AirCare - Results and Observations in 2009 and 2010

PACIFIC
VEHICLE TESTING
TECHNOLOGIES

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1.0 EXECUTIVE SUMMARY

This report presents observations and analysis of AirCare inspection and repair data for calendar years 2009 and 2010. For certain parameters, figures from earlier reports are provided to give an indication of long-term trends. In the reporting period, 90,582 failing vehicles were identified out of 802,261 tested (11%). Of these, more than 75% were re-inspected and passed. For these vehicles, pre-and post-repair mass emission data was used to quantify the emission reductions achieved. On an impact-weighted basis (discounting carbon monoxide emissions by a factor of 7), the percentage reduction in the light duty vehicle emission inventory resulting from AirCare repairs alone was 8.0% in 2009 and 7.2% in 2010.

There were 20,824 vehicles that did not return for a passing re-inspection after failing. For the 10,672 vehicles that failed in 2009 but did not return to pass within the expected time frame, 8,790 were still not licensed in the Lower Fraser Valley even as of August 2011. Therefore, it can be assumed with some confidence that the non-returning vehicles were effectively removed from use in the AirCare area. The emission reductions resulting from the removal of these vehicles correspond to a further reduction in the light-duty vehicle emissions inventory of 5.9% in 2009 and 6.1% in 2010.

Other benefits of the program, such as pre-inspection repairs and deterrence from tampering with emission control systems are not quantified in this report. The presence of an inspection program influences all vehicle owners to maintain their vehicles properly and to keep all emission control systems working as designed, even if the vehicle is new enough to be exempt from testing. In addition, the existence of the program improves the knowledge of the repair industry so that they can efficiently deal with emission-related repairs on any vehicle, whether it has failed a test or not. Without a program, it is reasonable to assume that the vehicle fleet as a whole would generate more emissions. The deterrence effect of the program can be almost as large as the direct benefits of repairs, bringing the impact of the program compared to no program at all to about 15% based on the difference between MOBILE 6.2C estimates for “No-I/M” and “With I/M” inventory values for the Lower Mainland fleet in 2010.

1.1 AIRCARE BENEFITS

As mentioned above, there are multiple mechanisms by which the AirCare program can reduce the annual inventory of emissions produced by motor vehicles. Two of the more quantifiable ones are discussed here.

1.1.1 DIRECT BENEFITS FROM VEHICLE REPAIRS

The reduction in emissions attributable to repairs performed on vehicles that have failed an AirCare inspection is a function of the number of repairs, the change in emissions output resulting from those repairs, and the number of kilometres driven per year.

As in previous years, the emission benefits were evaluated using full-duration IM240 emission tests performed on a representative sample of the fleet. “Sample” tests are performed after the mandatory test type has been administered and the pass/fail result determined. A minimum of 5,000 sample tests per year is prescribed in the service contract in order to provide enough examples to characterize the registered vehicle fleet. Additionally, for 1992-1997 vehicles, *all* of the failing IM240 tests are full-duration. The lane software requires that all re-inspections of vehicles that failed their initial IM240 test must also be full duration tests. This program feature resulted in more than 20,000 matched pairs of “initial fail” vs. “final pass” results being available on which to base the benefits analysis. The large mass emissions sample set makes it possible to determine average emission outputs for various categories of vehicles based on their inspection results. This includes passing vehicles and the multiple combinations of failure modes observed.

There were 38,882 vehicles in 2009 and 38,403 vehicles in 2010 that were re-inspected and passed after failing their initial inspection. The "Base Inventory", using emission factors from the 10,000+ sample tests and the 20,000+ vehicles with direct, before and after emission results, was calculated for the registered light-duty vehicle fleet as of January 1st of calendar years 2009 and 2010. For the "Base" inventory, all registered vehicles were assigned an emission rate based on their age, type, emission control technology, and initial AirCare test result. For vehicles not tested because they were exempt (2003 model year and newer in 2009 and 2004 model year and newer in 2010), estimated IM240 emission factors were generated based on new vehicle certification standards. For vehicles that *did* go through the inspection process, the emission factors assigned in the base case were based on the results of the *initial* inspection. The "Base Inventory" takes into account the natural changes in emissions of the light-duty fleet resulting from fleet growth, retirement of older vehicles, and AirCare-related repairs in the previous year. The "Base Inventory" decreases naturally each year because of the combined effects of new emission control technology and retirement of older, high-polluting vehicles. The additional benefits from AirCare repairs in the year being analyzed are calculated by substituting the *final* inspection result for each failing vehicle and re-calculating the inventory. Subtracting the smaller, "With Repairs" inventory from the "Base Inventory" provides the mass of emissions reduced from repairs.

The table below shows the overall effect on the inventory of Hydrocarbons (HC), Carbon Monoxide (CO), and Oxides of Nitrogen (NO_x), from the repairs performed in 2009 and 2010. The percentage reductions due to repairs in 2009 were 10%, 9% and 4% for HC, CO and NOx respectively. In 2010, the percentage reductions were 9%, 8% and 4%.

Effect of Repairs on In-Use Light-Duty Vehicles Mass Emissions Inventory (tonne/year)

	2009			2010		
	HC	CO	NO_x	HC	CO	NO_x
Base Inventory for Year (tonnes)	5,105	77,926	6,712	4,490	69,652	6,200
Inventory after Repairs (tonnes)	4,617	70,591	6,412	4,099	63,887	5,922
Reduction from Repairs (tonnes)	488	7,334	299	391	5,765	278
Reduction from Base (%)	10%	9%	4%	9%	8%	4%

1.1.2 VEHICLES REMOVED FROM USE AFTER FAILURE

A portion of the vehicles that fail an AirCare inspection, about 23,000 of them in this reporting period, did not re-appear at an inspection centre after having failed. Since these vehicles were administratively blocked from licensing for anything more than 3 months after expiration of the licence in effect on the date of inspection, it is logical to assume that they would have been removed from use in the AirCare area by being scrapped, placed in storage or registered outside the program area. For the purpose of this analysis, vehicles were considered to be removed from use in a given calendar year if they were not licensed 4 or more months after the date of a failing test result (e.g. fail in January – August, still not re-licensed as of December 31st). There were 11,506 such cases in the 2009 calendar year and 11,263 for the 2010 calendar year. Assuming that these vehicles would have otherwise continued to operate in the absence of an AirCare program, an emissions benefit can be claimed from taking them off the road sooner than otherwise expected.

Emission Benefits from Removed-from-Use Vehicles in 2009 and 2010

	2009			2010		
Removal-from-Use Reduction	HC	CO	NO_x	HC	CO	NO_x
Total Tonnes per Year	413	5,318	218	357	4,479	202
% Reduction per Year	8%	7%	3%	8%	6%	3%

Although it must be recognized that some portion of this group would have been retired anyway, so the program cannot take credit for *all* of these removals from use, a calculation has been performed to determine the total avoided emissions associated with the retirement of these vehicles.

1.1.3 PRE-AIRCARE REPAIRS

Another mechanism by which the program can generate emission benefits is from repairs made prior to inspection. This is particularly likely for vehicles subject to On-Board Diagnostic (OBD) testing. Since 1998, vehicles in Canada are equipped with technology that continuously monitors the emissions system. When the OBD system detects an emissions-related fault or defect, the operator is warned by the illumination of the Malfunction Indicator Lamp or MIL. Owners of vehicles with illuminated MIL's can be virtually assured that their vehicle will fail the AirCare inspection and should be motivated to repair their vehicle prior to its initial inspection. Since these vehicles will simply register as a Pass on their initial inspection, there is no way to determine the number of pre-inspection repairs by using inspection data. As a result, no pre-inspection benefits are included in this report. However, it is certain that there were unquantifiable emissions reduction benefits resulting from pre-inspection repairs.

1.1.4 "WITH AIRCARE" SCENARIO COMPARED TO "WITHOUT AIRCARE"

The AirCare program has operated in the Lower Fraser Valley region of BC since 1992. In the 18 years between program start and the end of the evaluation period, more than 14 million inspections have been performed on more than 2 million individual vehicles, of which 862,000 have failed on at least one occasion. The cumulative effect of the program on vehicle maintenance habits, the ability of the repair industry to effectively diagnose and repair emission-related problems, and public awareness of air quality issues is difficult to quantify but has undoubtedly had a positive impact on the state of air quality in the region. The measure of this impact is ideally represented by a comparison of what the air quality situation actually was in 2010 compared to what it would have been if the AirCare program had never existed.

The imaginary scenario of "No AirCare Ever" can be simulated using the MOBILE 6C emission inventory model. This model has been used to estimate the light-duty inventory in the default (imaginary) scenario in which an AirCare program was not implemented in 1992, yet all other factors remained constant. This is the only available mechanism of establishing a "control" group against which the "with-AirCare" scenario can be compared.

A dramatic reduction in total light-duty vehicle emissions between 1992 and 2010 would have happened even without the AirCare Program, due to the introduction of cleaner vehicles and the retirement of older vehicles that had limited or no emission control technology. With the 18-year presence of AirCare, in 2010, the, impact-weighted inventory is 19,150 tonnes compared to an inventory of 149,300 tonnes in 1992 when the program started. This represents a total reduction of 87% in impact-weighted vehicle emissions over that 18-year period. Without AirCare the 2010 impact-weighted inventory would have been approximately 68,700 tonnes, which would have been a 54% reduction from 1992 levels. In the intervening period the total cumulative amount of impact-weighted emissions that have been prevented by the program is estimated at 652,700 tonnes.

The AirCare program continued to generate significant emission reductions during the 2009-2010 review period, and the effect of repairs, is still quite large. However, because the fleet is getting cleaner, the absolute magnitude of the emission reductions is declining. The program now serves to identify the vehicles that have developed an emission-related defect since their last inspection. These vehicles are then mostly repaired and restored to normal emissions output. This ongoing cycle counteracts the natural degradation of the fleet and potential benefits of the AirCare Program will persist as long as vehicles are less than 100% reliable.

1.2 INSPECTION STATISTICS

In 2009, there were 498,316 inspections performed while, in 2010, the total increased to 533,599 inspections.

Due to the fact that some vehicles may be tested more than once, the number of vehicles tested in any given calendar year is always less than the number of inspections. In 2009, there were 423,111 individual vehicles that were presented for an AirCare inspection. In 2010, this number was 459,388 vehicles. Registration data from ICBC suggest that there are almost 1.4 million light-duty vehicles registered in the AirCare-eligible area.

A variety of test types can be performed in the inspection lanes. Due to the fact that OBD tests apply only to 1998-and-newer model year vehicles, the number of OBD tests grows each calendar year. In 2009, 181,755 OBD inspections were performed. In 2010, however, the 2003 model year vehicles came into the program for the first time, resulting in a jump to more than 252,050 OBD inspections. Just about 20,200 vehicles failed their OBD inspection – meaning that they were presented for inspection in most cases with the MIL illuminated. This represents about 5% of the vehicles tested using the OBD procedure. The failure rate for IM240 tailpipe tests was about 14% while the failure rate for the oldest vehicles (1991-and-older) was almost 18%.

The inspection data also show that about 16,000 gas caps were flagged as being defective during the reporting period – about 4% of the vehicles tested. Estimating the impact of these repairs is difficult, but a modest estimate of 15 tonnes of hydrocarbons per year has been determined. OBD-equipped vehicles do not require a gas cap test because the OBD system includes a leak check of the fuel system.

The two tables below show the breakdown by inspection type and result for both 2009 and 2010.

Summary of Inspection Data in 2009 and 2010

	2009	2010
Inspections Performed	498,316	533,599
Vehicles Inspected	423,111	459,388
Failed Test for all Reasons Combined (Vehicles)	65,948 (49,018)	61,517 (46,663)
Failed Test for Emissions Only (Vehicles)	52,519 (36,435)	45,733 (31,726)
Tested According to OBDII (Vehicles)	181,755 (166,447)	252,050 (233,064)
Failed OBDII (Vehicles)	9,472 (8,812)	12,134 (11,433)
Tested According to IM240 Test (Vehicles)	158,730 (131,404)	147,892 (122,407)
Failed IM240 Test (Vehicles)	27,639 (18,921)	25,777 (17,893)
Tested According to ASM/Idle Test (Vehicles)	138,842 (113,524)	110,829 (90,946)
Failed ASM/Idle Test (Vehicles)	27,435 (20,273)	22,219 (16,336)
Tested Idle-Only Test (Vehicles)	4,210 (3,143)	4,467 (3,245)
Failed Idle-Only Test (Vehicles)	1,148 (782)	1,147 (753)
Diesel Vehicles Inspected (Vehicles)	8,072 (7,734)	9,245 (8,877)
Failed Diesel Opacity Inspection (Vehicles)	249 (207)	233 (207)
Unloaded Diesel Opacity Inspection (Vehicles)	889 (859)	874 (849)
Failed Unloaded Diesel Opacity Inspection (Vehicles)	5 (4)	7 (7)

Summary of Ancillary Tests for 2009 and 2010

	2009	2010
Gas Cap Pressure Tests Conducted	216,340	183,125
Failed Gas Cap Pressure Test	8,266	7,697
Failed Gas Cap Pressure Test (% Fail)	3.82%	4.20%
Failed Catalytic Converter Presence Test (% Fail)	0.05%	0.03%
Catalytic Converter Advisories (1987-and-Older Only in %)	3.68%	3.47%

1.3 RESPONSE TO FAILED INSPECTION

Vehicles that do not meet AirCare inspection standards must achieve either a Pass or Conditional Pass before they can be licensed and insured. For motorists needing time to complete repairs, a one-time, 3-month licensing option is available and many take advantage of this opportunity, placing a significant delay between the initial failing test and the re-inspection. In order to "close the loop" on the vehicles that failed in any given calendar year, it is necessary to look beyond the first three months of the following year to find associated re-inspections.

Motorists are free to repair their vehicles in any way they choose. A certified repair industry is available, consisting of about 270 repair shops. AirCare Certified Repair Centres (ACRC's) can submit repair data to the program administration via an on-line system called RepairNet. In order to be eligible for a Conditional Pass (the vehicle is allowed to re-license, even though it did not pass re-inspection), repair data must be entered by an ACRC prior to the re-inspection. ACRC's are supposed to submit repair data for every AirCare repair they do, but the number of repair data forms submitted has declined to about 8,500 in 2009 and 7,700 in 2010, despite a fairly stable volume of failing vehicles.

The table below summarizes the observed responses to a failed inspection in both 2009 and 2010.

