparison of one measure to another measure even if the two have different types of results. The final results were a compilation of the ranks for each station on each of the measures potential inspection fraud. These compiled ranks are discussed in Section VI.C.

Inspection stations that are operated by the state tend to exhibit a substantially different range of results than the majority of privately operated stations, skewing the distribution of the results. These stations may be identified by the "G" within the station identification number and were excluded from all of the following analysis. Fleet inspection stations may also exhibit a different range of results than public stations, but since it is possible that a fleet might have incentive to perform clean-scanned inspections, the fleet inspection stations were retained for this analysis.

A. OBD DATA CHECKS FOR EVIDENCE OF STATION FRAUD

For a vehicle receiving an OBD inspection, "clean-scanning" refers to using a vehicle with no MIL illumination in place of a vehicle with MIL illumination in an attempt to receive a passing test result. Information downloaded from the OBD system during an inspection may be used to identify possible clean-scanning activities. Parameters collected during an OBD inspection establish an electronic signature. If test parameters do not match the parameters expected for the vehicle under test, it's possible that clean-scanning has occurred.

VI.A.1 Mismatch Between Inspector-Entered VIN and Vehicle-Downloaded eVIN

A majority of the vehicles receiving OBD tests report the VIN electronically. These VINs downloaded with a Mode $09 request from the engine control module are referred to as eVINs. All light-duty 2005 and newer vehicles are required to report eVINs, most 2002 to 2004 vehicles also report eVINs, and some 1996 to 2001 vehicles do as well. A comparison of the inspector-entered VIN against the eVIN via the OBD connection can help verify that all OBD inspections are performed on the correct vehicle. Both the inspector-entered VIN and the eVIN are recorded in each vehicle inspection record of the TIMS.

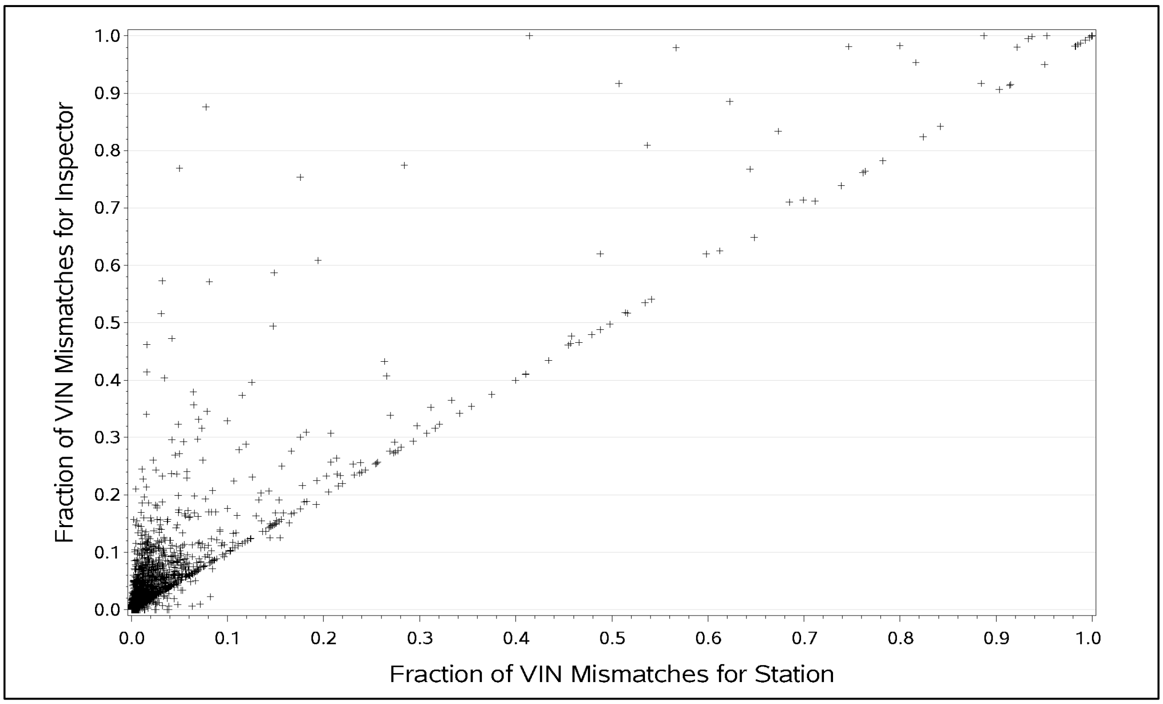
For this analysis, only those OBD inspection records that contained a valid eVIN were used (valid eVINs were confirmed using the check digit for the eVIN). This left about 17.1 million records in the dataset. For each of these records, the eVIN was compared with the VIN entered (either via keyboard or barcode scan) during the vehicle inspection. Of these, approximately 1% (224,179 records) were found to have VIN-to-eVIN discrepancies. An investigation of the VIN discrepancies, shown in Table VI-1, revealed that vehicles from the early years of OBD (1998 to 1999) had very high rates of discrepancies, with around 60% of vehicle records containing a discrepancy. Rates were very low for the later model years, largely due to federal requirements for the OBD system to provide the OBD eVIN on model year 2005 and newer vehicles. This may be because the vehicles that benefit from clean-scanning are those that fail an inspection, and that group would likely be dominated by the early model-year vehicles rather than the newer vehicles. However, the table also shows the rates of eVIN discrepancies separately for inspections that were passed and that were failed. The rates are very similar for the two sets of vehicles, even though much lower rates would be expected for the failing vehicles, if the eVIN discrepancies were caused by clean-scanning.

Table VI-1. Rates of OBD-Downloaded and Inspector-Entered VIN Discrepancies by Model Year

Model Year	Total Inspections With valid eVINs	Number of OBD Inspections with valid eVIN but VIN Mismatch	Percent of All OBD Inspections with VIN Mismatch	Percent of Passed OBD Inspections with VIN Mismatch	Percent of Failed OBD Inspections with VIN Mismatch
1998	1,840	1,253	68.1%	67.9%	84.6%
1999	4,974	2,700	54.3%	53.9%	78.2%
2000	25,648	4,778	18.6%	19.4%	6.5%
2001	93,184	6,867	7.4%	8.0%	2.4%
2002	121,278	7,893	6.5%	6.9%	2.6%
2003	147,572	9,105	6.2%	6.5%	2.5%
2004	193,123	10,476	5.4%	5.7%	2.2%
2005	357,311	12,450	3.5%	3.7%	1.8%
2006	426,135	13,738	3.2%	3.4%	1.6%
2007	568,804	15,842	2.8%	2.9%	1.6%
2008	617,716	14,869	2.4%	2.5%	1.3%
2009	462,127	9,745	2.1%	2.2%	1.4%
2010	607,018	10,662	1.8%	1.8%	1.1%
2011	718,589	11,465	1.6%	1.6%	1.0%
2012	892,098	12,225	1.4%	1.4%	1.0%
2013	1,109,950	12,277	1.1%	1.1%	0.8%
2014	1,231,997	12,074	1.0%	1.0%	0.7%
2015	1,427,431	11,426	0.8%	0.8%	0.6%
2016	1,413,747	9,427	0.7%	0.7%	0.6%
2017	1,529,083	8,953	0.6%	0.6%	0.6%
2018	1,527,135	8,052	0.5%	0.5%	0.6%
2019	1,536,095	8,141	0.5%	0.5%	0.6%
2020	1,285,216	6,497	0.5%	0.5%	0.7%
2021	691,230	2,780	0.4%	0.4%	0.7%
2022	100,465	409	0.4%	0.4%	0.4%
2023	16,129	68	0.4%	0.4%	0.2%
2024	814	7	0.9%	0.8%	1.1%
Total	**17,106,709**	**224,179**	**1.3%**	**1.3%**	**1.1%**

The rate at which VIN discrepancies were recorded was calculated for each station that performed OBD inspections, and for each inspector. These are compared graphically in Figure VI-1. The horizontal axis shows the fraction of OBD inspections that contained a VIN discrepancy for each station, while the vertical axis shows the fraction of OBD inspections with a VIN discrepancy for each inspector. To reduce errors due to small sample size, stations or inspectors that performed fewer than 100 inspections were excluded from the plot. The large cluster of points at the bottom left corner of the plot includes most stations and inspections: these had a near-zero rate of VIN discrepancies. The points closer to one on the horizontal or vertical axis indicate stations or inspectors that almost always produced OBD records with a VIN discrepancy. These very-high rates could in part result from practices other than clean-scanning, such as careless data entry when the VIN is manually entered, or vehicles with an invalid eVIN (earlier model years or PCM replacements).

Figure VI-1. Rates of OBD-Downloaded and Inspector-Entered VIN Discrepancies by Station and Inspector



One additional factor that was calculated for each station was the number of times the same VIN was downloaded in different OBD inspections. If clean-scanning is taking place, there is a good chance that the “clean” vehicle would be used repeatedly, and its VIN would be downloaded numerous times, whereas VIN typos would vary with each inspection. This analysis identified that some stations were downloading the same eVIN during different OBD inspections and revealed a single station had downloaded the same eVIN in over 16,000 inspections. The next most common eVINs were downloaded 10,000 times, 9,000 times, and 7,000 times.

These VIN mismatch findings were condensed into a rank for each station, based on the fraction of inspections that revealed a disagreement between the entered VIN and the downloaded VIN. Stations that performed fewer than 100 OBD inspections over the two-year period were again excluded from the results due to the possibility of spurious results from the small sample size. As an example of the findings, the VIN mismatch rates for the 10 worst offending stations are listed below in Figure VI-2. The table shows the rate at which there was a disagreement between the entered VIN and the eVIN, out of all inspections at that station that included a 17-digit VIN in both fields. The table also shows the maximum number of times a single VIN was tested at each station.

Table VI-2. Ten Worst Stations with Highest Rates of OBD and Entered VIN Mismatches

Station Rank	Percent of Inspections Where VIN Did Not Match	Total Number of Inspections Performed at Station	Maximum Number of Tests on a Single VIN	Percentile Rank for Station
1	100.0%	1,996	1,996	100.0
2	100.0%	1,622	922	100.0
3	100.0%	198	197	100.0
4	100.0%	2,048	1,985	99.9
5	100.0%	5,012	4,810	99.9
6	100.0%	147	147	99.9
7	100.0%	4,562	4,560	99.9
8	99.9%	1,358	1,358	99.9
9	99.7%	627	625	99.8
10	99.3%	272	164	99.8

VI.A.2 eVIN is Missing

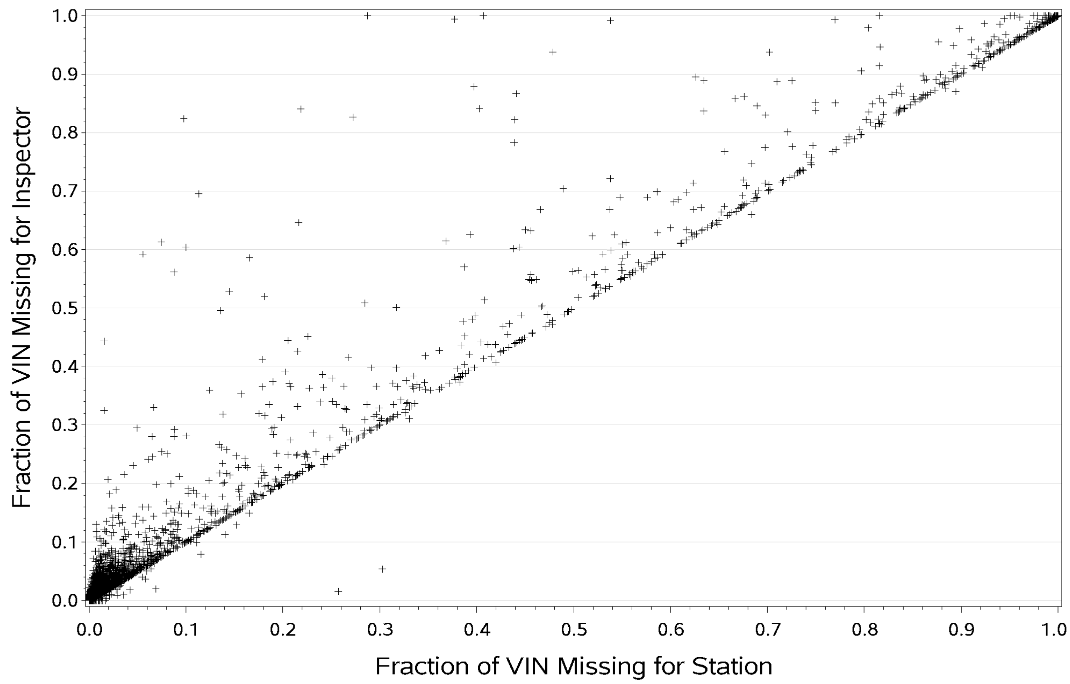
Vehicles of model years 2005 and newer are required to provide an eVIN that is downloaded during every OBD inspection. For this analysis, approximately 18.3 million inspection records for 2005 and newer vehicles that received OBD inspections during the two-year evaluation period were used. For each of these records, the eVIN was checked and the record flagged if the eVIN was missing. Of the OBD inspections for 2005 and newer vehicles, about 1.7 million inspections had a missing eVIN (entirely blank or entered as “N/A”). The counts by model year are given in Table VI-3. Rates are low for the newest model years, and much higher for the older model years, indicating that clean-scanning may be occurring. The table also shows the rates of missing eVINs separately for passed and failed inspections. It can be seen that the rates of missing eVINs are far higher for passed inspections than for failed inspections, which is another indication that clean-scanning may be occurring.

Table VI-3. Rates of OBD Inspections without eVIN by Model Year

Model Year	Total OBD Inspections	Number of OBD Inspections with Missing eVIN	Percent of All OBD Inspections with Missing eVIN	Percent of Passed OBD Inspections with Missing eVIN	Percent of Failed OBD Inspections with Missing eVIN
2005	497,603	136,343	27.4%	28.1%	1.6%
2006	576,074	146,639	25.5%	25.8%	1.3%
2007	748,633	177,679	23.7%	24.1%	1.2%
2008	780,610	160,933	20.6%	20.7%	1.0%
2009	564,594	101,314	17.9%	18.0%	1.0%
2010	717,570	109,282	15.2%	15.3%	1.0%
2011	837,404	117,284	14.0%	13.7%	1.0%
2012	1,012,963	119,519	11.8%	11.5%	0.7%
2013	1,230,641	119,248	9.7%	9.4%	0.7%
2014	1,346,757	113,514	8.4%	8.1%	0.7%
2015	1,535,410	106,709	6.9%	6.4%	0.7%
2016	1,496,847	82,324	5.5%	4.9%	0.5%
2017	1,599,204	69,503	4.3%	3.7%	0.6%
2018	1,579,440	51,901	3.3%	2.7%	0.5%
2019	1,581,940	45,518	2.9%	2.1/%	0.5%
2020	1,317,824	32,429	2.5%	1.5%	0.3%
2021	706,817	15,510	2.2%	0.9%	0.2%
2022	102,783	2,314	2.3%	0.5%	0.3%
2023	16,620	487	2.9%	0.4%	0.2%
2024	849	35	4.1%	0.1%	0.0%
Total	**18,250,583**	**1,708,485**	**9.4%**	**8.8%**	**0.8%**

The rate at which eVINs were missing was calculated for each station that performed OBD inspections, and for each inspector. These are compared graphically in Figure VI-1. The horizontal axis shows the fraction of OBD inspections that contained no eVIN for each station, while the vertical axis shows the fraction of OBD inspections that contained no eVIN for each inspector. To reduce errors due to small sample size, stations or inspectors that performed fewer than 100 inspections were excluded from the plot. The large cluster of points at the bottom left corner of the plot includes most stations and inspections: these OBD inspections almost always included an eVIN. The points closer to one on the horizontal or vertical axis indicate stations or inspectors that almost never performed OBD inspections that contained an eVIN.

Figure VI-2. Rates of OBD Inspections without eVIN by Station and Inspector



These findings of missing eVINs were condensed into a rank for each station based on the fraction of inspections that did not include an eVIN. Stations that performed fewer than 100 OBD inspections over the two-year period were again excluded from the results, due to the possibility of spurious results from the small sample size. As an example of the findings, the missing-eVIN rates for the 10 worst offending stations are listed below in Table VI-4. The table shows the rate at which the eVIN was missing from OBD inspections performed on model year 2005 and newer vehicles at the station.

Table VI-4. Ten Worst Stations with Highest Rates of Inspections without Downloaded eVINs

Station ID7	Percent of Inspections Without eVIN	Total Number of Inspections Performed at Station	Percentile Rank for Station
1	100.0%	561	100.0
2	100.0%	1,241	100.0
3	100.0%	1,445	100.0
4	100.0%	807	99.9
5	100.0%	1,322	99.9
6	100.0%	106	99.9
7	100.0%	1,539	99.9
8	100.0%	350	99.9
9	100.0%	1,603	99.9
10	100.0%	430	99.8

VI.A.3 Comparison of Vehicle-Specific Information between the First Test and Subsequent Tests

The purpose of this analysis was to compare OBD-downloaded information for a given vehicle on its first inspection to OBD-downloaded information on retests of that same vehicle. Certain types of OBD information may be combined to create unique "electronic profiles" for each vehicle, and the electronic profile should be the same at the initial inspection and at subsequent inspections. If the electronic profile changes from one inspection to the next, inspection fraud may be suspected. For this analysis, only those vehicle inspection cycles that included an initial test and at least one retest were used, and only records where readiness monitor values were present were used, reducing the dataset from about 20 million OBD inspections to about 1.6 million inspections. This includes 779,000 initial inspections, and 863,000 retests.

In earlier years of performing this I/M Program Evaluation (2016 and earlier), three variables were used to create the first "electronic profile" for each vehicle: the eVIN, the PCM ID, and the PID Count. Beginning with the 2018 analysis, three additional variables are added: the Communications Protocol (COMM_PROT), the calibration ID (CAL_ID) and the CVN (calibration verification number). The downloaded values for these six variables from all OBD tests conducted over the two-year audit period are summarized below:

- eVIN: eVINs (valid or invalid) were only available in 86% of the test records. The eVIN or the manually entered VIN was missing in the remaining 14% of the OBD test records. The 14% that did not download correctly could be due to factors other than inspection fraud, including the vehicles age, the DLC is not connected properly due to a bad pin or it is not fully plugged in, the scan tool communicates with a different module than the Engine Control Module, there is a pass-through device connected to the DLC, the vehicle battery is weak, or the VIN is just read incorrectly. Because of this, use of the eVIN alone would not be sufficient to positively identify clean-scanning.
- PCM ID: The PCM ID was available in all but 931 of the test records. There were 53 unique PCM ID values, but 58% of all PCM IDs had a value of "E8" and 21% had a value of "10." Two other PCM IDs each represented another 5% of records, three other PCM IDs each comprised an additional 1% of the test records, and the remaining test records were distributed among the other PCM IDs. Because of this, as with the eVIN, use of PCM ID alone would not be sufficient to positively identify clean-scanning (a substituted vehicle could easily have a value of "E8" or one of the other most common PCM IDs).
- PID Count: There were 94 unique PID Count values and all but 5,703 OBD test records contained a value for PID Count. Seven PID Count values were seen in 50% of all OBD test records, while the remaining test records contained one of the remaining PID Count values. Therefore, the use of the PID Count alone would not be sufficient to positively identify clean-scanning.

- COMM_PROT: There were seven unique values and all OBD test records contained a value for the COMM_PROT. Two COMM_PROT values were used for 79% of records, so the use of COMM_PROT along would not be sufficient to positively identify clean-scanning.
- CVN and CAL_ID each contain hundreds of unique values. These variables could be quite specific for identifying changes from one inspection to the next, except that they are only populated for about 78% of the OBD records, meaning that the other 22% of OBD records have the same values (missing) for these variables, and the CVN and CAL_ID combination alone would not be sufficient to positively identify clean-scanning.
- When the PCM ID, PID Count, COMM_PROT, CAL_ID, and CVN are looked at in combination, the five most common combinations of these variables comprise between 0.5% and 2% of inspections, with many hundreds of combinations each making up less than 1% of the remainder of inspections. Thus, the combination of these five variables is highly variable and may be a good indicator for identifying when a different vehicle is being substituted for the test.

The second electronic profile that was created was an “enabled profile.” For this analysis, OBD readiness monitors were identified 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 positive crankcase ventilation 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, EGR systems, evaporative 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: There were 23% not monitored, 77% monitored;
- Evaporative systems: There were 1% not monitored, 99% monitored;
- Heated O_2 systems: There were 2% not monitored, 98% monitored; and
- Secondary air systems: There were 95% not monitored, 5% monitored.

When the status of the four monitors is looked at together, two combinations of monitor status dominated the dataset, with 73% and 19% of vehicles. Smaller numbers of vehicles comprised the remaining 14 combinations and 8% of vehicles. 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.

An electronic profile and a monitored-status profile were created for each vehicle, for its initial inspection and for any re-inspections. Any tests where either profile differed from inspection to inspection were flagged. Tests where both the electronic profile and the monitored-status profiles changed would be an indicator that a different vehicle was being substituted for the test. Note that for any individual vehicle, these downloaded values may vary among analyzer manufacturers (in particular the PID Count), so the analysis was based on vehicle/analyzer combinations. All inspections where the initial inspection took place on a different type of analyzer than that used for the retest inspection were excluded from the analysis.

Occasionally, analyzer hardware upgrades or software updates could result in OBD system PID count mismatches between multiple tests on the same vehicle, and the eVIN 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 OBD 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.

