



STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION



November 16, 2006

Mr. David Conroy
EPA New England, Region 1
1 Congress Street, Suite 1100
Boston MA 02114-2023

Dear Mr. Conroy:

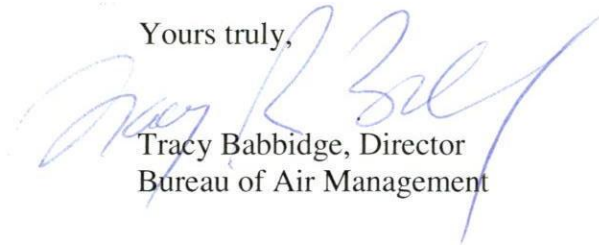
The enclosed report, "Evaluation of Test Data Collected in 2004 and 2005 from Connecticut's Inspection/Maintenance Program," dated October 2006, is being provided to satisfy the United States Environmental Protection Agency's (EPA) reporting requirements for the vehicle inspection and maintenance (I/M) program, pursuant to the Code of Federal Regulations, 40 CFR Part 51.

The Connecticut Department of Environmental Protection (DEP) evaluated data collected from the I/M program from November 11, 2004 to November 10, 2005. This timeframe coincides with the restart of the program following resolution of initial start-up issues. The evaluation focuses on Connecticut's transition to a decentralized program and OBDII testing for 1996 and newer vehicles, and assuring compliance with testing requirements by the decentralized test facilities.

We appreciate EPA's efforts to partner with us in ensuring a smooth program transition and would ask for your assistance and leadership in updating EPA's national list of vehicles in Appendix D to EPA's guidance document *Performing Onboard Diagnostic System Checks as Part of a Vehicle Inspection and Maintenance Program* (June 2001). These vehicles are exempted from the readiness criteria in 40 CFR Section 85.2222. As part of the I/M program evaluation, the DEP, in partnership with the Connecticut Department of Motor Vehicles, has identified additional vehicle models that are not currently exempted from readiness by Appendix D but have high (20% or greater) not ready rates. The EPA readiness exemption list for OBDII testing should be expanded to include at a minimum those vehicles listed in the report.

If you have any questions, please feel free to contact me at 860-424-3027.

Yours truly,



Tracy Babbidge, Director
Bureau of Air Management

TB/wm

Cc: Robert Judge, EPA Region 1

**EVALUATION OF TEST DATA
COLLECTED IN 2004 AND 2005 FROM
CONNECTICUT'S
INSPECTION/MAINTENANCE PROGRAM**

FINAL REPORT

Prepared for:

Connecticut Department of Environmental Protection

Prepared by:

dKC – de la Torre Klausmeier Consulting

October 2006

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Executive Summary

As required by the Clean Air Act Amendments of 1990, the Connecticut Department of Environmental Protection (DEP) in partnership with the Connecticut Department of Motor Vehicles (DMV) conducts periodic evaluations of its enhanced inspection/maintenance program. The 1st evaluation was completed in 2001; it analyzed data collected during the 1999 to 2000 time period. The 2nd evaluation was completed in 2003 and utilized data collected during the 2001 to 2002 time period. Both evaluations include comprehensive analysis of failure rates and compliance trends based on emissions test results from all vehicles. The large volume of data on exhaust emissions test results enabled DEP to independently estimate the impact of the program on exhaust emissions.

In 2003, Connecticut implemented a new I/M program. Unlike the previous centralized program where vehicles were tested in approximately 20 centrally located stations, in the new program vehicles are tested in a decentralized network of 300 inspection stations. In addition, in the new program, 1996 and newer vehicles receive OBDII tests which involve checks of the onboard diagnostic (OBD) system to determine if the vehicle complies with emission standards. Previously, 1996 and newer models as well as pre-1996 models received tailpipe emissions tests.

Using data collected from November 11, 2004 to November 10, 2005, DEP evaluated the new I/M program. In addition to providing analyses included in the previous two evaluations, this analysis focuses on items that were changed when the new program was implemented, particularly the following:

- The switch from tailpipe testing to OBDII testing for 1996 and newer vehicles; and
- The use of 300 private test facilities instead of 20 centralized test facilities.

Evaluating OBDII test results presents special challenges since tailpipe emission results are not available for each vehicle. The methodology for

this evaluation has instead, utilized data on different inspection components to determine if the appropriate number of vehicles are being failed and repaired. This approach is consistent with the purpose of OBDII system, since it assures that Connecticut is identifying and requiring the repair of vehicles that exceed design emission standards by more than 50%. As a further check on the integrity of the OBDII inspection, the analysis correlates emission readings from remote sensing devices with OBDII inspection results. This helps to determine if many high emitting vehicles are passing their OBDII inspection.

Evaluating the switch to decentralized inspections requires a comprehensive assessment of how well stations comply with mandated inspection procedures. Generally, there are greater opportunities for fraud in decentralized facilities, because there are more stations that need policing. Using data and procedures provided by the DMV, DEP assessed enforcement of the new program.

Following are the key findings of this study:

- ❖ Connecticut is failing the expected fraction of vehicles because they have evidence of being high emitters. Overall, 103,000 vehicles failed the their initial inspection. This equates to 9% of the vehicles tested. Failure rates for the OBDII test in Connecticut are equal or higher than failure rates recorded on OBDII tests conducted in centralized I/M programs.
- ❖ Connecticut conducts program evaluation tests where 0.5% of the vehicles being inspected receive on-road (remote sensing) tests. The purpose of these tests is to evaluate different components of Connecticut's I/M program. Comparing remote sensing data with corresponding OBDII test results shows that vehicles failing the OBDII test have higher emissions levels than vehicles that pass the OBDII test. This demonstrates OBDII tests identify vehicles with high emissions even though they do not directly measure emissions.
- ❖ In the 2004 to 2005 period, 99% of the vehicles tested complied with I/M program requirements. Connecticut's program requires vehicles

to pass I/M before they can be registered. This method of compliance enforcement was implemented with the new program; previously, compliance with the I/M test was enforced through the use of window stickers. Registration denial is the most effective way of ensuring compliance with the program by not allowing vehicles that do not pass or receive a waiver from legally being registered in Connecticut.

- ❖ DMV performs extensive quality assurance checks on Connecticut's Decentralized Analyzer Systems (CDAS). DMV also performs extensive anti-fraud checks, and routinely terminates stations that perform questionable tests. The program appears to have little fraud.

DEP and DMV will continue to evaluate Connecticut's I/M program as it evolves. Currently, 65% of the vehicles receive OBDII inspections. This percentage increases each year as old vehicles without OBDII systems are dropped from the program and new vehicles with OBDII systems are added. By 2010, when the contract for the current I/M contractor ends, about 95% of the vehicles in the program will receive OBDII tests. DEP and DMV will be collecting data for future evaluations that will allow estimates to be made on the cost-effectiveness of alternative I/M options. Future evaluations will include consideration of innovative inspection strategies that have emerged and are in use by other states to improve customer convenience and likely lower inspection costs.

1.0 Introduction

In 1983, the State of Connecticut implemented an inspection/maintenance (I/M) program. In an I/M program, vehicles are periodically inspected, and those with evidence that they exceed design emission standards must be repaired. I/M programs were mandated under the Clean Air Act in areas such as Connecticut that were designated as serious or severe non-attainment for ozone. Connecticut's I/M program identifies vehicles that have been tampered or have received improper maintenance. These vehicles must be repaired until they comply with emission standards. The Connecticut Department of Motor Vehicles (DMV) manages the I/M program; the Connecticut Department of Environmental Protection (DEP) ensures that the program achieves the air quality benefits as outlined in Connecticut's State Implementation Plan (SIP).

The original program implemented in 1983 subjected vehicles to two inspections – an idle test where exhaust concentrations of hydrocarbons (HC) and carbon monoxide (CO) were measured while the vehicle was idling and a visual inspection for the presence of emission control devices, such as the catalytic converter. In 1998, Connecticut substantially enhanced its existing I/M program to meet new SIP requirements. The emission test was changed from an unloaded idle emission test to a loaded-mode test (ASM2525). With this change, Connecticut began evaluating emissions of oxides of nitrogen¹ (NO_x) along with HC and CO. A loaded-mode test uses a chassis dynamometer to simulate on-road driving. If the vehicle could not be safely tested on a dynamometer, it received a pre-conditioned two-speed idle (PCTSI) test. In addition, the inspection included a gas cap pressure test to check to see if the gas cap holds pressure. Leaking gas caps are a major source of evaporative HC emissions. The inspection continued to include a visual emission control component check.

In 2003, DMV again made substantial revisions to the program. In response to an RFP for a new emissions test system, the inspection network was changed from a centralized system with about 30 inspection

¹ Nitric oxide (NO) is measured as a surrogate for oxides of nitrogen (NO_x)

stations to a decentralized system with about 300 stations. In addition, 1996 and newer models started receiving OBDII inspections², instead of ASM2525 tests. All 1996 and later model year light-duty vehicles sold in the U.S. contain the second generation of on-board diagnostic equipment (OBDII). OBDII systems monitor all components that make up the engine management and emission control systems. They can detect malfunctions or deterioration of these components, often well before the motorist becomes aware of any problem. Inspecting vehicles by reading the OBDII system codes can identify vehicles with serious emission control malfunctions more accurately and cost-effectively than traditional tailpipe tests, and help technicians diagnose and repair them. In the new program, diesel powered vehicles less than 10,000 lbs GVW receive tests for excessive exhaust smoke, if they cannot receive OBD tests.

dKC analyzed data collected from the new I/M program. The analysis concentrates on data collected since November 11, 2004. This was the date the program was restarted after some initial start-up problems were corrected. The primary goal of this analysis is to generate EPA required reports. Another goal is to evaluate issues that are relevant to the new program, particularly OBDII tests and enforcement of the decentralized inspection network.

2 1997 and newer light-duty diesels (<8500 lbs GVW) also get OBD inspections.

2.0 Observed Failure Rates for Gasoline Powered Vehicles

Failure rates for gasoline powered vehicles were calculated using test results from I/M test stations. Below is a brief description of the criteria used to determine if a vehicle passes or fails inspection.

Pass Fail Criteria

ASM2525 or Pre-Conditioned Two-Speed Idle (PCTSI) Inspection (pre-1996 vehicles): Vehicles fail if they exceed Connecticut's cutpoints (emissions standards). For the ASM2525 test, HC, CO and NOx emissions are evaluated. For the PCTSI test, HC and CO emissions are evaluated. A vehicle fails if it exceeds cutpoints. Connecticut uses cutpoints recommended by EPA.

Gas Cap Test: Vehicles fail if their gas cap cannot hold pressure. Beginning in November 2004, only pre-1996 light-duty vehicles receive gas cap tests. The OBDII system adequately tests the gas cap on most 1996 and newer vehicles.

OBDII Inspection: 1996 and newer light-duty vehicles get an OBDII inspection. The emissions test system is plugged into the OBDII connector and information on the status of the vehicle's OBD system is downloaded. Vehicles fail the OBDII inspection if they have the following problems:

- Malfunction Indicator Lamp (MIL)³ is commanded-on
- MIL not working (Termed Key-On Engine-Off, KOEO, failure⁴)
- OBD diagnostic link connector damaged

During this time period, vehicles that exceeded EPA's limits on the numbers of monitors that can be not ready were defaulted to the appropriate tailpipe test (ASM2525 or PCTSI). Vehicles that failed to communicate with Connecticut's test equipment also received tailpipe tests.

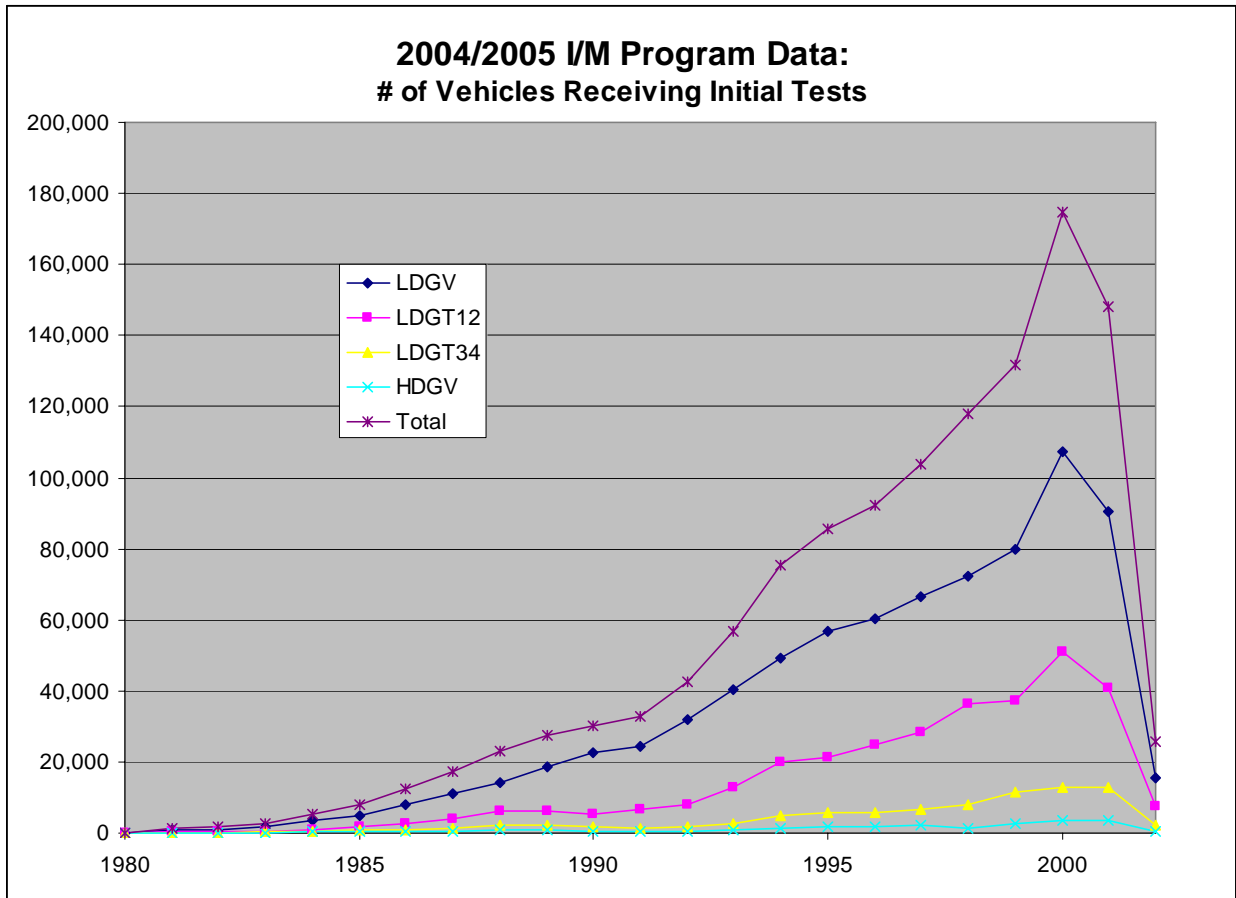
³ MIL is a term used for the light on the instrument panel, which notifies the vehicle operator of an emission related problem. The MIL is required to display the phrase "check engine" or "service engine soon" or the ISO engine symbol. The MIL is required to illuminate when a problem has been identified that could cause emissions to exceed a specific multiple of the standards the vehicle was certified to meet.

⁴ The Key-On Engine-Off (KOEO) determines if the MIL bulb is working. The bulb should illuminate when the vehicle is turned on but not started.

Summary of Fail Rates

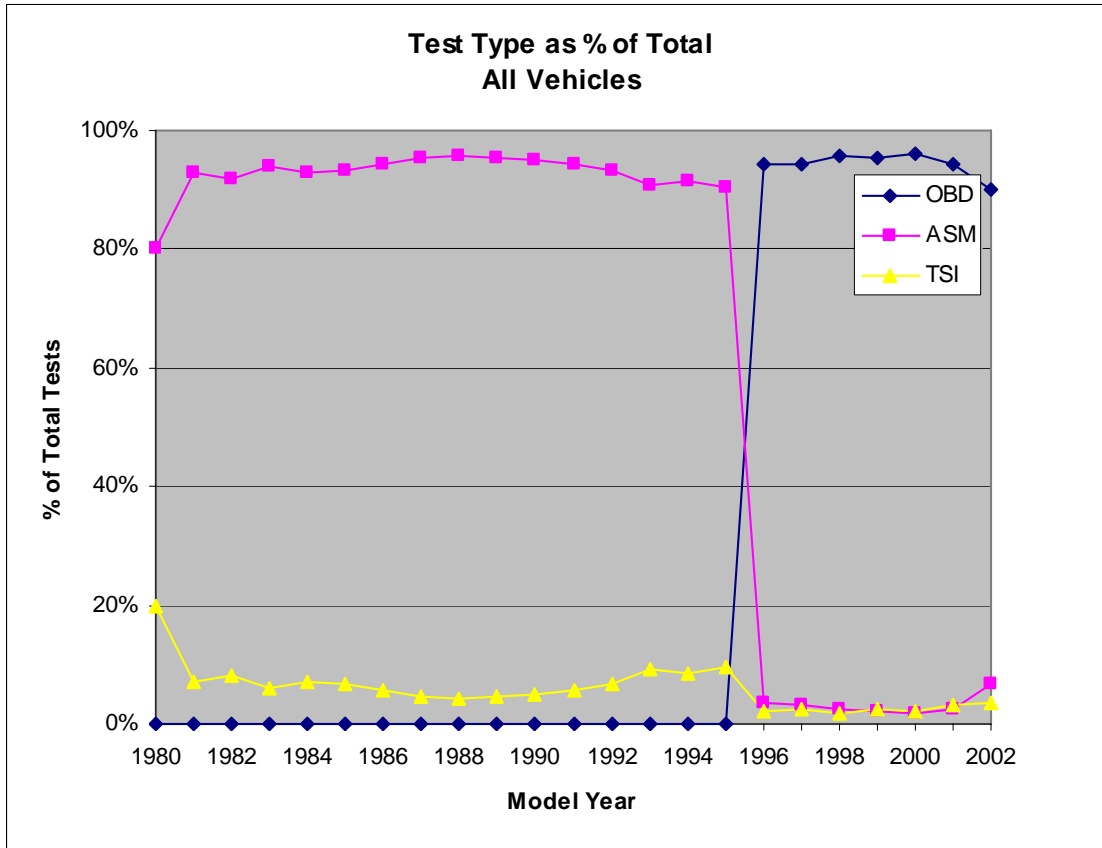
Following is a summary of test results for the November 11, 2004 to November 10, 2005 period. During this period 1,191,716 gasoline powered vehicles received initial tests.