Observations on Actions Taken after Failing Inspections

	2009	2010
Vehicles Not Returning for Re-inspection	10,672	10,152
Vehicles Repaired to Pass With Repair Information	5,788	5,838
Vehicles Re-Inspected to Pass Without Repair Information	27,425	26,089
Vehicles issued Conditional Pass	1,278	991
Gas Cap Replacements	3,855	3,593

The table shows that about 32,000 vehicles that failed in each year returned and passed a subsequent re-inspection. There were 5,788 vehicles repaired to pass by ACRC's in 2009 and 5,838 in 2010, based on the amount of repair data entered into the RepairNet system. This corresponds to about 20% of the total "repaired-to-pass" vehicle population. In both years, a much greater fraction of the failing vehicles returned and passed a re-inspection with no associated repair data. These "no-data" vehicles may have been repaired by non-certified repair facilities, by do-it-yourselfers, by certified shops that did not submit repair data, and some may have passed without any repairs having been performed at all. As there was no information available to indicate what transpired between the initial fail and the subsequent pass, it is impossible to categorize these "no-data" repairs. For the purpose of this analysis, however, it was assumed that any vehicle that was re-inspected and passed received some sort of corrective action that generated a reduction in emissions.

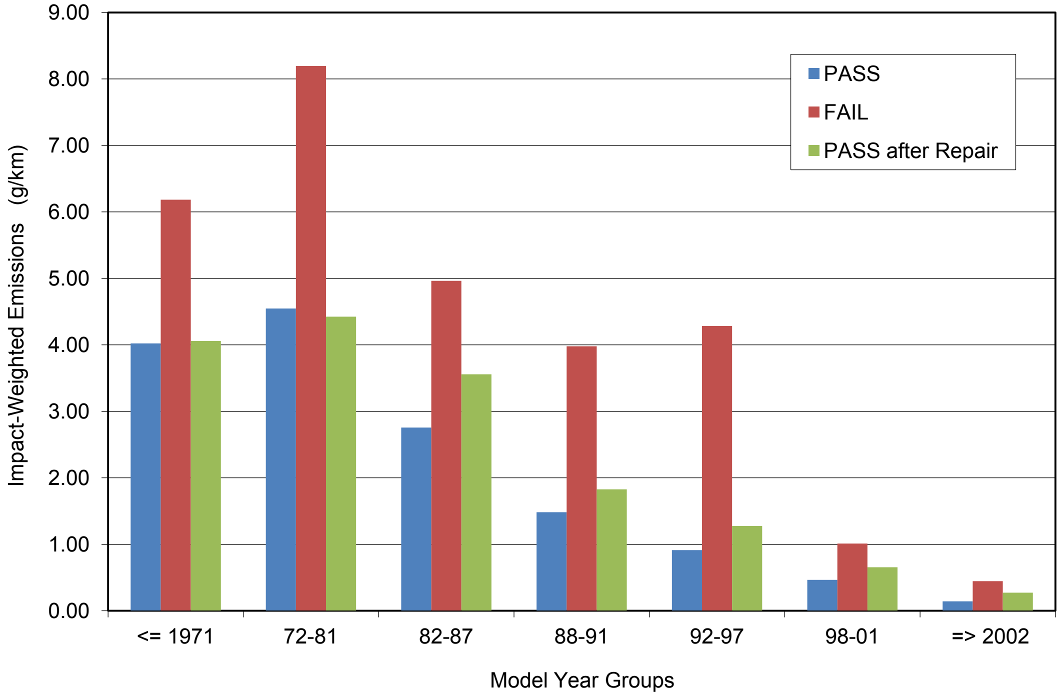
As mentioned earlier, only an ACRC can qualify a vehicle for a Conditional Pass. There were 1,278 such results in 2009 and 991 in 2010.

1.4 EFFECTIVENESS OF REPAIRS

1.4.1 COMPARISON OF MASS EMISSION RATES

The following figure illustrates the relative emission rates for “first-time-pass”, “first-time-fail”, and “repaired-to-pass” vehicles of various age groups and types. It can be seen that the “Repaired to Pass” emission rate is typically slightly higher than the rate for “Initial Pass” vehicles (first bar in each grouping), although not in all cases. This is a result observed in all previous AirCare program analyses and also in other I/M programs across North America. Various explanations have been offered by researchers for this phenomenon, but most agree that the reasons include incomplete diagnoses that leave some emission defects unattended and perhaps the use of after-market catalytic converters istead of OEM parts.

Another obvious trend is that the emission output of vehicles has decreased dramatically over time as a result of more effective emission control technology. In fact, the emission levels of failing vehicles in the newest segment of the tested fleet are usually better than the passing vehicle levels of the older technology vehicles. Vehicles of model years 1998-and-newer were mostly tested according to the OBD test procedure. A portion of these vehicles also received a full-duration IM240 test in order to characterize the emissions output corresponding to the OBD pass or failure mode. A similar process was followed when the vehicle appeared for re-inspection, establishing a post-repair emission rate. This data provided the basis for the bars shown on the chart.



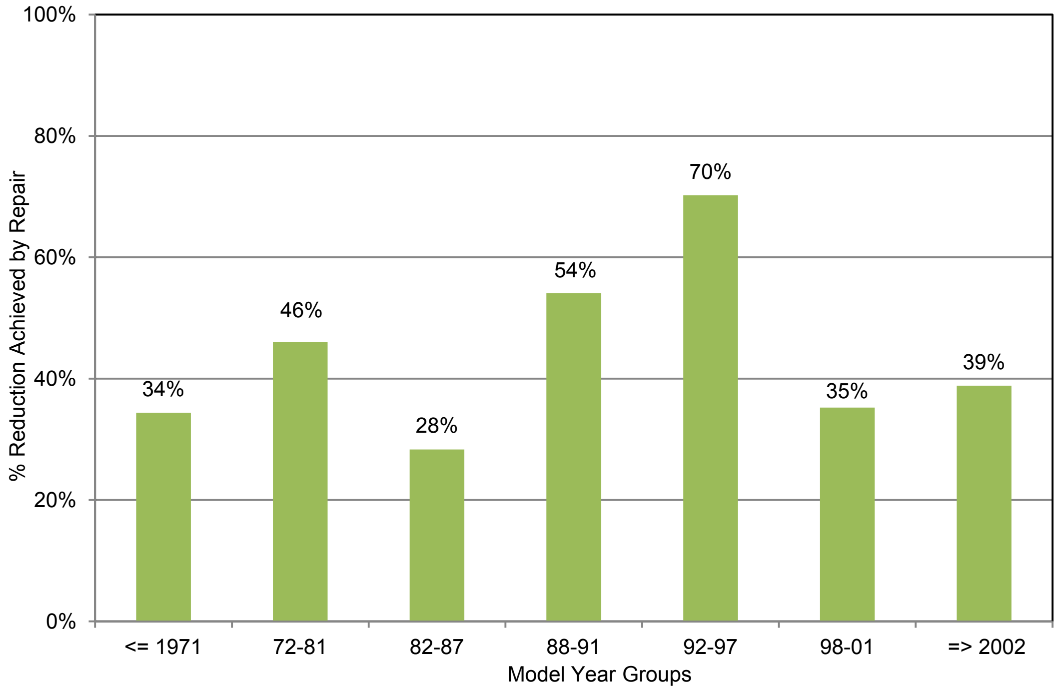
Impact-Weighted Emission Factors (HC + CO/7 + NOx)

The chart shows that the average emission rate for *failing* 1998-and-newer vehicles is usually lower than the average for *passing* vehicles from model years 1992-1997. This reflects the strides made by new vehicle manufacturers in reducing tailpipe emissions and improving the durability of vehicle emission control systems in recent years. However, OBD has also increased the stringency of in-use testing, because the system constantly monitors emission related parameters and will set codes and turn on the MIL whenever a fault is detected. Also, the OBD system can act in a preventative manner, flagging potential problems before tailpipe emissions have actually been affected. Some OBD faults, however, are related to the diagnostic system itself, meaning that the repair only restores proper operation of the OBD system with no effect on tailpipe emissions. Regardless, such repairs are valuable, as it is important that the OBD system be fully functional in order to detect the faults that do increase tailpipe emissions, should they occur.

Due to the fact that the OBD system identifies the problem area, repairs can be more focussed and more efficient. Over 95% of OBD re-inspections were successful during the review period.

1.4.2 EMISSION REDUCTION AS A PERCENTAGE OF INITIAL FAIL RESULT

Another measure of the effectiveness of repairs is to take the initial test results for each vehicle that failed and compare them to the final post-repair result. The next figure shows the emission reductions indicated by this method. All data is from full-duration IM240 tests.



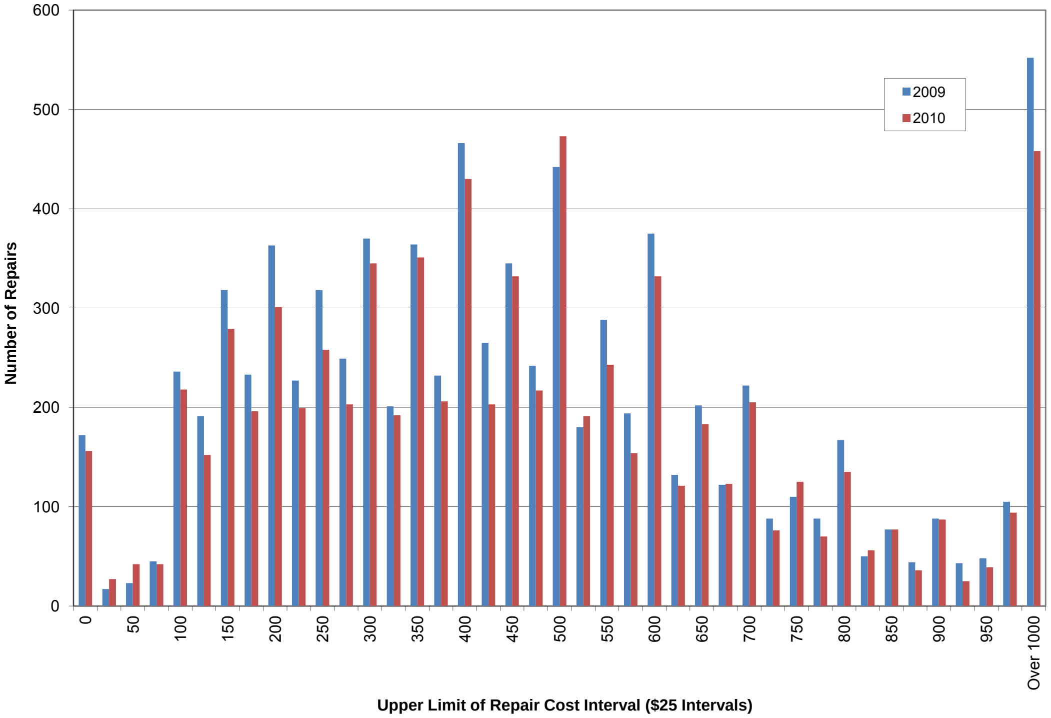
Effect of Repairs % Reduction = (Failed - Repaired) / Failed

It is apparent that post-repair emission test results vary significantly according to age groupings. Vehicles subject to the IM240 test process showed an average reduction of 70% in emissions after repair. Older vehicles, tested according to the less-rigorous ASM/Idle test, showed lower percentage reductions ranging from 28% to 54%. However, because the older, failing vehicles typically emit 5 to 7 grams per kilometre of impact-weighted pollutants compared to about 4.5 g/km for failing 1992-1997 vehicles, a 40% reduction from 7 g/km is a larger absolute emission reduction (3.36 g/km) than a 70% reduction from 4.5 g/km (3.15 g/km).

For vehicles subject to OBD inspections, the average reduction in tailpipe emissions was 37%. While this may appear small compared to the IM240 test, it must be remembered that there are a number of OBD failure modes that may have no direct effect on tailpipe emissions, for example, evaporative emission control defects, and OBD monitoring system defects. Analysis of the available data showed that OBD trouble codes associated with key emission control components like oxygen sensors or catalytic converters were strongly correlated with fairly large emission reductions. These cases, however, were offset by cases where the OBD repair had little or no indicated tailpipe emission benefit.

1.4.3 COST OF REPAIRS

The distributions of reported repair costs in 2009 and 2010 had much the same profile as in previous years. The median cost appears to be stabilizing from $400 in 2007 and $428 in 2006, to $425 and $430 in 2009 and 2010. Median values have been used instead of averages to minimize the effect of extreme values reported by repair shops. Some repairs are reported at zero cost and many with costs well over $1,000. It should be borne in mind that the applicability and representativeness of this data is compromised: the costs are only those reported as part of the repair data submitted by the certified repair industry, and these represent less than 20% of all repairs.

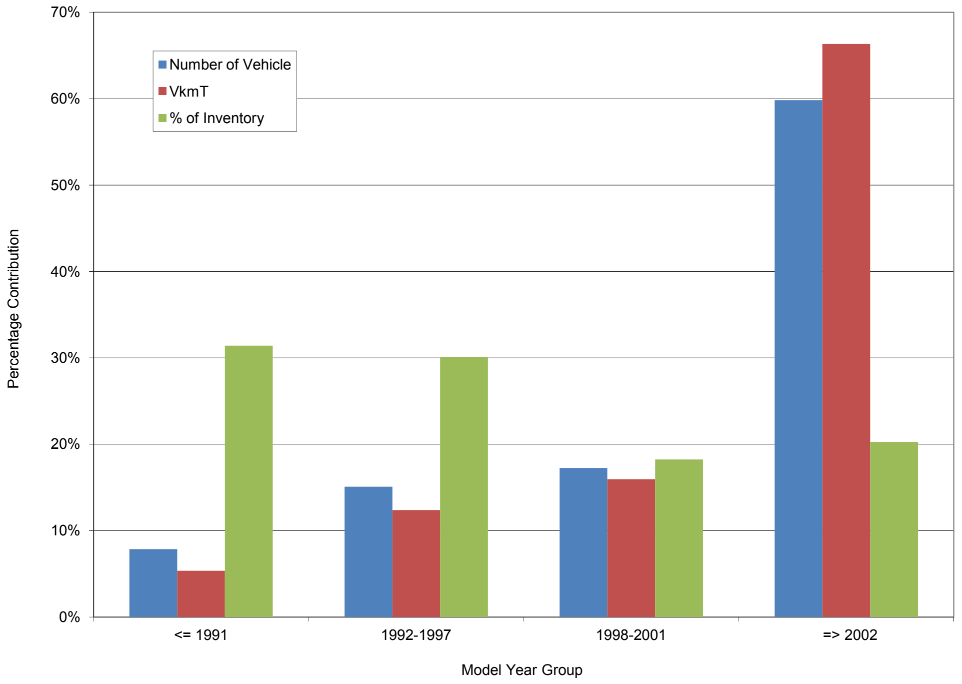


Distribution of Reported Repair Cost in 2009 and 2010

1.5 TOTAL EMISSIONS OUTPUT BY AGE GROUP

The total emission output by age/technology group is a function of the number of vehicles in each age group, their annual kilometres travelled, and their rate of emission output. For example, a relatively small population of high-emitting vehicles can contribute a significant fraction of the overall fleet emissions if the remainder of the population has very low emissions. The next figure shows the relationship between registered population, annual kilometres driven and percent of overall fleet emissions contributed by age group. On one hand, the number of vehicles and kilometres travelled increases steadily from the oldest to the newest age group.