As described above, the dataset included approximately 779,000 initial inspections and 863,000 retests. Retests that took place on an analyzer from a different manufacturer than the initial test were excluded from the results, leaving approximately 779,000 retests for analysis. The results of the analysis were:

- There were 677,681 (87.0%) retests that had matches for both the electronic profile and the readiness profile between initial test and subsequent retests on the same analyzer. These tests very likely indicate compliant testing.
- There were 34,221 (4.4%) retests that had a mismatch for both the electronic profile info and the readiness profile, between the initial test and at least one retest on the same analyzer. Test pairs where both PCM ID information and readiness profile differ are likely to be performed on two different vehicles (i.e., an indication of clean-scanning).
- There were 390 (<0.1%) retests that had a "readiness profile" mismatch between the initial test and at least one retest on the same analyzer, but the electronic profile 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 versus 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 these difficulties in interpreting these results, the

scenario of a readiness profile mismatch with a computer identification (ID) match is not considered to be a strong indicator of non-compliant testing.

- There were 66,462 (8.5%) retests that had an electronic profile 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 could occur only if another vehicle was substituted for a retest (clean-scanning), if an anomaly in the analyzer software interpreted the computer ID information two different ways on subsequent retests for the same vehicle, or if a vehicle repair was performed in which the vehicle's PCM was re-programmed with new ID information as a part of a repair. Although the last two scenarios are unlikely, it was not possible to quantify the likelihood of this occurring in 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 thought to be a good indicator of clean-scanning.

A summary of this information is provided in Table VI-5.

Table VI-5. Percentages of Tests with Various OBD Fraud Indicators

Retest Match Scenario	Retest-only Dataset
All match (compliant)	87.0%
Readiness mismatch (ambiguous)	<0.1%
PCM ID info mismatch (fraud likely)	8.5%
Both mismatch (fraud very likely)	4.4%
Estimated % of clean-scanning	4% to 13%

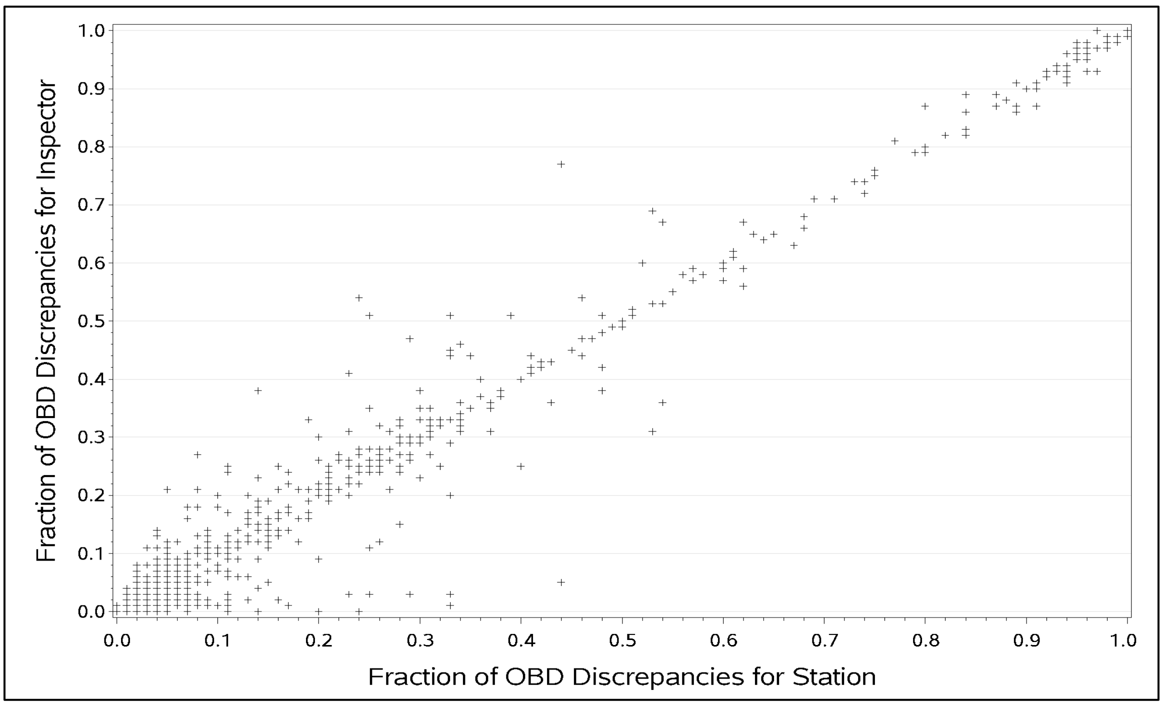
Next, using the complete dataset, which includes tests classified as initial tests, the following general statistics were seen for stations and inspectors with computer ID information or "readiness profile" mismatches.

- From January 1, 2022, through December 31, 2023, 85% of the 5,736 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 retest records for any one station was 2,841 records over the two-year period, and another 63 stations had more than 200 records with a mismatch. Some stations had mismatch rates as high as 100%, meaning 100% of the retest inspections performed at the station showed a mismatch in the readiness profile or computer ID information. These stations are almost certainly using clean-scanning to help failing vehicles to pass the retest.

- From January 1, 2022, through December 31, 2023, 43% of the 27,335 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 retest records for any one inspector was 1,496 records over the two-year period, while an additional 39 inspectors had more than 200 mismatch retest records. Inspector mismatch rates as high as 100% were identified.

The distribution of station and inspector mismatch rates is shown in Figure VI-3. The horizontal axis shows the fraction of retest records that contained an electronic profile or readiness profile mismatch for each station. The vertical axis shows the fraction for each inspector. The large concentration of data points in the lower left corner are stations and inspectors that produced retest records that rarely had a mismatch when compared to the information from the initial inspection. In contrast, the stations/inspectors in the upper right-hand portion of the chart are those that are most likely to be clean-scanning.

Figure VI-3. Rates of Retest Discrepancies in OBD Computer and Readiness Information, by Station and Inspector



These results were condensed into a rank for each station, based on the fraction of retest inspections performed at that station that included both an electronic profile mismatch and a readiness profile mismatch. Stations with fewer than 100 OBD retest inspections over the two-year period were excluded from the results, due to the possibility of spurious results from the small sample size. The 10 stations with the highest rates of profile mismatches are listed in Table VI-6. Some electronic profile and/or readiness mismatches are to be expected, and as mentioned above, 85% of stations had at least one case of a mismatch. However, most of those stations had only one or a few mismatches. Overall, about 4.4% of retest inspections resulted in a readiness profile and electronic profile mismatch. When stations with a mismatch in more than 90% of their inspections are seen, it suggests fraudulent testing is being performed.

Table VI-6. Ten Worst Stations with Highest Percent of Electronic Profile and Readiness Profile Mismatches

Station ID	Percent of Re-inspections with both Electronic & Readiness Mismatch	Number of Re-inspections at Station	Percentile Rank for Station
1	100.0%	121	100.0
2	99.5%	607	100.0
3	99.4%	177	99.9
4	98.3%	120	99.9
5	97.8%	321	99.8
6	97.7%	171	99.8
7	97.2%	181	99.7
8	97.1%	104	99.7
9	96.0%	201	99.7
10	95.6%	113	99.6

VI.A.4 Comparison of Downloaded and Expected Communication Protocol

As was done in the last program evaluation report, the OBD communications protocol indicator (TX96_COMM_PROT) was evaluated. This variable will have one of seven values, representing the six EPA approved communications protocols for vehicles sold in the U.S., or none as shown in Table VI-7.

Table VI-7. OBD Communications Protocol Codes

Code	Protocol
C	Controller Area Network (CAN)
D	CAN
P	PWM (Pulse Width Modulation)
I	ISO (International Organization for Standardization)
V	VPW (Variable Pulse Width)
K	KWP (Key Word Protocol)
N	(none found)

In theory, each type of vehicle that is manufactured uses one of the protocols, and all vehicles of the same type use the same protocol.[7]

[7] It is known that Chrysler vehicles from model years 1999–2005 have exhibited unreliable communications protocol values, so 1999–2005 Dodge, Jeep, and Chrysler makes were excluded from analysis in this section.

ERG's subcontractor, de la Torre Klausmeier Consulting, Inc. (dKC) has worked extensively with comparisons of expected communication protocols with the communication protocols recorded during the OBD test, for various I/M areas. For such comparisons, dKC constructed a look-up table of communication protocols by VIN stem (comprised of VIN digits in positions 1–8, 10, and 11), using reliable data from a highly controlled, centralized I/M program.

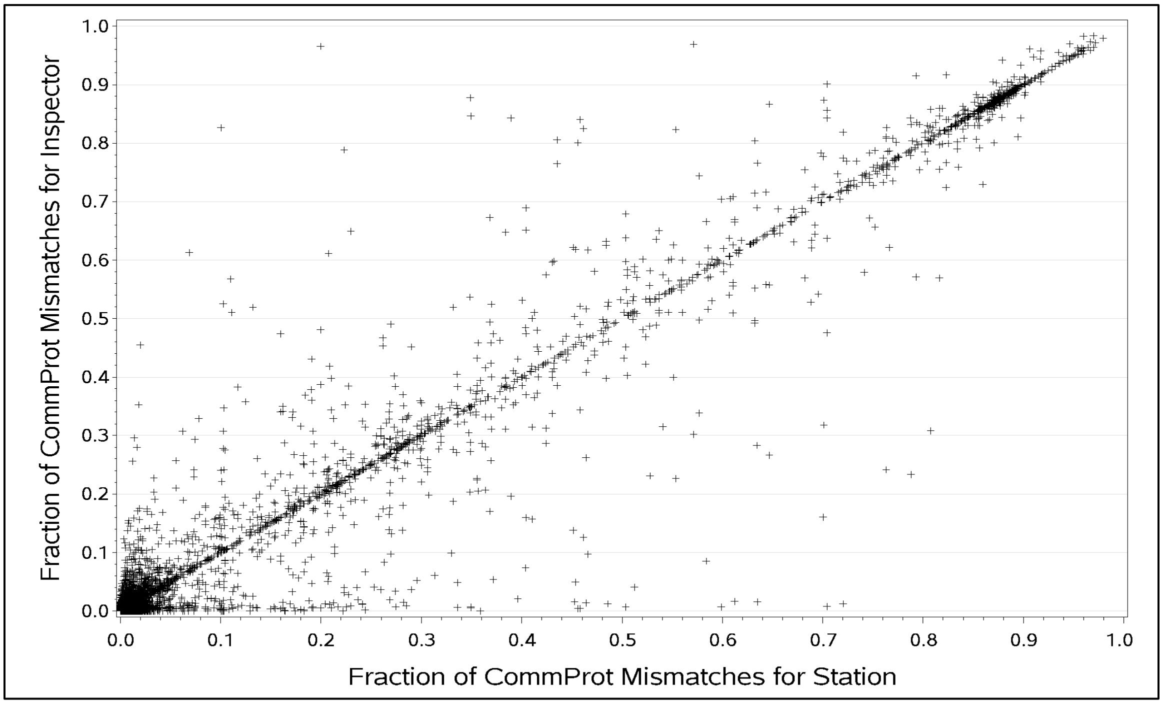
ERG was able to match about 2/3 of the 1998 through 2009 model year vehicles in the dataset using the dKC look-up table. Because almost all vehicles after 2010 use the CAN protocol, the dKC look-up table stops with the 2009 vehicle model year. Results by model year are shown in Table VI-8. The overall mismatch rate was much higher for passing tests than failing tests: 26% versus 1%. The mismatch rate is very high for vehicles of older model years where inspection fraud might be used to help the vehicle pass the inspection.

Table VI-8. Rates of Communication Protocol Mismatches by Model Year

	Mismatches: Failed Inspections		Mismatches: Passed Inspections	
Model Year	Number of Fails with Mismatch	Percent of Fails that had Mismatch	Number of Passes with Mismatch	Percent of Passes that had Mismatch
1998	31	1.3%	7,708	27.5%
1999	64	1.4%	14,456	26.2%
2000	96	1.2%	28,400	30.6%
2001	205	1.4%	38,531	35.1%
2002	198	1.3%	38,251	29.6%
2003	238	1.3%	46,051	27.7%
2004	296	1.5%	51,521	25.7%
2005	225	1.1%	52,887	24.0%
2006	258	1.0%	72,881	26.1%
2007	245	1.0%	84,824	24.9%
2008	199	0.8%	90,521	24.4%
2009	125	0.7%	59,505	20.6%
Total	**2,180**	**1.1%**	**585,536**	**25.6%**

The rate at which communication protocol mismatches were recorded was calculated for each station that performed OBD inspections and for each inspector. These are compared graphically in Figure VI-4. The horizontal axis shows the fraction of OBD inspections that contained a communication protocol mismatch for each station, while the vertical axis shows the fraction of OBD inspections with a mismatch for each inspector. To reduce errors due to small sample size, stations or inspectors that performed fewer than 100 inspections were excluded from the plot. The large cluster of points at the bottom left corner of the plot includes most stations and inspections: these had a very low rate of communication protocol discrepancies. The points closer to one on the horizontal or vertical axis indicate stations or inspectors that almost always produced OBD records with a communication protocol discrepancy.

Figure VI-4. Rates of Communication Protocol Mismatches by Station and Inspector



These results were condensed into a rank for each station, based on the fraction of inspections at that station that included a communication protocol mismatch. Stations with fewer than 100 OBD test inspections over the two-year period were excluded from the results due to the possibility of spurious results from the small sample size. The 10 stations with the highest rates of mismatches are listed in Table VI-9. Some mismatches are to be expected and most stations had at least one case of a mismatch. However, most of those stations had only one or a few mismatches. Overall, about 16% of inspections resulted in a communication protocol mismatch. As stated earlier, when stations have this high a level of mismatch it suggests fraudulent testing.

Table VI-9. Ten Worst Stations with Highest Percent of Communication Protocol Mismatches

Station ID	Percent of Inspections with Communication Protocol Mismatch	Number of Inspections at Station	Percentile Rank for Station
1	98.0%	2,807	100.0
2	97.2%	531	100.0
3	97.0%	1,562	100.0
4	96.7%	1,052	99.9
5	96.4%	3,366	99.9
6	96.0%	2,490	99.9
7	95.9%	687	99.9
8	95.8%	689	99.9
9	95.8%	3,211	99.9
10	95.7%	9,314	99.8

B. ADDITIONAL INSPECTION MANIPULATION

Several different types of inspection results have been identified that do not use OBD-downloaded information, but that may provide good indicators that emissions inspection fraud may be occurring at a given station. Several of these are extremely uncommon in the TIMS dataset overall but are relatively common for a handful of stations.

- Short Time Interval Between Inspections: Sometimes a failing inspection is followed by a passing inspection only a few minutes later. This could indicate the occasional warm-up or easy repair when it happens once or twice for each station, but when it occurs many times at only a few stations it is more likely to indicate clean-scanning.
- Safety-Only Inspection Rate: Vehicles that are between two and 24 years old are required to participate in the emissions inspection program by receiving OBD inspections. Vehicles older than 24 years are only required to receive a safety inspection, so it can be easier for them to pass their inspection. This can sometimes result for misclassification at the time of the inspection, but it happens more frequently at some stations than at others.
- Changing from Light-Duty to Heavy-Duty to Pass: Similarly, an initial failed inspection of a light-duty vehicle (GVWR<8,500 lbs.) is sometimes followed by a passed inspection of that vehicle as a heavy-duty vehicle. OBD pass/fail stringency is lower for HD vehicles, making the inspection easier to pass. This happens very infrequently in the dataset, but much more frequently at some stations.
- Pass/Fail Outliers: The overall failure rate at a station can be used as an indicator of whether fraud is occurring. Unusually high or unusually low failure rates may both be a cause for concern. This factor can be difficult to analyze since it is known that different areas with a different type of fleet (or a different socio-economic status) often have real differences in failure rates.

Each of these factors is discussed in more detail in the following sections, and a ranking is assigned to each station for each factor.

Short Time Interval Between Inspections

For inspection cycles that begin with a failing inspection, a retest (or retests) usually follows a day or several days after the initial failed inspection. Presumably, repairs are performed during that interval between inspections. However, some failing inspections are followed by a passing inspection within minutes, raising concern as to how the vehicle was successfully repaired so quickly, or if instead clean-scanning occurred for the passing retest. The dataset shows that many stations have one or a few cases of a passing retest following a failing initial test within a short time. These occasional cases may be the real result of a simple fix: a reconnection of a loose line or wire or other simple change. However, some stations show a much more frequent occurrence of initial inspections being quickly followed by passing inspections when compared to the majority of stations. In these cases, there may be cause for a suspicion of inspection fraud.

For this analysis, any inspections that were aborted or had dilution problems were deleted from the dataset. This left approximately 20.1 million observations in the dataset. In addition, only time differences on retest inspections that were conducted at the same inspection station as the initial inspection were used. This resulted in a dataset of about 647,000 retest observations.

The distribution of the number of times that a failed initial inspection was followed by a passing retest within 15 minutes at a given station over a two-year period is listed in Table VI-10. The table shows that this happened rarely or never for most stations. However, for 166 stations it happened 20 or more times (up to 112 times for the highest station, not shown in the table).

Table VI-10. Number of Close-in-Time Retests per Station

Number of Close-In-Time Retests	Number of Stations	Percent of Stations
0	2,051	36.4%
1	1,031	18.3%
2	574	10.2%
3	396	7.0%
4	279	5.0%
5	208	3.7%
6	199	3.5%
7	121	2.2%
8	102	1.8%
9	90	1.6%
10	82	1.5%
11	61	1.1%
12	57	1.0%
13	53	0.9%
14	39	0.7%
15	41	0.7%
16	29	0.5%
17	22	0.4%
18	19	0.3%
19	15	0.3%
20 or more	166	3.7%
Total	**5,635**	**100.0%**

The 10 stations with the highest rate of close-in-time retests are listed in Table VI-11. The percentage was calculated from the number of close-in-time retests and the total number of retests at that station. Stations that performed fewer than 100 retest inspections over the two-year period are excluded from the results. From Table VI-11, the highest ranked stations performed a third of their retest inspections within the short time period of 15 minutes or less after the initial passed inspection.

Table VI-11. Percent of Close-In-Time Retest Inspections for 10 Highest Ranking Stations

Station ID	Percent of Close-In-Time Retests	Number of Close-In-Time Retests	Total Number of Retest Inspections	Percentile Rank for Station
1	33.6%	37	110	100.0
2	32.3%	53	164	99.9
3	23.8%	31	130	99.9
4	22.8%	69	302	99.8
5	21.6%	58	269	99.8
6	21.5%	35	163	99.7
7	21.1%	28	133	99.7
8	19.9%	31	156	99.6
9	18.9%	28	148	99.6
10	18.6%	21	113	99.5

Safety-Only Inspection Rate

Another way that a station can help a vehicle to pass an inspection, even with high emissions, is to perform a safety-only inspection instead of performing both the safety and the emissions inspection. Safety-only inspections are, in fact, found in the database for vehicles in the age-range for emissions testing.

The performance of safety-only inspections is shown in Figure VI-5 and Figure VI-6. The figures include a green line for the number of safety-only inspections and a purple line for the number of emissions inspections, which both refer to the left vertical axis. The red line represents the percent of total inspections that were safety-only and refers to the right vertical axis. The figures focus on the older vehicle ages, 12 years and older, so that the differences can best be observed. Each figure is for one program year, either 2022 or 2023. The rate at which safety-only inspections were performed over the years is compared in Figure VI-7. This figure takes the line for the percent of total inspections that were safety-only and compares calendar years from 2018 through 2023. From Figure VI-7, it appears that the rates of safety-only inspections for the oldest model years have decreased in 2022 and 2023 compared to the prior years.