- Overall, 102,905 vehicles (8.6%) failed the initial inspection.
 - 16.5% of the vehicles failed their first retest.
 - Vehicles can fail for more than one reason.
- 27,721 (6.7%) vehicles failed the ASM2525 test.
 - 35.8% of the vehicles failed the first ASM2525 retest.
- 3,512 (7.0%) vehicles failed the PCTSI test.
 - 34.2% of the vehicles failed the first PCTSI retest.
- 20,587 (1.7%) vehicles failed the gas cap test.
 - 3.8% of the vehicles failed the first gas cap retest.
- 52,324 (6.9%) vehicles failed the OBD test.
 - 6.0% of the vehicles failed the test because the MIL was commanded-on.
 - 0.5% of the vehicles failed the test because the MIL bulb was not working.
 - 10.5% of the vehicles failed the first OBD retest.
- As of 12/31/04 fleets are allowed to self inspect, if they purchase required test equipment. Since 12/31/04, 32 Fleet Operators completed 2,002 initial inspections (OBD & PCTSI). OBDII fail rates were 3.66%; PCTSI fail rates were 4.22%.

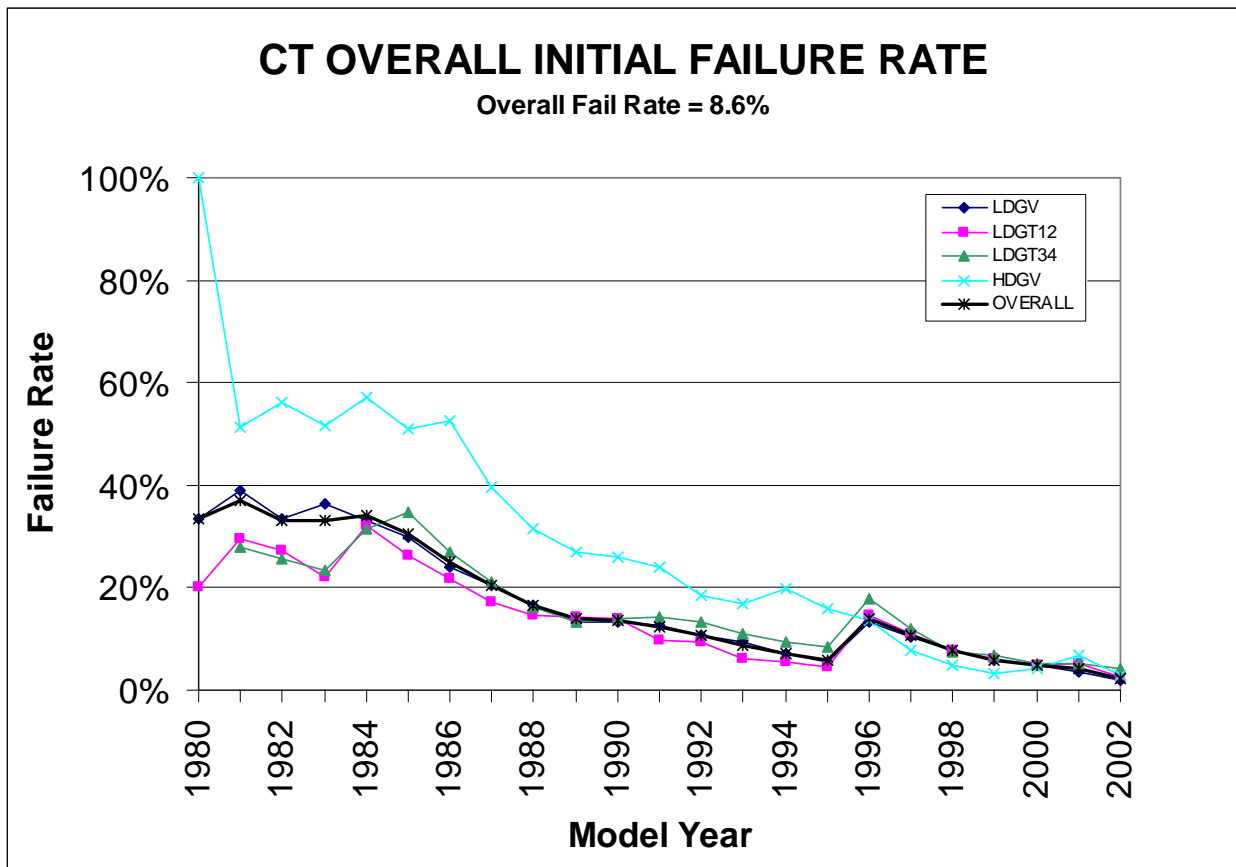


This chart shows the total number of inspections by model year and vehicle type. The 1st four model years are exempted from testing, so the number drops sharply after 2001.

**LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks
 HDGV = Heavy-duty gasoline powered vehicles**

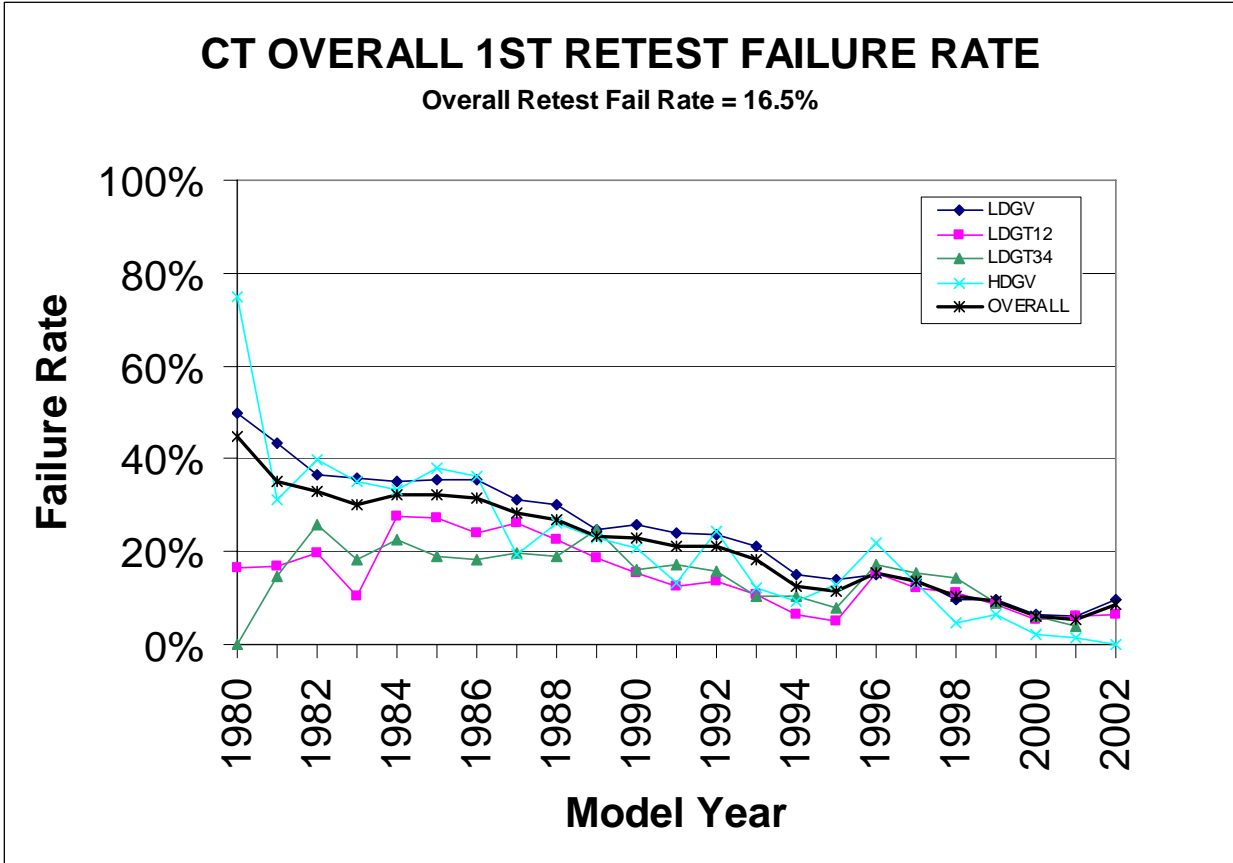


This chart shows the total number of inspections by model year and final inspection type. Most 1996+ vehicles received OBDII tests. Because of provisions to perform back-up tailpipe tests on vehicles that were not ready or failed to communicate with test system, some 1996+ vehicles received tailpipe tests. Also, a small fraction (2%) of the vehicles were heavy-duty models without OBD systems.



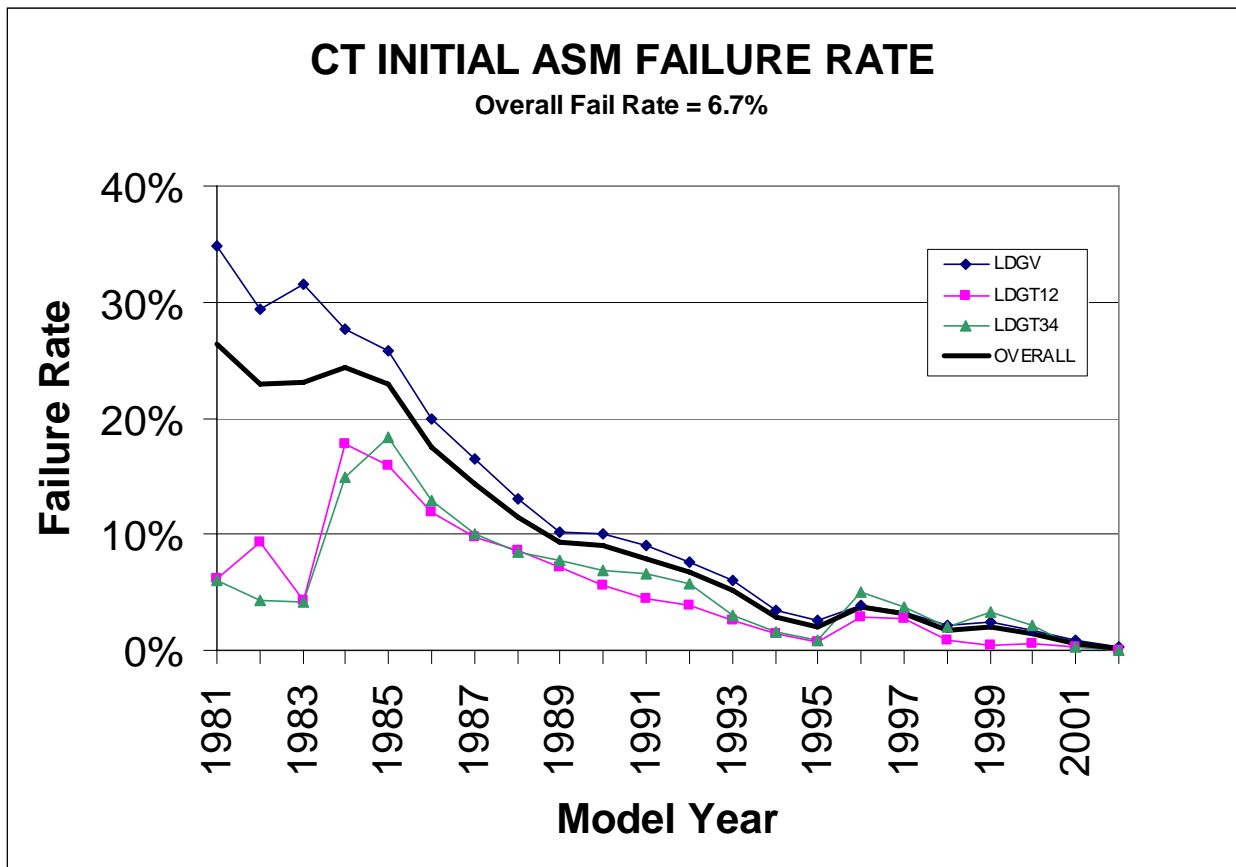
This chart shows the overall percent of vehicles that fail the tailpipe test, gas cap test, visual emission control component inspection, or the OBD test. Some vehicles fail more than one inspection component. As expected, the failure rate is lowest for new vehicles. The failure rate for light-duty cars and trucks spikes up for 1996 model year vehicles, due to implementation of the OBDII test. Compliance with the OBDII test is considered to be more difficult than compliance with the ASM2525 or PCTSI test.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks
 HDGV = Heavy-duty gasoline powered vehicles



This chart shows the percent of vehicles by model year that fail their first retest. The fail rate is highest for the older vehicles. Overall, 16.5% of the vehicles pass the first retest. As with the initial test failure rate, the retest failure rate spikes up for the 1996 model year.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks
 HDGV = Heavy-duty gasoline powered vehicles

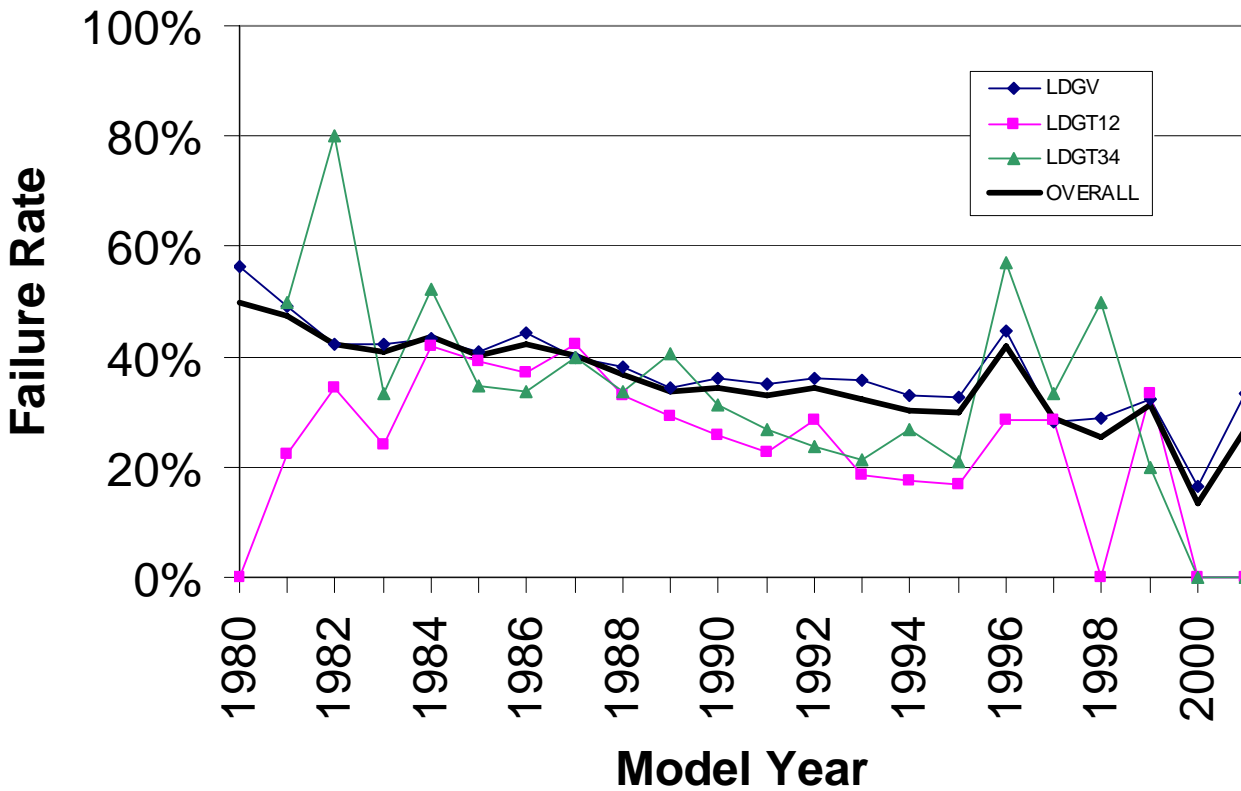


This chart shows failure rates by model year for the ASM2525 test. The average ASM2525 test failure rate for all vehicles was 6.7%. Typically, you expect a higher failure rate for older model year vehicles. The increase in 1996 corresponds with a major tightening of ASM2525 standards. Note: 1996 and newer vehicles received ASM2525 (or PCTSI) tests only if they were not ready or could not communicate with Connecticut's OBDII test system.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks
 HDGV = Heavy-duty gasoline powered vehicles