On the other hand, the emissions inventory contributions decrease in much the same proportions from old to new. Vehicles from model years 2002-and-newer constitute 60% of the fleet and contribute 66% of vehicle-kilometres-travelled, but account for a disproportionately small 20% of the total emissions. Conversely, vehicles from the 1991-and-older model year group comprise only 8% of the fleet and contribute an even smaller 5% of the total vehicle-kilometres-travelled, but account for 31% of the total emissions – well out of proportion to their numbers and driving activity. It is quite clear that as long as older, high emitting vehicles remain in the fleet, they will continue to have a disproportionate effect on the overall inventory.



VkmT vs. Emissions Contribution by Model Year Group

Some I/M programs in the United States have gone exclusively to OBD inspections, because 1996 model year vehicles were required by law to be OBD compliant, meaning that 80%+ of the in-use fleet can be tested with OBD. The preceding data show, however, that the majority of excess emissions is attributable to the oldest vehicles in the fleet. It appears that emission control technology is becoming less susceptible to degradation over time but it remains to be seen how these vehicles will perform when they age beyond 10 years. Registration data suggest that the life expectancy of a vehicle is now around 15 years. If major emission control components fail in this timeframe, there will continue to be an indefinite and disproportionate contribution of emissions by the oldest fraction of the fleet.

1.6 CONCLUSIONS

- On an impact-weighted basis, repairs directly related to AirCare failures reduced total light-duty vehicle-generated emissions by 8.0% in 2009 and 7.2% in 2010. A further potential 6.1% and 5.8%, respectively, resulted from a portion of the failing vehicle fleet being removed from use.

- The impact-weighted emissions attributable to light-duty vehicles decreased from 149,300 tonnes in 1992 to 19,150 tonnes by 2010 (an 87% reduction). This is the combined effect of new vehicle technology (54%) and AirCare (33%).
- The total cumulative amount of impact-weighted emissions that have been prevented by the AirCare program since 1992 is estimated at 652,700 tonnes.
- On average, vehicles passing re-inspection had emissions 28%-70% lower than the initial failing result. Reductions on a percentage basis were highest (70%) for the 1992-1997 model year group, but it is necessary to factor in the absolute emission rate in order to determine which group produces the largest inventory reductions
- AirCare continues to accelerate the retirement of excess emitting vehicles. Of the 10,672 vehicles that failed in 2009 and have never appeared for a re-inspection, more than 82% of them were not re-licensed 4+ months after failing, suggesting that they are no longer operating in the AirCare region.
- The amount of repair data submitted by AirCare Certified Repair Centres continues to decline each year. Less than 20% of re-inspections now have associated repair data.
- As the number of certified repairs decreases, the number of Conditional Passes also decreases. In 2010, the number fell below 1,000, the lowest level recorded so far in the history of the program. This confirms that a much higher percentage of failing vehicles are being successfully repaired than in previous years.
- The annual emission benefits related to repairs and removal from use appear to be stabilizing, suggesting a mature program in equilibrium. The cumulative, long-term benefits of AirCare testing have contributed to an accelerated decline in total emissions attributable to light-duty vehicles since the program began.
- The proportion of On-Board Diagnostic tests continues to increase with about 5% of the vehicles appearing for inspection with the MIL light commanded on. Due to the illumination of the warning light informing the vehicle driver of an impending AirCare failure, it is reasonable to assume that a portion of the OBD-eligible fleet was repaired prior to being tested. Thus, the failure rate likely underestimates the true percentage of 1998-and-newer model year vehicles that are in operation with the MIL illuminated, and the program benefits calculation underestimates the total emission reduction benefits of AirCare program.
- As directed by the provincial government, the AirCare program underwent a consultant’s study in 2010 to assess whether the program was worth retaining after 2011, when the current testing contract is set to expire. The review concluded that even the newest emission control technology was still susceptible to the same issues that have historically caused excess emissions in older vehicles, such as failure to perform preventative maintenance and ignoring the MIL light when problems do crop up. While the onset of elevated emissions may be delayed by better technology, there will always be a minority of vehicles that develop emission-related defects in their declining years.
- The consultants determined that the projected emission reductions attributable to AirCare in 2020 would prevent exposure of the population to poor air quality that would, in turn, prevent health care costs that significantly exceed the cost of the program to local residents.

2.0 ANALYSIS OF AIRCARE INSPECTION DATA

2.1 FLEET PROFILE

In order to interpret trends in vehicle inspection statistics over time, one must first consider the various social and economic factors that affect the composition of the in-use vehicle fleet. Several aspects of the AirCare program, such as inspection volumes, failure rates, average repair costs, financial performance, and air quality benefits, are directly affected by changes in the fleet composition.

Each year, a number of new vehicles are added to the in-use fleet and some older vehicles are removed by being scrapped. The number of new vehicles sold is a function of the state of the economy and consumer confidence. In prosperous years, vehicle sales are high and in poor economic times, vehicle sales drop off. The observed trend is that the number of vehicles removed from use is usually less than the number of new additions. This results in a net increase in the vehicle population year-by-year. Over time, the number of vehicles by model year tends to decrease as vehicles are retired from use or are written off due to collisions or theft. After about 14 years, the population tends to drop off rapidly, meaning that this is effectively the full useful life of a light-duty vehicle. The lifespan of vehicles has been increasing due to improvements in body integrity and powertrain design, but almost all of the vehicles purchased as new cars in a particular model year will have been scrapped 20 years later.

Figure 1 shows the numbers of light-duty vehicles licensed for use in the region, by model year, from October 2002 to October 2010. October was chosen for this plot because by October each year almost all of that model year's vehicles have been sold. And, in fact, some of the next year's vehicles have also been sold; which is shown by the points on the far right of the chart.

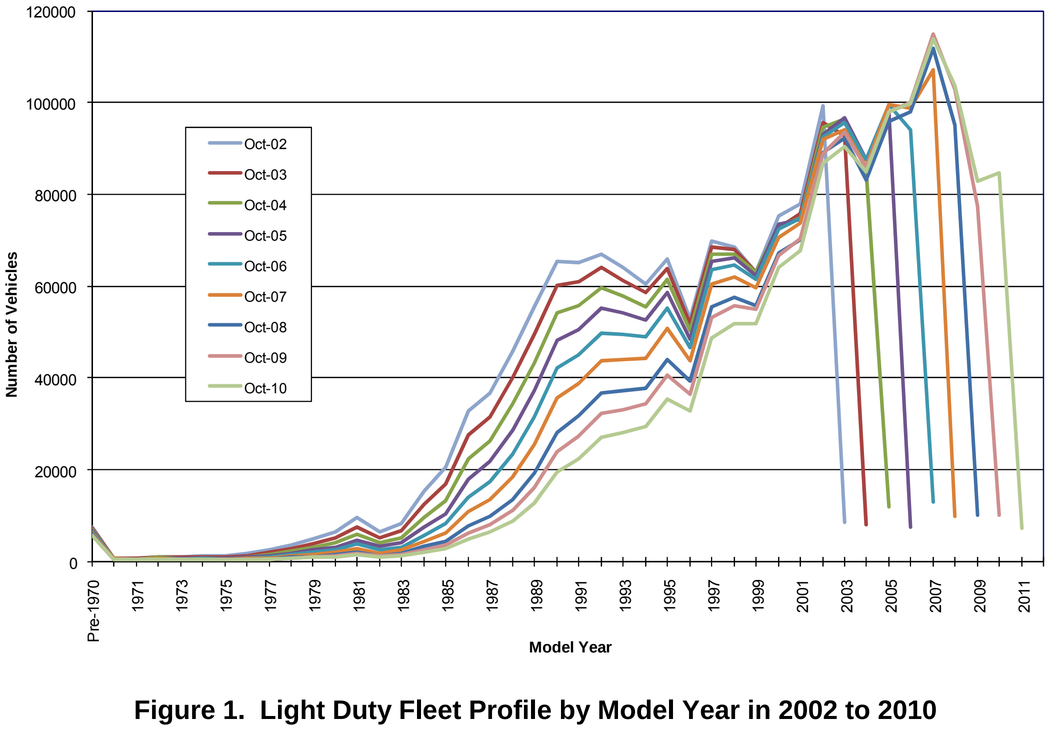


Figure 1. Light Duty Fleet Profile by Model Year in 2002 to 2010

Consider first the middle section of the chart. It shows that as time elapses, the number of vehicles in a particular model year decreases - so each line is lower than the one for the previous year. This just shows that old vehicles get retired, and they keep getting fewer in number. The maximum rate of loss is where the lines are furthest apart (vertically) and is for vehicles around 15 years old.

On the left side of the chart (oldest vehicles) the lines are much closer together but the same effect is present.

Just to the right of centre is the 1996 model year. This was a bad year for new vehicle sales, and their numbers still show the dip. There was also a lesser dip in 1999. Also, to the left of centre, the big drop in vehicle sales in 1981 and 1982 (economic recession) is still evident nearly 30 years later.

Table 1 shows the overall size of the light-duty fleet in the region over the same period. The rate of growth has been at something more than 2% each year, but October 2008 showed an actual decrease in fleet size. The deceleration of fleet growth was first noticed in analyses performed earlier in 2008 and was due to decreased sales of new vehicles.

Table 1. Overall Size of the Light Duty Fleet in 2002 to 2010

Period	**Total**	**Y-Diff**
Oct-02	1,167,760	N/A
Oct-03	1,191,103	2.00%
Oct-04	1,216,646	2.14%
Oct-05	1,249,123	2.67%
Oct-06	1,284,991	2.87%
Oct-07	1,317,874	2.56%
Oct-08	1,313,795	-0.31%
Oct-09	1,366,162	3.99%
Oct-10	1,384,794	1.36%

2.1.1 DISTRIBUTION OF INSPECTED VEHICLES BY MODEL YEAR

Figure 2 and Figure 3 below show the distribution by model year for the vehicles tested in calendar years 2009 and 2010, respectively.

The figures illustrate the biennial nature of the test cycle for 1992-and-newer vehicles, in which a sawtooth pattern is evident. The peaks of the teeth correspond to vehicles in the “on-year” while the valleys represent “off year” vehicles. Due to vehicles changing hands and other factors, the long-term trend in biennial testing is towards a levelling-out of the “on-off” effect. The figures for 2009 and 2010 show a sharp spike in the number of 2002 and 2003 model year vehicles inspected. This is because those models were completely exempt from testing in the previous year. For the 2003 vehicles, virtually none of these vehicles had ever been tested prior to it becoming mandatory in calendar 2010. It is anticipated that this “nothing-then-all” behaviour will continue as the 2004 and 2005 models come into the program in 2011 and 2012.

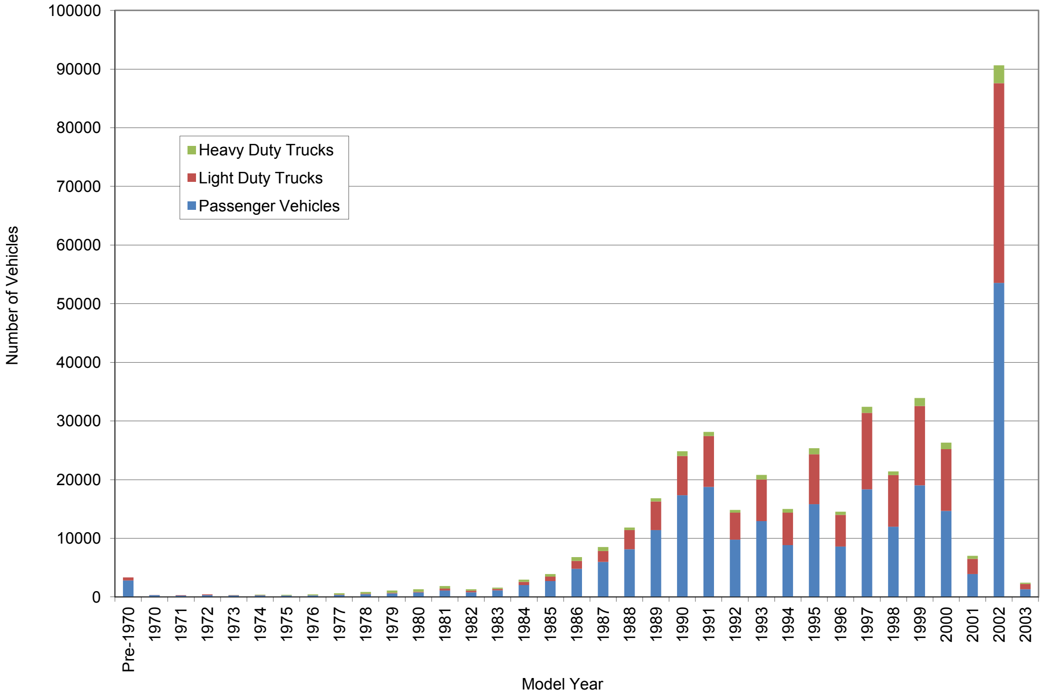


Figure 2. Number of Vehicles Inspected in 2009 by Model Year

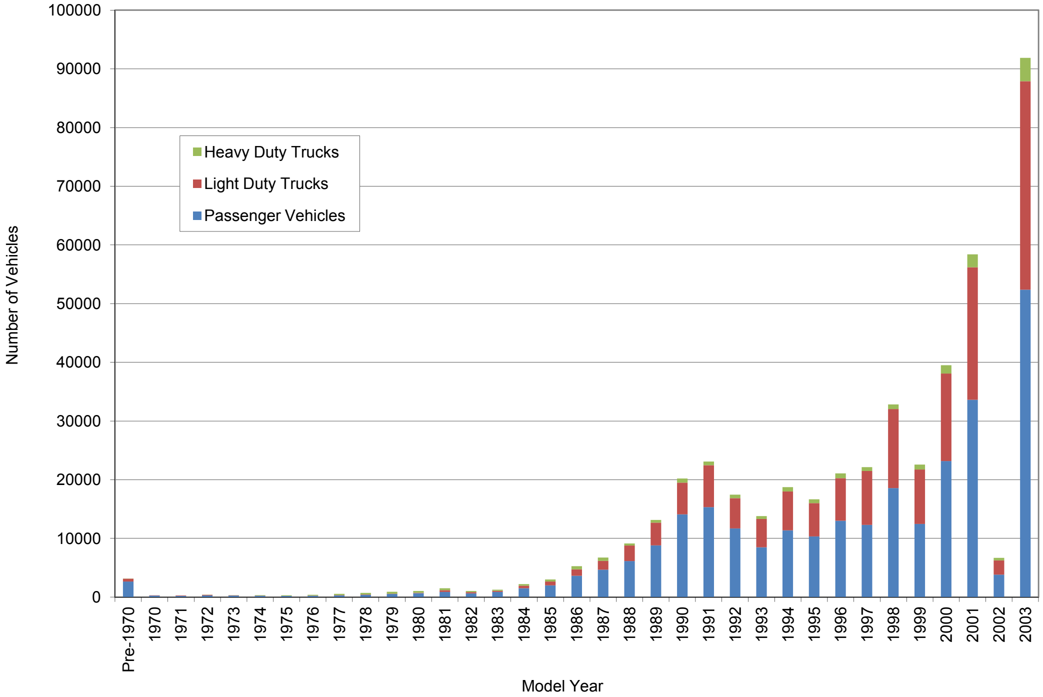


Figure 3. Number of Vehicles Inspected in 2010 by Model Year

2.2 INSPECTION STATISTICS

Table 2 shows the number of inspections and the number of vehicles inspected in each of the 2009 and 2010 calendar years. Due to re-inspections of failing vehicles, the number of inspections always exceeds the number of vehicles.