Figure VI-5. Number and Percent of Emissions and Safety-Only Inspections 2022

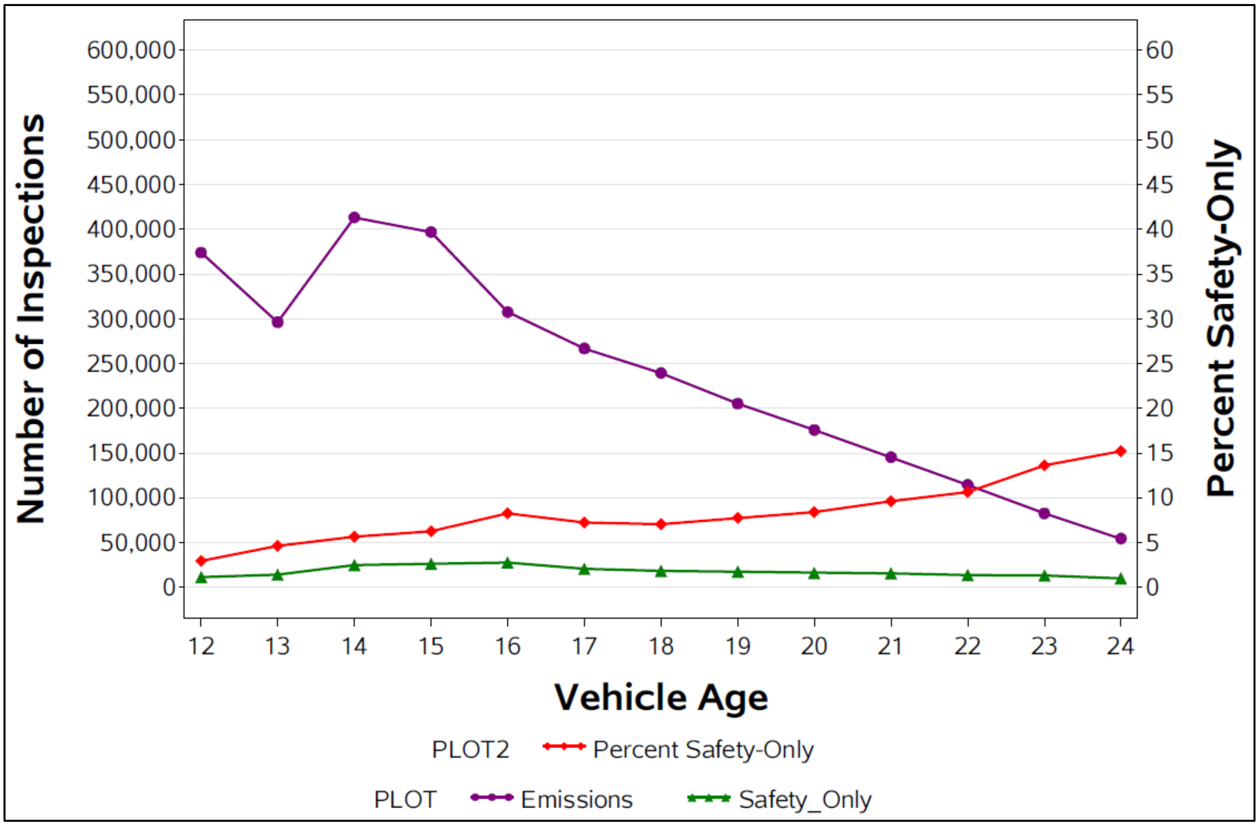


Figure VI-6. Number and Percent of Emissions and Safety-Only Inspections 2023

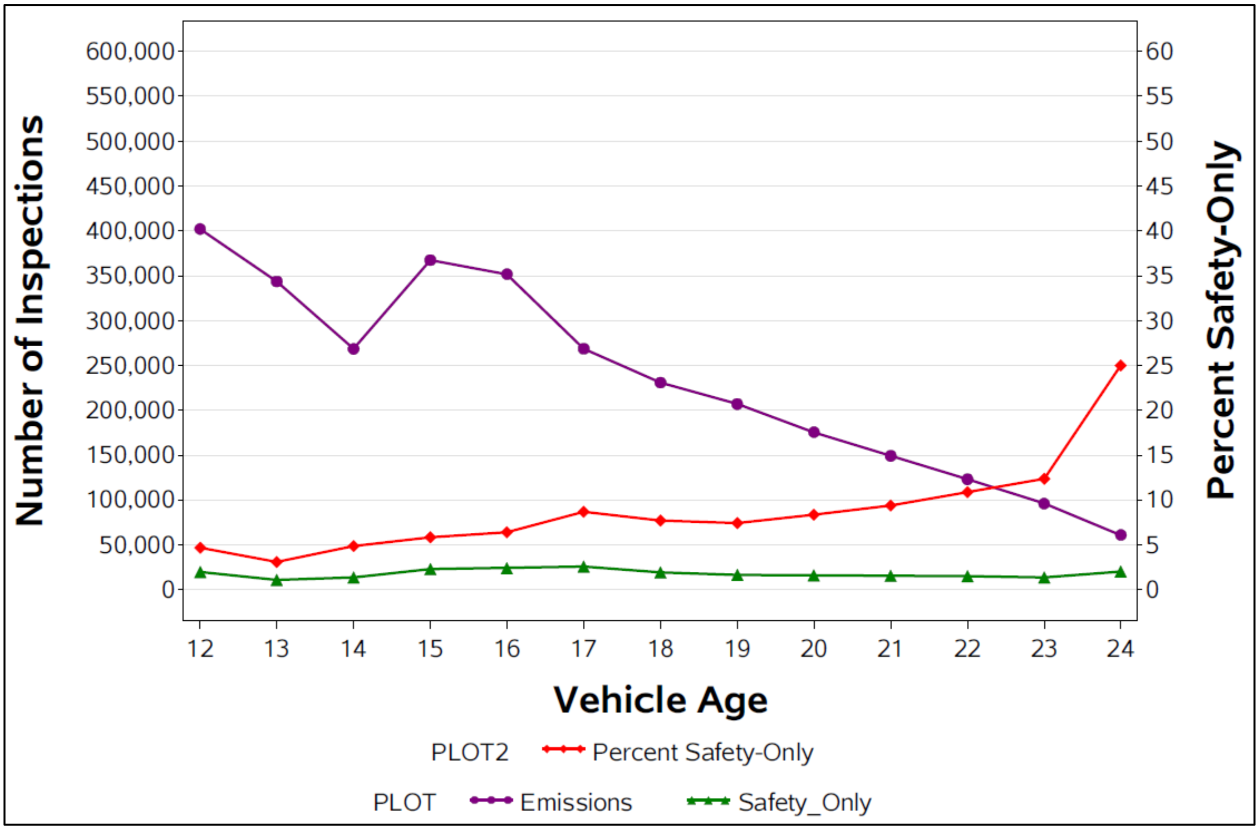
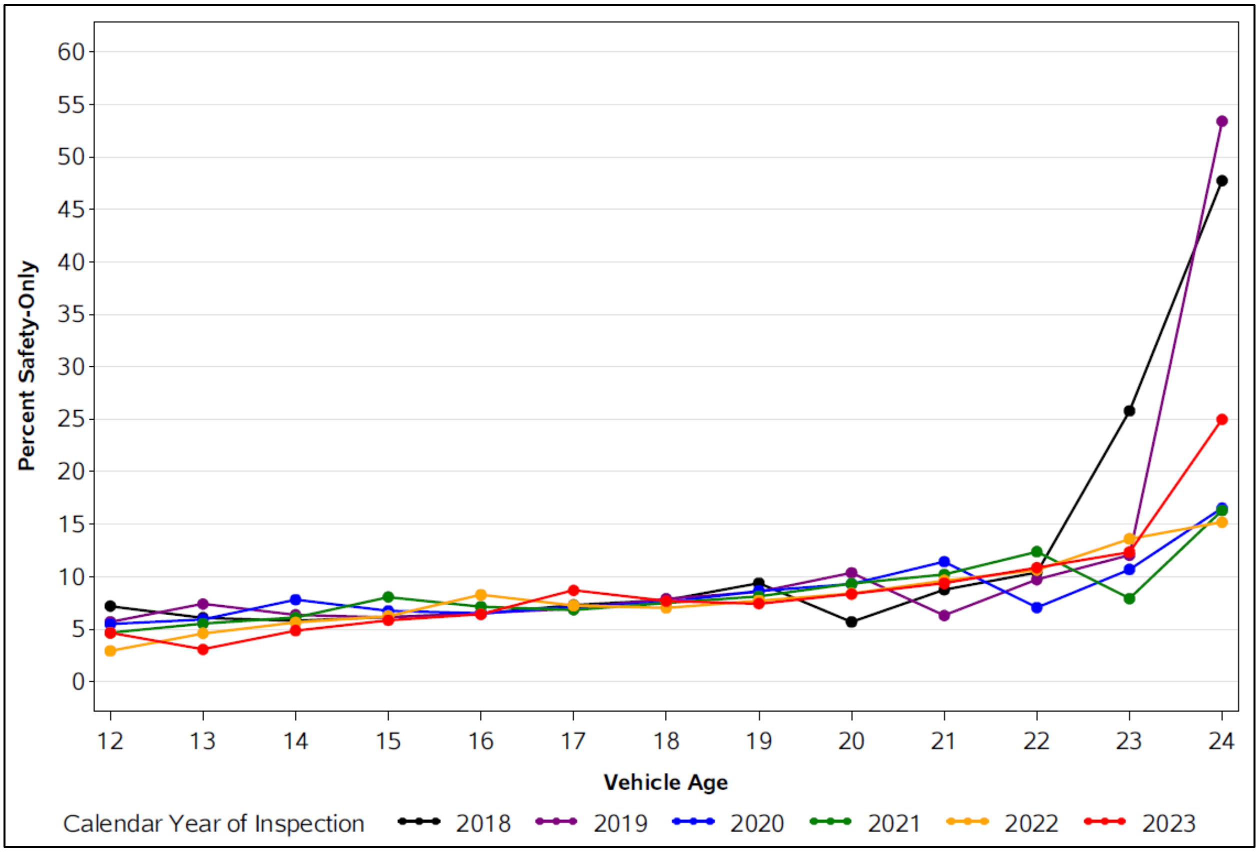


Figure VI-7. Percent of Inspections that Were Safety-Only, by Calendar Year

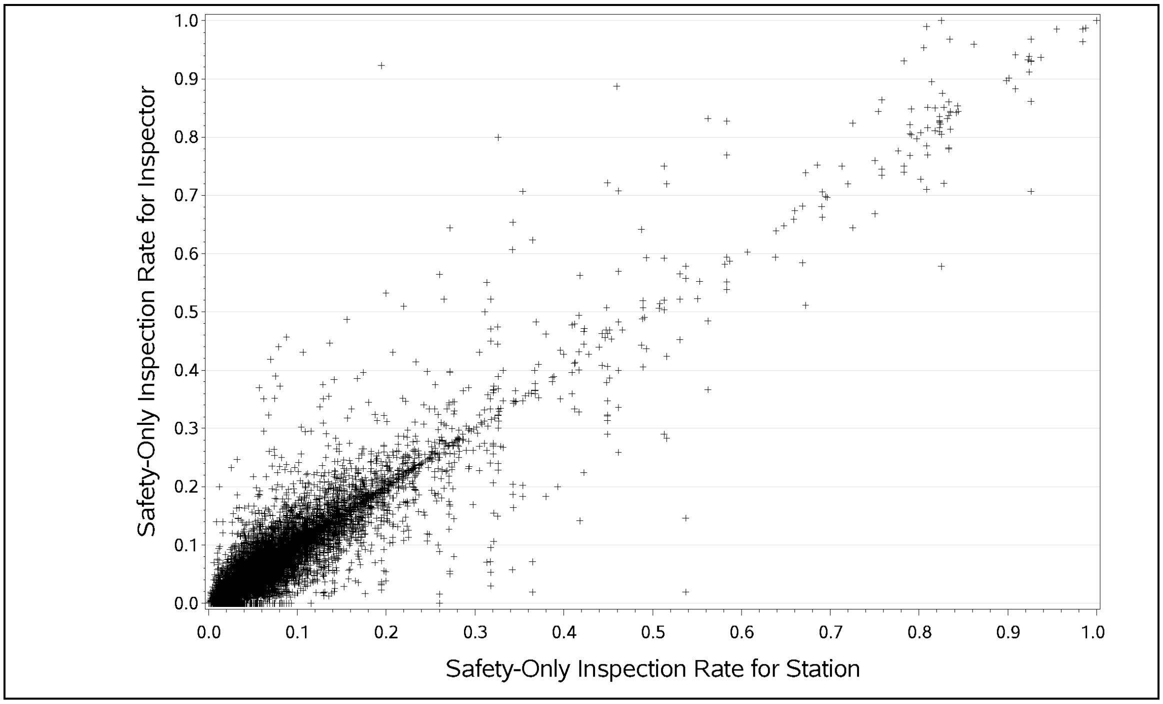


Overall, the rates of safety-only inspections are fairly low. However, they could be a possible indicator of inspection fraud if the station or inspector helped the vehicle to pass the inspection by avoiding the emissions component. If some stations show a more frequent rate of safety-only inspections than do others, then there might be cause for a suspicion of inspection fraud.

Rates of safety-only inspections were examined for all vehicles aged 12 to 24 years at the time of inspection. The data did show that some stations show a much more frequent rate of safety-only inspections than other stations: a few stations report thousands of safety-only inspections, while most stations report only one or a few. In these cases, there may be cause for a suspicion of inspection fraud.

The rate at which safety-only inspections were performed was calculated for each station that performed I/M inspections and for each inspector. All inspections for vehicles 12 to 24 years old were used for the graph. Vehicles between two and 12 years old were omitted from the figure because the data for this cohort is essentially the same as for those vehicles between 12 and 17 years old, i.e., fairly constant around 5%. The safety-only inspection rates are compared graphically in Figure VI-8. The horizontal axis shows the fraction of inspections that were safety-only for each station, while the vertical axis shows the fraction of inspections that were safety-only for each inspector. To reduce errors due to small sample size, stations or inspectors that performed fewer than 100 inspections were excluded from the plot. The large cluster of points at the bottom left corner of the plot includes most stations and inspections: these had a very low rate of safety-only inspections. The points closer to one on the horizontal or vertical axis indicate stations or inspectors that almost always produced inspection records with a safety-only test.

Figure VI-8. Rates of Safety-Only Tests Vehicles 12-24 Years Old for Stations and Inspectors



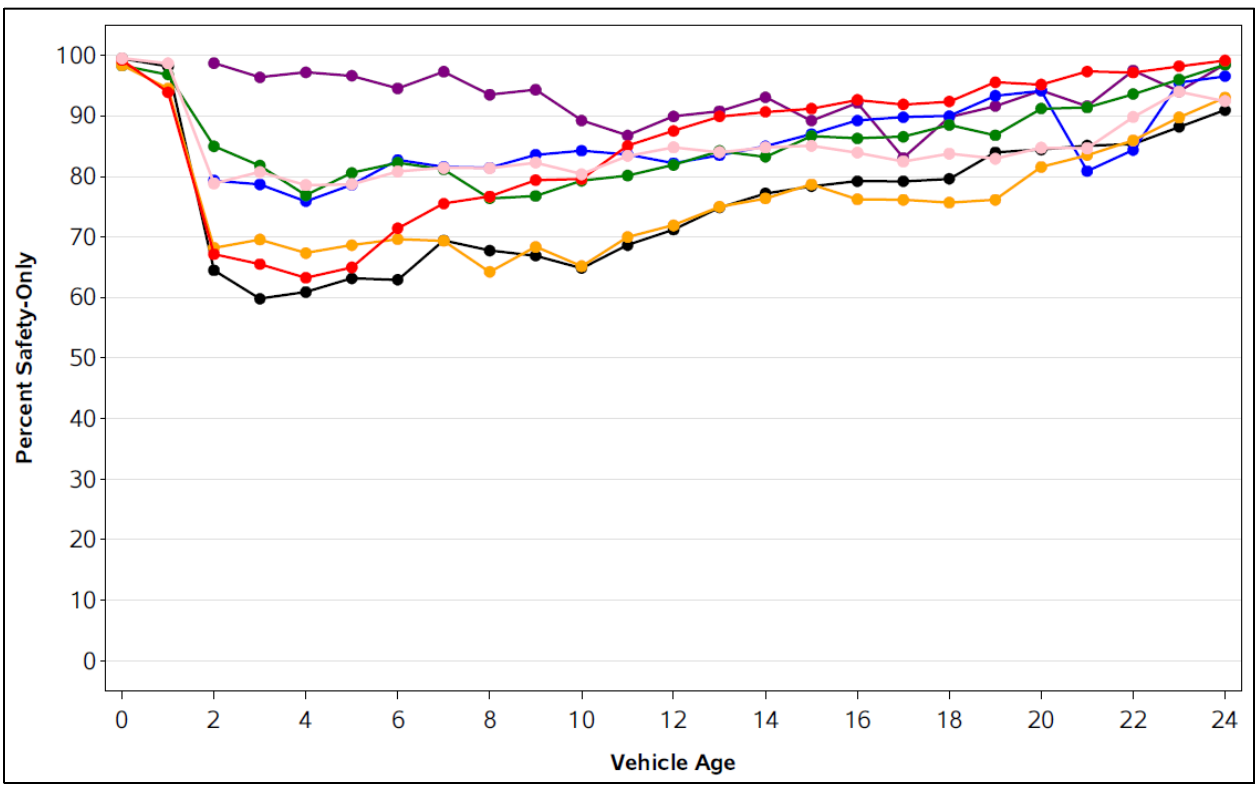
The 10 stations with the highest rate of safety-only inspections are listed in Table VI-12. Inspections for vehicles 12 years old and older, in 2022 or 2023, were used for these results: i.e., new vehicles were included, so two-year safety inspections of very new vehicles would not be included in these percentages. The percentage was calculated from the number of safety-only inspections and the total number of inspections (safety plus emissions) at that station. Stations that performed fewer than 100 inspections over the two-year period are excluded from the results. It can be seen from the table that the stations at the top of the list performed safety-only inspections on almost all of 12+ aged vehicles that they tested. It is notable that several “fleet” inspection facilities (with “F” in the second position of the station ID) made it into this top-10 list; the fleet facilities are not represented on the lists for many of the other analyses in this analysis of potentially fraudulent emissions inspections.

Table VI-12. Rate of Safety-Only Inspections for 10 Highest Ranking Stations

Station ID	Safety-Only Percent	Number of Safety-Only Inspections	Total Number of Inspections	Percentile Rank for Station
1	98.4%	253	249	100.0
2	98.8%	963	951	100.0
3	100.0%	163	163	100.0
4	90.9%	558	507	99.9
5	92.3%	1,321	1,219	99.9
6	92.4%	1,438	1,329	99.9
7	92.6%	7,293	6,752	99.9
8	93.7%	349	327	99.9
9	95.5%	156	149	99.9
10	90.1%	101	91	99.8

Because the rates of safety-only inspections are so high for some of the stations listed in Table VI-12, some of the dominant stations with the greatest numbers of safety-only inspections were investigated further. In Figure VI-9, the rate at which safety-only inspections were performed at a handful of stations are shown, each in their own color. This figure includes gasoline and non-gasoline fueled vehicles. The horizontal axis shows vehicle ages zero through 24, and it can be seen that these stations are performing safety-only inspections almost exclusively for the oldest vehicles, and a rate of 60% or more safety-only inspections for new vehicles, starting with two-year old vehicles.

Figure VI-9. Rates of Safety-Only Tests Vehicles 0-24 Years Old by Station



Changing Vehicle Type from Light-Duty to Heavy-Duty to Pass Vehicle

Given that inspection standards are less stringent for heavy-duty vehicles than for light-duty vehicles, ERG investigated whether switching a vehicle from having a light-duty GVWR (less than or equal to 8,500 lbs.) to a heavy-duty GVWR was ever used to manipulate emissions inspection results. The vehicle GVWR is an inspector-entered field in the inspection record.

For this analysis, any inspections that were aborted were deleted from the dataset. This resulted in a dataset of approximately 20.1 million inspection records. Only inspection cycles where the initial inspection and the retest inspection were conducted at the same station were used. This left about 647,000 retest inspections in the dataset.

Overall, it was found that only 0.25% of inspections (about 1,600 inspections) that were initially failed as a light-duty vehicle were followed by a passing retest as a heavy-duty vehicle. However, these inspections were clustered at a handful of stations, shown below in Table VI-13. The table shows the 10 inspection stations with the highest frequency of retests that involved a vehicle that failed as a light-duty vehicle on the initial inspection followed by a passed retest of the same vehicle as a heavy-duty vehicle. At the first station on the list, about 30% of vehicles that failed as a light-duty vehicle passed the retest when the inspector entered it as a heavy-duty vehicle.

Table VI-13. Percent of Retest Inspections Switched from Light-Duty to Heavy-Duty for 10 Highest Ranking Stations

Station ID	Percent of Retests Switched from LD to HD	Number of Switched Retests	Total Number of Retest Inspections	Percentile Rank for Station
1	29.9%	41	137	100.0
2	17.5%	20	114	99.9
3	13.2%	42	318	99.9
4	10.7%	32	300	99.8
5	10.6%	12	113	99.8
6	9.7%	11	113	99.7
7	9.0%	28	310	99.7
8	8.1%	20	246	99.6
9	8.0%	10	125	99.6
10	6.6%	7	106	99.5

Pass/Fail Outliers

Stations can also be evaluated based upon the percentage of vehicles that they pass or fail. Extremely high rates of either passing or failing vehicles may warrant further scrutiny by DPS.

It is recognized that differences in inspection failure rates among stations are often due to factors other than fraud. For instance, the age and maintenance level of the fleet tested at each station may vary widely. However, evaluation of the fleet quality and/or socio-economic status of the area for each station is beyond the scope of this evaluation and only overall pass/fail rates for each station are considered here.

Since it was necessary to identify both very low and very high failure rates, the stations were divided into two groups: stations with a failure rate that was above the mean failure rate over all stations and stations with a failure rate that was below the mean failure rate over all stations. The stations with a failure rate that was above the mean were ranked with the 0% rank for the station at the mean and the 100% rank for the station with the highest failure rate. The stations with a failure rate that was below the mean were ranked with the 0% rank for the station at the mean, and the 100% rank for the station with the lowest failure rate. Thus, each station gets one rank, either for being high or being low. The highest OBD failure rate stations are listed in Table VI-14, and the lowest failure rate stations are listed in Table VI-15. Stations with fewer than 100 inspections are excluded from the results.