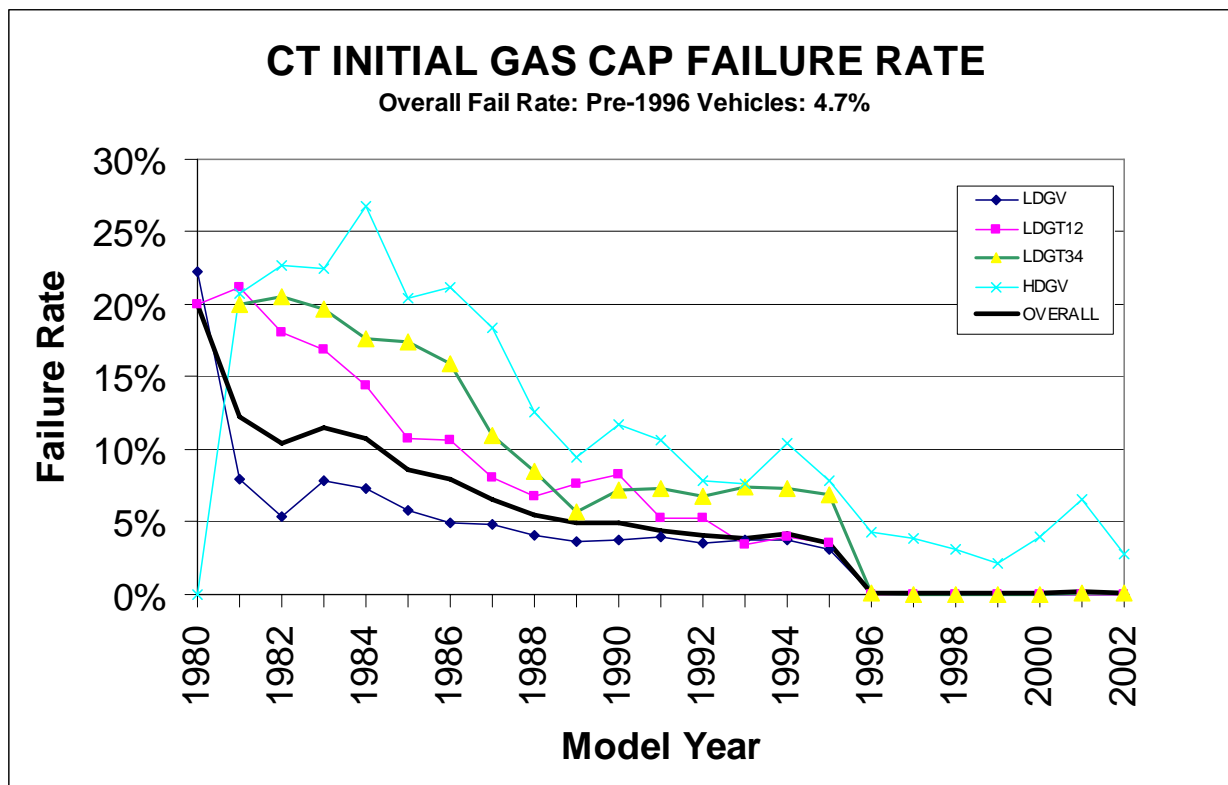
CT 1ST RETEST ASM FAILURE RATE

Overall Fail Rate = 35.8%



This chart shows the percent of vehicles by model year that fail their first ASM2525 retest. The retest fail rate is highest for the older vehicles. Overall, 35.8% of the vehicles fail the first ASM2525 retest. It appears that many vehicles are receiving inadequate diagnosis of the problem(s) causing high emissions.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
LDGT(12&34) = Light-duty gasoline powered trucks

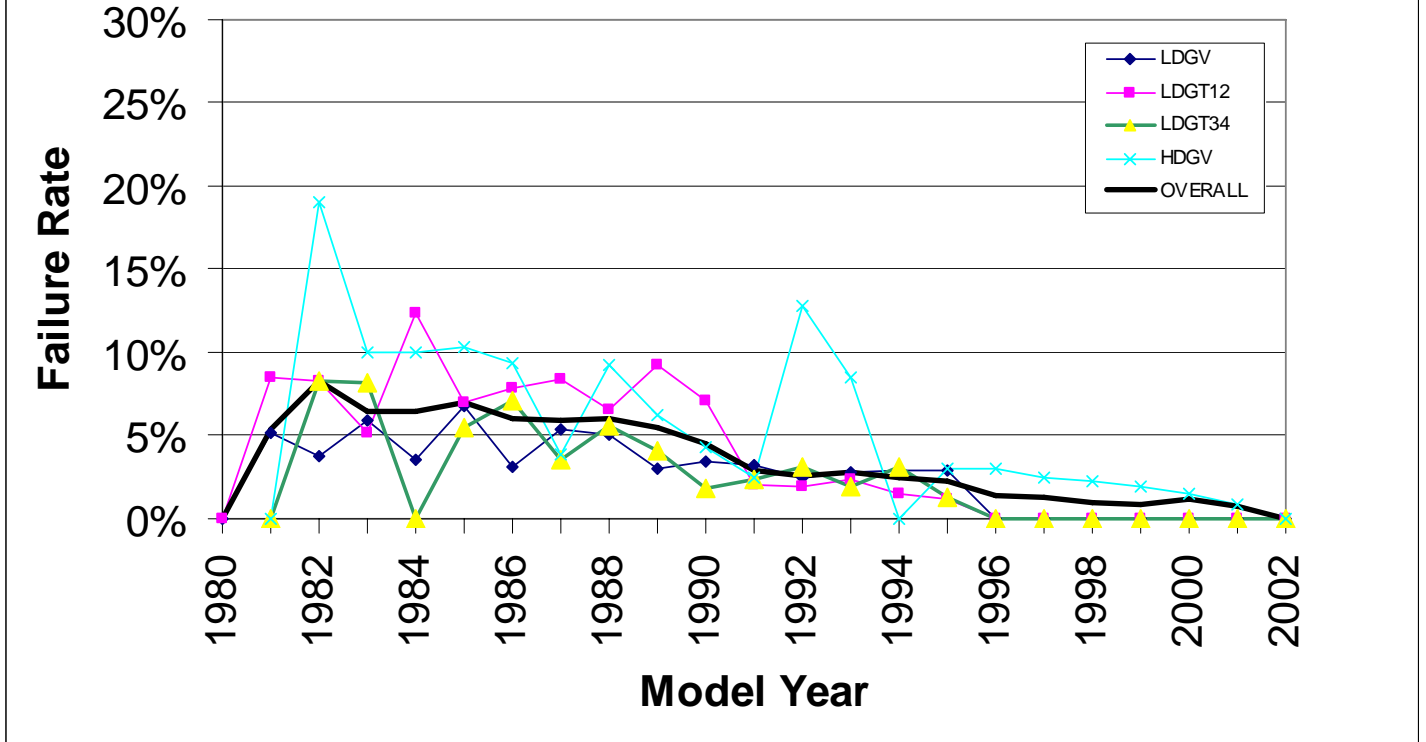


This chart shows the gas cap pressure test failure rate by model year. As with the ASM2525 test, the failure rate is higher for older vehicles. Note: 1996 and newer light-duty vehicles no longer receive gas cap tests.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks
 HDGV = Heavy-duty gasoline powered vehicles

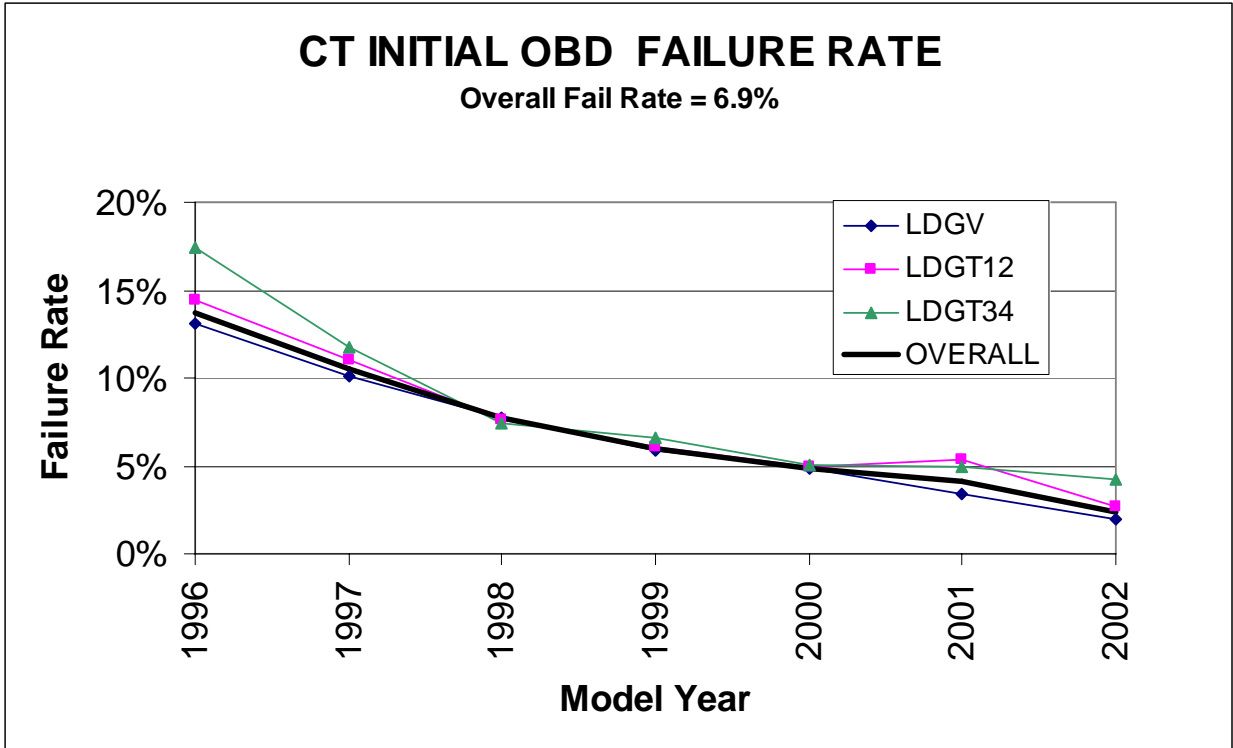
CT 1ST RETEST GAS CAP FAILURE RATE

Overall Average = 3.7%



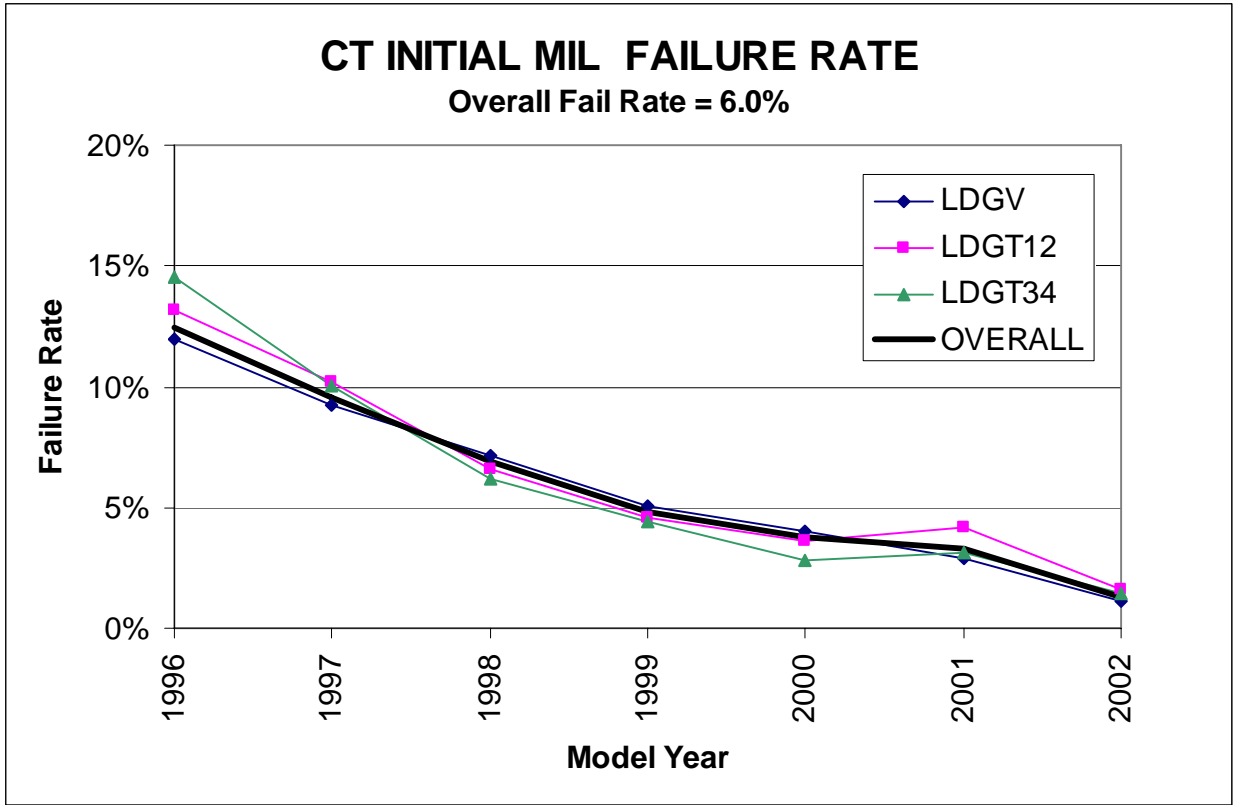
This chart shows the gas cap retest fail rate by model year. Overall, 4% of the vehicles fail the first gas cap retest.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
LDGT(12&34) = Light-duty gasoline powered trucks



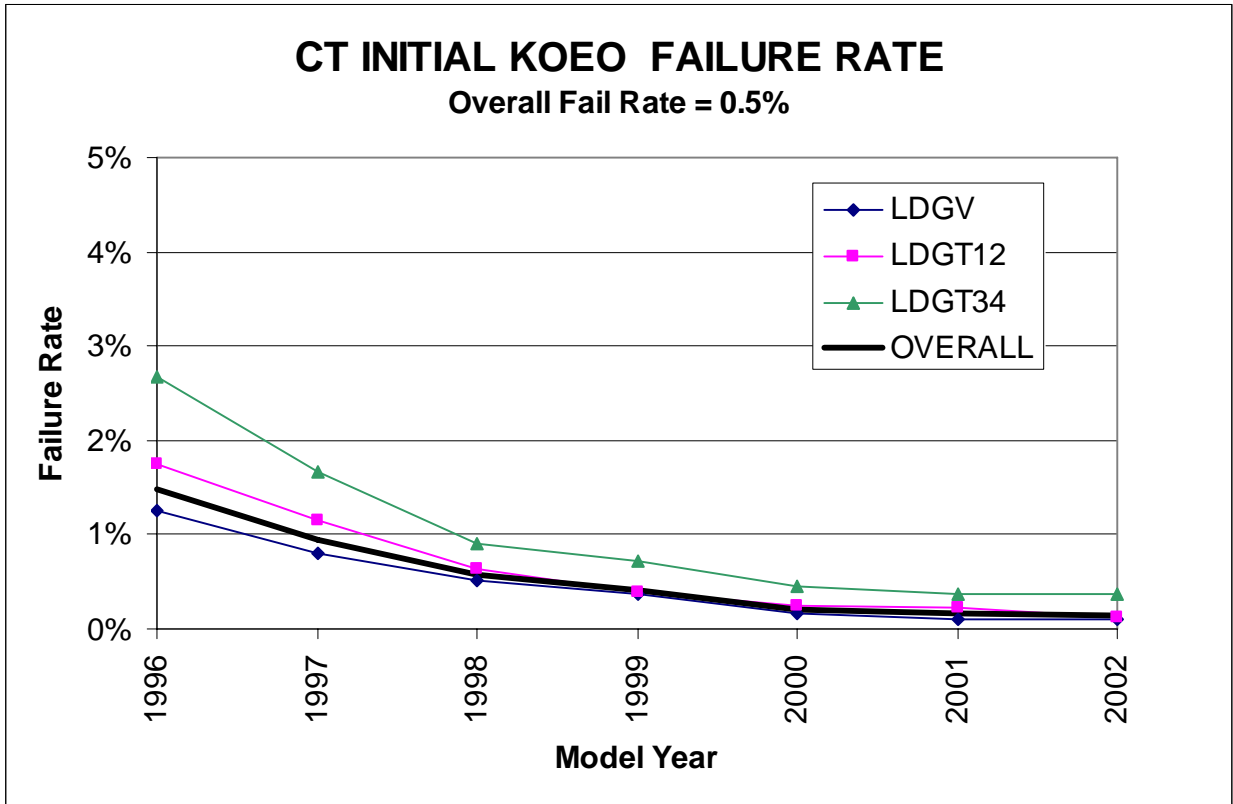
This chart shows failure rates by model year for the OBD test. The average OBD test failure rate for all vehicles was 6.9%. Typically, you expect a higher failure rate for older model year vehicles. 14% of the 1996 model year vehicles fail the test vs. 2% of the 2002 models.

**LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks**



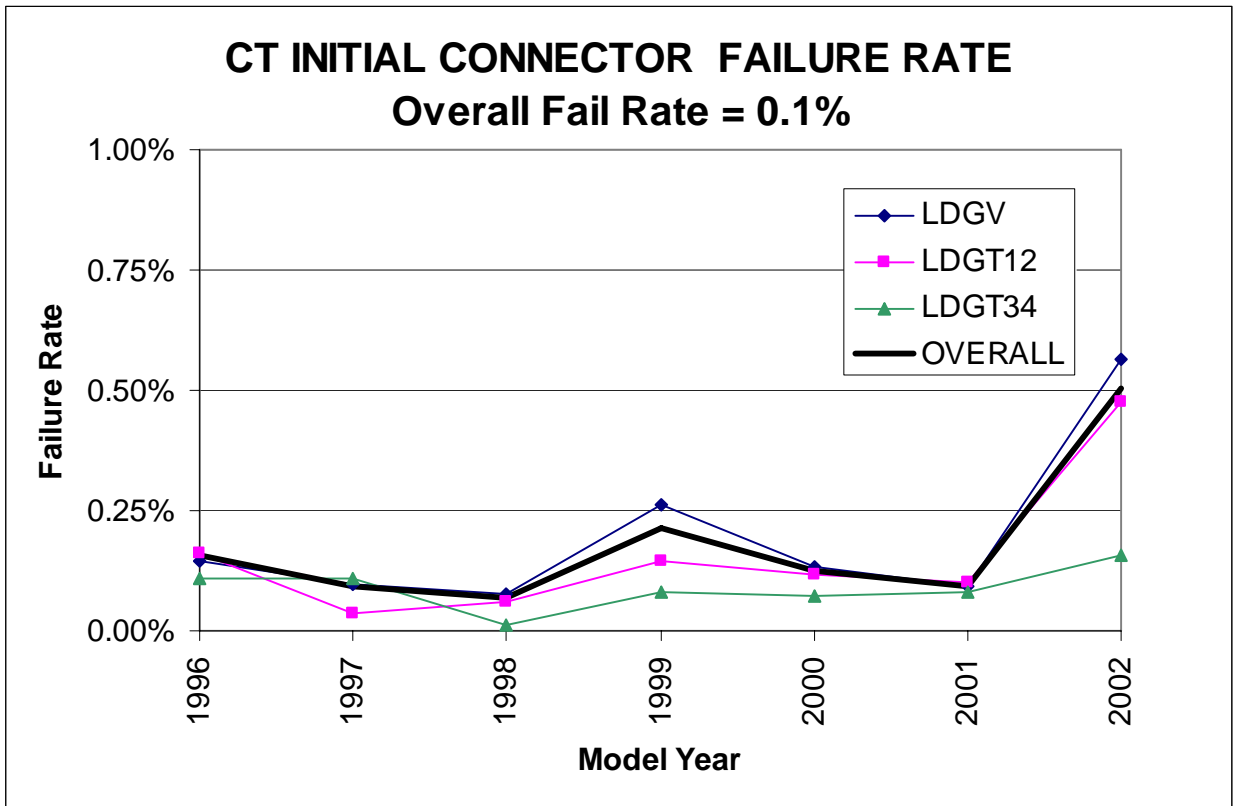
This chart shows the % of vehicles that fail the MIL-Command check that's part of the OBD test. Most OBDII failures are for the MIL command check. The average MIL failure rate for all vehicles was 6.1%. This graph shows that older vehicles have a higher failure rate, as expected.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks



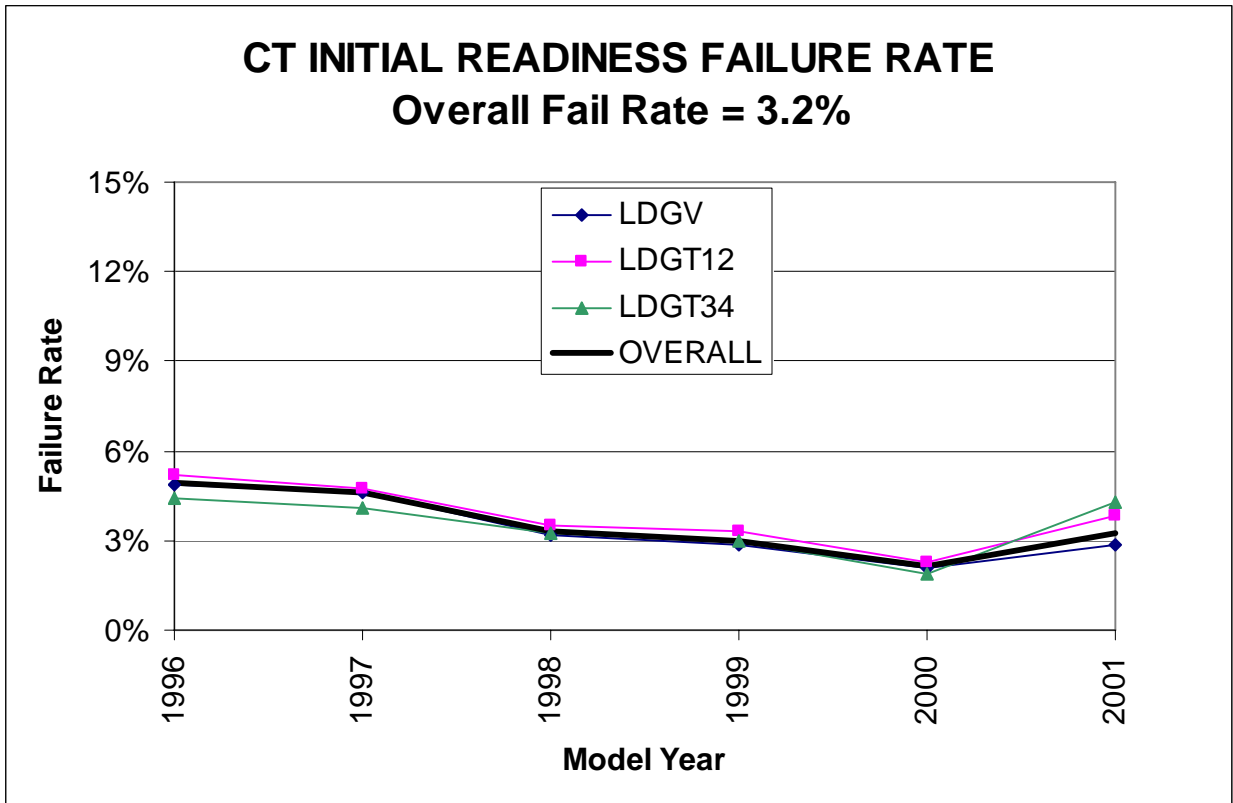
This chart shows failure rates by model year for the Key-On Engine Off (KOEO) test, which is part of the OBD test. The average KOEO failure rate for all vehicles was 0.5%. The Key-On Engine-Off (KOEO) determines if the MIL bulb is working. The bulb should illuminate when the vehicle is turned on but not started.

LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks

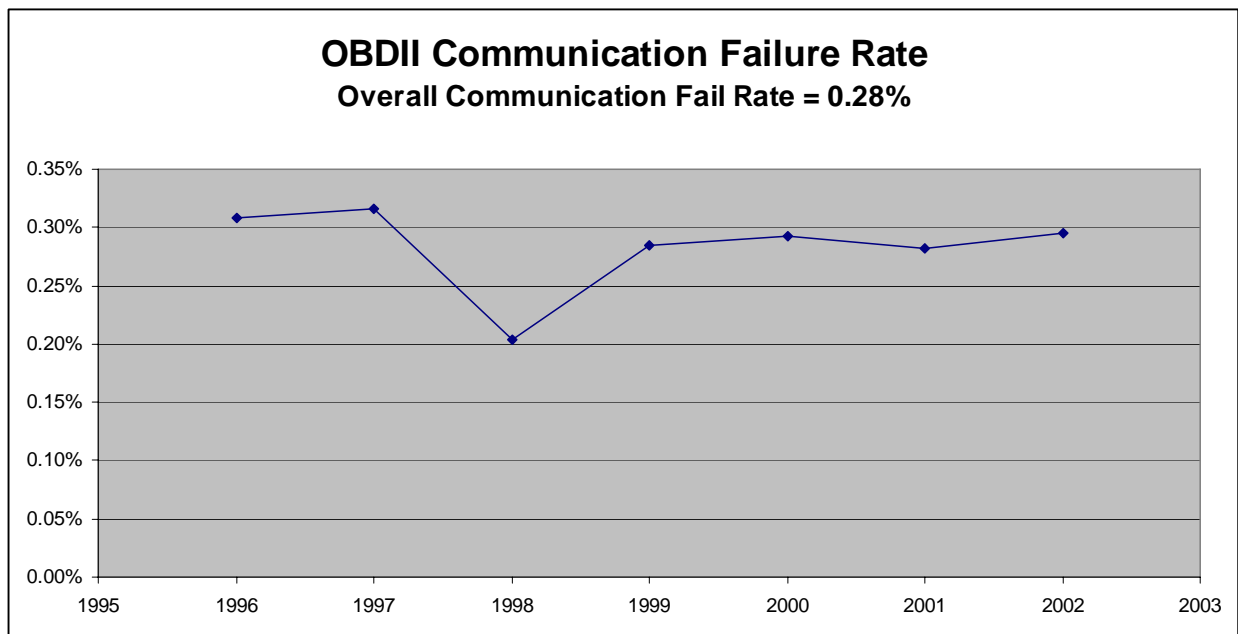


This chart shows the % of vehicles that fail because the OBDII connector (termed DLC) is missing or damaged. Overall, 0.1% of the vehicles fail for this reason.

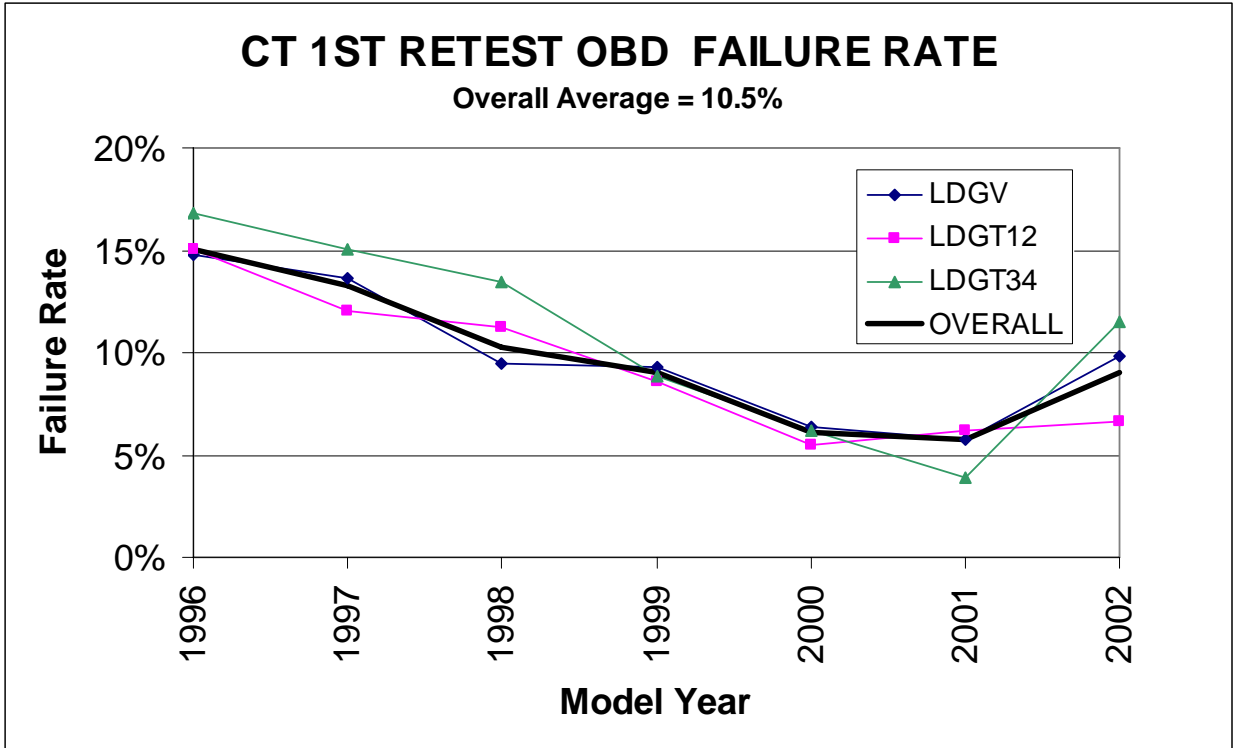
**LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks**



This chart shows the % of vehicles that exceed EPA’s readiness criteria. OBDII systems have up to 11 diagnostic monitors. Diagnostic monitors are periodic tests run on specific systems and components to ensure that they are performing within their prescribed range. OBDII systems must indicate whether or not the onboard diagnostic system has monitored each component. Components that have been diagnosed are termed “ready”, meaning they were tested by the OBDII system. During the time period these data were collected, vehicles that were not ready receive tailpipe emissions tests, if they pass all other OBDII inspection criteria. Overall, 3.2% of the vehicles fail EPA’s readiness criteria.



This chart shows the % of vehicles that fail to communicate with the OBDII test equipment. Overall, 0.3% of the vehicles fail for this reason. Currently, vehicles that fail to communicate with the test equipment receive tailpipe emissions tests, if they pass all other OBDII inspection criteria.



This chart shows failure rates by model year for the first OBD retest. The average failure rate for all vehicles in the first OBD retest was 10.5%. Note that Connecticut requires OBD failures to meet readiness requirements when retested. The fall-back tailpipe test for vehicles that are not ready is not an option for retests. If a vehicle does not meet readiness requirements when retested, the inspection is aborted. Vehicles that are not ready on retest are not included in the above fail percentage.

**LDGV = Light-duty gasoline powered vehicles (Passenger Cars)
 LDGT(12&34) = Light-duty gasoline powered trucks**

3.0 Observed Failure Rates for Diesel Powered Vehicles

Diesel powered vehicles less than 10,000 lbs GVW also are tested in Connecticut. If the vehicle is equipped with an OBDII system, an OBDII test is performed. Otherwise the vehicle receives a test for excessive exhaust smoke opacity.

Failure rates for diesel powered vehicles were calculated using test results from I/M test stations. Below is a brief description of the criteria used to determine if a vehicle passes or fails inspection.

Pass Fail Criteria

Loaded Mode Diesel (LMD) Test: Test using a dynamometer to simulate driving at 30 mph. Exhaust smoke opacity is measured.

Modified Snap Acceleration (MSA) Test: With this test, the throttle is snapped and exhaust smoke opacity is measured. Test is done in “neutral”. The average of 3 snaps is calculated and compared to the standard.

OBDII Inspection: 1997 and newer light-duty diesels get an OBDII inspection. The emissions test system is plugged into the OBDII connector and information on the status of the vehicle’s OBD system is downloaded. Vehicles fail the OBDII inspection if they have the following problems:

- Malfunction Indicator Lamp (MIL) is commanded-on
- MIL not working (Termed Key-On Engine-Off, KOEO, failure)
- OBD diagnostic link connector damaged

Summary of Fail Rates

Following is a summary of test results for the November 11, 2004 to November 10, 2005 period. During this period, 10,669 diesel powered vehicles received opacity tests and an additional 1,832 vehicles received OBD tests.

- 133 (6.0%) vehicles failed the Modified Snap Acceleration (MSA) test.
 - 33% of the vehicles failed the first MSA retest.
- 236 (2.8%) vehicles failed the Loaded Mode Diesel (LMD) test.
 - 29% of the vehicles failed the first MSI retest.
- 223 (12.2%) vehicles failed the OBD test.
 - 9.0% of the vehicles failed the first OBD retest.

4.0 Enforcement of Connecticut's I/M Program

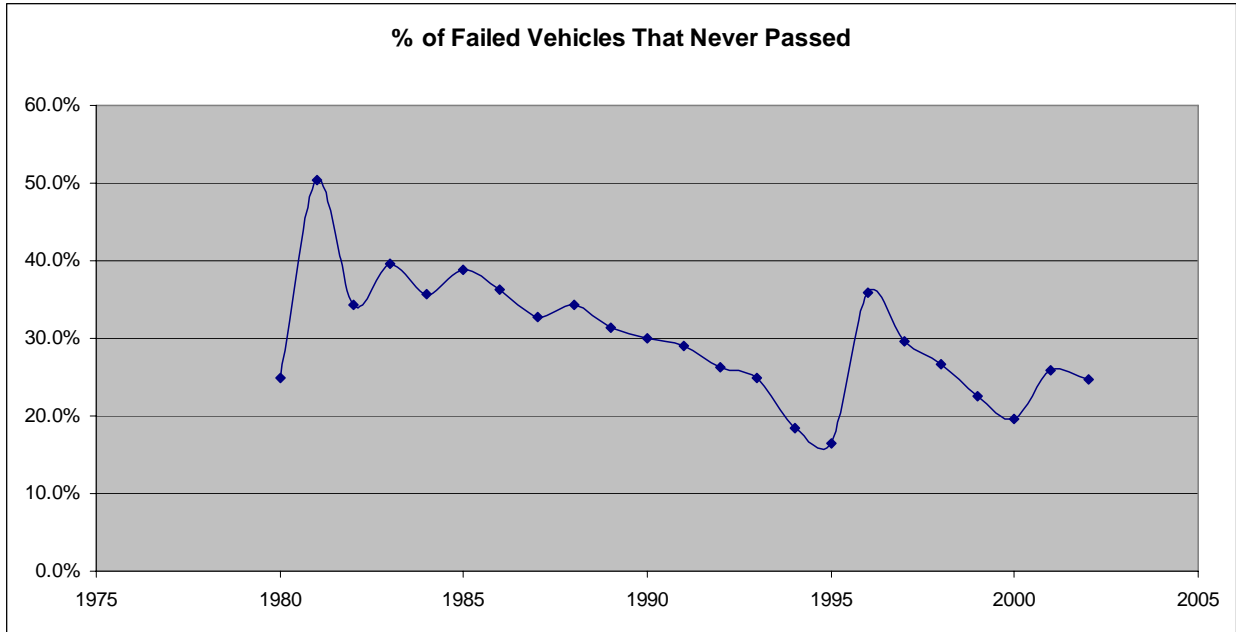
Compliance Rates and Penalties

What happens to vehicles failing their inspection? A central question is whether these vehicles ultimately pass the test. The fate of vehicles failing the I/M test in the 2004 to 2005 period was evaluated. Failures for the 3 month period beginning 11/11/04 were tracked through 11/10/05, and these results are shown in the table on page 27.

Overall, 28.5% of the failures during this three month period had not yet received a passing result (or waiver). Ultimately, these vehicles must comply or they cannot be registered in Connecticut, since DMV now makes I/M compliance a prerequisite for vehicle registration. Overall, 99% of the vehicles tested from 1/1/05 to 12/31/05 complied with I/M program requirements and are registered. In 2005, DMV denied registration for 10,744 vehicles, because they did not comply with I/M test standards. As of 12/31/05, DMV sent 7,206 late fee notices.

**Vehicles Tested from 11/11/04 to 11/10/05
with No Known Outcome**

Model Year	Initial Fail	Final Retest Pass	Final Retest Fail	No Retest Pass or Fail	% No Final Pass
1980	4	3	0	1	25.0%
1981	107	53	22	32	50.5%
1982	125	82	19	24	34.4%
1983	212	128	33	51	39.6%
1984	427	275	58	94	35.6%
1985	561	343	86	132	38.9%
1986	721	460	100	161	36.2%
1987	911	612	127	172	32.8%
1988	923	606	110	207	34.3%
1989	1,041	714	124	203	31.4%
1990	1,050	734	110	206	30.1%
1991	947	672	104	171	29.0%
1992	1,099	810	109	180	26.3%
1993	1,239	930	101	208	24.9%
1994	1,291	1,054	90	147	18.4%
1995	1,313	1,098	77	138	16.4%
1996	2,834	1,816	220	798	35.9%
1997	2,919	2,053	138	728	29.7%
1998	1,980	1,452	77	451	26.7%
1999	1,973	1,528	78	367	22.6%
2000	870	700	31	139	19.5%
2001	251	186	17	48	25.9%
2002	69	52	2	15	24.6%
TOTAL	22,867	16,361	1,833	4,673	28.5%



This chart shows the percentage of vehicles that fail the emission test that never ultimately pass. The increase from 1995 to 1996 indicates that compliance with the OBD test is more difficult than the tailpipe test used for pre-1996 vehicles.