Table 2. Number of Inspections and Vehicles in 2009 & 2010

Calendar Year	Number of Inspections	Number of Vehicles
2009	498,316	423,111
2010	533,599	459,388

2.2.1 FAILING INSPECTIONS

The overall inspection failure rate considering all possible mechanisms for failure was 13.83% in 2009 and 12.10% in 2010. These rates correspond to 65,948 and 61,517 inspections, and 49,018 and 46,663 vehicles, respectively, in each year.

Figure 4 shows the trend in failure rate by month, which is to say that there is not much of an indicated trend

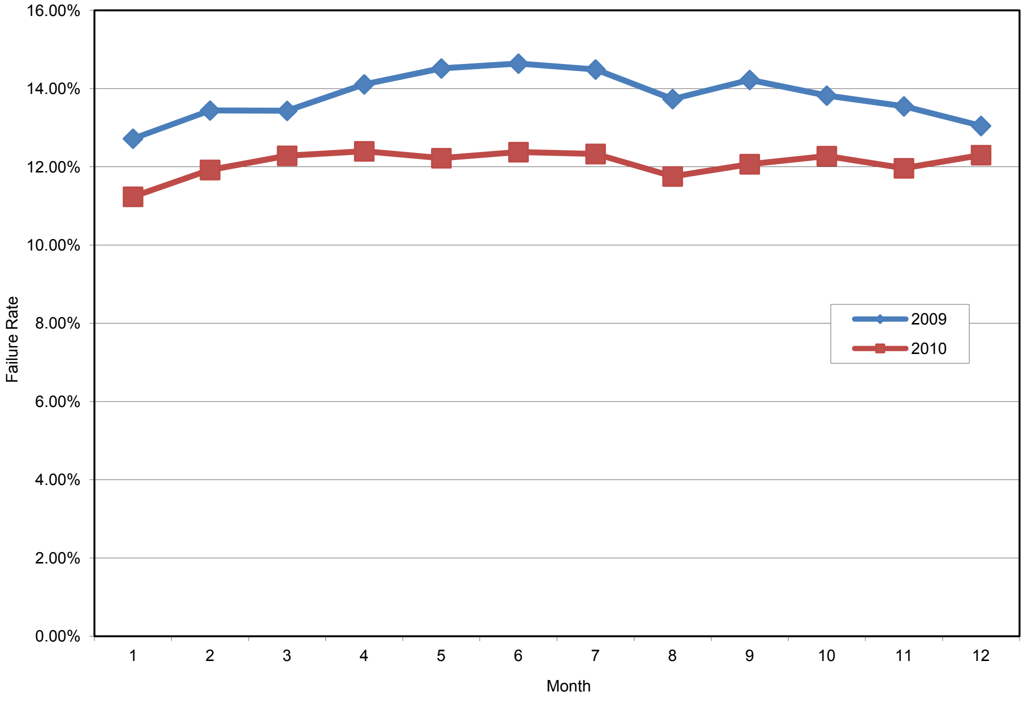


Figure 4. Overall Failure Rates by Month in 2009 and 2010

2.2.2 FAILING VEHICLES

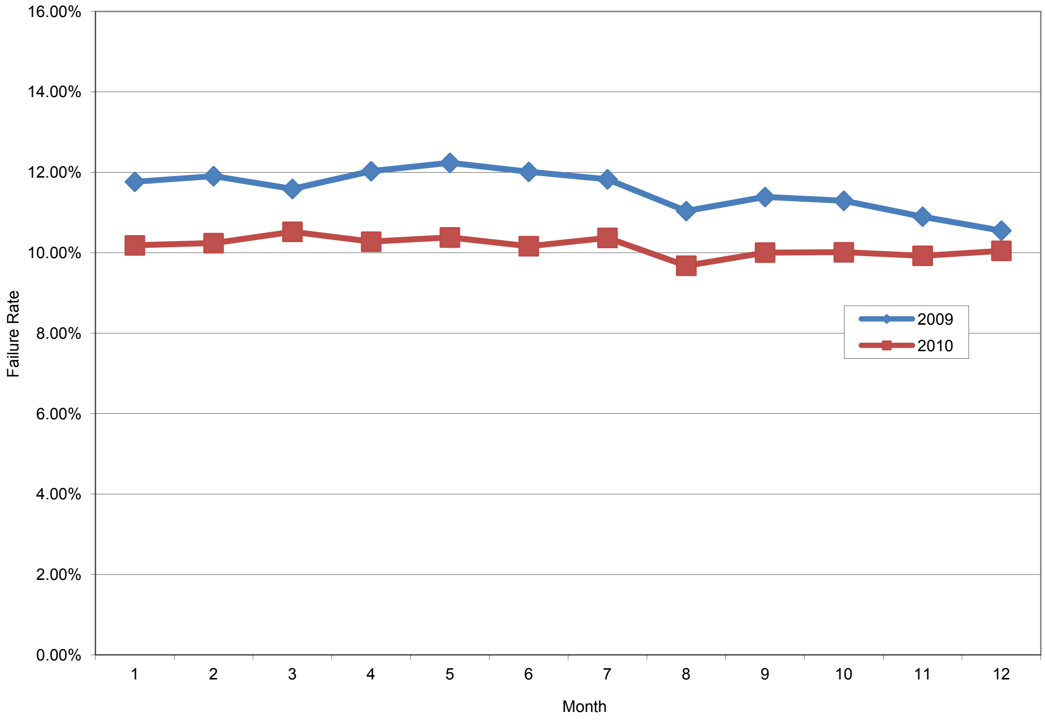


Figure 5. Initial Failure Rates by Month in 2009 & 2010

Figure 5 shows the initial inspection failure rates by month for 2009 and 2010, reflecting the state of the fleet as it was presented for inspection. The initial failure rate is the preferred indicator for the "state-of-health" of the vehicle fleet. As with Figure 4, not much of a trend is evident from month to month.

By definition, there are always more failing inspections than failing vehicles. This is due to the fact that some vehicles fail more than once. In 2009, there were 49,018 vehicles that failed at least once but the total number of failing inspections was 65,948. For 2010, there were 46,663 vehicles that failed their first test but the total number of failed inspections was 61,517. There are a number of reasons for this discrepancy, the most likely one being that owners of vehicles that fail may decide to try a second test before taking their vehicle to a repair shop. In any year, it is possible to find instances where 10 or more failed tests in a row were attempted. Some repeat failures result from incomplete repairs, where the repair shop or vehicle owner is trying to do as little as possible to eke out a pass at the lowest cost. This "roll the dice" approach inevitably results in multiple failures. This behaviour is expected to diminish as the proportion of vehicles subject to OBD testing increases. As long as the MIL is illuminated, there is no point in attempting another test, so it is more likely that any OBD re-inspection will have been preceded by some type of repair action.

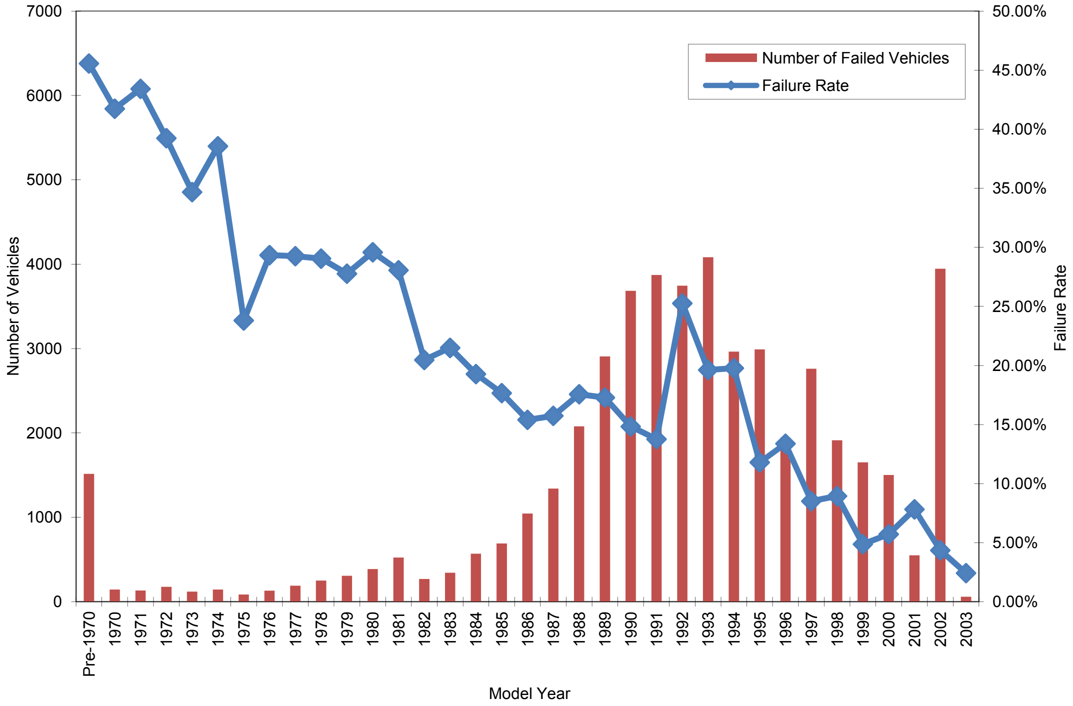


Figure 6. Number of Failing Vehicles and Initial Failure Rate by Model Year in 2009

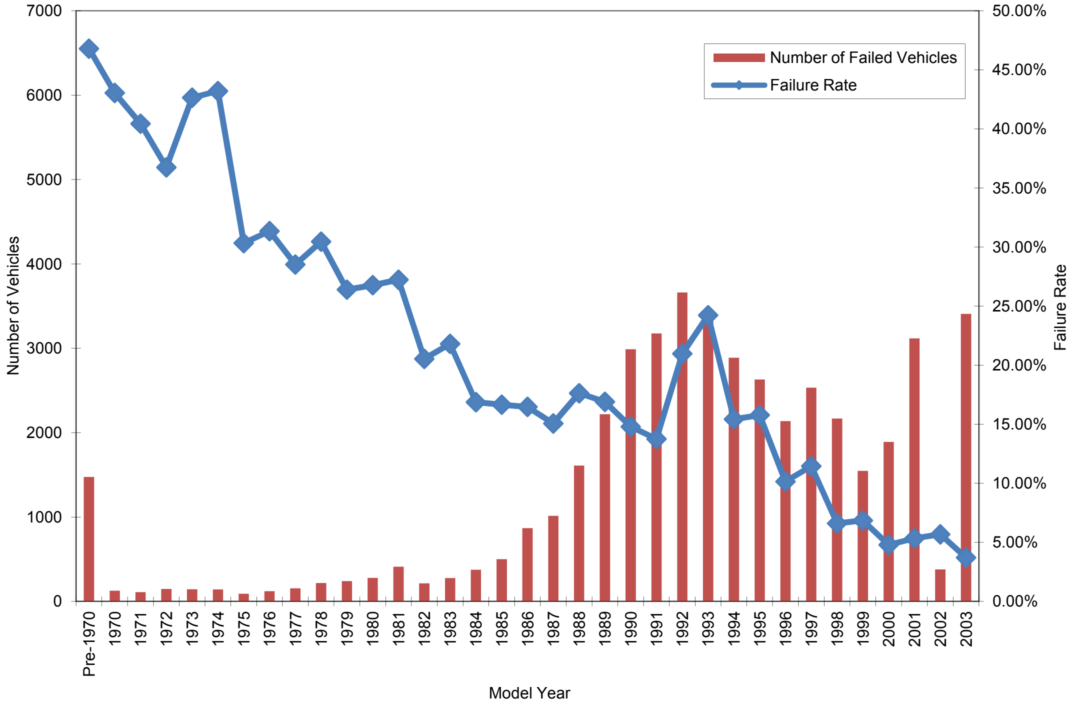


Figure 7. Number of Failing Vehicles and Initial Failure Rate by Model Year in 2010

Figure 6 and Figure 7 show the number of failed vehicles and the percentage initial failure rate by model year in 2009 and 2010.

Fluctuations in the volume of failing vehicles and the rate of failure are evident for the 1992-and-newer vehicles that get tested on a biennial cycle. Fewer vehicles are tested in "off-years" but the failure rate is higher. In 2009, the "off-years" were 1992, 1994, 1996, 1998, and 2001. In 2010, the "off-years" were 1993, 1995, 1997, 1999, and 2002.