Table VI-14. Stations with Highest OBD Failure Rates

Station ID	Failure Rate (%)	Number of Failed Inspections	Total Number of Inspections	Percentile Rank for Station
1	27.1%	35	129	100.0
2	25.9%	42	162	100.0
3	24.0%	176	734	99.9
4	23.4%	68	290	99.9
5	22.9%	24	105	99.8
6	21.9%	42	192	99.8
7	21.0%	177	844	99.7
8	20.7%	815	3,933	99.7
9	20.5%	72	351	99.7
10	19.8%	36	182	99.6

Table VI-15. Stations with Lowest OBD Failure Rates

Station ID	Failure Rate (%)	Number of Failed Inspections	Total Number of Inspections	Percentile Rank for Station
1	0.0%	0	703	100.0
2	0.0%	0	1,035	100.0
3	0.0%	0	378	99.9
4	0.0%	0	150	99.9
5	0.0%	0	620	99.9
6	0.0%	0	120	99.8
7	0.0%	0	149	99.8
8	0.0%	0	176	99.8

Station ID	Failure Rate (%)	Number of Failed Inspections	Total Number of Inspections	Percentile Rank for Station
9	0.0%	0	525	99.7
10	0.0%	0	1,385	99.7

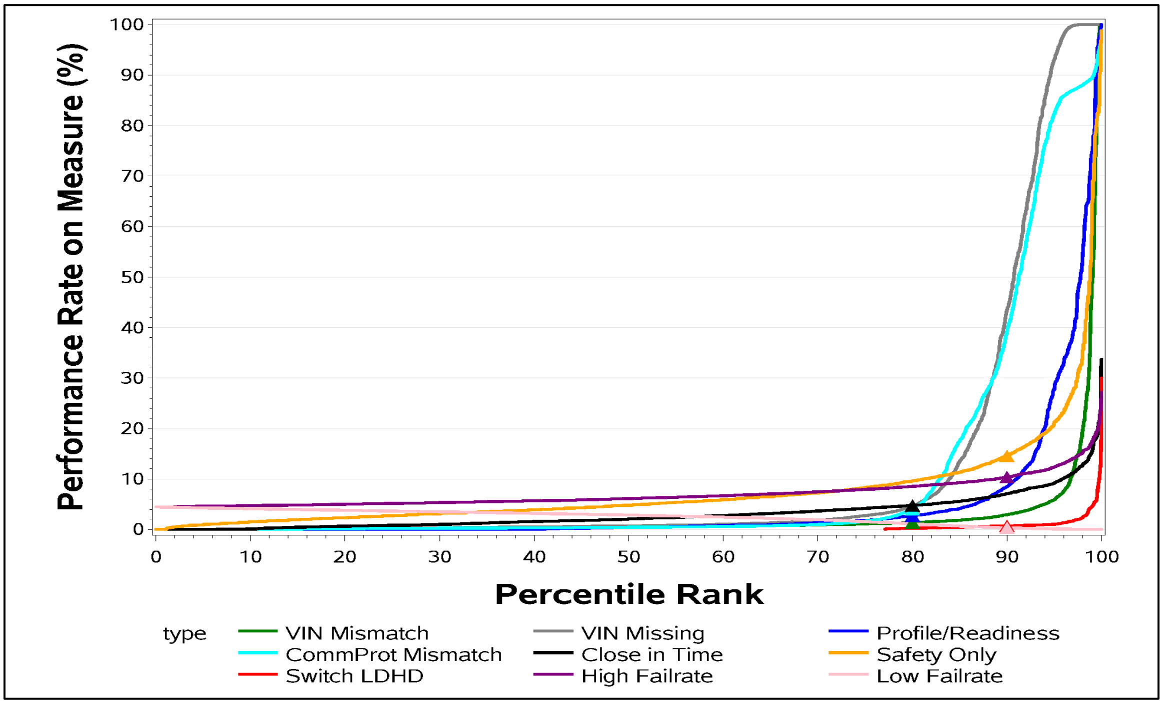
C. COMPILATION OF PERCENTILE RANKINGS

After a separate ranking was assigned for each of the measures of potential inspection fraud, the ranks were used to score the stations and identify the stations with the highest likelihood of inspection fraud.

Some of the details of the ranking procedure and the resulting ranks make it challenging to combine the ranks for an overall score. First, many stations did not perform enough inspections to receive a rank for all measures. Secondly, it is known from the measures listed in the previous sections that the range of results was not the same for each measure. For example, for the eVIN mismatch section about 80% of stations had very low VIN mismatch rates. The remaining 20% had VIN mismatch rates that might be cause for concern, or about the top 20 percentiles in the ranking. In contrast, for the high OBD inspection failure rates at least 90% of stations had reasonably low rates, and only the top 10% of stations would lead one to suspect possible fraud. Figure VI-10 shows the distribution of the results and the rankings that were created from those results for each of the measures of errors of commission (from sub-sections VI.A and VI.B).

The green line for the eVIN mismatch shows that the stations from zero to the 80th percentile had a very low percentage of mismatches. Above the 80th percentile, the mismatch rate quickly increases. Similarly, the blue line for the OBD electronic readiness profile shows that stations up to the 80th percentile had a low rate of mismatches. For the other measures, missing eVIN, rate of OBD communication protocol mismatch, the rate of overly close in time inspections, and retests switched from light-duty to heavy-duty, the stations below about the 80th percentile also had very low results. Above the 80th percentile, the rate of potentially fraudulent results rapidly increases. The red and purple lines show the rankings for OBD inspection failure rates. For both of those lines, the 0th percentile is the mean failure rate over all stations. The percentiles for the red line increase as the failure rate increases further above the mean, while the percentiles for the purple line increase as the failure rate decreases further below the mean. For both of these, one sees a “break” at about the 90th percentile, where the OBD fail rate starts to change rapidly as the percentile continues to increase.

Figure VI-10. Distribution of Results and Percentiles for Errors of Commission



At percentiles below the "break" (the percentile above which the results rapidly worsen) in each line on Figure VI-10, it is probably not likely that the station is performing the type of fraudulent activity that can be detected through this analysis. At percentiles above the break, there is evidence for suspicion of fraud. Thus, the visual results of the location of the break were used to create an indicator flag for each of the measures. Stations above the break for the given measure were flagged. Then, the total number of flags that each station received was determined. The stations were then sorted in descending order according to the number of flags received to create a final list ordered from most suspicious to least suspicious. The results for the top 50 most suspicious stations are given in Table VI-16. Table VI-17 gives the results for an additional 50 stations from near the middle of the range of results for comparison purposes.

Some of the first lines in the table show stations that should be investigated (if they have not already been, as a result of other analysis tools or audits). For example, the first station in the first row of the table had a very high rate of eVIN mismatches, high rates of OBD readiness and electronic profile mismatches, and a high rate of OBD communication protocol mismatches. This indicates a high possibility of OBD inspection fraud. This station also had a high rate of close-in-time retests, as well as a very low OBD inspection failure rate. This station is likely clean-scanning and would be a good candidate for an investigation.

If this table were to be used for identifying stations for investigations, audits, etc., the user would have to review the tables to identify the stations with the clearest combination of factors for the type of fraud being considered. The entire table with all stations is available in electronic format.

Table VI-16. Top 50 Most Suspicious Stations for Potentially Fraudulent Inspections

Station ID	Last Month of Testing at Station	Sum of Rank Flags	Max Rank for Station	Individual Ranks								
				eVIN Mismatch	OBD eVIN Missing	OBD Profile/ Readiness	OBD Communication Protocol Mismatch	Close-In-Time	Safety-Only Test	Switch LD to HD	OBD High Fail Rate	OBD Low Fail Rate
1	2023_03	6	99.3	97.2	90.8	97.3	91.3	91.9	24.1	66.0	99.3	
2	2023_12	6	97.9	91.7	81.8	91.8	81.4	50.5	97.8	86.3	97.9	
3	2023_10	6	95.3	93.3	89.1	95.3	89.6	93.8	28.1	94.2	11.4	
4	2023_08	5	100.0	100.0	96.9	98.4	97.7		13.4			94.1
5	2022_07	5	99.9	99.9	95.4	98.8	96.4		27.2			93.4
6	2022_07	5	99.9	99.9	93.9	96.4	97.6		11.3			91.5
7	2022_09	5	99.8	99.8	90.9	95.8	92.3		17.4			92.4
8	2023_02	5	99.8	99.8	96.1	98.9	97.0		15.7			90.2
9	2023_05	5	99.8	93.9	43.0	73.3	75.6	87.4	98.5	99.8	97.6	
10	2022_09	5	99.6	99.1	95.1	99.6	94.6		77.9			96.3
11	2023_06	5	98.5	55.6	81.9	10.1	42.1	95.3	93.3	98.5	92.0	
12	2023_06	5	98.3	85.6	85.9	85.2	69.8	32.4	98.3	3.0	97.0	
13	2023_03	5	98.2	97.3	94.3	98.2	94.5		7.1			93.9
14	2022_11	5	97.8	84.4	90.1		89.9	0.0	36.9	94.6	97.8	
15	2023_12	5	96.8	62.8	85.7	95.7	84.3	96.8	47.4	93.5	42.4	
16	2023_04	5	95.9	76.8	83.0	91.5	82.5	0.0	95.9	93.8	41.2	
17	2022_10	5	95.6	80.1	81.9	50.3	59.5	83.3	92.4	95.6	65.5	
18	2023_04	5	95.2	72.1	87.3	95.2	86.6	90.6	67.6	93.7	57.1	
19	2023_06	5	94.2	82.7	82.2	93.8	81.9	47.8	15.1	94.2	10.4	
20	2023_04	5	93.2	83.3	90.6	89.1	90.5	0.0	19.2	93.2		36.6
21	2023_05	5	92.4	61.6	88.9	80.2	88.6	92.4	76.5	92.2		52.7
22	2022_11	5	92.4	81.0	86.2		81.3		91.0		92.4	
23	2023_04	4	100.0		99.0	100.0	98.9		5.9			95.7
24	2023_09	4	100.0	42.3	90.5	97.9	90.6	100.0	89.5	48.4	78.2	
25	2022_11	4	100.0	100.0	89.2		93.5		5.6			95.6
26	2023_02	4	100.0		99.5	100.0	98.7		1.9			92.8
27	2022_02	4	99.9	77.9	91.3	90.4	91.4	99.9	10.0	49.5		1.4
28	2023_04	4	99.9		98.4	99.9	99.0		3.7			98.5
29	2022_09	4	99.9	99.9	95.7		97.2		12.6			92.1
30	2022_12	4	99.9	42.6	87.6	93.1	86.5	99.9	48.2	28.8	17.1	

Station ID	Last Month of Testing at Station	Sum of Rank Flags	Max Rank for Station	Individual Ranks								
				eVIN Mismatch	OBD eVIN Missing	OBD Profile/ Readiness	OBD Communication Protocol Mismatch	Close-In-Time	Safety-Only Test	Switch LD to HD	OBD High Fail Rate	OBD Low Fail Rate
31	2023_01	4	99.9	99.9	4.3	99.6	86.1		49.4			97.7
32	2023_01	4	99.9		98.2	99.9	98.7		3.6			98.3
33	2023_07	4	99.9	99.9	93.6		98.5		11.9			93.5
34	2023_07	4	99.8	97.3	60.7	93.5	80.6	99.8	80.4	53.4	16.6	
35	2023_02	4	99.8		99.4	96.3	99.8		24.5			95.8
36	2023_01	4	99.8		99.3	99.8	96.7		9.5			96.5
37	2022_09	4	99.8	83.2	80.1		46.2		99.8		99.3	
38	2023_04	4	99.8		98.4	99.8	97.5		13.9			97.1
39	2023_10	4	99.8	99.4	95.5		99.8		24.8			91.8
40	2022_10	4	99.8	99.8	94.1		94.3		24.8			93.7
41	2023_06	4	99.7		98.8	99.7	96.7		12.2			96.9
42	2022_10	4	99.7	94.5	46.6	90.3	75.9	99.5	69.4	99.7		12.0
43	2023_09	4	99.7	99.7	87.7		89.6		50.8			90.9
44	2022_10	4	99.7		99.2	96.2	99.7		18.4			94.5
45	2022_12	4	99.7	99.7	82.7	96.8	88.9		25.7			88.2
46	2023_03	4	99.7		98.0	99.7	97.4		24.6			95.4
47	2022_05	4	99.7	99.7	90.5	96.6	94.8		60.9			82.8
48	2023_08	4	99.7		99.7	97.2	96.9		5.9			95.0
49	2023_08	4	99.7	98.9	19.7	94.8	84.3	99.7	68.6	74.6	39.5	
50	2022_09	4	99.7	99.7	94.6		94.7		75.0			92.0

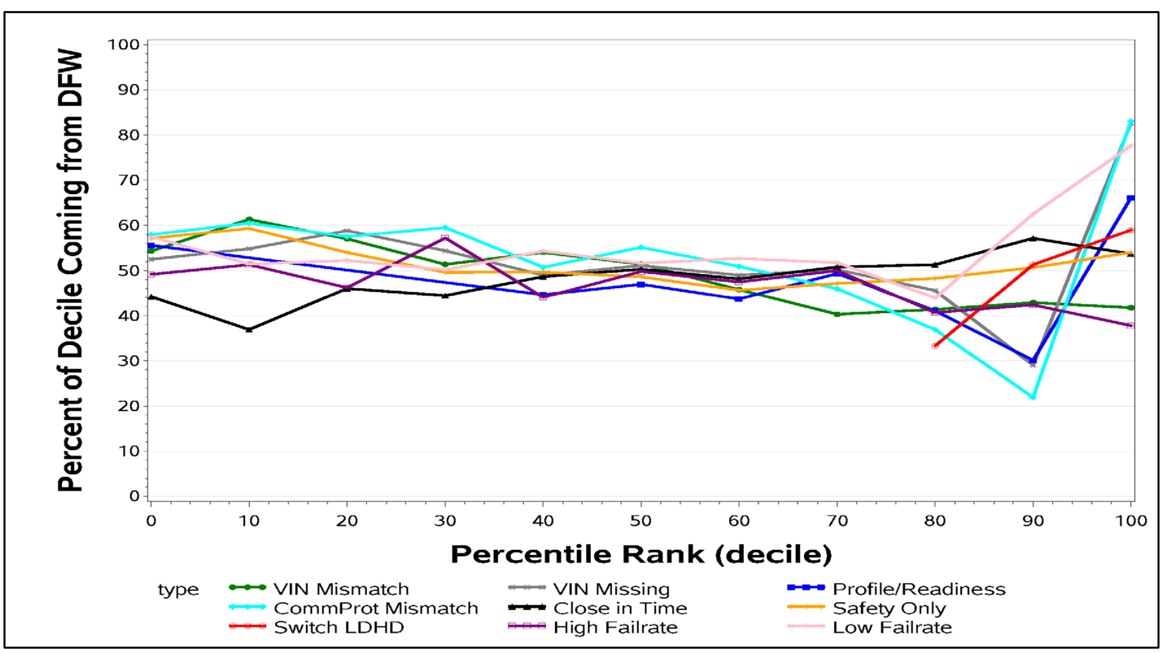
Table VI-17. 50 Mid-Range Stations for Potentially Fraudulent Inspections

Station ID	Last Month of Testing at Station	Sum of Rank Flags	Max Rank for Station	Individual Ranks								
				eVIN Mismatch	OBD eVIN Missing	OBD Profile/ Readiness	OBD Communication Protocol Mismatch	Close-In-Time	Safety-Only Test	Switch LD to HD	OBD High Fail Rate	OBD Low Fail Rate
3285	2023_12	0	82.3	58.8	73.5		58.9		79.2			82.3
3286	2022_04	0	82.3	25.0	24.6		35.0		82.3			13.3
3287	2023_12	0	82.3	58.3	31.9	68.0	66.6		82.3			81.8
3288	2023_12	0	82.3	12.0	11.1		19.9		82.3			7.5
3289	2023_12	0	82.3	71.2	48.6	55.2	48.1	78.6	67.3	82.3	27.2	
3290	2023_12	0	82.3	47.6	53.7		65.5		81.9			82.3
3291	2023_12	0	82.2	4.1	40.0	29.4	12.1	0.0	82.2	51.9		45.4
3292	2023_12	0	82.2	23.3	78.3	33.8	54.6	18.0	82.2	61.3		26.1
3293	2023_12	0	82.2	55.5	27.6		19.4		82.2			58.1
3294	2023_12	0	82.2	40.4	75.4	13.2	55.1	12.9	38.3	82.2	65.2	
3295	2023_12	0	82.1	35.7	7.5		46.5		2.5			82.1
3296	2023_12	0	82.1	34.5	77.9	57.5	59.8	32.4	80.3	82.1	11.2	
3297	2023_12	0	82.1	36.9	48.0	35.5	23.8	78.4	82.1	65.7		24.5
3298	2023_10	0	82.0	43.5	72.4		65.5		44.3			82.0
3299	2022_05	0	82.0	6.5	5.8		9.5		1.2			82.0
3300	2023_12	0	82.0	42.7	62.6	41.9	52.0	27.4	80.3	82.0	13.1	
3301	2023_12	0	82.0	0.3	44.9		0.5		82.0			17.7
3302	2023_12	0	82.0	32.2	27.5		0.9		82.0		17.1	
3303	2023_12	0	82.0	54.0	63.8	75.1	71.9		82.0			16.5
3304	2023_12	0	82.0	40.6	75.1		31.8		82.0			23.7
3305	2023_12	0	82.0	19.3	75.3		4.1					82.0
3306	2023_12	0	82.0	55.2	35.3	71.5	26.9	77.9	30.5	82.0	9.4	
3307	2023_12	0	81.9	38.1	13.9	60.2	60.1	57.1	8.7	81.9	19.3	
3308	2022_05	0	81.9	25.4	56.9		56.8		81.9		60.4	
3309	2023_12	0	81.9	7.1	20.3	30.2	6.8	0.0	81.9	53.9		54.3
3310	2023_12	0	81.9	71.9	46.8	27.8	54.7	65.4	58.8	49.5		81.9
3311	2023_12	0	81.9								81.9	
3312	2023_12	0	81.9	54.1	15.6	66.7	25.8	52.5	28.5	81.9		7.8
3313	2023_12	0	81.8	69.7	18.5	24.3	66.1	79.8	30.0	42.0	81.8	
3314	2023_12	0	81.8	66.6	31.2	36.8	57.9	68.7	81.8	69.4		41.0

Station ID	Last Month of Testing at Station	Sum of Rank Flags	Max Rank for Station	Individual Ranks								
				eVIN Mismatch	OBD eVIN Missing	OBD Profile/ Readiness	OBD Communication Protocol Mismatch	Close-In-Time	Safety-Only Test	Switch LD to HD	OBD High Fail Rate	OBD Low Fail Rate
3315	2023_12	0	81.8	68.2	32.1	45.2	49.5	34.8	32.8	81.8	66.7	
3316	2023_12	0	81.7	19.8	74.2	16.9	21.7	74.3	69.2	81.7		25.2
3317	2023_12	0	81.7	10.7	27.7	8.2	37.2	0.0	81.7	12.2	0.8	
3318	2023_12	0	81.7	22.5	22.6	31.2	23.4	48.5	81.7	56.1		21.6
3319	2023_12	0	81.7	67.2	48.1	70.4	70.2	0.0	17.9	34.2	81.7	
3320	2023_12	0	81.7				79.8					81.7
3321	2023_12	0	81.6	49.9	0.3		0.8					81.6
3322	2023_12	0	81.6	37.8	19.5		27.3		81.6			24.7
3323	2023_12	0	81.6	3.1	33.9		23.0		81.6		72.5	
3324	2023_12	0	81.6	36.5	29.6	33.6	37.0	78.5	49.7	81.6		8.8
3325	2023_11	0	81.5	32.6	27.5	55.4	59.9	0.0	41.0	56.3	81.5	
3326	2023_12	0	81.5	40.8	69.2		24.7		80.1			81.5
3327	2023_12	0	81.5	47.7	65.0	20.0	26.7	48.8	17.3	81.5	70.7	
3328	2023_12	0	81.5	28.3	34.1	12.6	40.2	50.3	81.5	19.6	23.8	
3329	2023_12	0	81.5	79.5	38.1	70.8	58.8	50.6	55.5	81.5		8.8
3330	2023_12	0	81.4	38.0	21.7		64.0		81.4		47.0	
3331	2023_12	0	81.4	62.5	71.8	72.6	76.6	62.5	81.4	59.8	51.6	
3332	2023_12	0	81.4	69.5	6.5		43.8		45.8		81.4	
3333	2023_12	0	81.3	15.0	19.3		7.2					81.3
3334	2023_12	0	81.3	27.8	42.3		56.3		57.9		81.3	

Finally, one additional investigation for this section is a comparison of the potential-fraud rates by I/M program area. If fraud rates were higher in one area than the other, it might be possible that this would result in the Texas I/M program having a different degree of impact in the two program areas. The result of the investigation is shown below in Figure VI-11. Each of the eight different types of errors of commission is shown on the plot (this is the same group of categories as was shown in Figure VI-10). However, the plot now shows the fraction of stations that are from the DFW program area, for each decile of the ranks. For example, looking at the green dots on the green line (VIN/eVIN mismatch), we can see that at the zero-percentile group, the fraction of stations in that group is 54% DFW (and by inference, 46% HGB). At the 10th decile group, we see about 64% of stations are from the DFW program area (and so 36% from the HGB program area). By contrast, at the 90th decile groups, the percentage of stations from the DFW program area is about 42% (so the HGB program area would be 58%). This indicates that at the low end of the ranks (where fraud of this type is unlikely), there are more DFW stations, and at the high end of the ranks (where fraud of this type is much more likely) there are more HGB stations. A similar, and even more significant, trend can be seen for the squares on the dark blue line, for the OBD electronic profile comparisons, and on the light blue line, for the OBD communication protocol mismatches. For the other measures, it is much more difficult to see any sort of meaningful trend. However, it does appear that for the three major OBD fraud checks, the eVIN missing, the electronic profile, and the communication protocol, more stations are potentially committing fraudulent inspections in the HGB program area than in the DFW program area. Since OBD vehicles now dominate the fleet, fraudulent OBD inspections could significantly undermine the Texas I/M program's effectiveness.

Figure VI-11. Fraction of Stations from the DFW Program Area by Rank Decile for Potential Inspection Fraud Indicators



VII. REFERENCES

1. Draft Guidance on Use of In-Program Data for Evaluation of I/M Program Performance, EPA420-P-01-003, August 2001.
2. Guidance on Use of Remote Sensing for Evaluation of I/M Program Performance, EPA420-B-04-010, July 2004.
3. Assessment of Vehicle Repair Activities, Final Report, Eastern Research Group, June 23, 2015.
4. T.H. DeFries, Texas I/M Program Evaluation Plan, Final Report, Eastern Research Group, August 29, 2004.
5. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas/Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group November 30, 2006.
6. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas/Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group November 30, 2009.
7. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group July 31, 2012.
8. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas-0Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group November 7, 2014.
9. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group June 30, 2016.
10. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group June 29, 2018.
11. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group June 30, 2020.
12. Evaluation of the Texas Inspection and Maintenance Programs in the Dallas-Fort Worth and Houston-Galveston-Brazoria Nonattainment Areas", Final Report, Eastern Research Group June 30, 2022

    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.