Enforcement of Proper Test Procedures

- DMV has developed a comprehensive set of Triggers. Triggers are reports to identify stations performing fraudulent or inaccurate inspections.
- Triggers focus on finding the following types of fraud:
 - Clean Scanning: Performing an OBDII test on a fault-free vehicle instead of the vehicle that should be tested.
 - Clean Piping: Performing a tailpipe test on a passing vehicle instead of the vehicle that should be tested.
- These reports are being generated frequently to identify stations performing improper inspections.
- Following is a summary of the trigger reports that were generated during the 2004/2005 period. Overall, inspection fraud is not a problem in Connecticut's I/M program, as indicated by the low percentage of questionable tests in Connecticut.

Triggers for Clean Scanning/Clean Piping

DMV runs several trigger reports to identify clean scanning and clean piping:

- **Mismatch between entered VIN and OBDII VIN** – Inspectors may be attempting to pass vehicles with OBDII faults by scanning problem free vehicles instead of vehicles that should be inspected.
 - If the vehicle has an electronic VIN available through the vehicle's OBDII system, clean scanning cases can be identified by comparing entered VIN with VIN provided by vehicle's OBDII system.
 - There have been 117 incidences of OBD VIN mismatches out of 40,000 tests with OBD VINs (0.29%).
- **Questionable Retests** – Mismatches between initial tests and retests could indicate that the inspector clean-scanned vehicles on retests. DMV checks the following parameters:
 - Supported readiness monitors – different vehicles have different monitors
 - OBD computer identifiers
 - To date, out of about 52,000 OBD failures, 63 tests (0.12%) have been flagged by this trigger.

- **Short Time Between Initial OBD Test Fail And Retest Pass** – Stations that often show short time periods between initial test failures and retest passes could be performing fraudulent inspections. (Short = ½ hour)
 - It is difficult to repair OBD failures and get failing vehicles to pass in a short time period:
 - MIL-On Fails – It takes time for the MIL to go off or readiness monitors to reset if codes are cleared
 - Readiness Fails – It takes time for readiness monitors to set to ready, especially the evaporative monitor.
 - To date, out of about 52,000 OBD failures, only 28 tests (0.05%) have been flagged by this trigger.

- **Large Emission Reductions In A Short Time Period (1981-1995 Vehicles)** – Stations reporting large emission reductions in a short time period are more likely to be clean piping the retests. (Short = ½ hour)
 - To date, out of about 28,000 ASM2525 failures, 76 tests (0.27%) have been flagged by this trigger.

Triggers Summaries

- DMV tabulates triggers by station.
- Stations with more than one minor trigger or any major trigger, e.g. large emission reductions in a short time period, are immediately investigated.
- About $\frac{3}{4}$ of the trigger incidences were in stations that had >1 trigger.
- Overall, less than 0.5% of the inspections were flagged by trigger reports, which indicates that inspection fraud is not a problem in Connecticut.

Example Report – Stations with the Most Trigger Hits

Station	<1hr OBD pass	<1hr>50 %	Looser ASM2525 Cutpoints	OBD Parameter Mismatch	OBD VIN Mismatch	Total
A		1		12		13
B		1		9		10
C		3	1	1	3	8
D	1	1	1	4		7
E	1		1		3	5
F		2		1	2	5
G		2	1		2	5
H			1	1	3	5
I				1	3	4
J	1	2	1			4
K		1	1		2	4
L			1	1	2	4
M			4			4
N			1		3	4

5.0 Analysis of Data from Remote Sensing Devices (RSD)

EPA requires that 0.5% of the tested vehicle population receive independent on-road emissions tests. Connecticut meets this requirement by using Remote Sensing Devices (RSD). DMV requires its contractor, Applus, to perform on-road tests with RSD.

Remote Sensing Devices (RSD) measure emissions by passing a light source across a highway to a source detector. The source detector measures absolute concentrations of hydrocarbons (HC), carbon monoxide (CO), nitric oxide⁵ (NO), and carbon dioxide (CO₂) in the diluted exhaust. From these measurements, exhaust concentrations of HC, CO, and NO in the undiluted exhaust are calculated.

RSD offers the opportunity to obtain vehicle emissions measurements in a relatively non-intrusive manner. Connecticut's I/M contractor, Applus, is required to conduct on-road emission tests using remote sensing devices (RSD), in order to meet EPA's on-road test requirements.

In July 2005, Applus contracted ESP⁶ to conduct approximately 21,000 tests using RSD. After removing invalid records and matching results with the vehicle I/M database, 5,379 records remained (~0.5% of the vehicles tested in the I/M program annually). The RSD program meets EPA's on-road test requirements.

Applus was able to match RSD results with I/M results from 2001. Applus generated two datasets:

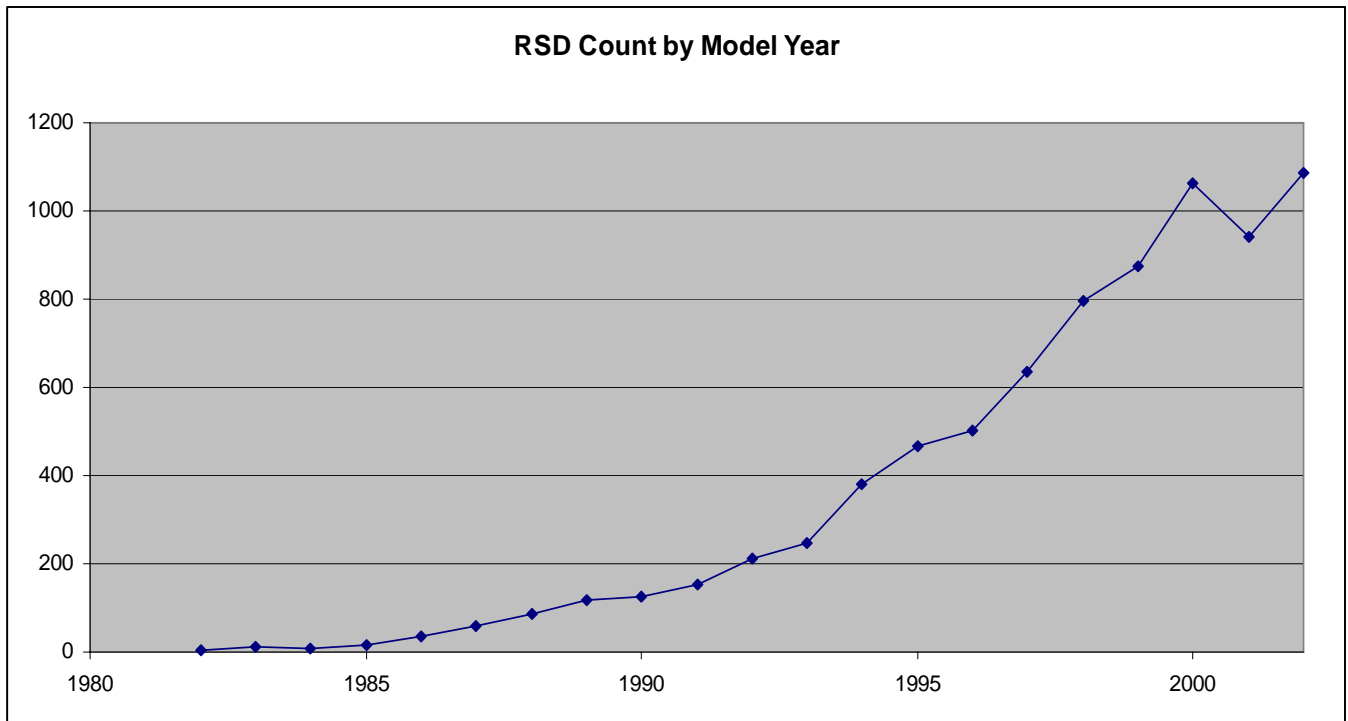
- RSD results before I/M: 1,553 valid observations
- RSD results after I/M: 3,826 valid observations

5 NO is used as a surrogate for oxides of nitrogen (NO_x).

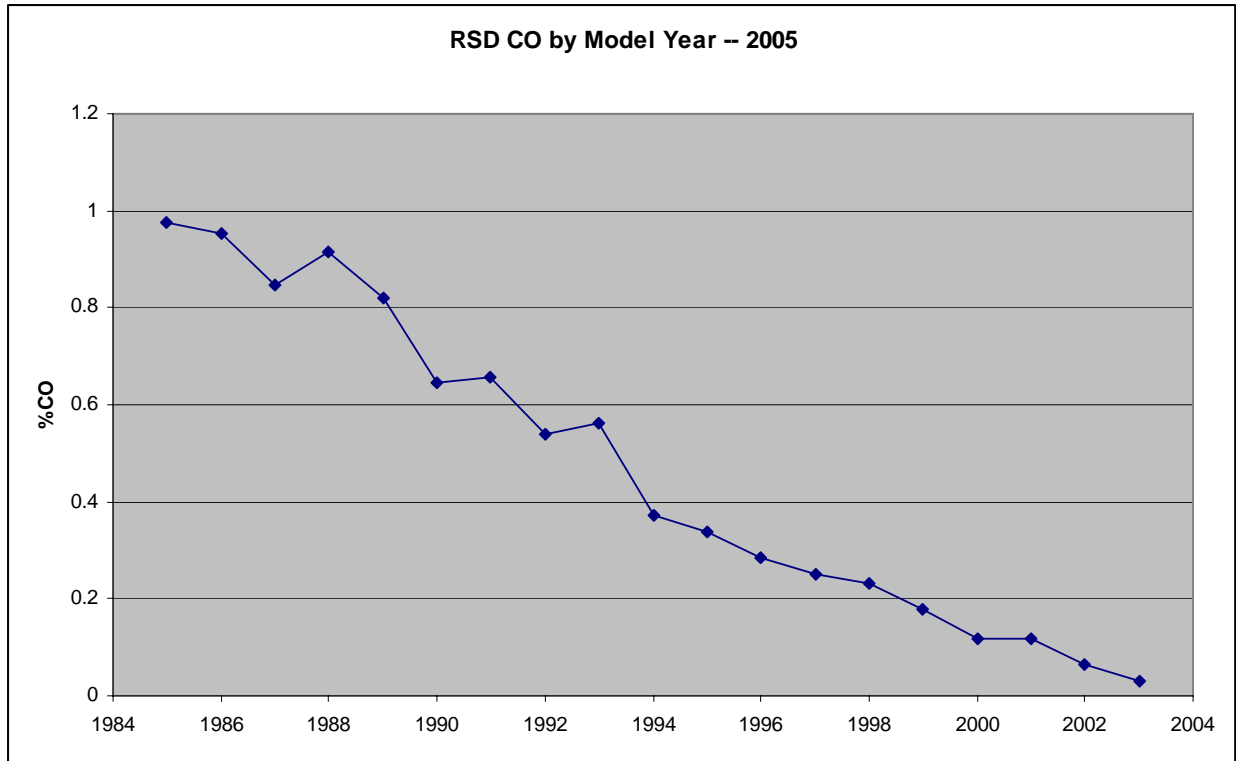
6 ESP is the only provider of Remote Sensing services.

Observed Remote Sensing Device (RSD) Emission Levels

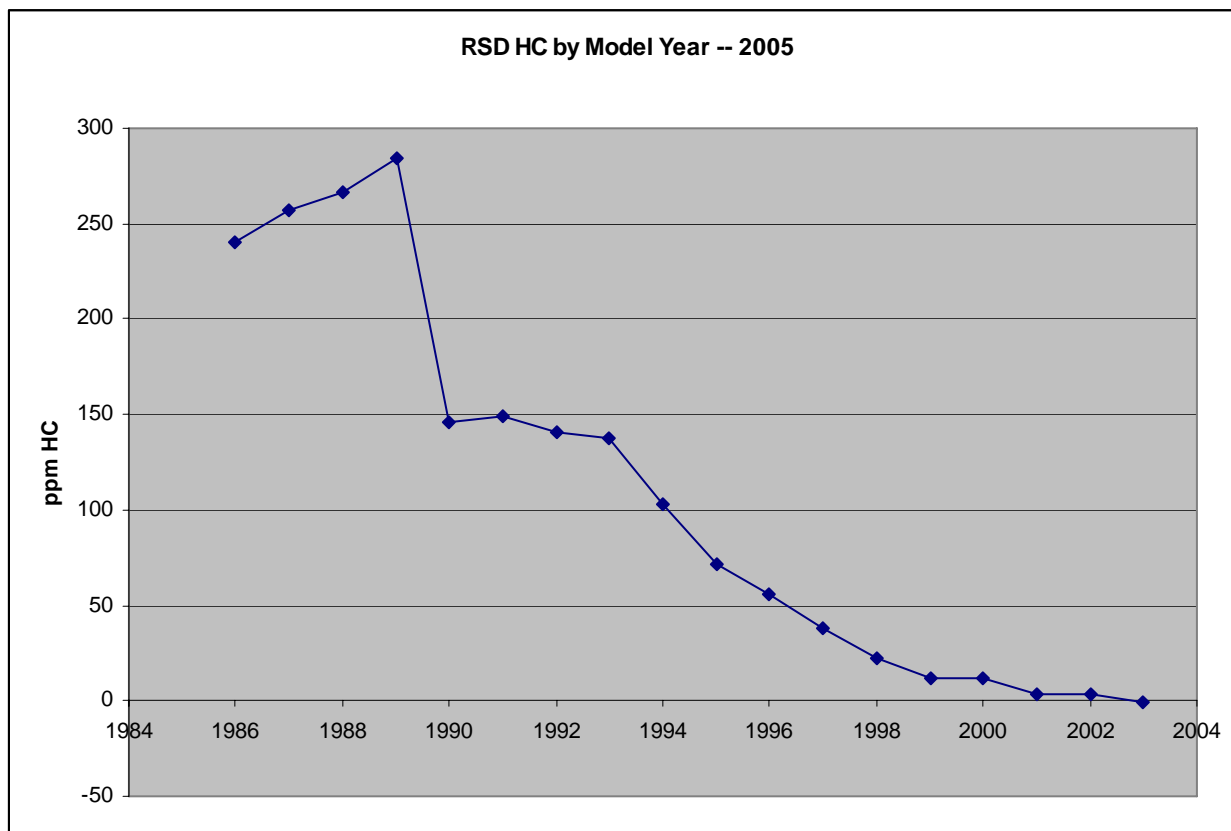
- As expected, average RSD emissions and the percentages of high emitters are lowest for the newest vehicles.
- 0.29% of the vehicles scanned exceeded the 6% RSD CO limit. This criteria is used in some programs to identify high emitting vehicles. In 2002, when the last survey was done, 0.33% of the vehicles tested exceeded the 6% RSD CO limit.
- Emission trends can be observed before and after the emissions inspection. Of particular interest are RSD emissions for vehicles that were scanned via RSD prior to failing I/M tests or after failing.
- Average RSD emission levels for vehicles that failed I/M tests were greater than average RSD emission levels for vehicles that had passed.



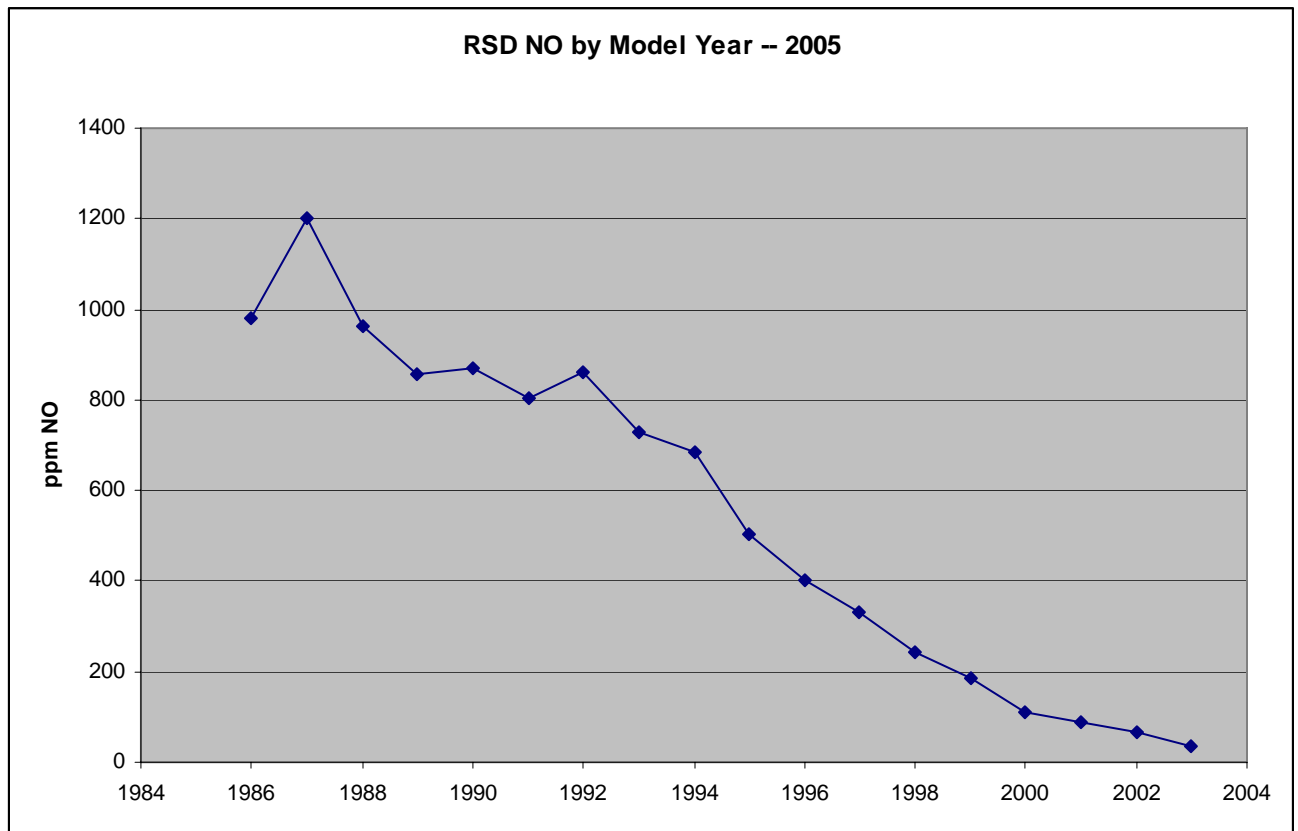
This chart shows the number of vehicles scanned by RSD by model year. Only the model years covered by the I/M program (1980 to 2002) are shown.