2.2.3 ABORTED INSPECTIONS

Occasionally, it is necessary to abort a test in progress for any of the following reasons:

- Tire problems
- Excessive fluid leaks
- Excessive exhaust leaks
- Vehicle unsafe to operate on dynamometer
- Vehicle unable to follow driving cycle
- Engine malfunction
- Inaccessible exhaust opening
- Incorrect/missing paperwork
- Sample dilution
- Excessive RPM
- Insufficient funds

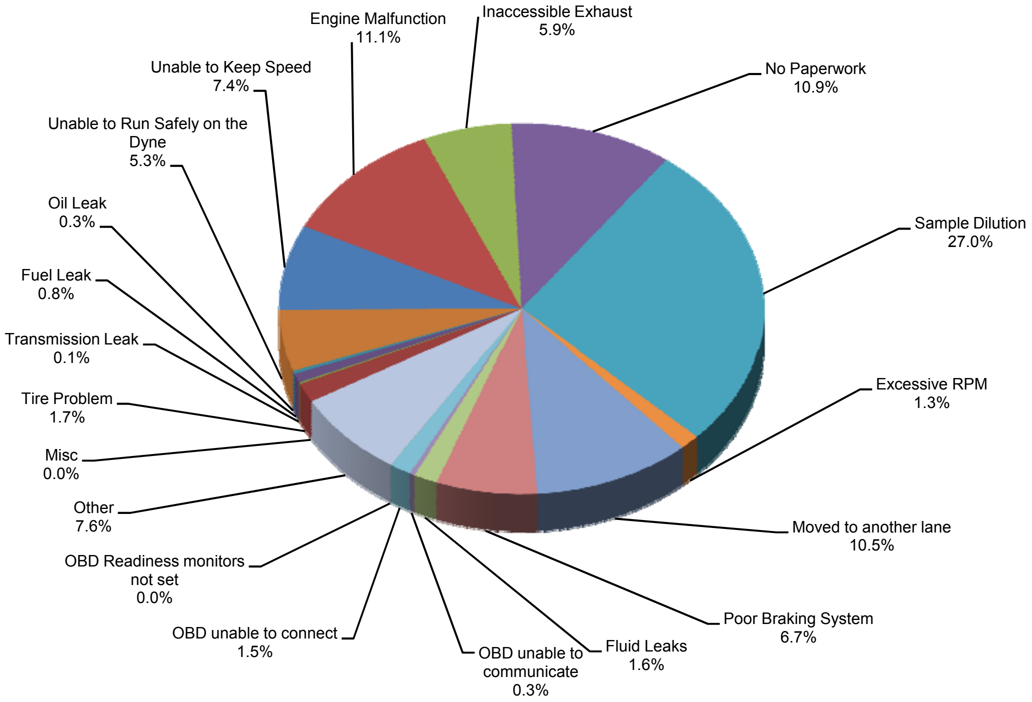


Figure 8. Distribution of Abort Codes in 2009

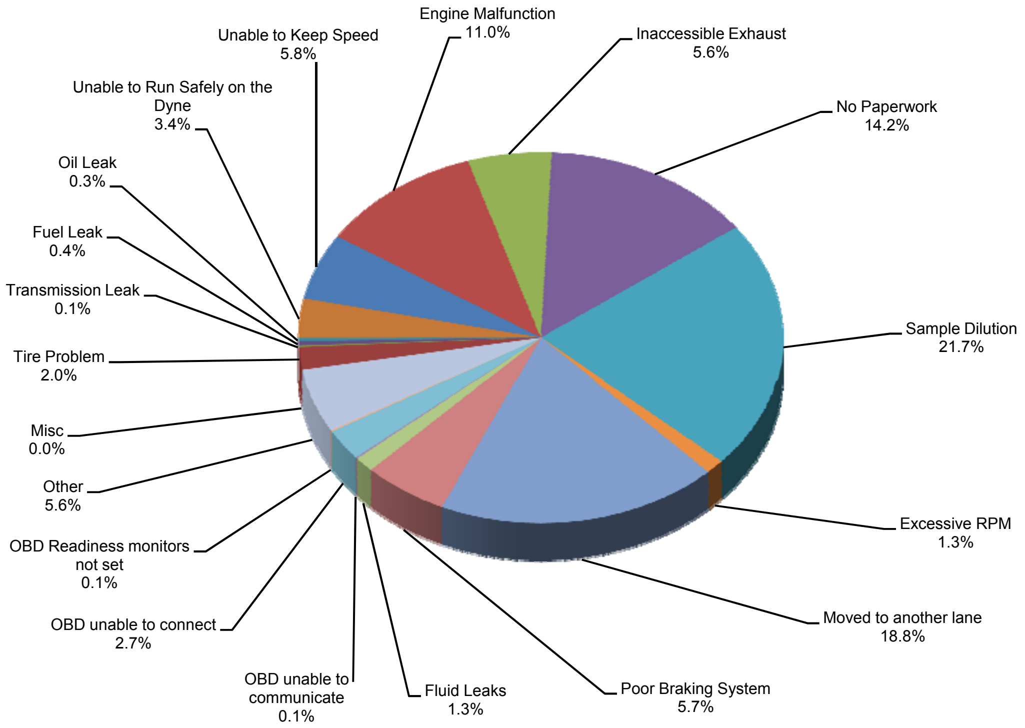


Figure 9. Distribution of Abort Codes in 2010

In 2009, there were 6,113 tests that were aborted. The number in 2010 was 5,969. This represents 1.28% and 1.17%, respectively, of all the inspections performed in each year. Figure 8 and Figure 9 shows the distribution of aborted tests in 2009 and 2010 by reason.

As in previous years, the most common reason for aborting a test was sample dilution, a situation normally caused by exhaust leaks in the vehicle being tested.

2.2.4 VOIDED INSPECTIONS

On rare occasions, it is necessary to void a completed test due to an error made during the process. Voiding the test generates a financial credit that can be offset against a subsequent, correct test. A low rate of void inspections is desirable as it reflects consistent adherence to proper test procedures. There were 339 void tests in 2009 and 324 in 2010. This represents less than one-tenth of a percent of all inspections performed, and is fractionally lower than in previous years.

2.3 INSPECTIONS BY TEST TYPE

Table 3 illustrates the growing importance of OBD inspections. As new vehicles are added to the tested fleet and older vehicles drop out, the proportion of vehicles with OBD capability will continue to grow. In 2010, the number of OBD inspections was approaching 50% of the total inspection volume.

Figure 10 and Figure 11 show the number of inspections of each type performed by month in 2009 and 2010. As expected, the volume of ASM tests has decreased over time as the number of 1991-and-older vehicles declines as they reach the end of their lives.

Table 3. Inspections by Test Type in 2009 and 2010

Test Type	2009	2010
OBD II	181,755	252,050
IM240	158,730	147,892
ASM	138,842	110,829
Idle Only	4,210	4,467
Diesel	8,072	9,245
Idle Diesel	889	874

The drop in test volume in November and December is normal and has been observed consistently since 1992. The reduced numbers of IM240 inspections in 2010 was because of the larger number of newer vehicles exempt from the program. With the additional of model year 2003 vehicles in 2010, the number of OBD II inspections is now significantly higher than other type of inspections.

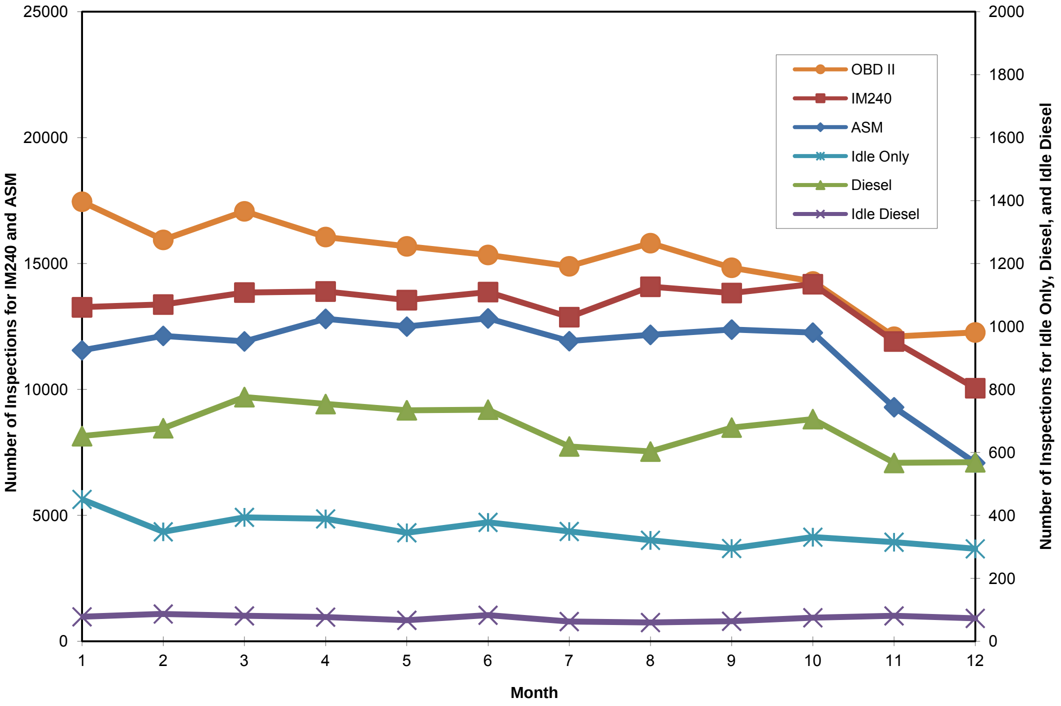


Figure 10. Number of Inspections for Each Test Type in 2009 by Month

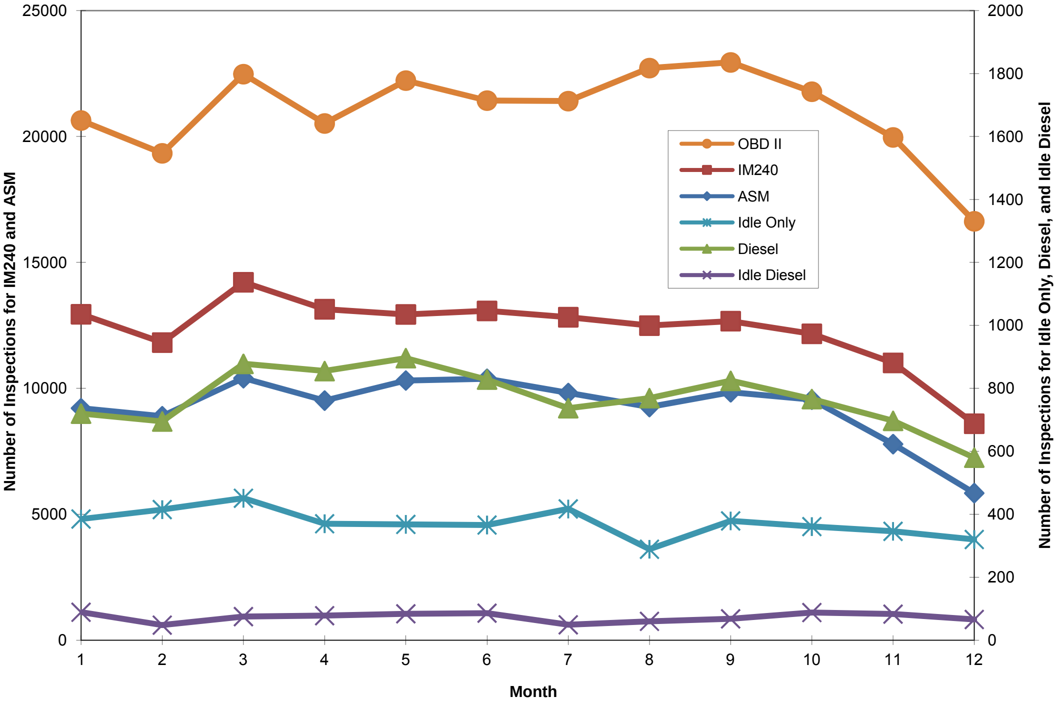


Figure 11. Number of Inspections for Each Test Type in 2010 by Month

2.3.1 OBD INSPECTIONS

In Canada, OBD systems were required under the Motor Vehicle Safety Act (later transferred to the Canadian Environmental Protection Act [CEPA 99]) as of the 1998 model year. In the United States, full compliance with OBD requirements was achieved in 1996. Most Canadian vehicles of the 1996 and 1997 model years are equipped with OBD systems but some are not. Given that OBD was not required by regulation in Canada until 1998, AirCare has restricted OBD inspections to 1998-and-newer vehicles.

Due to the seven-model-year exemption for new vehicles, the OBD-eligible fleet in 2009 consisted of the 1998 through 2002 model years. In 2010, the 2003 model year was added to the eligible fleet, representing over 91,000 vehicles. This trend will continue with more newer-model-year vehicles adding to the inspection pool each year. With the population of 1997-and-older vehicles naturally declining at the same time, the tailpipe testing program will be effectively replaced by an OBD-based program in the near future.

As mentioned previously, a vehicle subject to an OBD inspection will fail if interrogation of the on-board computer indicates that the computer is commanding the Malfunction Indicator Lamp to be turned on. In most cases, this will mean that the yellow dashboard warning light is illuminated. However, sometimes the bulb is burned out or has been intentionally removed. Thus, most vehicle owners presenting their vehicle for OBD inspections can be reasonably assured of passing if the MIL light is off and virtually assured of failing if the MIL is on. Vehicle owners are given prior notification of the fact that their vehicle will fail if the MIL light is on. This information is included in the AirCare information insert sent out with their ICBC renewal notice and signs are posted outside of the inspection centres. This warning gives owners the option of having the repairs performed before bringing their vehicle for inspection. It is interesting to observe that, despite prior warning, about 5% of 1998-and-newer vehicle owners arrive at the inspection centre with the MIL illuminated and proceed through the inspection. Figure 12 and

Figure 13 illustrate the failure rate by month for calendar years 2009 and 2010. There is little variation evident by month.