Appendix A- OBD Communication Rates by Vehicle Model Code for Elevated Miscommunications

Table A-1. OBD Communication Rates by Vehicle Model Code for Elevated Miscommunications

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
ACUR								
	1	0.01%	15	0.11%	13,649	99.88%	13,665	0.08%
3.2TL	1	0.04%	5	0.18%	2,739	99.78%	2,745	0.02%
MDX	7	0.01%	70	0.09%	74,007	99.90%	74,084	0.43%
RDX	2	0.00%	56	0.09%	60,611	99.90%	60,669	0.35%
RL	2	0.12%	3	0.17%	1,734	99.71%	1,739	0.01%
RSX	1	0.04%	6	0.26%	2,324	99.70%	2,331	0.01%
TL	3	0.01%	35	0.11%	31,974	99.88%	32,012	0.19%
TSX	4	0.02%	11	0.05%	23,151	99.94%	23,166	0.14%
Integra	1	0.16%	4	0.65%	615	99.19%	620	0.00%
TLX	2	0.01%	12	0.05%	24,700	99.94%	24,714	0.14%
ALFA								
	2	0.08%	8	0.32%	2,499	99.60%	2,509	0.01%
Giulia	1	0.05%	7	0.37%	1,869	99.57%	1,877	0.01%
Giulia Ti	2	0.08%	3	0.12%	2,551	99.80%	2,556	0.01%
Stelvio	1	0.05%	1	0.05%	2,082	99.90%	2,084	0.01%
AUDI								
	3	0.01%	27	0.12%	22,480	99.87%	22,510	0.13%
A4	2	0.01%	44	0.17%	25,455	99.82%	25,501	0.15%
A5 Cabriolet	1	0.02%	9	0.18%	5,065	99.80%	5,075	0.03%
A6	3	0.02%	19	0.10%	19,186	99.89%	19,208	0.11%
Q3	1	0.01%	14	0.09%	15,157	99.90%	15,172	0.09%
Q5	1	0.01%	26	0.14%	17,948	99.85%	17,975	0.11%
Q5/SQ5	2	0.01%	31	0.09%	32,714	99.90%	32,747	0.19%
Q7	8	0.03%	38	0.13%	30,006	99.85%	30,052	0.18%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
TT	2	0.07%	9	0.32%	2,763	99.60%	2,774	0.02%
A3	1	0.01%	9	0.08%	11,828	99.92%	11,838	0.07%
A4/S4	1	0.03%	8	0.23%	3,431	99.74%	3,440	0.02%
A5	1	0.02%	12	0.23%	5,116	99.75%	5,129	0.03%
Q8	3	0.05%	6	0.11%	5,558	99.84%	5,567	0.03%
R8	1	0.10%	1	0.10%	990	99.80%	992	0.01%
RS5	1	0.04%	1	0.04%	2,227	99.91%	2,229	0.01%
BENT								
	1	0.03%	8	0.21%	3,749	99.76%	3,758	0.02%
BMW								
	5	0.02%	58	0.19%	31,194	99.80%	31,257	0.18%
320i	1	0.01%	15	0.19%	8,083	99.80%	8,099	0.05%
325i	1	0.02%	4	0.09%	4,631	99.89%	4,636	0.03%
328i	5	0.02%	53	0.17%	31,780	99.82%	31,838	0.19%
335i	2	0.02%	27	0.33%	8,183	99.65%	8,212	0.05%
428i	1	0.02%	10	0.17%	5,858	99.81%	5,869	0.03%
528i	1	0.01%	24	0.15%	15,897	99.84%	15,922	0.09%
528i xDrive	1	0.08%	4	0.30%	1,319	99.62%	1,324	0.01%
530i	2	0.02%	10	0.11%	9,234	99.87%	9,246	0.05%
X3	6	0.01%	74	0.17%	43,856	99.82%	43,936	0.26%
X3 3.0i	1	0.07%	2	0.13%	1,491	99.80%	1,494	0.01%
X5	10	0.02%	73	0.14%	51,919	99.84%	52,002	0.30%
X6	2	0.03%	6	0.08%	7,600	99.89%	7,608	0.04%
128i	1	0.04%	6	0.22%	2,726	99.74%	2,733	0.02%
323i	1	0.18%	1	0.18%	561	99.64%	563	0.00%
325Ci	1	0.05%	8	0.38%	2,114	99.58%	2,123	0.01%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
328i SULEV	1	0.06%	2	0.13%	1,564	99.81%	1,567	0.01%
430i xDrive	1	0.11%	4	0.44%	906	99.45%	911	0.01%
440i	1	0.04%	2	0.08%	2,401	99.88%	2,404	0.01%
525i	1	0.05%	1	0.05%	2,098	99.90%	2,100	0.01%
530xi	1	0.42%	1	0.42%	234	99.15%	236	0.00%
535i	1	0.01%	15	0.11%	13,458	99.88%	13,474	0.08%
740i	1	0.02%	4	0.09%	4,545	99.89%	4,550	0.03%
740i (Auto)	1	0.41%	1	0.41%	242	99.18%	244	0.00%
750i	1	0.04%	4	0.15%	2,580	99.81%	2,585	0.02%
M3	3	0.06%	9	0.19%	4,830	99.75%	4,842	0.03%
M4	1	0.04%	2	0.08%	2,563	99.88%	2,566	0.01%
X1	3	0.03%	17	0.15%	11,561	99.83%	11,581	0.07%
X7	2	0.03%	16	0.24%	6,665	99.73%	6,683	0.04%
Z3	1	0.05%	7	0.33%	2,128	99.63%	2,136	0.01%
BUIC								
	1	0.04%	2	0.09%	2,264	99.87%	2,267	0.01%
Enclave	8	0.02%	49	0.10%	46,627	99.88%	46,684	0.27%
Encore	5	0.01%	42	0.10%	42,048	99.89%	42,095	0.25%
LaCrosse CXL	2	0.05%	12	0.27%	8,910	199.68%	8,924	0.05%
LeSabre Custom	3	0.04%	16	0.24%	6,671	99.72%	6,690	0.04%
Lucerne CXL	3	0.05%	5	0.09%	5,702	99.86%	5,710	0.03%
Rendezvous 2WD	2	0.07%	5	0.17%	3,008	99.77%	3,015	0.02%
Enclave FWD	1	0.03%	5	0.13%	3,747	99.84%	3,753	0.02%
LaCrosse	1	0.02%	4	0.09%	4,648	99.89%	4,653	0.03%
Park Avenue	1	0.05%	2	0.11%	1,864	99.84%	1,867	0.01%
CADI								