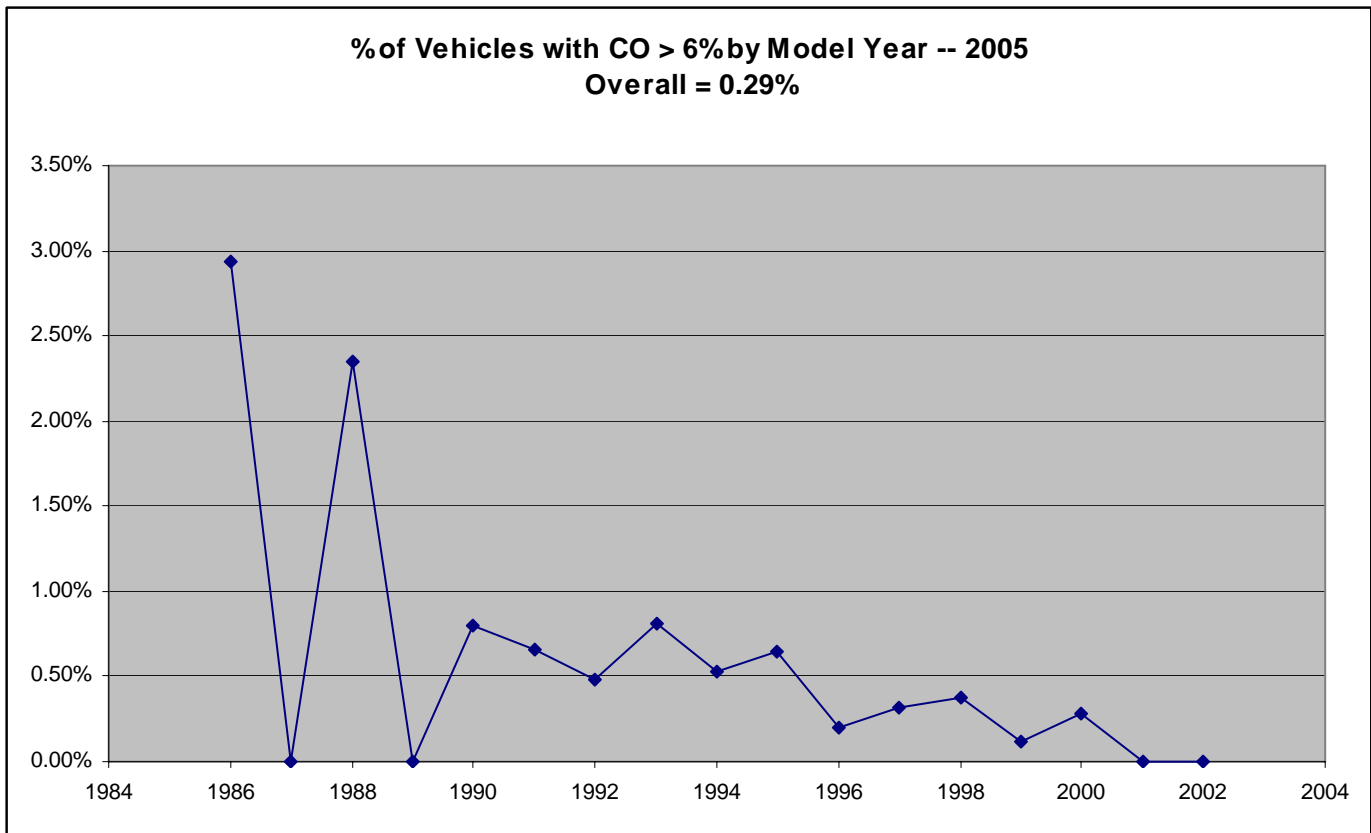
This figure shows average carbon monoxide (CO) RSD readings by model year. Increasingly more stringent EPA emission standards for newer vehicles and expected deterioration of emission controls in older vehicles result in newer vehicles having lower emissions.



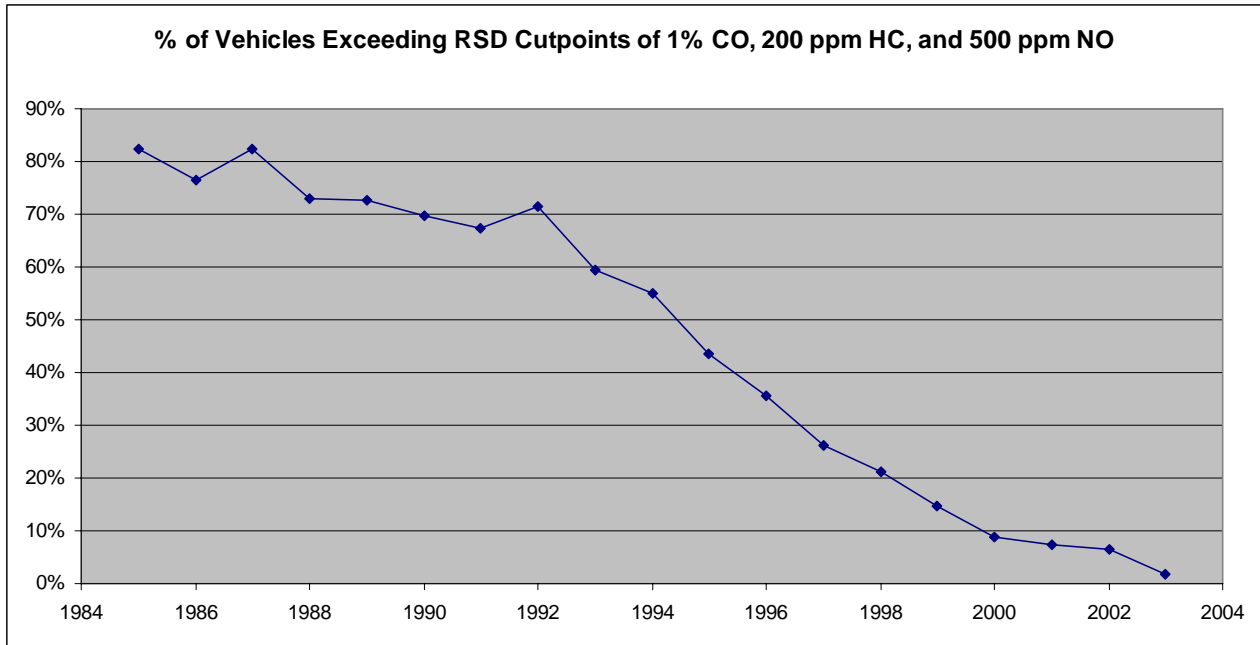
This figure shows average hydrocarbon (HC) RSD readings by model year. Increasingly more stringent EPA emission standards for newer vehicles and expected deterioration of emission controls in older vehicles result in newer vehicles having lower emissions. The low sample sizes for the older vehicles causes considerable variation in average readings.



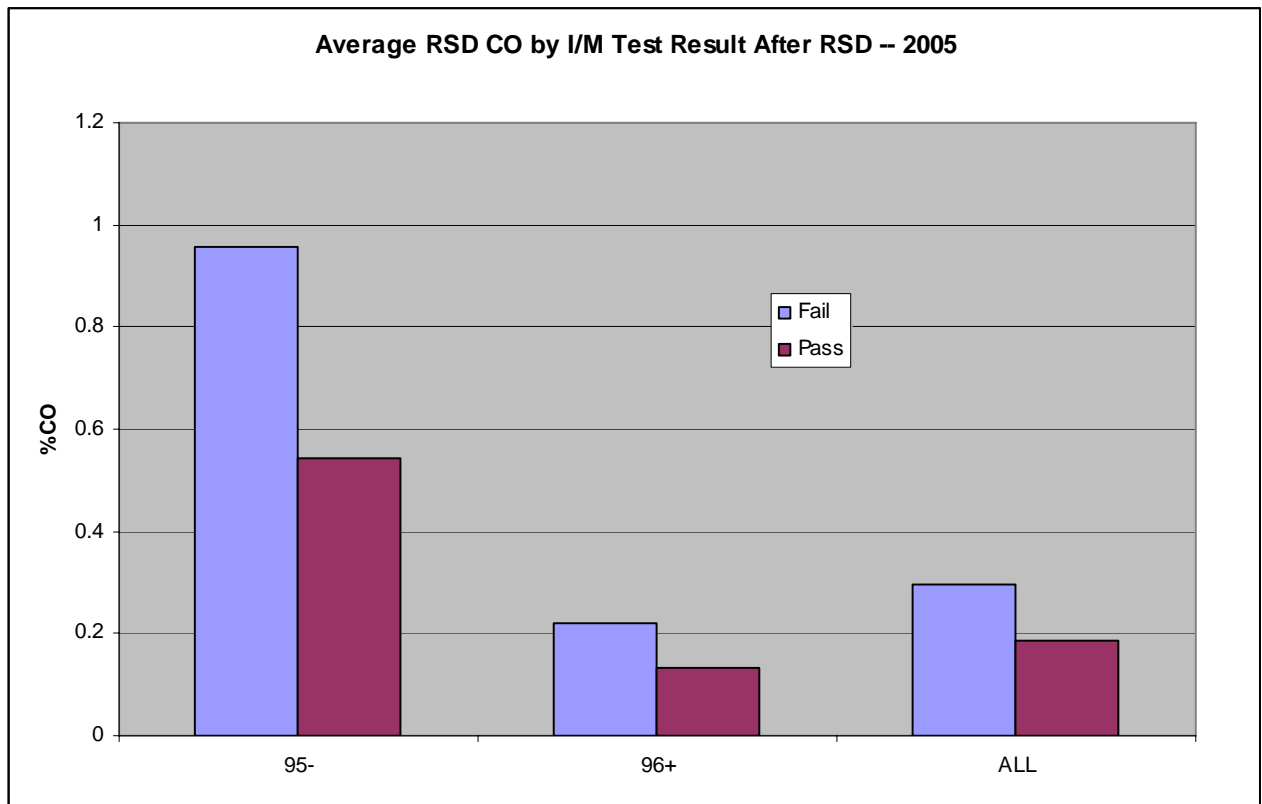
This figure shows average RSD readings for nitric oxide (NO) by model year. Increasingly more stringent EPA emission standards for newer vehicles and expected deterioration of emission controls in older vehicles result in newer vehicles having lower emissions.



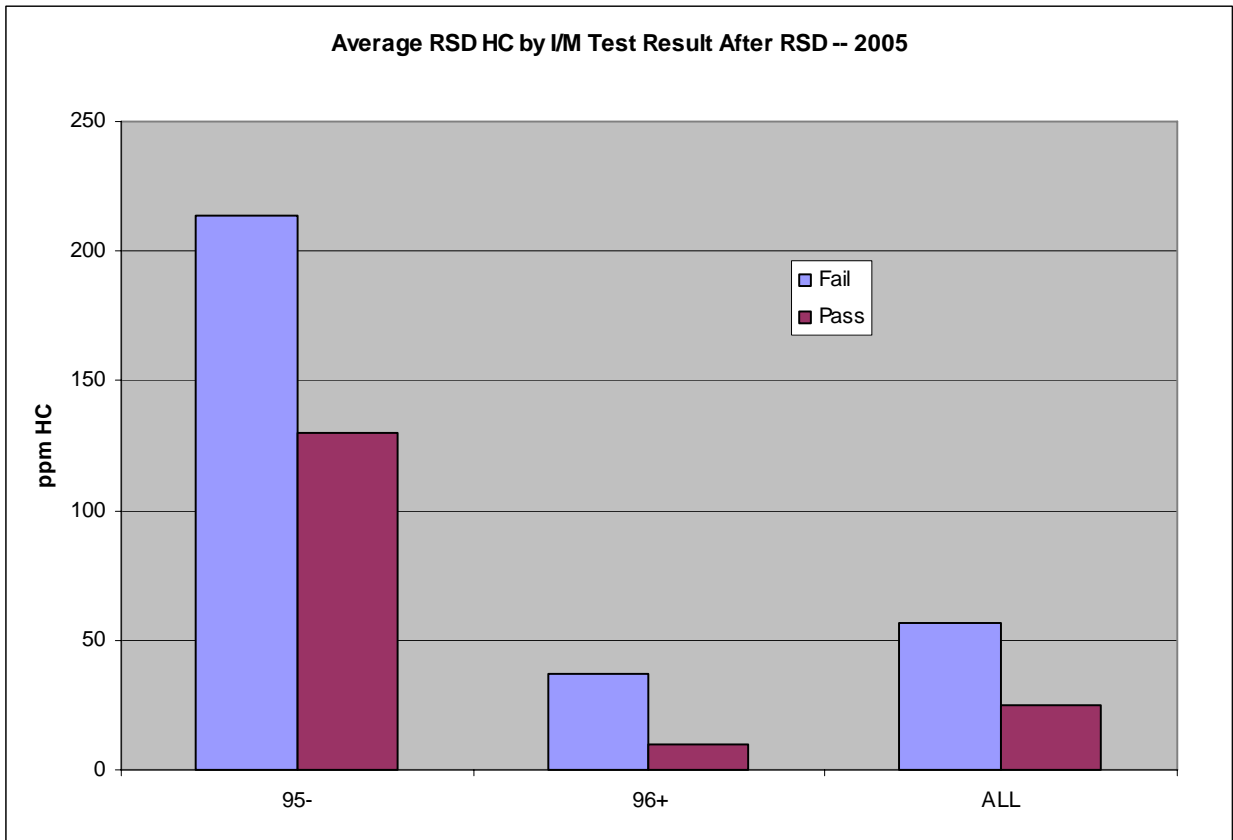
This figure shows the percent of vehicles exceeding 6% CO by model year. 6% CO is typically used as a gross emitter criteria for on-road emissions tests. The greatest percentages of failed vehicles are between the 1986 and 1990 model years. The low sample sizes for the older vehicles causes considerable variation in the percentages.



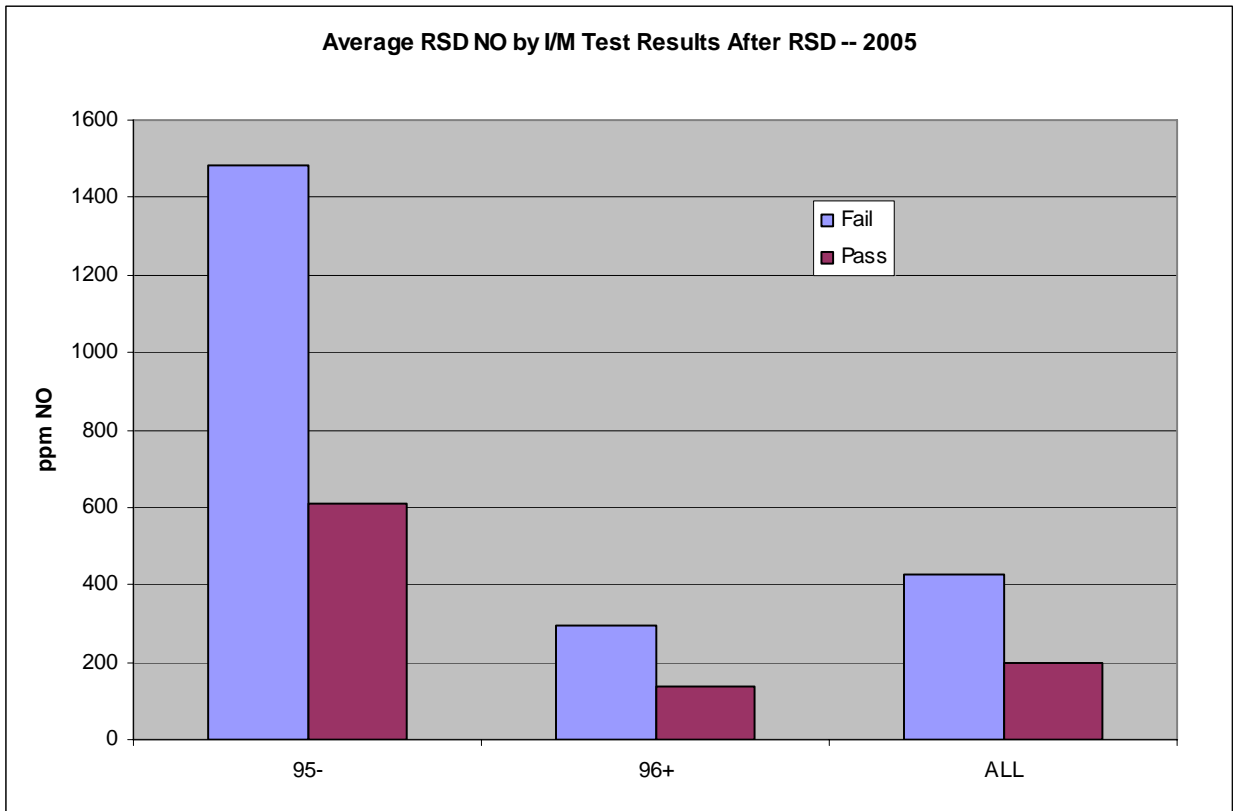
This figure shows the percent of vehicles by model year that exceed cutpoints of 1% CO, 200 ppm HC, and 500 ppm NO. These cutpoints are similar to ASM2525 cutpoints for late model light-duty vehicles. As expected, older models have much higher percentages of failed vehicles.