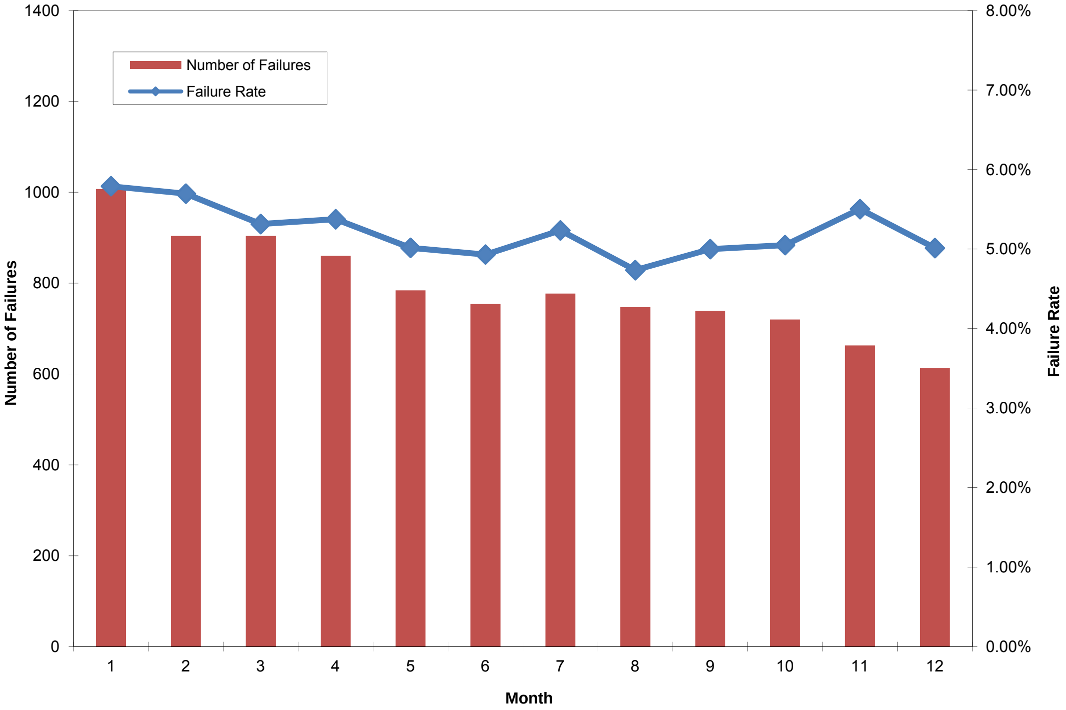


Figure 12. OBDII Number of Failures and Overall Failure Rate by Month in 2009

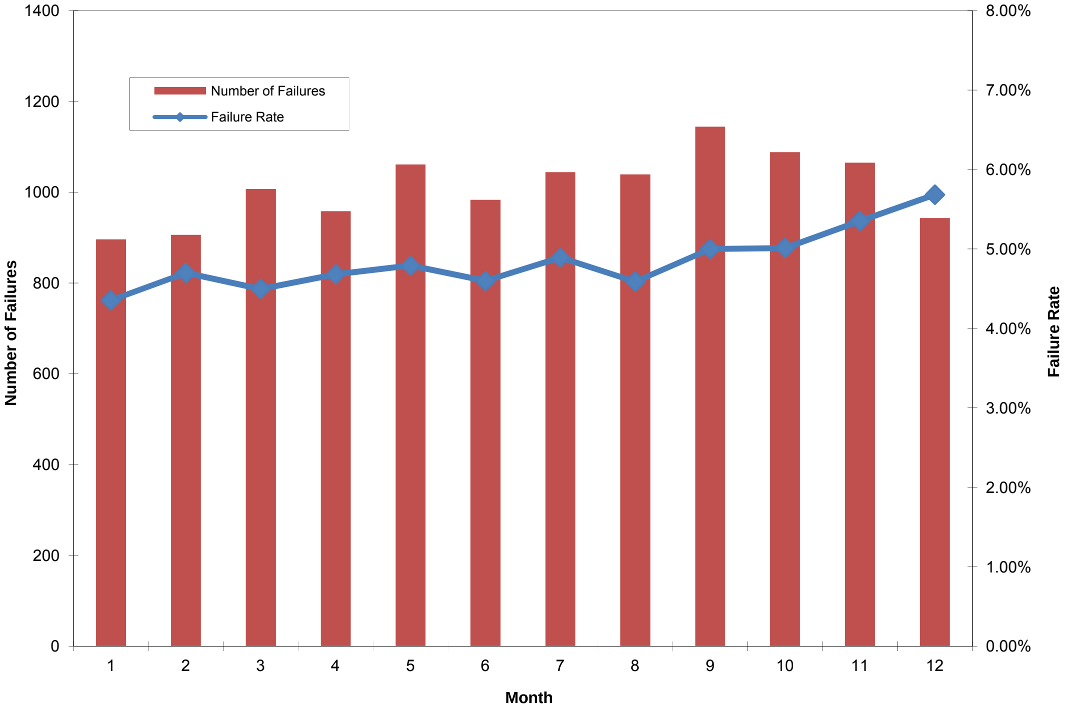


Figure 13. OBDII Number of Failures and Overall Failure Rate by Month in 2010

2.3.1.1 OBD Readiness

Unless the MIL is commanded ON, a vehicle with two or more of its OBD monitors shown as ‘not-ready’, will be rejected from the OBD inspection.

Table 4 shows the readiness results of all monitors for gasoline vehicles that arrived for their initial inspection during 2009 and 2010. Three of the monitors, Comprehensive, Fuel and Misfire, are known as Continuous monitors and are present on all OBD-II vehicles. They should achieve a status of ready as soon as the vehicle is started up. Although this was the case in about 98% of the tests, there were a very small number shown as ‘not-ready’ which is a little surprising, and very significant numbers shown as ‘not-supported’ which is very concerning. One possible explanation is that there is a fault in their PCM computers, or it has been changed to an aftermarket unit. Most of the other cases where monitors are shown as ‘not-supported’ are of equal concern. In fact the only monitors that could legitimately show as ‘not-supported’ are the ones for EGR because it is not used on all vehicles; Heated Catalyst, because none of the vehicles subject to inspection have this system; and Secondary Air, which is also used only on some vehicles to control cold-start emissions.

Table 4. Monitor Readiness of Gasoline Vehicles at Initial Inspection in 2009 and 2010

OBDII Monitor	Description	Status			% of Supported Not-Ready
		Not-Supported	Not-Ready	Ready	
CAT	Catalyst	924	31,707	386,601	7.6%
COMP	Comprehensive	4,477	220	414,535	0.1%
EGR	EGR	214,297	9,667	195,268	4.7%
EVAP	Evaporative	20,953	41,611	356,668	10.4%
FUEL	Fuel	4,839	338	414,055	0.1%
HOXY	O2 Sensor Heater	6,143	9,783	403,306	2.4%
MISF	Misfire	4,841	24	414,367	0.0%
OXY	O2 Sensor	832	17,322	401,078	4.1%
SAIR	Secondary Air	376,226	3,223	39,783	7.5%

The purpose of Table 4 is to show which monitors are most commonly ‘not-ready’ and are therefore responsible for vehicles being rejected from the OBD inspection. Clearly the EVAP monitor is most commonly ‘not-ready’, closely followed by the CAT monitor. As follows, there are generally three possible reasons why a monitor may be ‘Not-Ready’:

1) Someone has recently cleared the codes and all the other OBD information, either using a scan tool or by disconnecting the battery. This could be in order to extinguish the MIL, or could simply be because the battery has been changed or disconnected to prevent it draining. This type of situation is usually indicated by most or all of the non-continuous

monitors being ‘not-ready’. The situation is usually resolved by driving the vehicle sufficiently to get the monitors to run.

2) The conditions necessary for certain monitors to complete simply have not been encountered since the OBD information was last cleared. The monitor most often affected this way is the EVAP monitor. Unless the vehicle is exposed to the required variations in ambient temperature and the vehicle has the required amounts of gasoline in the fuel tank, the EVAP monitor will not run. Another monitor that can sometimes take a while to complete is the CAT monitor. Each manufacturer programs their catalyst monitor strategy in different ways; some require just a certain amount of highway driving, but others require driving at certain speeds for specific periods. If a vehicle is not operated in the way required for its own catalyst monitor to run, it will simply remain ‘Not-Ready’. Resolving this type of situation may require some research into exactly what operating cycle is required for the specific vehicle to run the monitor.

3) There is some underlying problem that prevents the monitor completing. All monitors have their own list of pre-conditions, which include certain operating conditions as described above, but also require that certain components are operating properly. A simple example is the catalyst monitor, which relies on upstream and downstream oxygen sensor signals to derive its assessment of catalyst efficiency. If a problem is detected with the oxygen sensors, the catalyst monitor simply does not run. This type of problem might be suspected if a monitor still hasn’t completed after a long period, or when one is sure that its required operating conditions have been provided. Its resolution requires some actual troubleshooting and diagnosis to find out what the underlying fault is.

Table 5 shows the number of vehicles found with zero to 8 ‘not-ready’ monitors at the time of their initial inspection. Of all the light-duty gasoline vehicles presented for their first inspection, there were 88% that were completely ‘ready’ as shown by having zero monitors set to ‘not-ready’, and another 6% where only one monitor was ‘not-ready’.

Table 5. Overall Readiness of Gasoline Vehicles on Initial Inspection in 2009 and 2010 Combined

Number of 'Not-Ready' Monitors	Number of Tests with that Many 'Not-Ready'	Cumulative Number of Tests with that Many or More 'Not-Ready'
0	351,192	403,483
1	26,159	52,291
2	11,445	26,132
3	7,483	14,687
4	4,757	7,204
5	2,115	2,447
6	328	332
8	4	4

This means that 94% of all these vehicles simply proceeded with the OBD inspection. Another 3% had two monitors ‘not-ready’ and 2% had three monitors ‘not-ready; so an additional 5% of the presented vehicles would have been switched to the IM240 ‘fallback’ test. This left only about 1% of the vehicles to be sent away without a test because they had four or more monitors shown as ‘not-ready’.

Table 6 shows the monitor readiness status of gasoline vehicles returning for a re-inspection after having failed.

Table 6. Monitor Readiness of Gasoline Vehicles at Re-inspection in 2009 and 2010 Combined

OBDII Monitor	Description	Status			% of Supported Not-Ready
		Not-Supported	Not-Ready	Ready	
CAT	Catalyst	51	8,695	17,596	33.1%
COMP	Comprehensive	315	70	25,957	0.3%
EGR	EGR	12,249	2,641	11,452	18.7%
EVAP	Evaporative	1,118	13,513	11,711	53.6%
FUEL	Fuel	342	114	25,886	0.4%
HOXY	O2 Sensor Heater	512	2,967	22,863	11.5%
MISF	Misfire	344	7	25,991	0.0%
OXY	O2 Sensor	46	4,299	21,997	16.3%
SAIR	Secondary Air	22,775	1,294	2,273	36.3%

The data suggest that most of the vehicles probably had all the monitors reset as part of the repair procedure. This left about half of them with the EVAP monitor ’not-ready‘, and about one-third with the CAT monitor ‘not-ready’. Although about a third of the SAIR monitors were also ‘not-ready’, this system is only used on a small fraction of the total number, meaning that a high proportion of SAIR-equipped vehicles showed up with that monitor ‘not-ready’. Overall there was a high fraction of vehicles appearing for re-inspection that did not meet the readiness criteria of 0-1 monitors ‘not-ready’.

Table 7 indicates that from a total of 24,764 re-inspections only 8,353 (34%) were completely ready, and an additional 8,065 (33%) had all but one monitor ready. This means that the remaining vehicles (33%) would have been rejected from the OBD inspection for not being ready. Reducing this fraction is desirable, as it represents wasted time and effort on the part of the vehicle driver and the inspection contractor.

Table 7. Overall Readiness of Gasoline Vehicles at Re-inspection in 2009 and 2010 Combined

Number of 'Not-Ready' Monitors	Number of Tests with that Many 'Not-Ready'	Cumulative Number of Tests with that Many or More 'Not-Ready'
0	8,353	24,764
1	8,065	16,411
2	4,285	8,346
3	2,254	4,061
4	1,171	1,807
5	563	636
6	72	73
7	1	1

2.3.1.2 Most Common OBD Trouble Codes

There are thousands of different diagnostic trouble codes (DTCs) that can be set by the OBD system and any one of them can result in the MIL being illuminated. However, some codes are much less common than others. In fact, in the two-year period covered by this report, a total of only 269 different generic codes have been observed. Table 8 shows the 20 most common DTCs that have been observed in this period for gasoline vehicles arriving for their initial inspection.

Overall, 89% of OBD failures had one of the Top 20 codes set, and 68% had one of the Top 10 codes set. But we can go even further by looking at what the DTCs are for. The two most common codes are P0171 and P0174, which are for System Too Lean Bank 1 and Bank 2 respectively. Between them we see that 22% of all the gasoline vehicles that had the MIL commanded ON were indicating lean operation. This is consistent with the previous reporting period (2007-2008). The other codes in the Top 10 and Top 20 are equally consistent. They are typically for Catalyst Efficiency, EGR operation, O2 sensor problems, Misfires, and Evaporative system problems.

It has also been observed that more than half of the vehicles that have the MIL commanded ON, have only one DTC, and there are very few that have more than two. Therefore, although in principle the OBD system is capable of indicating thousands of different problem conditions and combinations of problems, in reality, the number of problems actually encountered is relatively limited.

Table 8. Most Common Trouble Codes where MIL Commanded ON in 2009 and 2010 Combined

DTC	Number	Description	% of Total
P0171	3052	System Too Lean (Bank 1)	13%
P0174	2203	System Too Lean (Bank 2)	9%
P0401	2101	Exhaust Gas Recirculation Flow Insufficient Detected	9%
P0420	1795	Catalyst System Efficiency Below Threshold	8%
P0442	1214	Evaporative Emission System Leak Detected (small leak)	5%
P0135	1202	O2 Sensor Heater Circuit	5%
P0440	1172	Evaporative Emission System	5%
P0455	1139	Evaporative Emission System Leak Detected (large leak)	5%
P0300	1008	Random/Multiple Cylinder Misfire Detected	4%
P0141	925	O2 Sensor Heater Circuit	4%
	15,811	Total top 10 codes	68%
P0301	617	Cylinder 1 Misfire Detected	3%
P0446	554	Evaporative Emission System Vent Control Circuit	2%
P0302	541	Cylinder 2 Misfire Detected	2%
P0304	538	Cylinder 4 Misfire Detected	2%
P0303	468	Cylinder 3 Misfire Detected	2%
P0325	428	Knock Sensor 1 Circuit	2%
P0441	428	Evaporative Emission System Incorrect Purge Flow	2%
P0172	398	System Too Rich	2%
P0138	397	O2 Sensor Circuit High Voltage	2%
P0133	377	O2 Sensor Circuit Slow Response	2%
	20,557	Total top 20 codes	89%
	23,197	Total number initial Gasoline with MIL commanded ON	100%

2.3.2 IM240 INSPECTIONS

The IM240 inspection is a transient driving cycle/mass emissions measurement test procedure that is performed on most 1992-1997 model year vehicles. The name IM240 is derived from “Inspection and Maintenance” (IM) and the number of seconds in the test cycle (240).

Figure 14 shows the overall emissions-only failure rate by month in 2009 for IM240 tests (mostly 1992-1997 vehicles). In 2009, the fail rate remained fairly consistent throughout the year. Figure 15 is the equivalent figure for 2010, showing a slight upward trend in the failure rate.