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
	1	0.05%	3	0.16%	1,825	99.78%	1,829	0.01%
CTS	1	0.01%	7	0.09%	7,647	99.90%	7,655	0.04%
CTS Auto RWD	1	0.03%	1	0.03%	3,463	99.94%	3,465	0.02%
CTS Luxury	2	0.01%	8	0.06%	13,375	99.93%	13,385	0.08%
CTS Standard	1	0.04%	1	0.04%	2,297	99.91%	2,299	0.01%
DeVille	1	0.02%	10	0.20%	4,890	99.78%	4,901	0.03%
Escalade	8	0.02%	29	0.09%	32,695	99.89%	32,732	0.19%
Escalade 1500 2WD	2	0.04%	9	0.19%	4,849	99.77%	4,860	0.03%
Escalade 1500 2WD Luxury	1	0.03%	12	0.32%	3,765	99.66%	3,778	0.02%
Escalade 1500 4WD	2	0.02%	11	0.13%	8,468	99.85%	8,481	0.05%
Escalade 1500 4WD Luxury	1	0.02%	9	0.16%	5,786	99.83%	5,796	0.03%
Escalade ESV	1	0.00%	38	0.18%	21,419	99.82%	21,458	0.13%
SRX	11	0.02%	28	0.06%	49,930	99.92%	49,969	0.29%
XTS	1	0.00%	25	0.06%	39,935	99.93%	39,961	0.23%
ATS Performance	2	0.13%	1	0.06%	1,542	99.81%	1,545	0.01%
ATS Standard	2	0.02%	5	0.06%	8,223	99.91%	8,230	0.05%
CT5 Sport	1	0.11%	1	0.11%	922	99.78%	924	0.01%
CTS Performance	1	0.02%	9	0.20%	4,558	99.78%	4,568	0.03%
CTS V6 RWD HF Nav	2	0.12%	3	0.18%	1,702	99.71%	1,707	0.01%
DTS	3	0.05%	2	0.03%	6,595	99.92%	6,600	0.04%
XT4	2	0.02%	18	0.15%	12,178	99.84%	12,198	0.07%
XT6	1	0.01%	1	0.01%	7,068	99.97%	7,070	0.04%
XTS Livery	1	0.25%	1	0.25%	402	99.50%	404	0.00%
XTS Luxury	2	0.02%	15	0.11%	13,231	99.87%	13,248	0.08%
CHEV								
	40	0.01%	280	0.09%	294,497	99.89%	294,817	1.72%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
1500 2WD	43	0.03%	151	0.09%	167,025	99.88%	167,219	0.98%
1500 4WD	10	0.04%	18	0.06%	28,485	99.90%	28,513	0.17%
2500 2WD	4	0.02%	19	0.09%	21,476	99.89%	21,499	0.13%
2500 4WD	3	0.06%	6	0.13%	4,627	99.81%	4,636	0.03%
3500 2WD	1	0.02%	2	0.05%	4,324	99.93%	4,327	0.03%
Astro 2WD	2	0.04%	5	0.09%	5,505	99.87%	5,512	0.03%
Blazer / Trailblazer 2WD	3	0.02%	21	0.13%	15,540	99.85%	15,564	0.09%
C1500 Pickup 2WD	22	0.03%	111	0.16%	70,006	99.81%	70,139	0.41%
C1500 Silverado 2WD	22	0.04%	92	0.18%	51,349	99.78%	51,463	0.30%
C1500 Suburban 2WD	7	0.02%	54	0.15%	35,756	99.83%	35,817	0.21%
C2500 Pickup 2WD	1	0.02%	7	0.16%	4,397	99.82%	4,405	0.03%
C3500 Pickup 2WD	1	0.15%	1	0.15%	660	99.70%	662	0.00%
Camaro 1LT	3	0.01%	19	0.08%	22,523	99.90%	22,545	0.13%
Camaro Sport	2	0.06%	9	0.26%	3,387	99.68%	3,398	0.02%
Cavalier	3	0.06%	7	0.13%	5,290	99.81%	5,300	0.03%
Colorado Work Truck	3	0.02%	37	0.20%	18,849	99.79%	18,889	0.11%
Corvette	6	0.03%	57	0.26%	22,054	99.72%	22,117	0.13%
Equinox	8	0.01%	69	0.09%	75,404	99.90%	75,481	0.44%
Equinox 1LT	5	0.01%	25	0.06%	40,566	99.93%	40,596	0.24%
Equinox 2LT	1	0.00%	22	0.08%	26,823	99.91%	26,846	0.16%
Equinox LS	2	0.01%	13	0.06%	20,627	99.93%	20,642	0.12%
Express 1500	4	0.07%	7	0.12%	5,693	99.81%	5,704	0.03%
Express 1500 2WD	7	0.07%	18	0.17%	10,563	99.76%	10,588	0.06%
Express 2500	2	0.05%	6	0.16%	3,681	99.78%	3,689	0.02%
Express 2500 2WD	2	0.06%	4	0.11%	3,485	99.83%	3,491	0.02%
Express 3500	1	0.05%	6	0.30%	1,970	99.65%	1,977	0.01%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Express 3500 2WD	1	0.05%	3	0.14%	2,105	99.81%	2,109	0.01%
G1500 Van 2WD	1	0.12%	1	0.12%	840	99.76%	842	0.00%
HHR	2	0.02%	10	0.08%	11,776	99.90%	11,788	0.07%
Impala LS	1	0.01%	13	0.09%	14,344	99.90%	14,358	0.08%
Impala LS Sedan	1	0.01%	4	0.04%	9,609	99.95%	9,614	0.06%
Impala LT	3	0.01%	16	0.06%	25,619	99.93%	25,638	0.15%
Impala LT Sedan	2	0.02%	7	0.06%	10,964	99.92%	10,973	0.06%
Impala Police Sedan	1	0.12%	1	0.12%	856	99.77%	858	0.01%
K1500 Pickup 4WD	3	0.02%	20	0.14%	13,773	99.83%	13,796	0.08%
K1500 Silverado 4WD	2	0.03%	8	0.12%	6,532	99.85%	6,542	0.04%
K1500 Suburban 4WD	1	0.01%	15	0.17%	8,719	99.82%	8,735	0.05%
Malibu 1LS	1	0.03%	7	0.20%	3,581	99.78%	3,589	0.02%
Malibu LS	4	0.01%	39	0.13%	29,120	99.85%	29,163	0.17%
Malibu LT	9	0.03%	40	0.13%	30,601	99.84%	30,650	0.18%
NV200	1	0.05%	5	0.24%	2,094	99.71%	2,100	0.01%
S10 Pickup 2WD	1	0.03%	4	0.14%	2,859	99.83%	2,864	0.02%
Sierra 1500 2WD	2	0.12%	5	0.30%	1,678	99.58%	1,685	0.01%
Sierra 1500 Pickup 2WD	2	0.32%	1	0.16%	628	99.52%	631	0.00%
Silverado	19	0.02%	172	0.15%	114,703	99.83%	114,894	0.67%
Silverado 1500	29	0.01%	298	0.09%	346,610	99.91%	346,937	2.03%
Silverado 3500	1	0.14%	3	0.42%	712	99.44%	716	0.00%
Silverado LS	2	0.01%	9	0.07%	13,385	99.92%	13,396	0.08%
SSR / Colorado / Trailblazer	5	0.03%	26	0.15%	16,867	99.82%	16,898	0.10%
Suburban LT	4	0.01%	37	0.14%	27,114	99.85%	27,155	0.16%
Tahoe 2WD	28	0.04%	129	0.17%	75,318	99.79%	75,475	0.44%
Tahoe 4WD	7	0.03%	36	0.17%	20,705	99.79%	20,748	0.12%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Tahoe LS	1	0.00%	27	0.10%	26,414	99.89%	26,442	0.15%
Tahoe LT	5	0.01%	65	0.09%	69,441	99.90%	69,511	0.41%
Tahoe LTX	2	0.02%	6	0.07%	8,198	99.90%	8,206	0.05%
Tahoe LTZ	2	0.01%	20	0.08%	23,972	99.91%	23,994	0.14%
Traverse 2LT	2	0.01%	18	0.09%	20,582	99.90%	20,602	0.12%
Traverse LT/Traverse 1LT	7	0.02%	24	0.06%	39,212	99.92%	39,243	0.23%
Avalanche LTZ	3	0.09%	3	0.09%	3,168	99.81%	3,174	0.02%
Aveo	1	0.02%	5	0.09%	5,287	99.89%	5,293	0.03%
Blazer	3	0.02%	16	0.11%	14,702	99.87%	14,721	0.09%
Blazer 2WD	2	0.03%	21	0.32%	6,498	99.65%	6,521	0.04%
Camaro 1SS	1	0.02%	7	0.15%	4,622	99.83%	4,630	0.03%
Camaro 2LT	2	0.01%	26	0.14%	18,186	99.85%	18,214	0.11%
Camaro 2SS	1	0.01%	22	0.11%	19,708	99.88%	19,731	0.12%
Colorado	1	0.09%	2	0.17%	1,164	99.74%	1,167	0.01%
Colorado / SSR 2WD	1	0.03%	4	0.10%	3,891	99.87%	3,896	0.02%
Colorado 1LT	2	0.01%	22	0.09%	24,874	99.90%	24,898	0.15%
Colorado 2LT	2	0.02%	12	0.11%	10,437	99.87%	10,451	0.06%
Cruze LT	1	0.01%	12	0.06%	19,864	99.93%	19,877	0.12%
Cruze Premier	1	0.03%	2	0.05%	3,672	99.92%	3,675	0.02%
HHR LT/HHR 1LT	1	0.03%	5	0.17%	2,907	99.79%	2,913	0.02%
Impala LTZ	3	0.03%	6	0.06%	10,030	99.91%	10,039	0.06%
Malibu	1	0.02%	16	0.29%	5,448	99.69%	5,465	0.03%
Monte Carlo LS	1	0.06%	3	0.19%	1,553	99.74%	1,557	0.01%
SS	1	0.05%	6	0.31%	1,905	99.63%	1,912	0.01%
Silverado 2500	3	0.06%	9	0.19%	4,789	99.75%	4,801	0.03%
Sonic LS	2	0.06%	3	0.08%	3,564	99.86%	3,569	0.02%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Spark LS	4	0.04%	13	0.12%	11,152	99.85%	11,169	0.07%
Suburban LS	1	0.01%	14	0.09%	16,398	99.91%	16,413	0.10%
Tahoe	3	0.03%	24	0.20%	11,797	99.77%	11,824	0.07%
Tahoe FL	1	0.09%	4	0.37%	1,069	99.53%	1,074	0.01%
Tahoe Police 2WD	1	0.14%	2	0.28%	713	99.58%	716	0.00%
Tahoe RST	1	0.09%	3	0.26%	1,143	99.65%	1,147	0.01%
Tahoe Z71	3	0.11%	5	0.19%	2,639	99.70%	2,647	0.02%
Traverse	2	0.01%	28	0.09%	30,357	99.90%	30,387	0.18%
Traverse FWD	2	0.06%	2	0.06%	3,112	99.87%	3,116	0.02%
Traverse LS	1	0.02%	4	0.08%	5,140	99.90%	5,145	0.03%
Trax	1	0.01%	12	0.07%	17,954	99.93%	17,967	0.11%
Venture / Uplander	1	0.03%	2	0.07%	2,931	99.90%	2,934	0.02%
CHRY								
	1	0.00%	32	0.11%	29,269	99.89%	29,302	0.17%
300 Touring	3	0.02%	15	0.09%	17,087	99.89%	17,105	0.10%
300C	3	0.02%	8	0.06%	12,779	99.91%	12,790	0.07%
300S	1	0.01%	15	0.11%	13,173	99.88%	13,189	0.08%
Sebring LX	2	0.09%	3	0.14%	2,106	99.76%	2,111	0.01%
Sebring Touring	1	0.02%	2	0.05%	4,170	99.93%	4,173	0.02%
Town & Country	1	0.01%	17	0.09%	19,192	99.91%	19,210	0.11%
Town & Country FWD LWB & SWB	1	0.03%	3	0.08%	3,730	99.89%	3,734	0.02%
Town & Country Touring FWD	2	0.07%	1	0.03%	2,988	99.90%	2,991	0.02%
300 Limited	2	0.01%	19	0.09%	20,130	99.90%	20,151	0.12%
300C SRT8	1	0.17%	3	0.51%	581	99.32%	585	0.00%
PT Cruiser Touring LHD	1	0.03%	4	0.13%	3,168	99.84%	3,173	0.02%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
DODG								
1500	9	0.03%	17	0.07%	26,116	99.90%	26,142	0.15%
	12	0.03%	30	0.08%	36,251	99.88%	36,293	0.21%
Avenger R/T	1	0.03%	2	0.06%	3,571	99.92%	3,574	0.02%
Avenger SE	4	0.02%	18	0.09%	20,141	99.89%	20,163	0.12%
Caliber SXT	1	0.02%	3	0.06%	5,255	99.92%	5,259	0.03%
Caravan / Grand Caravan SE	2	0.06%	4	0.12%	3,238	99.82%	3,244	0.02%
Caravan / Grand Caravan SXT FW	2	0.03%	7	0.11%	6,264	99.86%	6,273	0.04%
Caravan C/V FWD	2	0.03%	7	0.11%	6,127	99.85%	6,136	0.04%
Caravan SE / Grand Caravan SE	1	0.09%	6	0.54%	1,110	99.37%	1,117	0.01%
Challenger	2	0.01%	17	0.12%	14,603	99.87%	14,622	0.09%
Challenger R/T	8	0.05%	21	0.14%	15,065	99.81%	15,094	0.09%
Challenger SCAT Pack	2	0.03%	13	0.20%	6,557	99.77%	6,572	0.04%
Challenger SXT	1	0.00%	21	0.10%	20,659	99.89%	20,681	0.12%
Charger	2	0.01%	11	0.06%	19,826	99.93%	19,839	0.12%
Charger (RWD)	4	0.04%	10	0.10%	10,327	99.86%	10,341	0.06%
Charger R/T	4	0.02%	19	0.09%	22,080	99.90%	22,103	0.13%
Charger SXT	7	0.02%	42	0.11%	39,682	99.88%	39,731	0.23%
Dakota 2WD	1	0.02%	11	0.21%	5,173	99.77%	5,185	0.03%
Dakota SLT 2WD	1	0.02%	3	0.05%	6,151	99.94%	6,155	0.04%
Dart SXT	2	0.02%	11	0.10%	10,583	99.88%	10,596	0.06%
Durango 4WD	1	0.08%	1	0.08%	1,236	99.84%	1,238	0.01%
Durango SXT	3	0.02%	24	0.14%	17,220	99.84%	17,247	0.10%
Grand Caravan GT	1	0.01%	7	0.08%	9,193	99.91%	9,201	0.05%
Grand Caravan SE	2	0.01%	16	0.10%	15,780	99.89%	15,798	0.09%
Grand Caravan SXT	4	0.02%	12	0.06%	20,267	99.92%	20,283	0.12%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Journey SE	9	0.03%	23	0.09%	25,842	99.88%	25,874	0.15%
Journey SXT	4	0.02%	13	0.07%	18,429	99.91%	18,446	0.11%
Neon SXT	1	0.08%	1	0.08%	1,181	99.83%	1,183	0.01%
ProMaster City	1	0.06%	8	0.50%	1,593	99.44%	1,602	0.01%
Ram Pickup 1500 2WD	32	0.03%	83	0.08%	103,527	99.89%	103,642	0.61%
Ram Pickup 1500 4WD	5	0.04%	17	0.13%	12,930	99.83%	12,952	0.08%
Ram Pickup 2WD	7	0.04%	57	0.33%	16,999	99.62%	17,063	0.10%
RAM PK Light Duty 1500	4	0.03%	13	0.09%	14,079	99.88%	14,096	0.08%
Avenger SXT	1	0.01%	7	0.10%	6,775	99.88%	6,783	0.04%
Charger Police	3	0.05%	12	0.21%	5,792	99.74%	5,807	0.03%
Dakota SXT 2WD	1	0.08%	2	0.16%	1,215	99.75%	1,218	0.01%
Durango GT	4	0.02%	16	0.09%	17,068	99.88%	17,088	0.10%
Grand Caravan	2	0.08%	3	0.12%	2,490	99.80%	2,495	0.01%
Grand Caravan ES FWD	1	0.56%	1	0.56%	177	98.88%	179	0.00%
Nitro Heat	2	0.08%	4	0.16%	2,533	99.76%	2,539	0.01%
Ram Van/Wagon	1	0.08%	4	0.34%	1,174	99.58%	1,179	0.01%
Stratus SXT	1	0.09%	2	0.18%	1,124	99.73%	1,127	0.01%
Viper SRT-10	1	0.19%	13	2.52%	502	97.29%	516	0.00%
FORD								
	3	0.04%	10	0.14%	7,273	99.82%	7,286	0.04%
Crown Victoria	1	0.10%	1	0.10%	1,043	99.81%	1,045	0.01%
E350 2WD	1	0.06%	3	0.18%	1,695	99.76%	1,699	0.01%
Econoline E350	1	0.06%	5	0.32%	1,551	99.61%	1,557	0.01%
Ecosport SE	3	0.05%	10	0.17%	5,968	99.78%	5,981	0.03%
Edge SEL	3	0.01%	38	0.14%	26,993	99.85%	27,034	0.16%
Edge Titanium	1	0.00%	21	0.10%	21,562	99.90%	21,584	0.13%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Escape	9	0.01%	46	0.07%	66,800	99.92%	66,855	0.39%
Escape S	23	0.11%	378	1.73%	21,455	98.17%	21,856	0.13%
Escape SE	88	0.16%	1,354	2.42%	54,481	97.42%	55,923	0.33%
Escape SEL	30	0.24%	812	6.42%	11,802	93.34%	12,644	0.07%
Escape Titanium	6	0.03%	120	0.56%	21,346	99.41%	21,472	0.13%
Escape XLS 2WD	2	0.02%	13	0.15%	8,622	99.83%	8,637	0.05%
Escape XLT 2WD	4	0.02%	24	0.14%	16,847	99.83%	16,875	0.10%
Expedition	2	0.01%	26	0.07%	34,956	99.92%	34,984	0.20%
Expedition Eddie Bauer 2WD	3	0.01%	30	0.11%	27,755	99.88%	27,788	0.16%
Expedition XLT 2WD	3	0.01%	14	0.06%	21,848	99.92%	21,865	0.13%
Expedition XLT 4WD	2	0.07%	6	0.22%	2,671	99.70%	2,679	0.02%
Explorer	16	0.02%	96	0.13%	75,055	99.85%	75,167	0.44%
Explorer Limited	2	0.01%	41	0.12%	35,054	99.88%	35,097	0.21%
Explorer LTD 2WD	3	0.13%	4	0.18%	2,243	99.69%	2,250	0.01%
Explorer Platinum	2	0.03%	11	0.16%	6,743	99.81%	6,756	0.04%
Explorer Sport	2	0.01%	29	0.18%	16,059	99.81%	16,090	0.09%
Explorer Sport 2WD	1	0.04%	6	0.23%	2,570	99.73%	2,577	0.02%
Explorer Sport Trac 2WD	1	0.01%	16	0.14%	11,344	99.85%	11,361	0.07%
Explorer XLS 2WD	1	0.01%	14	0.20%	7,088	99.79%	7,103	0.04%
Explorer XLT	9	0.01%	108	0.16%	67,122	99.83%	67,239	0.39%
Explorer XLT 2WD	4	0.03%	23	0.15%	15,695	99.83%	15,722	0.09%
F150	227	0.03%	2,926	0.41%	711,693	99.56%	714,846	4.18%
F150 2WD	24	0.03%	94	0.10%	94,431	99.88%	94,549	0.55%
F150 2WD Super Crew	17	0.02%	73	0.08%	94,175	99.90%	94,265	0.55%
F150 4WD	2	0.02%	19	0.15%	12,839	99.84%	12,860	0.08%
F150 4WD Super Crew	6	0.02%	21	0.07%	29,913	99.91%	29,940	0.17%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
F150 Heritage 2WD	1	0.04%	4	0.18%	2,278	99.78%	2,283	0.01%
F150 Super Cab Styleside	2	0.02%	13	0.14%	9,549	99.84%	9,564	0.06%
F150 Super Crew 2WD	6	0.02%	59	0.16%	36,507	99.82%	36,572	0.21%
F150 Super Crew 4WD	5	0.06%	16	0.19%	8,426	99.75%	8,447	0.05%
F250	2	0.04%	14	0.27%	5,111	99.69%	5,127	0.03%
F350	1	0.11%	7	0.78%	892	99.11%	900	0.01%
Fiesta SE	4	0.02%	24	0.09%	26,012	99.89%	26,040	0.15%
Focus S	2	0.02%	11	0.11%	10,339	99.87%	10,352	0.06%
Focus SE	10	0.01%	54	0.08%	70,740	99.91%	70,804	0.41%
Focus SEL	1	0.01%	5	0.06%	8,541	99.93%	8,547	0.05%
Focus SES	1	0.02%	7	0.11%	6,588	99.88%	6,596	0.04%
Fusion Hybrid	1	0.04%	13	0.55%	2,367	99.41%	2,381	0.01%
Fusion S	4	0.02%	43	0.19%	22,023	99.79%	22,070	0.13%
Fusion SE	21	0.02%	214	0.20%	106,233	99.78%	106,468	0.62%
Fusion SE Hybrid	3	0.02%	34	0.25%	13,785	99.73%	13,822	0.08%
Fusion SEL	6	0.04%	70	0.41%	16,919	99.55%	16,995	0.10%
Mustang	3	0.01%	43	0.14%	30,652	99.85%	30,698	0.18%
Mustang GT	4	0.01%	73	0.13%	56,651	99.86%	56,728	0.33%
Mustang I4	4	0.01%	44	0.14%	31,007	99.85%	31,055	0.18%
Ranger	8	0.03%	56	0.21%	26,432	99.76%	26,496	0.15%
Ranger 2WD	10	0.02%	66	0.15%	43,450	99.83%	43,526	0.25%
Ranger Regular Cab 2WD	1	0.04%	2	0.08%	2,616	99.89%	2,619	0.02%
Ranger Super Cab 2WD	3	0.08%	6	0.17%	3,586	99.75%	3,595	0.02%
Taurus SE	2	0.02%	14	0.11%	12,332	99.87%	12,348	0.07%
Taurus SEL	1	0.01%	14	0.09%	14,931	99.90%	14,946	0.09%
Transit Connect	10	0.04%	73	0.29%	25,037	99.67%	25,120	0.15%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Transit T150	1	0.08%	7	0.55%	1,269	99.37%	1,277	0.01%
Bronco Sport	25	0.47%	669	12.58%	4,622	86.95%	5,316	0.03%
C-Max Compact FHEV SEL	1	0.09%	1	0.09%	1,116	99.82%	1,118	0.01%
Crown Victoria (Police)	3	0.07%	5	0.12%	4,024	99.80%	4,032	0.02%
Crown Victoria LX	2	0.08%	5	0.19%	2,609	99.73%	2,616	0.02%
Econoline E150	1	0.09%	3	0.26%	1,158	99.66%	1,162	0.01%
Ecosport S	2	0.05%	1	0.03%	3,673	99.92%	3,676	0.02%
Edge	3	0.01%	51	0.10%	50,915	99.89%	50,969	0.30%
Edge SE	1	0.01%	17	0.20%	8,411	99.79%	8,429	0.05%
Edge SEL AWD	1	0.20%	1	0.20%	500	99.60%	502	0.00%
Edge SEL FWD	2	0.06%	4	0.11%	3,585	99.83%	3,591	0.02%
Escape Hybrid SE	8	0.65%	179	14.49%	1,048	84.86%	1,235	0.01%
Escape Hybrid Titanium	10	0.71%	209	14.84%	1,189	84.45%	1,408	0.01%
Escape Limited 2WD	2	0.06%	4	0.12%	3,249	99.82%	3,255	0.02%
Expedition King Ranch	1	0.07%	4	0.27%	1,481	99.66%	1,486	0.01%
Expedition Limited	1	0.01%	22	0.13%	17,410	99.87%	17,433	0.10%
Expedition Max XLT	1	0.01%	15	0.15%	9,687	99.84%	9,703	0.06%
Expedition XLT	2	0.01%	35	0.18%	19,898	99.81%	19,935	0.12%
Explorer Eddie Bauer 2WD	1	0.02%	17	0.26%	6,464	99.72%	6,482	0.04%
Explorer Eddie Bauer 4WD	2	0.13%	5	0.33%	1,493	99.53%	1,500	0.01%
Explorer LTD 4WD	1	0.14%	3	0.43%	690	99.42%	694	0.00%
Explorer XLT 4WD	2	0.05%	3	0.07%	4,240	99.88%	4,245	0.02%
F150 Heritage	1	0.04%	7	0.25%	2,813	99.72%	2,821	0.02%
F250 4WD	1	0.37%	1	0.37%	270	99.26%	272	0.00%
Freestar SEL	1	0.18%	1	0.18%	564	99.65%	566	0.00%
Fusion Sport	2	0.12%	8	0.47%	1,685	99.41%	1,695	0.01%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Fusion Titanium	2	0.01%	17	0.12%	13,613	99.86%	13,632	0.08%
Fusion Titanium HEV	3	0.09%	6	0.19%	3,234	99.72%	3,243	0.02%
Transit T250	2	0.09%	12	0.53%	2,255	99.38%	2,269	0.01%
Transit T350	1	0.08%	3	0.24%	1,266	99.69%	1,270	0.01%
GENS								
	1	0.01%	6	0.08%	7,349	99.90%	7,356	0.04%
GMC								
1500 2WD	8	0.02%	40	0.10%	41,678	99.88%	41,726	0.24%
1500 Suburban 4WD Luxury	1	0.04%	2	0.09%	2,249	99.87%	2,252	0.01%
2500 2WD	1	0.02%	1	0.02%	5,499	99.96%	5,501	0.03%
Acadia SLT(1) FWD	1	0.04%	3	0.12%	2,418	99.83%	2,422	0.01%
Canyon / Envoy 2WD	1	0.02%	8	0.14%	5,719	99.84%	5,728	0.03%
Envoy/Envoy XL SLE 2WD	2	0.03%	15	0.20%	7,660	99.78%	7,677	0.04%
Full Size Truck 1500 4WD	1	0.07%	3	0.22%	1,358	99.71%	1,362	0.01%
Full Size Truck 4WD 1500	1	0.14%	2	0.28%	701	99.57%	704	0.00%
Sierra 1500	15	0.01%	157	0.09%	181,031	99.91%	181,203	1.06%
Sierra 1500 2WD	13	0.06%	25	0.12%	21,649	99.82%	21,687	0.13%
Sierra 1500 Pickup 2WD	1	0.01%	11	0.14%	7,940	99.85%	7,952	0.05%
Sierra 1500 Pickup 4WD	1	0.02%	10	0.22%	4,569	99.76%	4,580	0.03%
Sierra 2500 Pickup 2WD	1	0.13%	3	0.39%	772	99.48%	776	0.00%
Sierra Denali / Yukon 1500 4WD	1	0.02%	3	0.06%	5,286	99.92%	5,290	0.03%
Sierra SLE	1	0.02%	1	0.02%	4,360	99.95%	4,362	0.03%
Terrain SLE1	1	0.01%	7	0.04%	15,781	99.95%	15,789	0.09%
Yukon 2WD	5	0.03%	37	0.20%	18,673	99.78%	18,715	0.11%
Yukon Denali	1	0.00%	26	0.09%	28,389	99.90%	28,416	0.17%
Acadia Denali	2	0.01%	16	0.10%	16,658	99.89%	16,676	0.10%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Acadia SLE1	1	0.01%	11	0.09%	11,622	99.90%	11,634	0.07%
Acadia SLT1	2	0.01%	12	0.05%	22,975	99.94%	22,989	0.13%
Canyon	2	0.01%	9	0.06%	16,249	99.93%	16,260	0.10%
Savana 2WD 3500	1	0.32%	1	0.32%	310	99.36%	312	0.00%
Sierra / Yukon / 1500 4WD	2	0.04%	3	0.05%	5,500	99.91%	5,505	0.03%
Sonoma Pickup 2WD	1	0.06%	2	0.12%	1,684	99.82%	1,687	0.01%
Terrain SLT2	1	0.02%	7	0.12%	6,048	99.87%	6,056	0.04%
Yukon 4WD	1	0.02%	11	0.27%	4,129	99.71%	4,141	0.02%
Yukon XL	3	0.06%	3	0.06%	4,885	99.88%	4,891	0.03%
Yukon XL SLT	1	0.01%	20	0.15%	13,164	99.84%	13,185	0.08%
HOND								
Accord	4	0.03%	12	0.09%	13,382	99.88%	13,398	0.08%
Accord EX	24	0.02%	116	0.12%	96,150	99.85%	96,290	0.56%
Accord EX L	7	0.05%	8	0.05%	14,854	99.90%	14,869	0.09%
Accord EX-L	7	0.01%	51	0.11%	47,709	99.88%	47,767	0.28%
Accord EX-L Sensing	2	0.06%	3	0.09%	3,318	99.85%	3,323	0.02%
Accord EX-L V6	3	0.01%	35	0.11%	33,163	99.89%	33,201	0.19%
Accord LX	26	0.02%	126	0.10%	129,353	99.88%	129,505	0.76%
Accord LX Premium	1	0.01%	4	0.05%	8,706	99.94%	8,711	0.05%
Accord SE	6	0.03%	34	0.16%	21,212	99.81%	21,252	0.12%
Accord Sport	16	0.02%	67	0.09%	75,454	99.89%	75,537	0.44%
Accord Sport SE	2	0.03%	11	0.15%	7,193	99.82%	7,206	0.04%
Accord Touring	2	0.01%	15	0.10%	15,664	99.89%	15,681	0.09%
Accrod EX-L	3	0.02%	13	0.09%	15,030	99.89%	15,046	0.09%
Civic	4	0.05%	11	0.14%	7,758	99.81%	7,773	0.05%
Civic EX	13	0.01%	90	0.09%	101,015	99.90%	101,118	0.59%