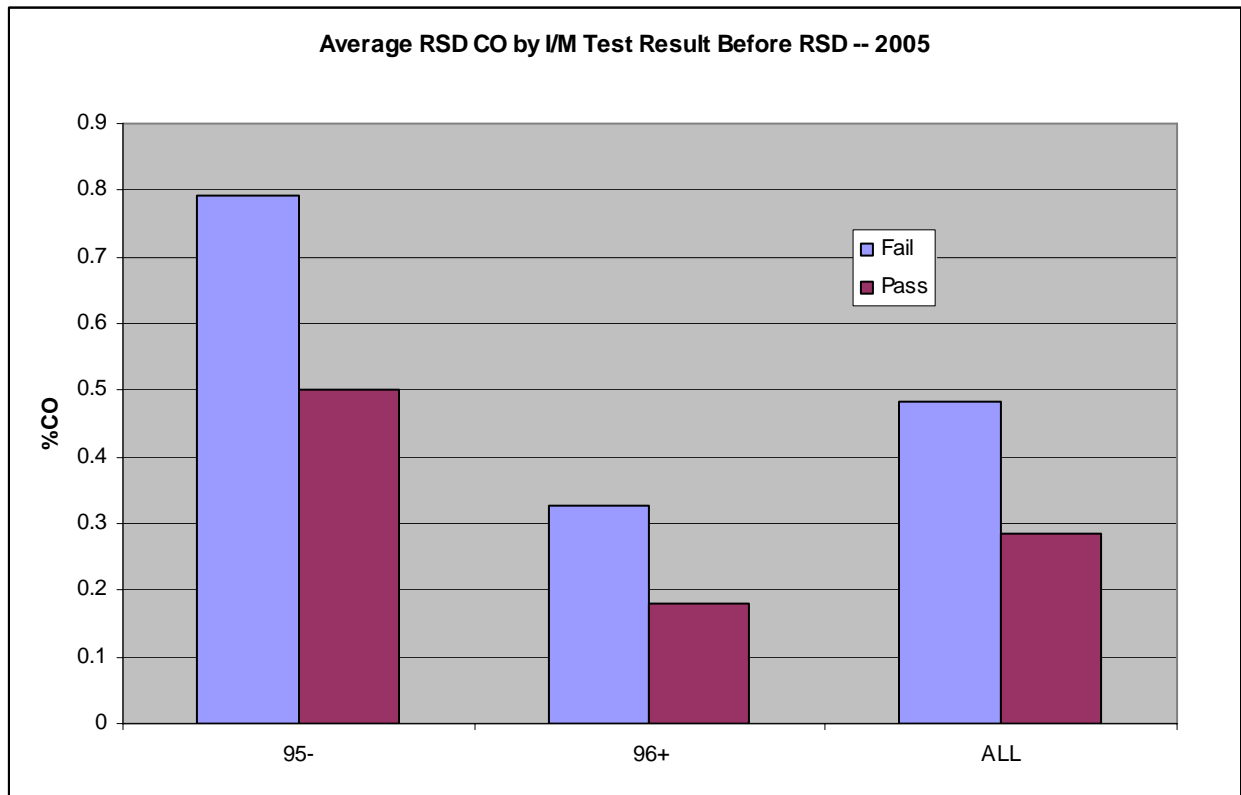
This figure shows average RSD CO emissions for vehicles that received an I/M test after they were observed by RSD. Results are broken down by model year and I/M pass/fail status. RSD emission levels for vehicles that failed the subsequent I/M test were much higher than emission levels for vehicles that passed. Results for 1996+ vehicles, which receive OBD tests instead of tailpipe tests, indicate that the OBD test identifies a lot of vehicles with high emissions.



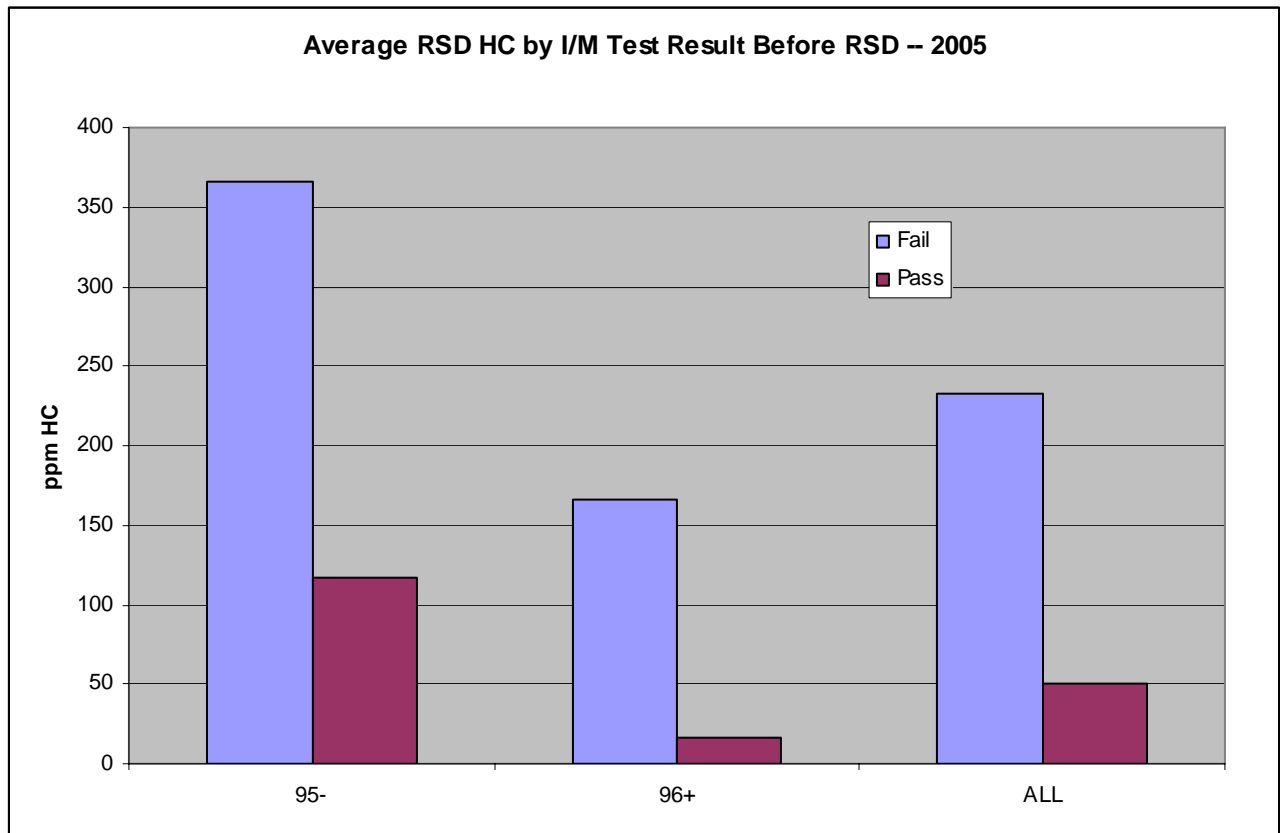
This figure shows average RSD HC emissions for vehicles that received an I/M test after they were observed by RSD. Results are broken down by model year and I/M pass/fail status. RSD emission levels for vehicles that failed their subsequent I/M test were much higher than RSD emission levels for vehicles that passed their I/M test. Results for 1996+ vehicles, which receive OBD tests instead of tailpipe tests, indicate that the OBD test identifies a lot of vehicles with high HC emissions.



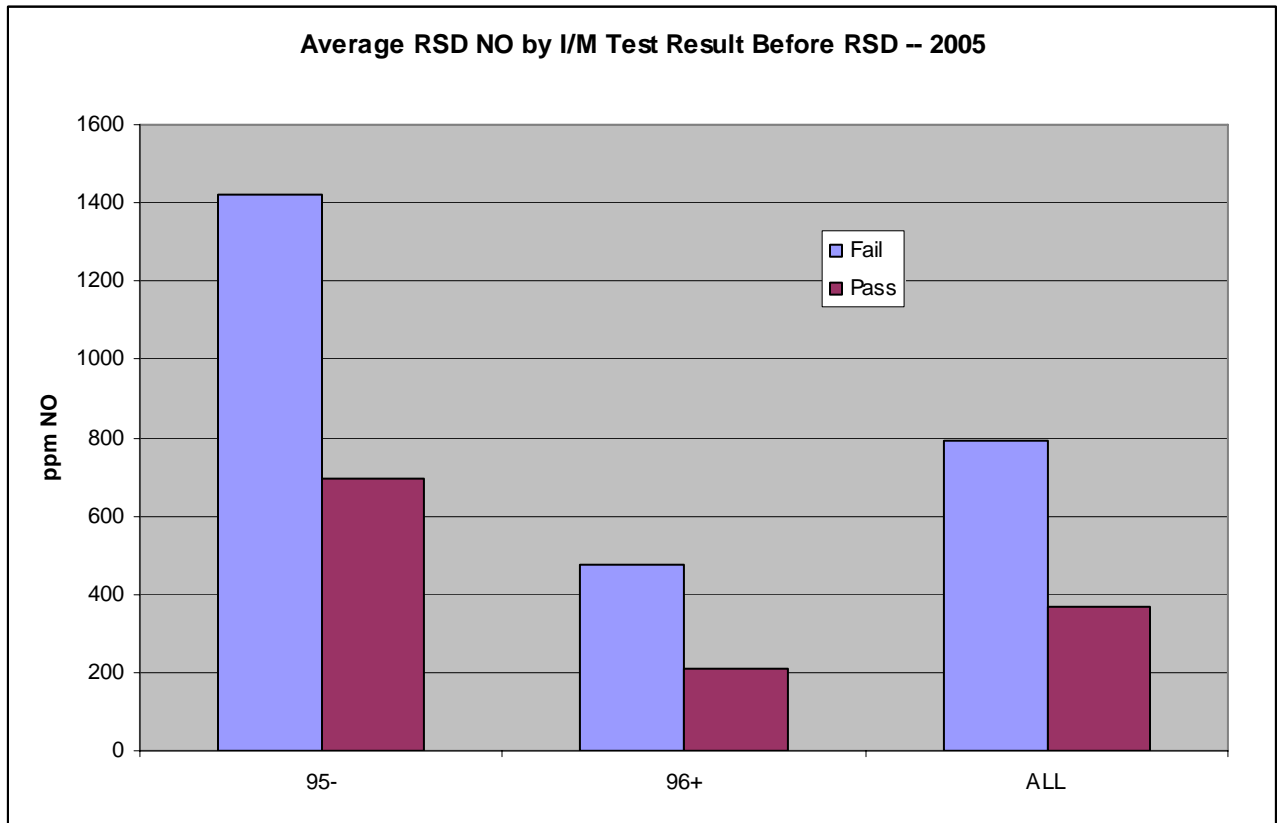
This figure shows average RSD NO emissions for vehicles that received an I/M test after they were observed by RSD. Results are broken down by model year and I/M pass/fail status. RSD emission levels for vehicles that failed their subsequent I/M test were much higher than RSD emission levels for vehicles that passed their I/M test. Results for 1996+ vehicles, which receive OBD tests instead of tailpipe tests, indicate that the OBD test identifies vehicles with high NO emissions.



This figure shows average RSD CO emissions for vehicles that received an I/M test before they were observed by RSD. Results are broken down by model year and I/M pass/fail status of the last test before the RSD observation. RSD emission levels for vehicles that failed their previous I/M test were much higher than RSD emission levels for vehicles that passed their I/M test. This indicates that RSD can be used to identify vehicles that have yet to comply with I/M program requirements.



This figure shows average RSD HC emissions for vehicles that received an I/M test before they were observed by RSD. Results are broken down by model year and I/M pass/fail status of the last test before the RSD observation. RSD emission levels for vehicles that failed their previous I/M test were much higher than emission levels for vehicles that passed. This indicates that RSD can be used to identify vehicles that have yet to comply with I/M program requirements.



This figure shows average RSD NO emissions for vehicles that received an I/M test before they were observed by RSD. Results are broken down by model year and I/M pass/fail status of the last test before the RSD observation. RSD emission levels for vehicles that failed their previous I/M test were much higher than emission levels for vehicles that passed. This indicates that RSD can be used to identify vehicles that have yet to comply with I/M program requirements.

Emission Reduction Estimates Based on Remote Sensing Device (RSD) Readings

Based on the analysis of RSD emission levels for vehicles that received an I/M test before they were observed by RSD, dKC calculated emission reductions from the I/M program. They are shown below. Please note that these emission reductions cannot be compared to estimates based on mass emissions tests. The sample sizes are too small to make an accurate calculation of emission reductions for the I/M program. In addition, results of remote sensing tests do not correlate well with mass emissions tests. This comparison is mainly useful in determining if the program appears to be getting the benefits calculated by the MOBILE6 model. HC and NOx emissions are the primary concerns due to their role in forming ozone. HC benefits based on remote sensing tests are higher than predicted by MOBILE6, while NOx benefits are slightly lower. We conclude that the program is getting the benefits predicted by MOBILE6.

Emission Reductions Based on Remote Sensing Device (RSD) Readings

Model Year	Pollutant		
	CO (%)	HC (ppm)	NOx (ppm)
pre-1995	5.6%	17.4%	9.6%
1996+	4.2%	29.4%	6.2%
ALL	4.8%	20.3%	7.6%

Emission Levels for 2003 and Newer Vehicles

Currently, Connecticut exempts the newest 4 model years from the I/M program. In 2005, this meant that the newest model year tested was 2002. dKC analyzed data on 2003 and newer vehicles that received RSD emissions tests to determine if there would be value in reducing the number of model year exemptions. ***dKC concludes that Connecticut should continue to exempt the newest 4 model years from the emissions test program.***

- There were no cases of 2003 or newer models having CO > 6%, which some states use as criteria to define a gross polluter.
- There were few vehicles that exceeded emissions levels comparable to ASM cutpoints. ASM pass/fail criteria is approximately CO > 1%, HC > 200 ppm, or NOx > 500 ppm. Only 1.7% of the 2003 and newer vehicles exceeded these limits. In the vehicle sample subject to emissions tests, 26% of the vehicles tested exceeded these limits. 6.5% of the 2002 models exceeded these limits.

6.0 Assessment of OBD Testing Issues

Fallback Tailpipe Test For Vehicles That Are Not Ready, But Otherwise Pass OBDII

During the 1st OBDII inspection cycle, Connecticut's I/M program allows vehicles that are not ready (>2 monitors for pre-2001 and >1 monitor for 2001 and newer) but otherwise pass the OBDII inspection to receive a back-up tailpipe test (ASM2525 or PCTSI depending on vehicle). From November 11, 2004 until November 10, 2005, 21,981 vehicles (~3% of the OBDII fleet) received back-up tailpipe tests under this provision. During this period 52,324 vehicles failed their OBDII inspection because the MIL was commanded-on or the bulb did not work.

So far, it appears that most motorists and inspection stations do not clear codes on vehicles with MILs on prior to inspection. Clearing codes could allow the vehicle to pass a tailpipe test⁷, instead of failing the OBD inspection. If codes were being cleared, MIL-command-on rates would be lower and not ready rates would be higher than other programs. As shown on the following figures, Connecticut's MIL command-on rates are similar to Delaware's, while its not ready rates are lower than Delaware's, based on data collected since the program restarted in November 2004. Delaware operates a centralized (test-only) program and has not allowed back-up tailpipe tests since January 1, 2005.

Data from on-road tests performed in Connecticut provide further evidence that few high emitting vehicles passed their I/M test, because they received back-up tailpipe tests in response to a not-ready condition. As mentioned earlier, Connecticut's contractor performs on-road tests using remote sensing devices (RSD), in order for the State to meet EPA's requirement to independently test at least 0.5% of the tested vehicle population. On-road emissions levels for 3 groups were evaluated:

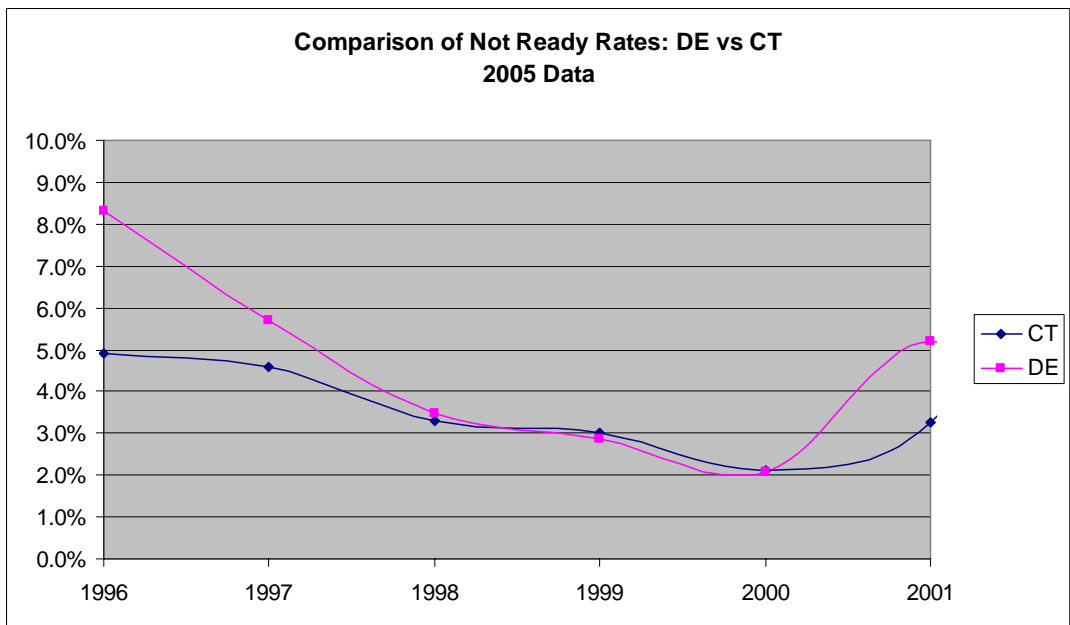
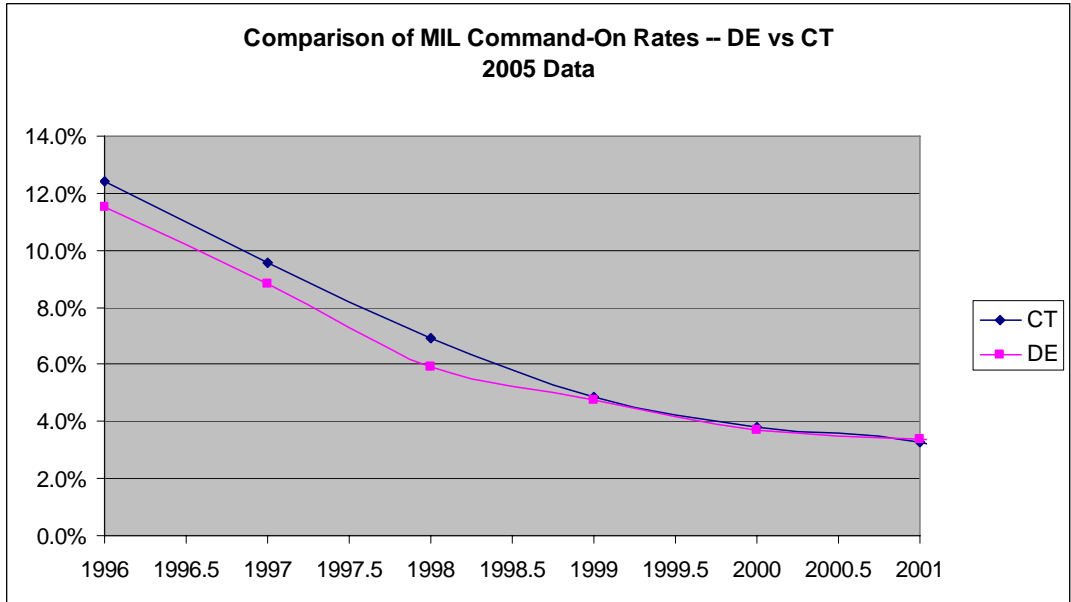
- Received OBD test and failed, Vehicles fail if Malfunction Indicator Light (MIL) is commanded-on, MIL does not illuminate

⁷ Readiness status for all monitors is set to "not ready" when fault codes are cleared and the MIL is extinguished by a technician with a scan tool.