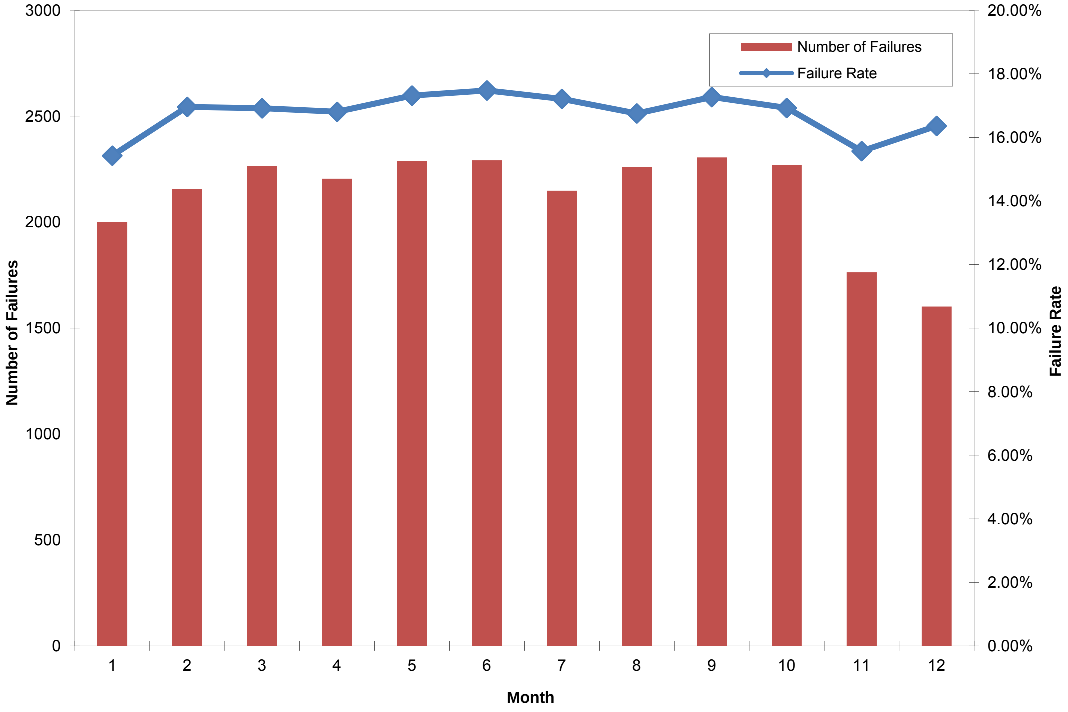


Figure 14. IM240 Number of Failures and Overall Failure Rate by Month in 2009

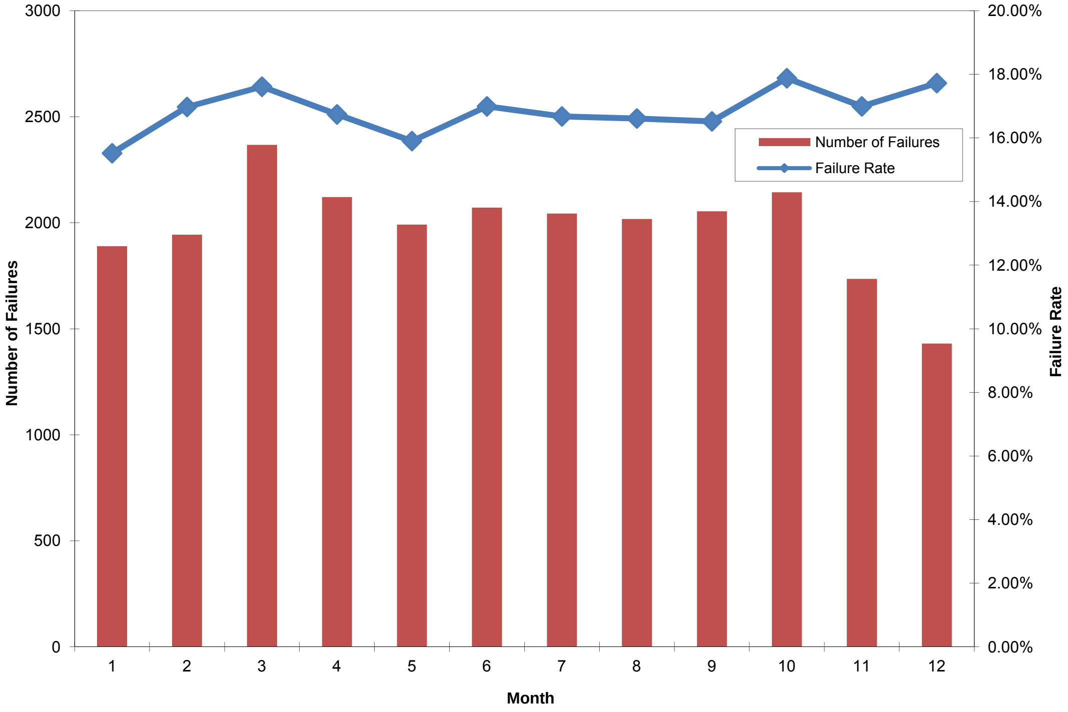


Figure 15. IM240 Number of Failures and Overall Failure Rate by Month in 2010

Figure 16 and Figure 17 show the IM240 failure rate according to model year. As expected, the failure rate increases with age. The 1992 model year shows a particularly high failure rate due to the combined effects of the vehicles being old and subject to a fairly rigorous inspection procedure

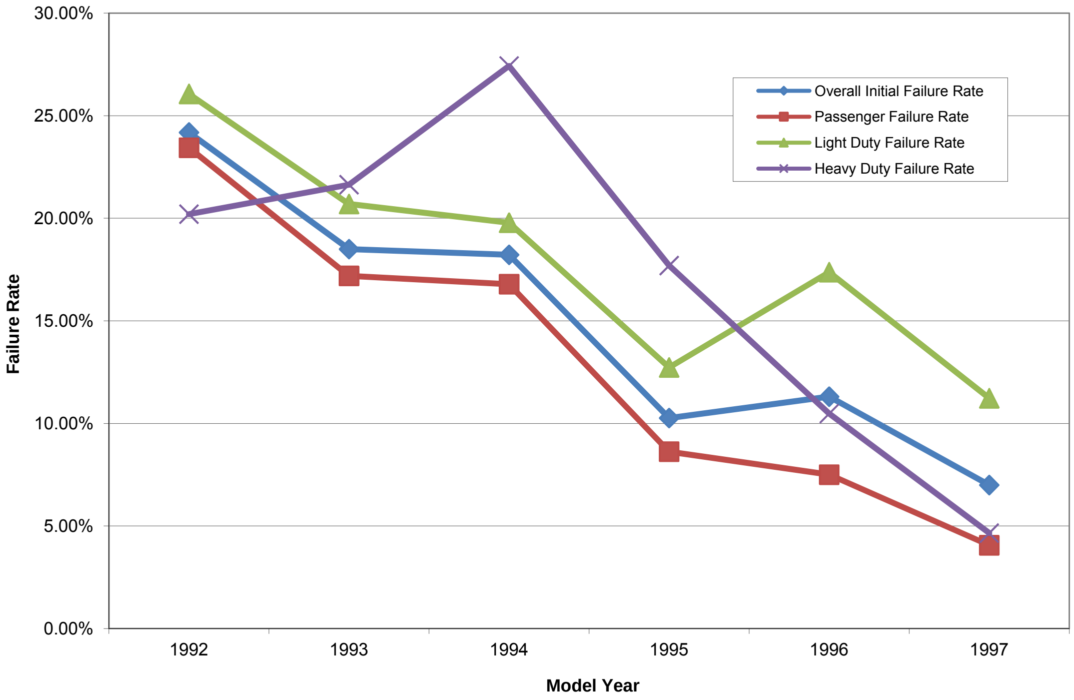


Figure 16. IM240 Initial Failure Rate by Model Year and Vehicle Type in 2009

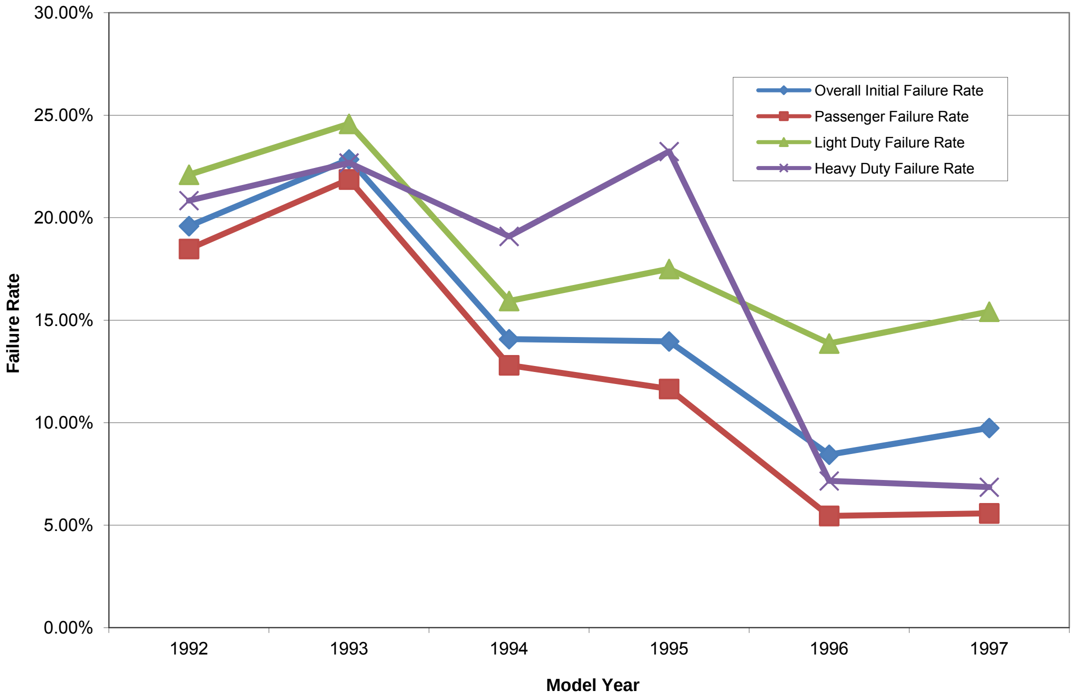


Figure 17. IM240 Initial Failure Rate by Model Year and Vehicle Type in 2010

The graphs show a slight discontinuity between 1995 and 1996 due to a change in the stringency of the IM240 standards for 1996 and later model years. Despite the tougher standards, fail rates for 1996 and 1997 vehicles are still quite low. This is likely the result of the full implementation of U.S. EPA Tier 1 emission standards coincident with the 1996 model year. As a result of these regulations, vehicles were required to meet more stringent emission standards for a longer period of time, meaning that more effective and more durable emission control systems were developed and put into production.

2.3.3 ASM + IDLE INSPECTIONS

The Acceleration Simulation Mode (ASM) + Idle inspection procedure is a steady-state, loaded mode test procedure that is performed in conjunction with an idle test on most 1991-and-older vehicles. Like the IM240, it is a tailpipe-based test but somewhat simpler and quicker to perform. However, it is not as rigorous a test as the IM240, so it is prescribed annually rather than biennially. Each year the number of vehicles in this age range decreases, so each year there are fewer ASM+Idle inspections.

As shown in Figure 18 and Figure 19, the overall failure rates for 1991-and-older vehicles tested to the ASM 2525 + Idle test procedure were fairly stable throughout the review period. In both 2009 and 2010, the failure rates were very stable - ranging from 18% to 21%.

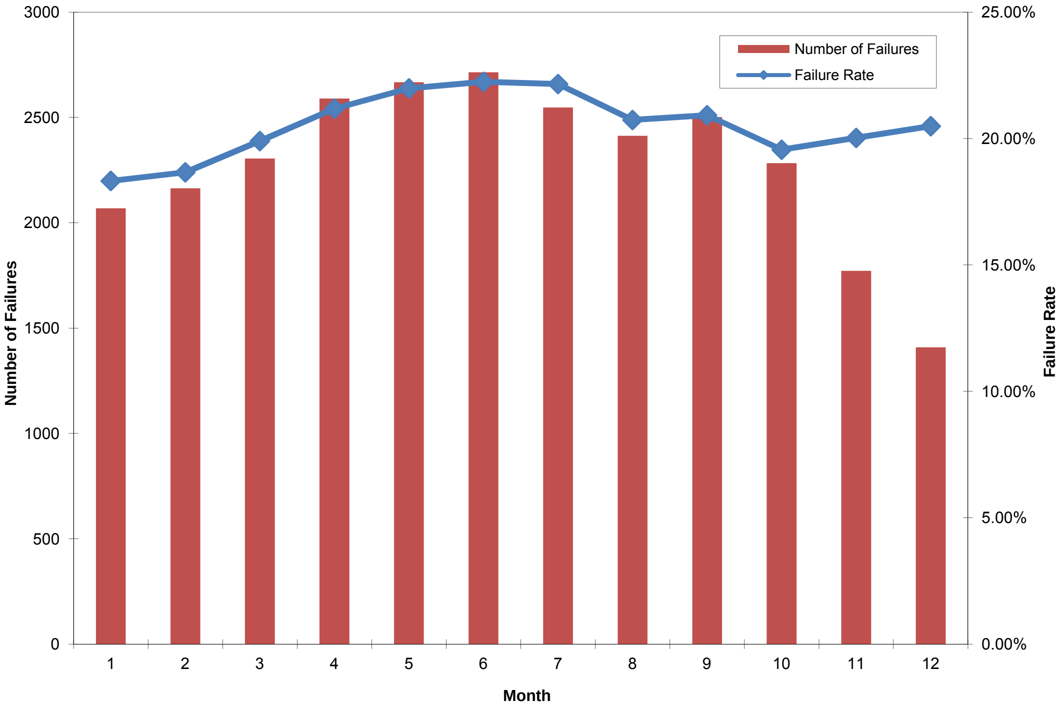


Figure 18. ASM + Idle Number of Failures and Overall Failure Rate by Month in 2009