	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	
Make/Model	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Civic EX L	3	0.08%	3	0.08%	3,601	99.83%	3,607	0.02%
Civic EX-L	1	0.01%	10	0.06%	15,844	99.93%	15,855	0.09%
Civic Hybrid	3	0.04%	9	0.13%	6,944	99.83%	6,956	0.04%
Civic LX	30	0.02%	129	0.07%	184,942	99.91%	185,101	1.08%
Civic Si	4	0.03%	13	0.10%	13,594	99.88%	13,611	0.08%
Civic Sport	4	0.02%	17	0.07%	22,973	99.91%	22,994	0.13%
CR-V	34	0.01%	241	0.09%	261,767	99.90%	262,042	1.53%
CR-V EX 2WD	1	0.02%	4	0.08%	4,810	99.90%	4,815	0.03%
CR-V LX	1	0.01%	10	0.11%	8,999	99.88%	9,010	0.05%
Element	3	0.02%	19	0.15%	12,611	99.83%	12,633	0.07%
FIT HB Sport	1	0.01%	5	0.07%	7,586	99.92%	7,592	0.04%
Fit Sport	2	0.02%	4	0.04%	8,975	99.93%	8,981	0.05%
Odyssey	16	0.01%	159	0.10%	161,489	99.89%	161,664	0.94%
Pilot	22	0.01%	185	0.10%	178,723	99.88%	178,930	1.05%
Ridgeline	2	0.01%	26	0.10%	25,827	99.89%	25,855	0.15%
S2000	2	0.06%	10	0.31%	3,189	99.63%	3,201	0.02%
Accord Crosstour	1	0.01%	9	0.11%	8,547	99.88%	8,557	0.05%
Accord EX V6	1	0.05%	2	0.11%	1,868	99.84%	1,871	0.01%
Accord LX P	4	0.04%	11	0.11%	9,626	99.84%	9,641	0.06%
Accord LX-S	1	0.03%	2	0.06%	3,314	99.91%	3,317	0.02%
Accord VP	2	0.06%	8	0.26%	3,100	99.68%	3,110	0.02%
CR-Z EX	1	0.06%	2	0.11%	1,751	99.83%	1,754	0.01%
Civic EX-L (Canada)	1	0.04%	3	0.11%	2,772	99.86%	2,776	0.02%
Civic EX-T	1	0.01%	11	0.12%	9,012	99.87%	9,024	0.05%
Civic LX S	1	0.07%	2	0.15%	1,366	99.78%	1,369	0.01%
Civic LX-P	1	0.04%	3	0.12%	2,591	99.85%	2,595	0.02%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Civic SE	1	0.03%	3	0.10%	3,081	99.87%	3,085	0.02%
Fit	3	0.06%	5	0.10%	5,122	99.84%	5,130	0.03%
Fit EX-L	2	0.03%	5	0.08%	6,463	99.89%	6,470	0.04%
Insight Touring	1	0.06%	7	0.45%	1,555	99.49%	1,563	0.01%
Prelude	1	0.10%	3	0.30%	995	99.60%	999	0.01%
HUMM								
	1	0.03%	13	0.33%	3,926	99.64%	3,940	0.02%
H3 - SUV 4WD	1	0.03%	6	0.19%	3,166	99.78%	3,173	0.02%
H2 (no designated trim) 4WD	1	0.09%	2	0.18%	1,127	99.73%	1,130	0.01%
H3 - Base 4WD	2	0.10%	3	0.15%	2,040	99.76%	2,045	0.01%
HYUN								
	18	0.02%	111	0.12%	95,467	99.87%	95,596	0.56%
Accent	3	0.01%	22	0.07%	32,568	99.92%	32,593	0.19%
Elantra	13	0.01%	79	0.06%	123,400	99.93%	123,492	0.72%
Genesis / Equus	2	0.01%	15	0.09%	16,721	99.90%	16,738	0.10%
Santa Fe	11	0.01%	99	0.08%	117,735	99.91%	117,845	0.69%
Sonata	26	0.02%	124	0.09%	136,075	99.89%	136,225	0.80%
Tucson	1	0.00%	42	0.09%	45,550	99.91%	45,593	0.27%
Veloster	2	0.01%	15	0.10%	14,344	99.88%	14,361	0.08%
Kona	2	0.01%	16	0.12%	13,870	99.87%	13,888	0.08%
Palisade/Venue	1	0.01%	18	0.13%	13,926	99.86%	13,945	0.08%
Tucson/Nexo	3	0.01%	23	0.10%	23,306	99.89%	23,332	0.14%
INFI								
EX35	1	0.03%	2	0.05%	3,711	99.92%	3,714	0.02%
G35	4	0.03%	12	0.09%	12,783	99.87%	12,799	0.07%
G35 Coupe	5	0.04%	8	0.06%	12,963	99.90%	12,976	0.08%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
G37	3	0.02%	8	0.06%	12,542	99.91%	12,553	0.07%
I30	1	0.08%	1	0.08%	1,208	99.83%	1,210	0.01%
Murano	2	0.01%	28	0.10%	28,943	99.90%	28,973	0.17%
Q50	1	0.01%	12	0.06%	18,628	99.93%	18,641	0.11%
QX56	3	0.05%	6	0.09%	6,583	99.86%	6,592	0.04%
QX60	6	0.01%	62	0.12%	52,751	99.87%	52,819	0.31%
FX35 or FX45	1	0.01%	9	0.13%	6,906	99.86%	6,916	0.04%
G35 Sport	1	0.03%	7	0.22%	3,172	99.75%	3,180	0.02%
JX35	1	0.01%	6	0.09%	6,975	99.90%	6,982	0.04%
Q50 / Q60	4	0.02%	20	0.08%	25,496	99.91%	25,520	0.15%
JAGU								
	1	0.01%	24	0.16%	15,155	99.84%	15,180	0.09%
V D P	1	0.14%	2	0.28%	707	99.58%	710	0.00%
XF	3	0.07%	2	0.05%	4,406	99.89%	4,411	0.03%
XJ	2	0.04%	10	0.18%	5,446	99.78%	5,458	0.03%
XJ / XF	1	0.06%	2	0.12%	1,728	99.83%	1,731	0.01%
XK8 / XKR	1	0.13%	3	0.39%	773	99.49%	777	0.00%
JEEP								
	17	0.05%	69	0.20%	35,197	99.76%	35,283	0.21%
Cherokee	23	0.03%	114	0.16%	69,334	99.80%	69,471	0.41%
Cherokee 2WD	1	0.04%	9	0.36%	2,515	99.60%	2,525	0.01%
Compass	1	0.01%	19	0.18%	10,754	99.81%	10,774	0.06%
Compass/Reneade	9	0.02%	71	0.18%	38,646	99.79%	38,726	0.23%
Grand Cherokee	13	0.01%	153	0.11%	144,107	99.88%	144,273	0.84%
Grand Cherokee 2WD	1	0.03%	5	0.17%	2,916	99.79%	2,922	0.02%
Grand Cherokee Laredo 2WD	2	0.02%	6	0.06%	9,955	99.92%	9,963	0.06%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Grand Cherokee Limited 2WD	1	0.04%	2	0.09%	2,289	99.87%	2,292	0.01%
Grand Cherokee Limited 4WD	1	0.04%	2	0.07%	2,846	99.89%	2,849	0.02%
Liberty Sport 2WD	1	0.01%	6	0.09%	7,046	99.90%	7,053	0.04%
Patriot	8	0.03%	40	0.13%	31,663	99.85%	31,711	0.19%
Renegade	8	0.03%	38	0.12%	31,951	99.86%	31,997	0.19%
Wrangler	13	0.01%	225	0.14%	162,909	99.85%	163,147	0.95%
Wrangler 4WD	1	0.01%	20	0.23%	8,657	99.76%	8,678	0.05%
Wrangler Sahara / Unlimited Sa	1	0.02%	2	0.04%	4,992	99.94%	4,995	0.03%
Wrangler Sport	1	0.03%	5	0.14%	3,652	99.84%	3,658	0.02%
Wrangler X / Wrangler Willys	1	0.03%	6	0.18%	3,413	99.80%	3,420	0.02%
Liberty	1	0.01%	7	0.10%	7,245	99.89%	7,253	0.04%
Liberty Sport 4WD	1	0.03%	4	0.12%	3,403	99.85%	3,408	0.02%
Wrangler Rubicon / Unlimited R	1	0.05%	4	0.19%	2,054	99.76%	2,059	0.01%
Wrangler Sahara/Unlimited Saha	1	0.03%	2	0.06%	3,180	99.91%	3,183	0.02%
Wrangler Sport / Unlimited XLH	1	0.08%	1	0.08%	1,308	99.85%	1,310	0.01%
Wrangler X / Sport LHD 4WD	3	0.10%	2	0.07%	2,853	99.83%	2,858	0.02%
KIA								
	8	0.01%	95	0.10%	97,259	99.89%	97,362	0.57%
Optima	1	0.02%	2	0.03%	6,434	99.95%	6,437	0.04%
Optima / Optima Hybrid	11	0.01%	67	0.09%	75,344	99.90%	75,422	0.44%
Rio	2	0.01%	18	0.08%	22,096	99.91%	22,116	0.13%
Sedona VQ	1	0.03%	1	0.03%	3,706	99.95%	3,708	0.02%
Sorento	1	0.00%	29	0.10%	27,629	99.89%	27,659	0.16%
Sorento 2WD	1	0.01%	7	0.08%	9,236	99.91%	9,244	0.05%
Sorento/Sportage	5	0.01%	42	0.07%	59,456	99.92%	59,503	0.35%
Soul/Tucson	6	0.01%	46	0.05%	85,019	99.94%	85,071	0.50%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Spectra	1	0.01%	8	0.06%	13,821	99.93%	13,830	0.08%
Azera	2	0.01%	8	0.05%	17,163	99.94%	17,173	0.10%
Forte / Forte Koup	1	0.01%	4	0.02%	17,846	99.97%	17,851	0.10%
Rio - Rio F/L	1	0.61%	4	2.44%	159	96.95%	164	0.00%
Rondo	1	0.05%	1	0.05%	2,215	99.91%	2,217	0.01%
Sedona	2	0.01%	13	0.09%	14,461	99.90%	14,476	0.08%
Soul/Tucson/Nexo	2	0.01%	14	0.07%	21,497	99.93%	21,513	0.13%
Sportage	1	0.01%	6	0.05%	12,155	99.94%	12,162	0.07%
Sportage 2WD	1	0.02%	10	0.17%	5,934	99.81%	5,945	0.03%
LEXS								
	5	0.01%	37	0.05%	71,776	99.94%	71,818	0.42%
ES 350	5	0.01%	47	0.07%	68,777	99.92%	68,829	0.40%
ES300	2	0.02%	15	0.14%	10,675	99.84%	10,692	0.06%
ES330	3	0.02%	19	0.16%	12,103	99.82%	12,125	0.07%
ES350	6	0.03%	16	0.07%	22,283	99.90%	22,305	0.13%
GS 350	3	0.01%	19	0.09%	20,339	99.89%	20,361	0.12%
GS300	1	0.02%	2	0.05%	4,001	99.93%	4,004	0.02%
GS300/GS450	1	0.03%	9	0.25%	3,527	99.72%	3,537	0.02%
GX470	1	0.01%	12	0.11%	10,770	99.88%	10,783	0.06%
IS 250	1	0.00%	12	0.05%	24,284	99.95%	24,297	0.14%
IS250	7	0.05%	14	0.10%	14,247	99.85%	14,268	0.08%
NX 200t	2	0.01%	13	0.06%	23,232	99.94%	23,247	0.14%
RX 350	11	0.01%	102	0.06%	166,629	99.93%	166,742	0.97%
RX300	4	0.04%	16	0.17%	9,527	99.79%	9,547	0.06%
RX330	2	0.01%	21	0.15%	14,391	99.84%	14,414	0.08%
RX350	7	0.03%	22	0.11%	20,679	99.86%	20,708	0.12%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
ES 300h	2	0.03%	6	0.09%	6,526	99.88%	6,534	0.04%
GX 460	1	0.00%	29	0.06%	49,288	99.94%	49,318	0.29%
IS 350	1	0.02%	5	0.08%	5,881	99.90%	5,887	0.03%
IS 350C	1	0.06%	3	0.17%	1,747	99.77%	1,751	0.01%
IS350	1	0.03%	4	0.13%	3,013	99.83%	3,018	0.02%
LS460	1	0.02%	4	0.06%	6,607	99.92%	6,612	0.04%
RC 350	1	0.02%	6	0.13%	4,657	99.85%	4,664	0.03%
LINC								
	22	0.03%	518	0.73%	70,906	99.24%	71,446	0.42%
Aviator	2	0.09%	3	0.14%	2,168	99.77%	2,173	0.01%
LS	1	0.05%	4	0.21%	1,940	99.74%	1,945	0.01%
Mark LT 2WD SuperCrew	2	0.08%	2	0.08%	2,577	99.85%	2,581	0.02%
MKS	1	0.02%	7	0.11%	6,533	99.88%	6,541	0.04%
MKX FWD	1	0.03%	5	0.14%	3,650	99.84%	3,656	0.02%
MKZ	3	0.02%	20	0.12%	16,042	99.86%	16,065	0.09%
Navigator 2WD	4	0.04%	9	0.08%	10,840	99.88%	10,853	0.06%
Town Car Executive	1	0.03%	7	0.18%	3,795	99.79%	3,803	0.02%
Town Car Signature	2	0.03%	19	0.31%	6,154	99.66%	6,175	0.04%
Town Car Ultimate	1	0.12%	1	0.12%	801	99.75%	803	0.00%
MKZ Reserve	1	0.03%	9	0.27%	3,318	99.70%	3,328	0.02%
MKZ Select	1	0.10%	2	0.21%	963	99.69%	966	0.01%
LNDR								
Range Rover	15	0.02%	96	0.10%	93,550	99.88%	93,661	0.55%
LOTU								
Elise	2	0.92%	3	1.38%	212	97.70%	217	0.00%
MASE								

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
	3	0.07%	15	0.33%	4,569	99.61%	4,587	0.03%
MAZD								
3	3	0.02%	50	0.30%	16,442	99.68%	16,495	0.10%
5	3	0.11%	6	0.23%	2,603	99.66%	2,612	0.02%
6	3	0.04%	56	0.69%	8,093	99.28%	8,152	0.05%
	3	0.03%	27	0.30%	8,834	99.66%	8,864	0.05%
CX-5	6	0.01%	52	0.06%	81,324	99.93%	81,382	0.48%
CX-7	8	0.08%	83	0.86%	9,544	99.06%	9,635	0.06%
CX-9	2	0.01%	17	0.07%	22,769	99.92%	22,788	0.13%
CX-9 GS	1	0.02%	2	0.05%	4,302	99.93%	4,305	0.03%
Mazda 2	4	0.11%	15	0.42%	3,574	99.47%	3,593	0.02%
Mazda 3	18	0.06%	149	0.49%	30,507	99.46%	30,674	0.18%
Mazda 6	11	0.14%	85	1.08%	7,783	98.78%	7,879	0.05%
Mazda 6 Touring	2	0.02%	2	0.02%	8,207	99.95%	8,211	0.05%
Mazda3	3	0.01%	21	0.09%	22,661	99.89%	22,685	0.13%
MPV	1	0.05%	15	0.73%	2,049	99.23%	2,065	0.01%
MX5 Miata	4	0.27%	21	1.43%	1,439	98.29%	1,464	0.01%
MX-5 Miata	2	0.03%	30	0.46%	6,446	99.51%	6,478	0.04%
Protege	1	0.03%	15	0.50%	2,959	99.46%	2,975	0.02%
CX-9 Sport/GX	1	0.08%	2	0.17%	1,193	99.75%	1,196	0.01%
Mazda 3 Sport	1	0.02%	5	0.09%	5,483	99.89%	5,489	0.03%
Mazda6	1	0.01%	8	0.07%	12,289	99.93%	12,298	0.07%
Tribute ES 2WD	1	0.09%	3	0.27%	1,103	99.64%	1,107	0.01%
Tribute LX 2WD	2	0.08%	4	0.16%	2,570	99.77%	2,576	0.02%
MERC								
Grand Marquis GS	1	0.01%	7	0.10%	7,262	99.89%	7,270	0.04%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Grand Marquis LS	3	0.02%	19	0.15%	12,256	99.82%	12,278	0.07%
Milan	2	0.11%	4	0.22%	1,850	99.68%	1,856	0.01%
MERZ								
	6	0.01%	79	0.17%	47,306	99.82%	47,391	0.28%
C250	4	0.02%	22	0.12%	17,994	99.86%	18,020	0.11%
C300	4	0.01%	44	0.15%	29,809	99.84%	29,857	0.17%
CLA250	2	0.01%	12	0.07%	16,347	99.91%	16,361	0.10%
CLK350	1	0.04%	4	0.14%	2,787	99.82%	2,792	0.02%
CLK430	1	0.14%	2	0.28%	705	99.58%	708	0.00%
E300	3	0.02%	34	0.26%	13,179	99.72%	13,216	0.08%
E350	6	0.01%	45	0.11%	41,696	99.88%	41,747	0.24%
GL450	1	0.01%	15	0.12%	12,028	99.87%	12,044	0.07%
GL550	1	0.03%	3	0.10%	2,972	99.87%	2,976	0.02%
GLA250	2	0.01%	27	0.15%	17,841	99.84%	17,870	0.10%
GLB250	1	0.02%	18	0.34%	5,265	99.64%	5,284	0.03%
GLC300	4	0.01%	78	0.19%	42,005	99.81%	42,087	0.25%
GLE350	2	0.01%	68	0.19%	35,422	99.80%	35,492	0.21%
GLK350	2	0.01%	13	0.08%	15,350	99.90%	15,365	0.09%
ML320	2	0.12%	2	0.12%	1,679	99.76%	1,683	0.01%
ML350	2	0.01%	34	0.13%	26,173	99.86%	26,209	0.15%
S550	4	0.02%	14	0.08%	17,413	99.90%	17,431	0.10%
A250	2	0.04%	27	0.54%	4,967	99.42%	4,996	0.03%
AMG C43	1	0.08%	1	0.08%	1,281	99.84%	1,283	0.01%
AMG E53	1	0.12%	6	0.72%	826	99.16%	833	0.00%
C230	1	0.02%	9	0.16%	5,517	99.82%	5,527	0.03%
CLS450	1	0.07%	11	0.72%	1,506	99.21%	1,518	0.01%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
E320S	1	0.53%	1	0.53%	187	98.94%	189	0.00%
E320W	1	0.02%	13	0.31%	4,179	99.67%	4,193	0.02%
G550	1	0.03%	9	0.29%	3,122	99.68%	3,132	0.02%
G63 AMG	1	0.03%	2	0.06%	3,301	99.91%	3,304	0.02%
GLC43 AMG	1	0.06%	3	0.18%	1,672	99.76%	1,676	0.01%
GLE400	1	0.09%	1	0.09%	1,128	99.82%	1,130	0.01%
GLE450	1	0.04%	14	0.50%	2,797	99.47%	2,812	0.02%
GLS450	3	0.03%	38	0.34%	11,018	99.63%	11,059	0.06%
GLS550	1	0.06%	4	0.22%	1,788	99.72%	1,793	0.01%
GT53	1	0.21%	5	1.04%	477	98.76%	483	0.00%
S430V	1	0.05%	1	0.05%	1,864	99.89%	1,866	0.01%
S500	2	0.34%	2	0.34%	581	99.32%	585	0.00%
S560	1	0.04%	7	0.28%	2,506	99.68%	2,514	0.01%
S580	1	0.13%	1	0.13%	744	99.73%	746	0.00%
SL500R	1	0.04%	2	0.09%	2,329	99.87%	2,332	0.01%
MITS								
Eclipse GS	1	0.05%	10	0.47%	2,111	99.48%	2,122	0.01%
Endeavor LS FWD	1	0.06%	5	0.30%	1,660	99.64%	1,666	0.01%
Galant FE	1	0.05%	14	0.74%	1,879	99.21%	1,894	0.01%
Mirage DE	2	0.08%	3	0.11%	2,661	99.81%	2,666	0.02%
Montero Sport 2WD	3	0.17%	2	0.11%	1,811	99.72%	1,816	0.01%
Outlander GT AWC	1	0.13%	2	0.26%	773	99.61%	776	0.00%
Outlander SE FWD	1	0.01%	26	0.23%	11,201	99.76%	11,228	0.07%
Eclipse Cross	2	0.06%	2	0.06%	3,322	99.88%	3,326	0.02%
Eclipse Spyder GS	1	0.14%	1	0.14%	723	99.72%	725	0.00%
Galant ES/SE	3	0.15%	28	1.37%	2,008	98.48%	2,039	0.01%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Lancer ES	1	0.01%	5	0.04%	11,145	99.95%	11,151	0.07%
Mirage ES	1	0.02%	4	0.07%	5,848	99.91%	5,853	0.03%
Outlander LS FWD	1	0.14%	9	1.23%	720	98.63%	730	0.00%
Outlander SE AWC	3	0.14%	2	0.10%	2,072	99.76%	2,077	0.01%
Outlander Sport ES FWD	2	0.01%	16	0.10%	16,595	99.89%	16,613	0.10%
MNNI								
Cooper	1	0.02%	12	0.22%	5,354	99.76%	5,367	0.03%
Cooper S	2	0.05%	6	0.15%	3,918	99.80%	3,926	0.02%
Mini Cooper	2	0.02%	20	0.17%	11,842	99.81%	11,864	0.07%
Mini Cooper S	1	0.01%	13	0.13%	9,697	99.86%	9,711	0.06%
NISS								
	10	0.02%	89	0.15%	60,637	99.84%	60,736	0.35%
Altima	57	0.01%	343	0.09%	381,053	99.90%	381,453	2.23%
Armada/Titan	3	0.02%	7	0.04%	16,880	99.94%	16,890	0.10%
Frontier	16	0.02%	86	0.09%	92,210	99.89%	92,312	0.54%
I30	2	0.06%	4	0.12%	3,269	99.82%	3,275	0.02%
Juke	1	0.00%	16	0.07%	21,800	99.92%	21,817	0.13%
Kicks	6	0.03%	29	0.13%	22,342	99.84%	22,377	0.13%
Maxima	6	0.01%	92	0.13%	71,941	99.86%	72,039	0.42%
Murano	7	0.01%	105	0.10%	106,193	99.89%	106,305	0.62%
NV200	1	0.01%	16	0.14%	11,128	99.85%	11,145	0.07%
Pathfinder	11	0.01%	72	0.07%	96,196	99.91%	96,279	0.56%
Pathfinder Armada	4	0.03%	11	0.08%	13,162	99.89%	13,177	0.08%
Pickup Crew Cab	2	0.03%	7	0.10%	6,683	99.87%	6,692	0.04%
Quest	1	0.01%	7	0.07%	10,309	99.92%	10,317	0.06%
Rogue	17	0.01%	177	0.08%	235,186	99.92%	235,380	1.38%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Rogue Select	1	0.01%	9	0.07%	13,483	99.93%	13,493	0.08%
Rogue Sport	5	0.02%	37	0.11%	33,190	99.87%	33,232	0.19%
Sentra	25	0.01%	182	0.09%	204,279	99.90%	204,486	1.20%
Titan	13	0.03%	51	0.11%	48,059	99.87%	48,123	0.28%
Versa	10	0.01%	78	0.09%	89,055	99.90%	89,143	0.52%
Versa Note	1	0.01%	13	0.07%	19,350	99.93%	19,364	0.11%
Xterra	3	0.01%	30	0.13%	23,623	99.86%	23,656	0.14%
370z	2	0.02%	6	0.07%	8,050	99.90%	8,058	0.05%
OTHR								
	6	0.05%	24	0.21%	11,222	99.73%	11,252	0.07%
CR-V	1	0.16%	1	0.16%	633	99.69%	635	0.00%
Grand Caravan SE	1	0.11%	5	0.53%	943	99.37%	949	0.01%
MPV	1	0.80%	3	2.40%	121	96.80%	125	0.00%
Odyssey	5	0.05%	4	0.04%	9,467	99.91%	9,476	0.06%
Transit Connect	3	0.24%	2	0.16%	1,246	99.60%	1,251	0.01%
PONT								
Formula / Trans Am	1	0.04%	8	0.32%	2,488	99.64%	2,497	0.01%
G6 SE1	1	0.02%	19	0.35%	5,406	99.63%	5,426	0.03%
Vibe	2	0.03%	4	0.07%	5,907	99.90%	5,913	0.03%
G6	1	0.15%	2	0.30%	674	99.56%	677	0.00%
Grand Prix 367P Sedan	1	0.10%	1	0.10%	989	99.80%	991	0.01%
Solstice	1	0.06%	4	0.22%	1,791	99.72%	1,796	0.01%
Vibe GT	1	0.09%	3	0.26%	1,150	99.65%	1,154	0.01%
PORS								
911	3	0.02%	75	0.42%	17,823	99.56%	17,901	0.10%
986 Boxster	1	0.04%	17	0.66%	2,562	99.30%	2,580	0.02%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Boxster / Cayman	2	0.03%	11	0.16%	6,743	99.81%	6,756	0.04%
Cayenne	1	0.00%	32	0.15%	21,492	99.85%	21,525	0.13%
Cayman / Boxster	1	0.04%	17	0.73%	2,324	99.23%	2,342	0.01%
Macan	2	0.01%	13	0.09%	15,125	99.90%	15,140	0.09%
Panamera	4	0.04%	49	0.50%	9,821	99.46%	9,874	0.06%
RAM								
1500	8	0.01%	131	0.11%	115,904	99.88%	116,043	0.68%
	12	0.01%	107	0.10%	108,475	99.89%	108,594	0.63%
ProMaster City	7	0.17%	30	0.74%	4,017	99.09%	4,054	0.02%
RAM 1500	3	0.02%	16	0.09%	18,056	99.89%	18,075	0.11%
RAM PK Light Duty 1500	1	0.01%	9	0.12%	7,438	99.87%	7,448	0.04%
SAA								
45538	2	0.09%	3	0.14%	2,168	99.77%	2,173	0.01%
SCIO								
	6	0.02%	33	0.12%	27,543	99.86%	27,582	0.16%
Scion tC	2	0.01%	13	0.09%	14,806	99.90%	14,821	0.09%
Scion xA	3	0.09%	5	0.15%	3,251	99.75%	3,259	0.02%
STRN								
LS1 / LW1 Auto	1	0.15%	2	0.31%	649	99.54%	652	0.00%
SC2 / SL1 / SW1	1	0.49%	1	0.49%	203	99.02%	205	0.00%
Vue FWD	3	0.05%	10	0.16%	6,320	99.79%	6,333	0.04%
SUBA								
BRZ	2	0.05%	14	0.35%	4,030	99.60%	4,046	0.02%
Forester	3	0.00%	111	0.17%	64,314	99.82%	64,428	0.38%
Impreza	3	0.02%	26	0.13%	19,857	99.85%	19,886	0.12%
Legacy / Outback	1	0.05%	3	0.14%	2,211	99.82%	2,215	0.01%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Outback	7	0.01%	43	0.07%	61,704	99.92%	61,754	0.36%
Legacy/Outback	1	0.02%	12	0.24%	5,077	99.74%	5,090	0.03%
TOYT								
	15	0.01%	153	0.08%	188,231	99.91%	188,399	1.10%
4dr Wagon 2WD	1	0.03%	8	0.21%	3,742	99.76%	3,751	0.02%
4Runner	5	0.01%	77	0.08%	99,377	99.92%	99,459	0.58%
4Runner Limited	1	0.01%	16	0.14%	11,075	99.85%	11,092	0.06%
4Runner SR5	10	0.02%	51	0.10%	49,220	99.88%	49,281	0.29%
Avalon	9	0.01%	77	0.10%	73,670	99.88%	73,756	0.43%
Camry	134	0.02%	558	0.09%	602,898	99.89%	603,590	3.53%
Camry Hybrid	2	0.01%	20	0.11%	18,183	99.88%	18,205	0.11%
Corolla	47	0.01%	373	0.09%	411,070	99.90%	411,490	2.40%
Corolla/Matrix	8	0.02%	48	0.10%	49,877	99.89%	49,933	0.29%
FJ Cruiser	2	0.01%	8	0.05%	17,703	99.94%	17,713	0.10%
Highlander	12	0.02%	58	0.08%	68,332	99.90%	68,402	0.40%
Highlander LE	1	0.01%	9	0.05%	19,199	99.95%	19,209	0.11%
Highlander Ltd	2	0.01%	16	0.09%	18,272	99.90%	18,290	0.11%
Highlander SE/XLE	8	0.03%	33	0.11%	30,353	99.87%	30,394	0.18%
Highlander XLE	1	0.01%	14	0.08%	17,687	99.92%	17,702	0.10%
Matrix	3	0.03%	8	0.08%	9,607	99.89%	9,618	0.06%
Prius	1	0.01%	8	0.05%	14,889	99.94%	14,898	0.09%
Prius Hybrid	5	0.01%	64	0.14%	45,287	99.85%	45,356	0.27%
Prius V Hybrid	2	0.03%	8	0.12%	6,782	99.85%	6,792	0.04%
RAV4	5	0.01%	38	0.07%	53,106	99.92%	53,149	0.31%
RAV4 LE	5	0.01%	57	0.09%	65,481	99.91%	65,543	0.38%
RAV4 XLE	2	0.00%	59	0.09%	69,031	99.91%	69,092	0.40%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Sequoia Limited	1	0.01%	8	0.08%	10,602	99.92%	10,611	0.06%
Sienna	3	0.03%	5	0.05%	10,437	99.92%	10,445	0.06%
Sienna 5dr	2	0.13%	2	0.13%	1,479	99.73%	1,483	0.01%
Sienna LE	8	0.01%	45	0.08%	59,189	99.91%	59,242	0.35%
Sienna Ltd	3	0.01%	15	0.06%	25,623	99.93%	25,641	0.15%
Sienna XLE	2	0.01%	21	0.08%	26,256	99.91%	26,279	0.15%
Solara	2	0.02%	19	0.14%	13,230	99.84%	13,251	0.08%
Tacoma	4	0.01%	70	0.13%	54,337	99.86%	54,411	0.32%
Tacoma Deluxe	8	0.03%	35	0.14%	25,753	99.83%	25,796	0.15%
Tacoma DLX	7	0.02%	47	0.11%	43,991	99.88%	44,045	0.26%
Tacoma Ltd	1	0.02%	7	0.13%	5,341	99.85%	5,349	0.03%
Tacoma PreRunner XTRACAB	2	0.08%	7	0.29%	2,438	99.63%	2,447	0.01%
Tacoma SR/SR5/TRD	3	0.01%	24	0.08%	30,910	99.91%	30,937	0.18%
Tacoma SR5	2	0.02%	21	0.21%	9,802	99.77%	9,825	0.06%
Tacoma SR5/TRD	4	0.01%	29	0.10%	29,402	99.89%	29,435	0.17%
Tacoma XTRACAB 2WD	1	0.07%	4	0.26%	1,519	99.67%	1,524	0.01%
Tundra	3	0.02%	12	0.07%	17,478	99.91%	17,493	0.10%
Tundra SR/SR5	9	0.02%	30	0.06%	49,482	99.92%	49,521	0.29%
Tundra Ltd	2	0.01%	16	0.09%	17,323	99.90%	17,341	0.10%
Tundra Platinum	2	0.01%	16	0.08%	20,652	99.91%	20,670	0.12%
Tundra SR5	24	0.02%	89	0.08%	113,576	99.90%	113,689	0.66%
Tundra SR5/TRD	5	0.01%	24	0.07%	35,973	99.92%	36,002	0.21%
4Runner 2WD	2	0.03%	11	0.19%	5,736	99.77%	5,749	0.03%
C-HR	3	0.03%	16	0.14%	11,486	99.83%	11,505	0.07%
Echo	1	0.04%	3	0.13%	2,232	99.82%	2,236	0.01%
Highlander Hybrid XLE	1	0.19%	1	0.19%	524	99.62%	526	0.00%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Highlander LE/LE Plus	2	0.04%	1	0.02%	5,685	99.95%	5,688	0.03%
Highlander Ltd/Ltd Platinum	1	0.01%	14	0.13%	10,809	99.86%	10,824	0.06%
MR2 Spyder	1	0.11%	2	0.21%	942	99.68%	945	0.01%
RAV4 Hybrid	1	0.02%	5	0.10%	4,820	99.88%	4,826	0.03%
RAV4 Limited	1	0.01%	4	0.05%	7,490	99.93%	7,495	0.04%
RAV4 SE	1	0.02%	2	0.03%	5,933	99.95%	5,936	0.03%
Sequoia Platinum	2	0.03%	4	0.06%	7,000	99.91%	7,006	0.04%
Sienna Hybrid LE	1	0.07%	3	0.21%	1,411	99.72%	1,415	0.01%
Sienna Hybrid XLE	1	0.04%	1	0.04%	2,279	99.91%	2,281	0.01%
Sienna SE	1	0.02%	1	0.02%	5,293	99.96%	5,295	0.03%
Tacoma SR/SR5	3	0.02%	14	0.08%	18,318	99.91%	18,335	0.11%
Tundra DX	4	0.16%	2	0.08%	2,481	99.76%	2,487	0.01%
Tundra Limited	3	0.03%	7	0.08%	8,920	99.89%	8,930	0.05%
Venza	1	0.01%	10	0.11%	8,722	99.87%	8,733	0.05%
Venza LE/XLE	1	0.02%	6	0.09%	6,576	99.89%	6,583	0.04%
VOLK								
Beetle	4	0.03%	27	0.17%	15,913	99.81%	15,944	0.09%
Golf / GTI / Jetta Wagon	1	0.06%	8	0.47%	1,704	99.47%	1,713	0.01%
Golf/GTI	4	0.03%	35	0.22%	15,601	99.75%	15,640	0.09%
Golf/GTI/Jetta/Jetta Sportwage	3	0.01%	46	0.17%	26,889	99.82%	26,938	0.16%
Jetta	6	0.01%	95	0.16%	58,114	99.83%	58,215	0.34%
Jetta/Rabbit/GTI	6	0.04%	43	0.31%	13,992	99.65%	14,041	0.08%
New Beetle	2	0.04%	17	0.35%	4,770	99.60%	4,789	0.03%
New Beetle Convertible	1	0.04%	7	0.26%	2,680	99.70%	2,688	0.02%
Passat	9	0.02%	87	0.18%	48,070	99.80%	48,166	0.28%
Tiguan	6	0.01%	63	0.12%	50,444	99.86%	50,513	0.30%