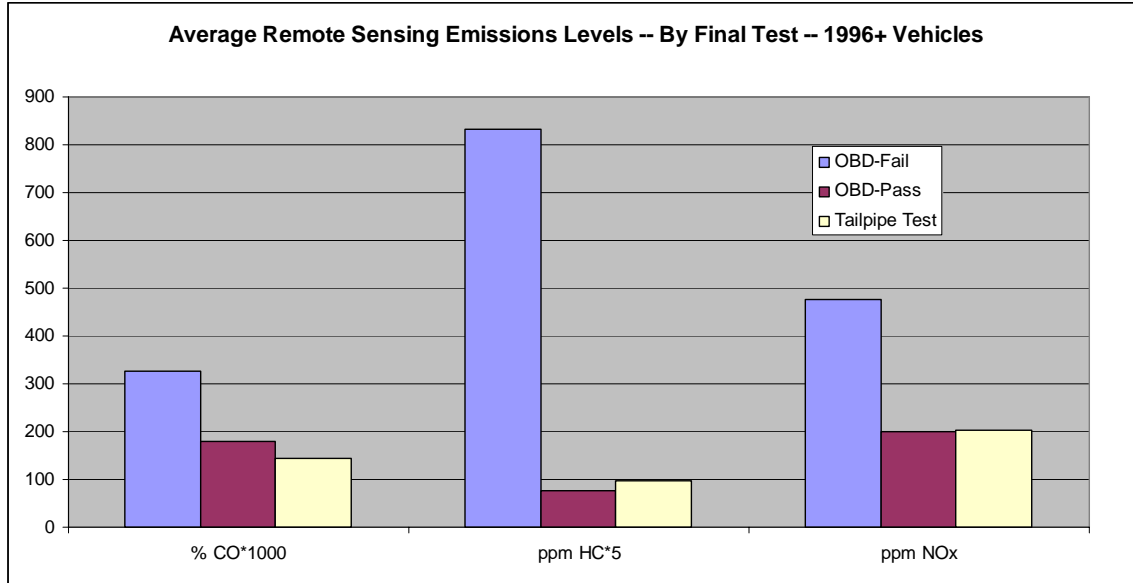
during KOEO, or DLC is damaged or missing.

- Received OBD test and passed. These vehicles had no OBD faults and met readiness criteria.
- Received back-up tailpipe test because vehicle was not ready or failed to communicate with test system.

RSD emission levels for vehicles that received back-up tailpipe tests were nearly identical to emission levels for vehicles that passed the OBD test. Emission levels for vehicles that failed the OBD test were much higher than the other vehicle categories.



These charts compare MIL-Command on fail rates and not ready rates in Connecticut with rates in Delaware. Delaware uses a State-Operated centralized scenario, and does not perform back-up tailpipe tests. The fail rates are nearly identical, while Connecticut has slightly lower not ready rates.



This chart compares RSD emission levels for 3 groups of OBDII equipped vehicles: 1) Received OBD test and failed, 2) Received OBD test and passed, and 3) Received back-up tailpipe test because vehicle was not ready or failed to communicate with test system. RSD emission levels for vehicles that received back-up tailpipe tests were nearly identical to emission levels for vehicles that passed the OBD test. Emission levels for vehicles that failed the OBD test were much higher than the other vehicle categories.

Vehicles with Readiness Issues that are not Currently Exempted from Readiness Requirements

EPA allows states to exempt vehicles from readiness requirements, if they have design flaws that cause them to frequently fail for readiness. Based on data from tests since November 11, 2004, several vehicle models that are not currently exempted from readiness by EPA have high not ready rates. Other states have reported similar problems with these vehicles. ***These vehicles are listed in the following table.***

Vehicles That Should Be Added To Readiness Exemption List

Model Year	Make	Model	# OBD tested	# Not Ready	% Not Ready
1996	DODGE	AVENGER	177	57	32.2%
1996	DODGE	INTREPID	776	199	25.6%
1996	DODGE	NEON	580	174	30.0%
1996	DODGE	STRATUS	500	110	22.0%
1996	EAGLE	TALON	74	38	51.4%
1996	EAGLE	VISION	75	36	48.0%
1996	FORD	E250 SUPER VAN	13	3	23.1%
1996	FORD	PROBE	125	25	20.0%
1996	FORD	TAURUS SHO	14	4	28.6%
1996	GEO	TRACKER	300	61	20.3%
1996	HYUNDAI	ACCENT	242	51	21.1%
1996	HYUNDAI	ELANTRA	216	47	21.8%
1996	HYUNDAI	SONATA	55	29	52.7%
1996	MAZDA	MILLENIA	75	19	25.3%
1996	MERCEDES-BENZ	S420	34	8	23.5%
1996	PLYMOUTH	NEON	501	139	27.7%
1996	PORSCHE	911 CARRERA	10	6	60.0%
1996	PORSCHE	911 TURBO	12	6	50.0%
1996	SUZUKI	X-90	27	12	44.4%
1996	VOLKSWAGEN	GTI	65	14	21.5%
1996	VOLKSWAGEN	PASSAT	296	86	29.1%
1997	CHEVROLET	G15	10	2	20.0%
1997	EAGLE	TALON	48	16	33.3%
1997	GEO	TRACKER	149	31	20.8%
1997	HYUNDAI	SONATA	153	75	49.0%
1997	KIA	SEPHIA	139	30	21.6%
1997	PORSCHE	911 CARRERA 2	58	17	29.3%
1997	PORSCHE	911 CARRERA 4	30	9	30.0%
1997	PORSCHE	911 TURBO	11	4	36.4%
1998	CHEVROLET	TRACKER	137	28	20.4%
1998	FORD	E250	16	4	25.0%

Model Year	Make	Model	# OBD tested	# Not Ready	% Not Ready
1998	HYUNDAI	SONATA	145	52	35.9%
1998	SUZUKI	SIDEKICK	20	6	30.0%
1998	TOYOTA	CELICA	37	8	21.6%
2000	PLYMOUTH	PROWLER	13	3	23.1%
2001	FORD	EXCURSION	10	6	60.0%
2001	FORD	F250	37	26	70.3%
2001	FORD	F350	15	5	33.3%
2002	BUICK	RENDEZVOUS AWD	106	28	26.4%
2002	BUICK	RENDEZVOUS FWD	33	10	30.3%
2002	CHEVROLET	BLAZER 4WD	226	57	25.2%
2002	CHRYSLER	SEBRING	117	25	21.4%
2002	CHRYSLER	VOYAGER	36	11	30.6%
2002	DODGE	RAM VAN 1500	12	3	25.0%
2002	FORD	CROWN VIC	25	15	60.0%
2002	FORD	TAURUS WAGON	35	8	22.9%
2002	GMC	SAFARI	13	3	23.1%
2002	MERCEDES-BENZ	C320	32	8	25.0%
2002	PONTIAC	AZTEK	12	4	33.3%
2002	TOYOTA	SIENNA	106	24	22.6%
2002	TOYOTA	TUNDRA 2WD	15	3	20.0%
2002	VOLVO	C70	17	7	41.2%
2002	VOLVO	V70 AWD	226	50	22.1%

Vehicles That Fail to Communicate with Connecticut's Test System

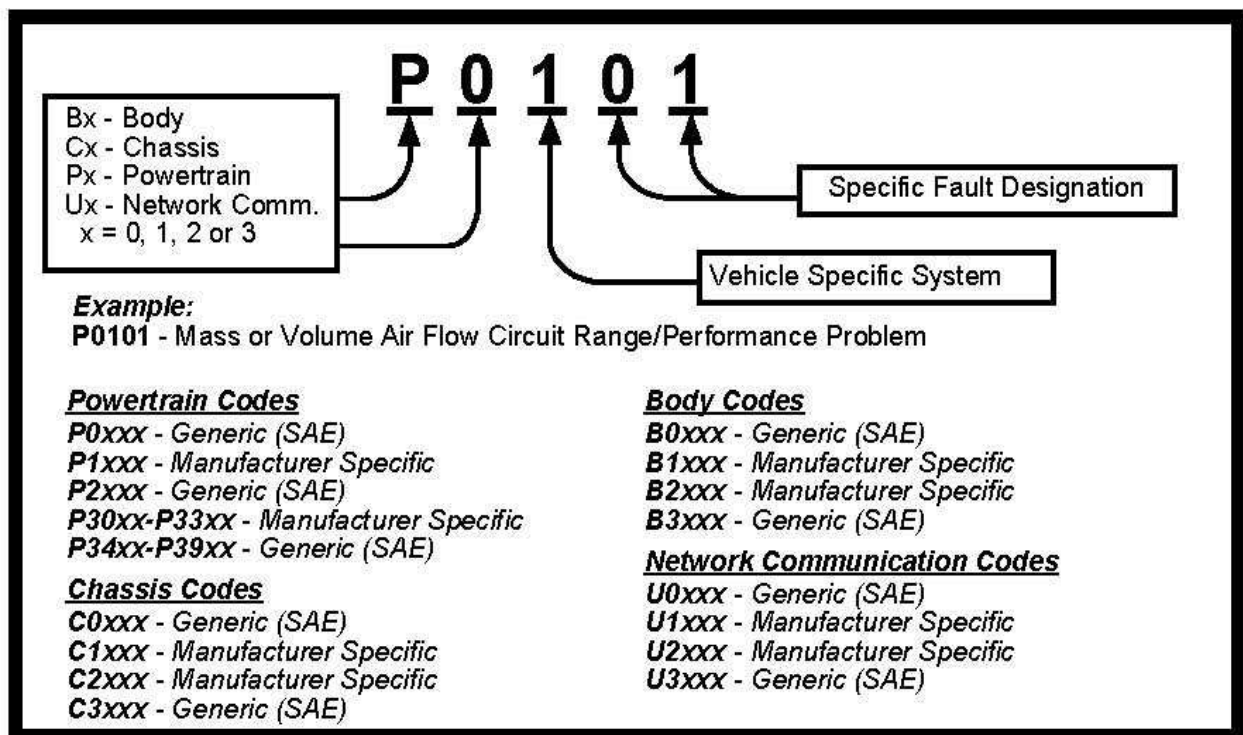
A small percentage (0.3%) of the vehicles with OBDII systems fail to communicate with Connecticut's inspection system. Currently these vehicles receive back-up tailpipe test if there is no visual evidence that the MIL is on. The vehicles listed below have high no communication percentage. Overall, few vehicles have trouble communicating with Connecticut's OBDII test system.

Vehicles With High No Communication Rates

Model Year	Make	Model	OBD Tested	# No COM	No COM Rate
1997	ACURA	2.5TL	87	70	80.5%
2001	BMW	M3	39	34	87.2%
2002	BMW	M3	26	26	100.0%
2000	BMW	M5	63	38	60.3%
2001	BMW	M5	30	25	83.3%
2001	BMW	Z8	20	15	75.0%
1996	FORD	E350 ECONOLINE	13	5	38.5%

Diagnostic Trouble Codes (DTCs) Recorded in OBDII Failures

Whenever the Malfunction Indicator Light (MIL) is illuminated a Diagnostic Trouble Code (DTC) should be stored in the vehicle's computer. DTCs describe the problem that caused the MIL to go on. Before OBDII, each manufacturer had their own specific trouble code list and code definitions. Under the OBDII requirements, all manufacturers must comply with a standardized convention for DTCs. The universal DTC format consists of a 5-character alphanumeric code, consisting of a single letter character followed by four numbers.



Top 10 DTCs in Connecticut

Following is a list of the most prevalent DTCs in Connecticut. Note that the top 10 DTCs are present in 61% of the MIL-on cases, even though there are over 1000 possible DTCs.

Rank	DTC	%
1	P0420 – Low Catalyst Efficiency	11.1%
2	P0171 -- System Too Lean	9.9%
3	P0401 -- EGR Flow Insufficient	7.9%
4	P0174 -- System Too Rich	5.6%
5	P0300 -- Random Misfire	5.1%
6	P0141 -- O2 Sensor Heater Circuit Malfunction	4.9%
7	P0133 -- O2 Sensor Circuit Slow Response	4.4%
8	P0325 -- Knock Sensor 1 Circuit Malfunction	4.2%
9	P0135 -- O2 Sensor Heater Circuit Malfunction	4.1%
10	P0440 -- Evaporative Emission Control System Malfunction	3.8%
	Total Top 10	61.0%

Comparison of Top 10 DTCs in Different States

dKC compiled data on top 10 DTCs in California and Delaware and compared this list with Connecticut's top 10 DTCs. The top 5 DTCs were similar in all 3 states, which indicates that these vehicle fleets have similar emissions related problems. States can team-up to help define the best way for technicians to attack these problems. Discrepancies at the bottom of the list are likely due to climate and/or emission standards differences.

Diagnostic Trouble Codes (DTC)	Rank		
	CA	CT	DE
P0420 -- Low Catalyst Efficiency	1	1	1
P0171 -- System Too Lean	2	2	2
P0401 -- EGR Flow Insufficient	3	3	3
P0174 -- System Too Rich	4	4	5
P0300 -- Random Misfire	5	5	4
P0141 -- 02 Sensor Heater Circuit Malfunction	6	6	6
P1443 -- Ford Evaporative Control Valve Failure	7	14	21
P0135 -- 02 Sensor Heater Circuit Malfunction	8	9	10
P0133 -- 02 Sensor Circuit Slow Response	9	7	7
P0455 -- Evaporative Emission Control System Leak Detected (gross leak)	10	13	15

7.0 Audits and Other QA Activities

The State and its contractor (Applus) perform extensive Quality Assurance (QA) activities, which are summarized below.

State Oversight

The Connecticut Department of Motor Vehicles (DMV) performs the following oversight functions:

- Overt audits of equipment, procedures and inspectors – twice/mo. – 25 Field Agents/Contract Compliance Officers
- Covert audits of Stations/inspectors – both testing and repair – twice/year per station
- 4 Dedicated Video auditors – monitoring inspections during station operating hours
- 3 Record auditors – monitoring trigger and anomaly audits daily
- 4 QA auditors performing equipment and calibration 2 point and 5 point audits
- Digital Web Cameras – Video Monitoring System
 - Real time monitoring/control of vehicle inspections
 - Video auditors can selectively view inspections
 - If anomalies are detected – inspection can be halted
- Remote wireless auditing/viewing of station (planned but not yet implemented)
- Customer satisfaction surveys
- Registration denial via the EDBMS – this will eliminate the need to enforce emissions stickers

Contractor QA Activities

Fraud Prevention Systems

- Secure IRIS recognition system – use of biometrics
- Trend analysis monitoring –
 - Test time duration
 - Initial & Retest pass/fail rate
 - Repair costs
 - Waivers
 - Speed variability check
 - Gas cap failure analysis
 - After hours inspection analysis
 - Aborted inspection analysis

Analyzer QA Functions

- Sample system leak check
- Analyzer gas calibrations – Every 72 hours or system will lock out testing
- CDAS units require a 2 point calibration with BAR 97 High gas – followed by BAR 97 Low gas blend
- CDAS units have passed BAR 97 certification tests
- Dynamometer undergo a coast down every 72 hours
- Raw transport time verification
- Various other Hardware checks are done every 72 hours
- Low sample flow, Sample dilution checks etc.

Contractor QA Activities (cont.)

Inspection Results Analysis Audits – monitoring of performance indicators

- # of offline inspections
- Short period between tests
- Transient failures
- Gas Cap failures
- OBD failures
- After hours testing

Digital Audits – monitoring of equipment service and repair

- Leak check failures
- NO cell age
- Gas cap calibration failure
- NO response time
- CO response time
- O2 response time
- NO low calibration gas drift
- Bench low calibration failure rate
- Parasitic loss changes

8.0 Conclusions

Following are the key conclusions from this analysis:

- ❖ Connecticut is failing the expected fraction of vehicles because they have evidence of being high emitters. Overall, 103,000 vehicles failed the emissions test. This equates to 9% of the vehicles tested.
- ❖ 28% of the failures during the test period did not receive a passing result (or waiver). Ultimately these vehicles must comply, since compliance with I/M standards is now a prerequisite to vehicle registration.
- ❖ Connecticut's I/M test identifies vehicles that were observed to have high emissions during independent on-road (remote sensing) tests. The fraction failing tailpipe and OBDII tests has much higher average emissions than the fraction that passes. OBDII and tailpipe tests identify vehicles with high emissions levels.
- ❖ Connecticut conducts extensive Quality Assurance (QA) and enforcement activities on the new I/M program. The new program has little fraud.
- ❖ After review of RSD data there appears to be no significant air quality impact of exempting the newest four model years from emissions testing. Therefore, Connecticut should continue to exempt the newest four model years from the emissions test program.
- ❖ Connecticut should expand remote sensing tests, so that emissions benefits for 1996 and newer vehicles (that only receive OBDII tests) can be accurately estimated.
- ❖ The EPA readiness exemption list for OBDII testing should be expanded to include at a minimum those vehicles listed on pages 54 and 55.