Make/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 Make	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Atlas	2	0.01%	40	0.12%	32,218	99.87%	32,260	0.19%
CC	3	0.04%	7	0.10%	6,738	99.85%	6,748	0.04%
VOLV								
XC60	3	0.01%	21	0.09%	22,245	99.89%	22,269	0.13%
XC90	2	0.01%	38	0.14%	26,574	99.85%	26,614	0.16%
S60	3	0.02%	21	0.12%	17,155	99.86%	17,179	0.10%
Grand Total	**3,223**	**36.21%**	**25,188**	**182.46%**	**17,082,217**	**74081.33%**	**17,110,628**	**100.00%**

Appendix B-
DTC Groups

Table B-1. Evap DTCs

DTC	DTC Description	DTC	DTC Description
P0093	Fuel System Leak Detected - Large Leak	P0496	Evap High Purge Flow
P0094	Fuel System Leak Detected - Small Leak	P0497	Evap Low Purge Flow
P0440	Evap Malfunction	P0498	Evap Vent Valve Control Circuit Low
P0441	Evap Incorrect Purge Flow	P0499	Evap Vent Valve Control Circuit High
P0442	Evap Leak Detected (small leak)	P2024	Evap Fuel Vapor Temperature Sensor Circuit
P0443	Evap Purge Control Valve Circuit	P2025	Evap Fuel Vapor Temperature Sensor Performance
P0444	Evap Purge Control Valve Circuit Open	P2026	Evap Fuel Vapor Temperature Sensor Circuit Low Voltage
P0445	Evap Purge Control Valve Circuit Shorted	P2027	Evap Fuel Vapor Temperature Sensor Circuit High Voltage
P0446	Evap Vent Control Circuit Malfunction	P2028	Evap Fuel Vapor Temperature Sensor Circuit Intermittent
P0447	Evap Vent Control Circuit Open	P2400	Evap Leak Detection Pump Control Circuit/Open
P0448	Evap Vent Control Circuit Shorted	P2401	Evap Leak Detection Pump Control Circuit Low
P0449	Evap Vent Valve/Solenoid Circuit Malfunction	P2402	Evap Leak Detection Pump Control Circuit High
P0450	Evap Pressure Sensor Malfunction	P2403	Evap Leak Detection Pump Sense Circuit/Open
P0451	Evap Pressure Sensor Range/Performance	P2404	Evap Leak Detection Pump Sense Circuit Range/Performance
P0452	Evap Pressure Sensor Low Input	P2405	Evap Leak Detection Pump Sense Circuit Low
P0453	Evap Pressure Sensor High Input	P2406	Evap Leak Detection Pump Sense Circuit High
P0454	Evap Pressure Sensor Intermittent	P2407	Evap Leak Detection Pump Sense Circuit Intermittent/Erratic
P0455	Evap Leak Detected (gross leak)	P2408	Fuel Cap Sensor/Switch Circuit
P0456	Evap Leak Detected (very small leak)	P2409	Fuel Cap Sensor/Switch Circuit Range/Performance
P0457	Evap Leak Detected (fuel cap loose/off)	P2410	Fuel Cap Sensor/Switch Circuit Low
P0458	Evap Purge Control Valve Circuit Low	P2411	Fuel Cap Sensor/Switch Circuit High
P0459	Evap Purge Control Valve Circuit High	P2412	Fuel Cap Sensor/Switch Circuit Intermittent/Erratic
P0465	Purge Flow Sensor Circuit Malfunction	P2418	Evap Switching Valve Control Circuit / Open
P0466	Purge Flow Sensor Circuit Range/Performance	P2419	Evap Switching Valve Control Circuit Low
P0467	Purge Flow Sensor Circuit Low Input	P2420	Evap Switching Valve Control Circuit High
P0468	Purge Flow Sensor Circuit High Input	P2421	Evap Vent Valve Stuck Open
P0469	Purge Flow Sensor Circuit Intermittent	P2422	Evap Vent Valve Stuck Closed

Table B-2. Catalyst DTCs[8]

DTC	DTC Description	DTC	DTC Description
P0420	Catalyst System Efficiency Below Threshold	P0431	Warm Up Catalyst Efficiency Below Threshold
P0421	Warm Up Catalyst Efficiency Below Threshold	P0432	Main Catalyst Efficiency Below Threshold
P0422	Main Catalyst Efficiency Below Threshold	P0433	Heated Catalyst Efficiency Below Threshold
P0423	Heated Catalyst Efficiency Below Threshold	P0434	Heated Catalyst Temperature Below Threshold
P0424	Heated Catalyst Temperature Below Threshold	P0435	Catalyst Temperature Sensor
P0425	Catalyst Temperature Sensor	P0436	Catalyst Temperature Sensor Range/Performance
P0426	Catalyst Temperature Sensor Range/Performance	P0437	Catalyst Temperature Sensor Low
P0427	Catalyst Temperature Sensor Low	P0438	Catalyst Temperature Sensor High
P0428	Catalyst Temperature Sensor High	P0439	Catalyst Heater Control Circuit
P0429	Catalyst Heater Control Circuit	P2423	HC Adsorption Catalyst Efficiency Below Threshold
P0430	Catalyst System Efficiency Below Threshold	P2424	HC Adsorption Catalyst Efficiency Below Threshold

Table B-3. EGR DTCs

DTC	DTC Description	DTC	DTC Description
P0400	EGR Flow	P0489	EGR Control Circuit Low
P0401	EGR Flow Insufficient Detected	P0490	EGR Control Circuit High
P0402	EGR Flow Excessive Detected	P2141	EGR Throttle Control Circuit Low
P0403	EGR Control Circuit	P2142	EGR Throttle Control Circuit High
P0404	EGR Control Circuit Range/Performance	P2143	EGR Vent Control Circuit/Open
P0405	EGR Sensor "A" Circuit Low	P2144	EGR Vent Control Circuit Low
P0406	EGR Sensor "A" Circuit High	P2145	EGR Vent Control Circuit High
P0407	EGR Sensor "B" Circuit Low	P2413	EGR System Performance
P0408	EGR Sensor "B" Circuit High	P2425	EGR Cooling Valve Control Circuit/Open
P0409	EGR Sensor "A" Circuit	P2426	EGR Cooling Valve Control Circuit Low
P0486	EGR Sensor "B" Circuit	P2427	EGR Cooling Valve Control Circuit High
P0487	EGR Throttle Position Control Circuit	P2428	Exhaust Gas Temperature Too High
P0488	EGR Throttle Position Control Range/Perf	P2429	Exhaust Gas Temperature Too High

[8] Includes heated catalyst DTCs, although none were present in the data analyzed for this study.

Table B-4. O_2 System DTCs[9]

DTC	DTC Description	DTC	DTC Description
P0030	HO2S Heater Control Circuit	P0166	O2 Sensor Circuit No Activity Detected
P0031	HO2S Heater Control Circuit Low	P0167	O2 Sensor Heater Circuit
P0032	HO2S Heater Control Circuit High	P2195	O2 Sensor Signal Stuck Lean
P0036	HO2S Heater Control Circuit	P2196	O2 Sensor Signal Stuck Rich
P0037	HO2S Heater Control Circuit Low	P2197	O2 Sensor Signal Stuck Lean
P0038	HO2S Heater Control Circuit High	P2198	O2 Sensor Signal Stuck Rich
P0040	O2 Sensor Signals Swapped B1 S1/ B2 S1	P2231	O2 Sensor Signal Circuit Shorted to Heater Circuit
P0041	O2 Sensor Signals Swapped B1 S2/ B2 S2	P2232	O2 Sensor Signal Circuit Shorted to Heater Circuit
P0042	HO2S Heater Control Circuit	P2233	O2 Sensor Signal Circuit Shorted to Heater Circuit
P0043	HO2S Heater Control Circuit Low	P2234	O2 Sensor Signal Circuit Shorted to Heater Circuit
P0044	HO2S Heater Control Circuit High	P2235	O2 Sensor Signal Circuit Shorted to Heater Circuit
P0050	HO2S Heater Control Circuit	P2236	O2 Sensor Signal Circuit Shorted to Heater Circuit
P0051	HO2S Heater Control Circuit Low	P2237	O2 Sensor Positive Current Control Circuit/Open
P0052	HO2S Heater Control Circuit High	P2238	O2 Sensor Positive Current Control Circuit Low
P0053	HO2S Heater Resistance	P2239	O2 Sensor Positive Current Control Circuit High
P0054	HO2S Heater Resistance	P2240	O2 Sensor Positive Current Control Circuit/Open
P0055	HO2S Heater Resistance	P2241	O2 Sensor Positive Current Control Circuit Low
P0056	HO2S Heater Control Circuit	P2242	O2 Sensor Positive Current Control Circuit High
P0057	HO2S Heater Control Circuit Low	P2243	O2 Sensor Reference Voltage Circuit/Open
P0058	HO2S Heater Control Circuit High	P2244	O2 Sensor Reference Voltage Performance
P0059	HO2S Heater Resistance	P2245	O2 Sensor Reference Voltage Circuit Low
P0060	HO2S Heater Resistance	P2246	O2 Sensor Reference Voltage Circuit High
P0061	HO2S Heater Resistance	P2247	O2 Sensor Reference Voltage Circuit/Open
P0062	HO2S Heater Control Circuit	P2248	O2 Sensor Reference Voltage Performance
P0063	HO2S Heater Control Circuit Low	P2249	O2 Sensor Reference Voltage Circuit Low
P0064	HO2S Heater Control Circuit High	P2250	O2 Sensor Reference Voltage Circuit High
P0130	O2 Sensor Circuit	P2251	O2 Sensor Negative Current Control Circuit/Open
P0131	O2 Sensor Circuit Low Voltage	P2252	O2 Sensor Negative Current Control Circuit Low`
P0132	O2 Sensor Circuit High Voltage	P2253	O2 Sensor Negative Current Control Circuit High
P0133	O2 Sensor Circuit Slow Response	P2254	O2 Sensor Negative Current Control Circuit/Open
P0134	O2 Sensor Circuit No Activity Detected	P2255	O2 Sensor Negative Current Control Circuit Low
P0135	O2 Sensor Heater Circuit	P2256	O2 Sensor Negative Current Control Circuit High
P0136	O2 Sensor Circuit	P2270	O2 Sensor Signal Stuck Lean
P0137	O2 Sensor Circuit Low Voltage	P2271	O2 Sensor Signal Stuck Rich
P0138	O2 Sensor Circuit High Voltage	P2272	O2 Sensor Signal Stuck Lean
P0139	O2 Sensor Circuit Slow Response	P2273	O2 Sensor Signal Stuck Rich
P0140	O2 Sensor Circuit No Activity Detected	P2274	O2 Sensor Signal Stuck Lean
P0141	O2 Sensor Heater Circuit	P2275	O2 Sensor Signal Stuck Rich
P0142	O2 Sensor Circuit	P2276	O2 Sensor Signal Stuck Lean
P0143	O2 Sensor Circuit Low Voltage	P2277	O2 Sensor Signal Stuck Rich
P0144	O2 Sensor Circuit High Voltage	P2278	O2 Sensor Signals Swapped B1 S3 / B2 S3
P0145	O2 Sensor Circuit Slow Response	P2297	O2 Sensor Out of Range During Deceleration
P0146	O2 Sensor Circuit No Activity Detected	P2298	O2 Sensor Out of Range During Deceleration
P0147	O2 Sensor Heater Circuit	P2414	O2 Sensor Exhaust Sample Error
P0150	O2 Sensor Circuit	P2415	O2 Sensor Exhaust Sample Error
P0151	O2 Sensor Circuit Low Voltage	P2416	O2 Sensor Signals Swapped B1 S2 / B1 S3

[9] Includes oxygen sensor and oxygen sensor heater.

DTC	DTC Description	DTC	DTC Description
P0152	O2 Sensor Circuit High Voltage	P2417	O2 Sensor Signals Swapped B2 S2 / B2 S3
P0153	O2 Sensor Circuit Slow Response	P2626	O2 Sensor Pumping Current Trim Circuit/Open
P0154	O2 Sensor Circuit No Activity Detected	P2627	O2 Sensor Pumping Current Trim Circuit Low
P0155	O2 Sensor Heater Circuit	P2628	O2 Sensor Pumping Current Trim Circuit High
P0156	O2 Sensor Circuit	P2629	O2 Sensor Pumping Current Trim Circuit/Open
P0157	O2 Sensor Circuit Low Voltage	P2630	O2 Sensor Pumping Current Trim Circuit Low
P0158	O2 Sensor Circuit High Voltage	P2631	O2 Sensor Pumping Current Trim Circuit High
P0159	O2 Sensor Circuit Slow Response	P2A00	O2 Sensor Circuit Range/Performance
P0160	O2 Sensor Circuit No Activity Detected	P2A01	O2 Sensor Circuit Range/Performance
P0161	O2 Sensor Heater Circuit	P2A02	O2 Sensor Circuit Range/Performance
P0162	O2 Sensor Circuit	P2A03	O2 Sensor Circuit Range/Performance
P0163	O2 Sensor Circuit Low Voltage	P2A04	O2 Sensor Circuit Range/Performance
P0164	O2 Sensor Circuit High Voltage	P2A05	O2 Sensor Circuit Range/Performance
P0165	O2 Sensor Circuit Slow Response		

Table B-5. Secondary Air Intake System DTCs

DTC	DTC Description	DTC	DTC Description
P0410	Secondary Air Injection System	P2431	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Range/Performance
P0411	Secondary Air Injection System Incorrect Flow Detected	P2432	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Low
P0412	Secondary Air Injection System Switching Valve "A" Circuit	P2433	Secondary Air Injection System Air Flow/Pressure Sensor Circuit High
P0413	Secondary Air Injection System Switching Valve "A" Circuit Open	P2434	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Intermittent/Erratic
P0414	Secondary Air Injection System Switching Valve "A" Circuit Shorted	P2435	Secondary Air Injection System Air Flow/Pressure Sensor Circuit
P0415	Secondary Air Injection System Switching Valve "B" Circuit	P2436	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Range/Performance
P0416	Secondary Air Injection System Switching Valve "B" Circuit Open	P2437	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Low
P0417	Secondary Air Injection System Switching Valve "B" Circuit Shorted	P2438	Secondary Air Injection System Air Flow/Pressure Sensor Circuit High
P0418	Secondary Air Injection System Control "A" Circuit	P2439	Secondary Air Injection System Air Flow/Pressure Sensor Circuit Intermittent/Erratic
P0419	Secondary Air Injection System Control "B" Circuit	P2440	Secondary Air Injection System Switching Valve Stuck Open
P0491	Secondary Air Injection System Insufficient Flow	P2441	Secondary Air Injection System Switching Valve Stuck Closed
P0492	Secondary Air Injection System Insufficient Flow	P2442	Secondary Air Injection System Switching Valve Stuck Open
P2257	Secondary Air Injection System Control "A" Circuit Low	P2443	Secondary Air Injection System Switching Valve Stuck Closed
P2258	Secondary Air Injection System Control "A" Circuit High	P2444	Secondary Air Injection System Pump Stuck On
P2259	Secondary Air Injection System Control "B" Circuit Low	P2445	Secondary Air Injection System Pump Stuck Off
P2260	Secondary Air Injection System Control "B" Circuit High	P2446	Secondary Air Injection System Pump Stuck On
P2430	Secondary Air Injection System Air Flow/Pressure Sensor Circuit	P2447	Secondary Air Injection System Pump Stuck Off