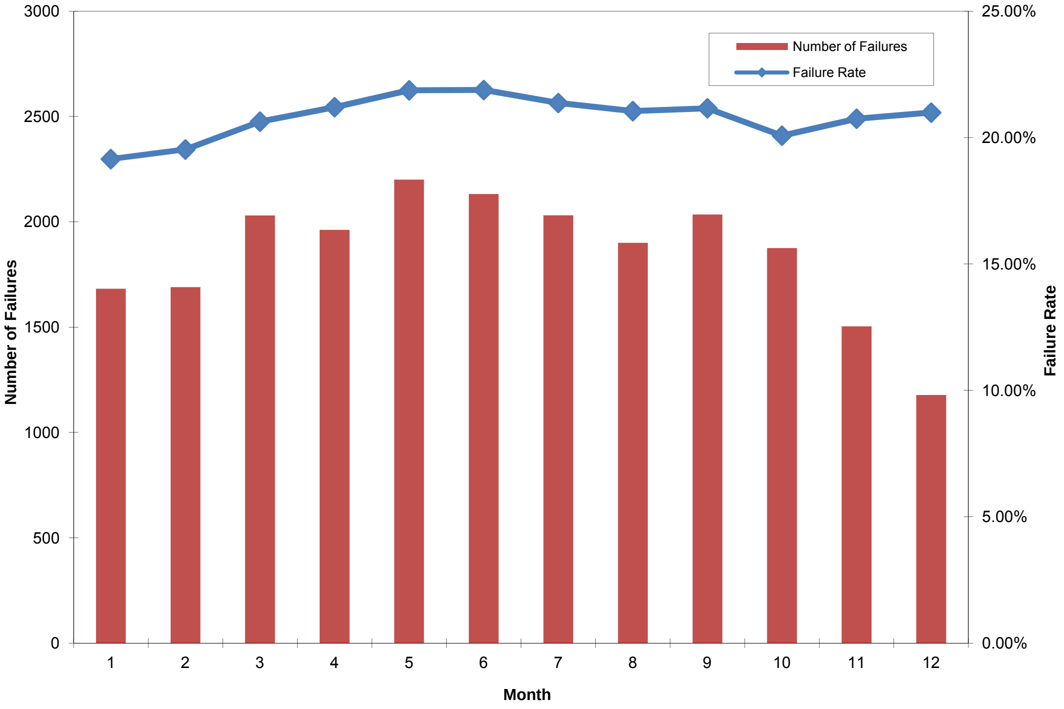


Figure 19. ASM + Idle Number of Failures and Overall Failure Rate by Month in 2010

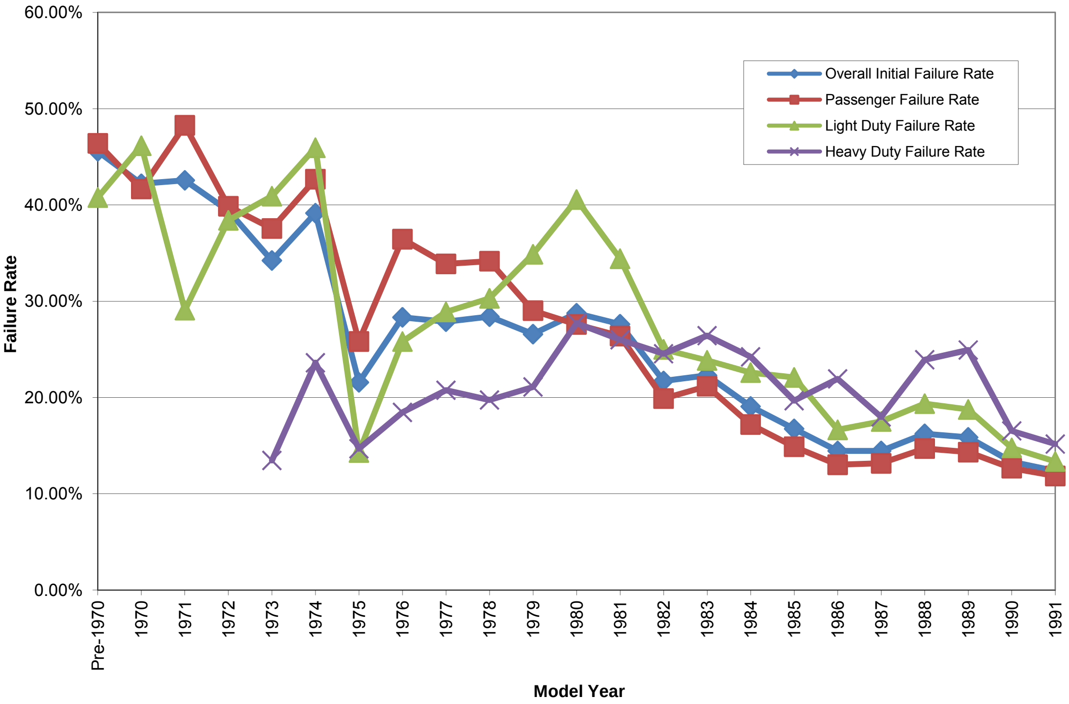


Figure 20. ASM + Idle Initial Failure Rate by Model Year and Vehicle Type in 2009

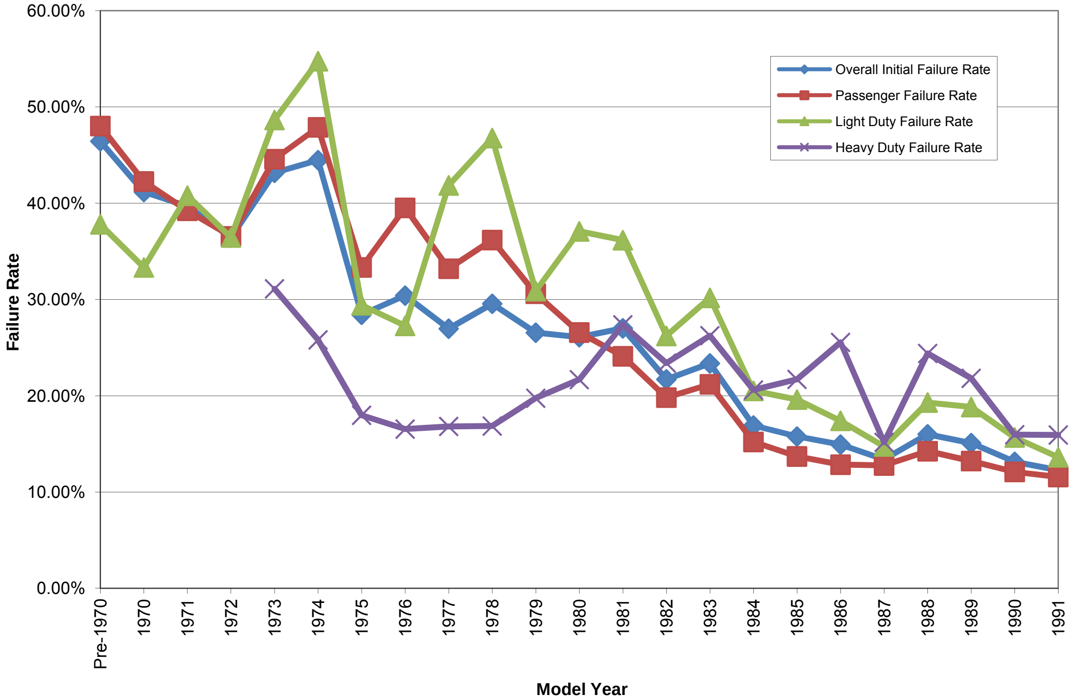


Figure 21. ASM + Idle Initial Failure Rate by Model Year and Vehicle Type in 2010

Figure 20 and Figure 21 show the initial failure rates for ASM + Idle tests by model year and vehicle type in 2009 and 2010, respectively. These figures illustrate that the failure rate increases as vehicles get older. These data are very similar to the figures previously published.

2.3.4 IDLE-ONLY INSPECTIONS

In tailpipe tests, a loaded dynamometer test is always preferred over unloaded tests. However, sometimes it is not possible to perform a loaded test because the vehicle cannot be operated on the dynamometer.

In such cases, an idle test is performed. With the transmission in neutral (manual transmission) or PARK (automatic transmission), the engine is subjected to a preconditioning at a steady 2500 rpm for 15 seconds prior to a 30-second sample of idling emissions being taken at curb idle (typically 600-850 rpm). If the recorded readings for HC and CO are below the applicable pass/fail standard, the vehicle passes. If the results of either or both emissions are greater than the allowable maximum, a second 15-second preconditioning cycle is performed, followed by a second idle sample. If the results of this second test indicate passing results, the first results are ignored and the vehicle is declared to have passed.

Figure 22 and Figure 23 show the overall failure rates and numbers of inspections by month for idle tests in both 2009 and 2010. As has been the trend in previous years, the overall failure rate for idle-only inspections is not much lower than for ASM + Idle inspections. It seems that the relatively low stringency of the idle-only test must be offset by some other factor related to the type of vehicles that are receiving this test instead of a dynamometer test. For example, lowered vehicles may not be able to run on the dynamometer and will therefore receive an idle-only test. In addition to being lowered, these vehicles may also have engine modifications that increase their likelihood of failing the emission test.

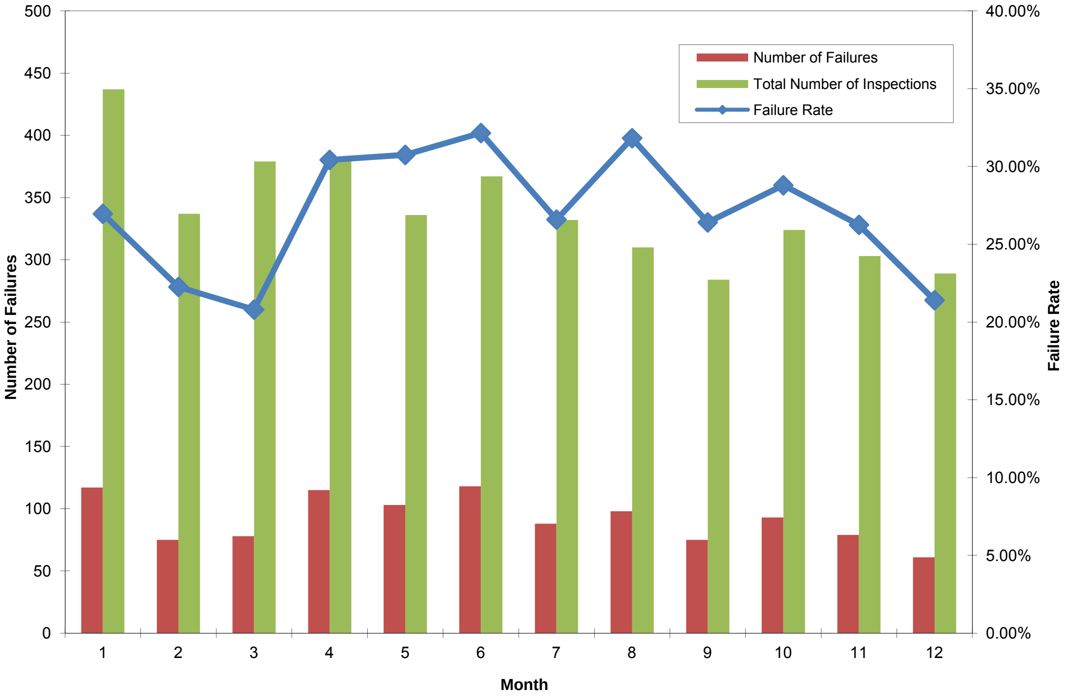


Figure 22. Idle-Only Overall Failure Rate and Number of Inspections by Month in 2009

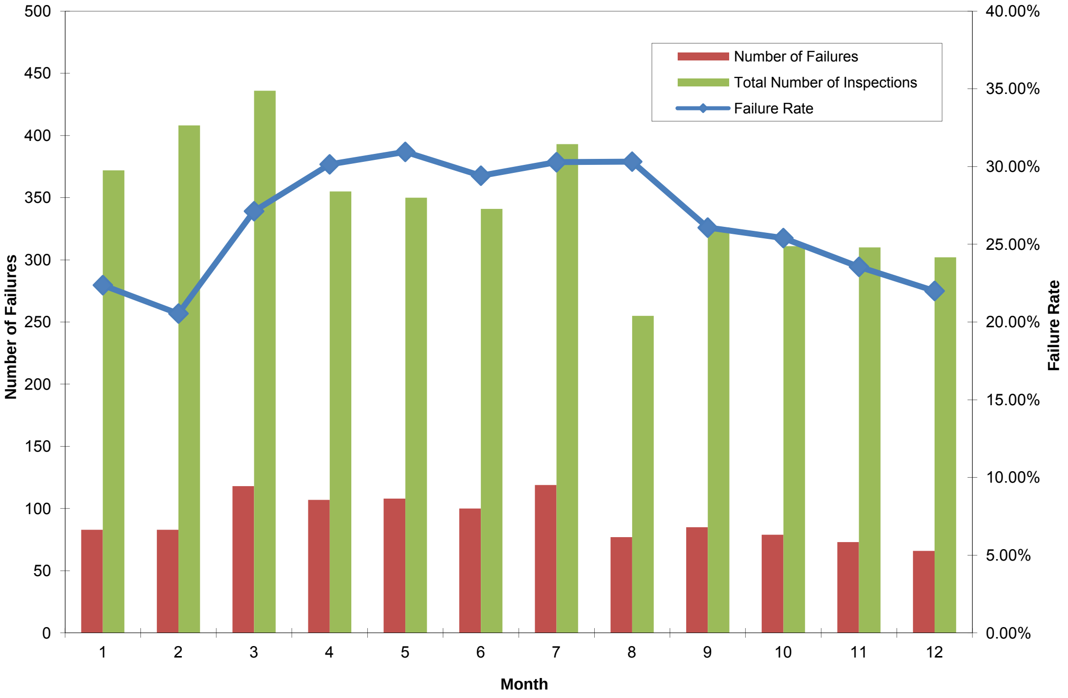


Figure 23. Idle-Only Overall Failure Rate and Number of Inspections by Month in 2010

The small sample size for Idle–Only tests results in a great deal of scatter in failure rates by vehicle type and model year. Unlike the other inspection types where a relationship can be established between age and emissions performance, there is no such trend evident for Idle-Only inspections. However, instead of using age, the reasons for the Idle-Only inspection can be used to provide a better understanding of the results.

Possible reasons for not performing a dynamometer test include:

- lowered chassis, or low-profile tires;
- vehicles fitted with studded snow tires (legal only from October through April);
- trucks with exhaust terminating ahead of the rear axle;
- vehicles too wide to fit on the dynamometer;
- all-wheel-drive or traction control equipped vehicles with wheelbase too long to fit dynamometer;
- vehicles fitted with handicap controls;
- mechanical problem;
- underpowered vehicle; and
- Collector vehicle

Figure 24 and Figure 25 show the relative frequency of the different reasons for reverting to an idle-only test.

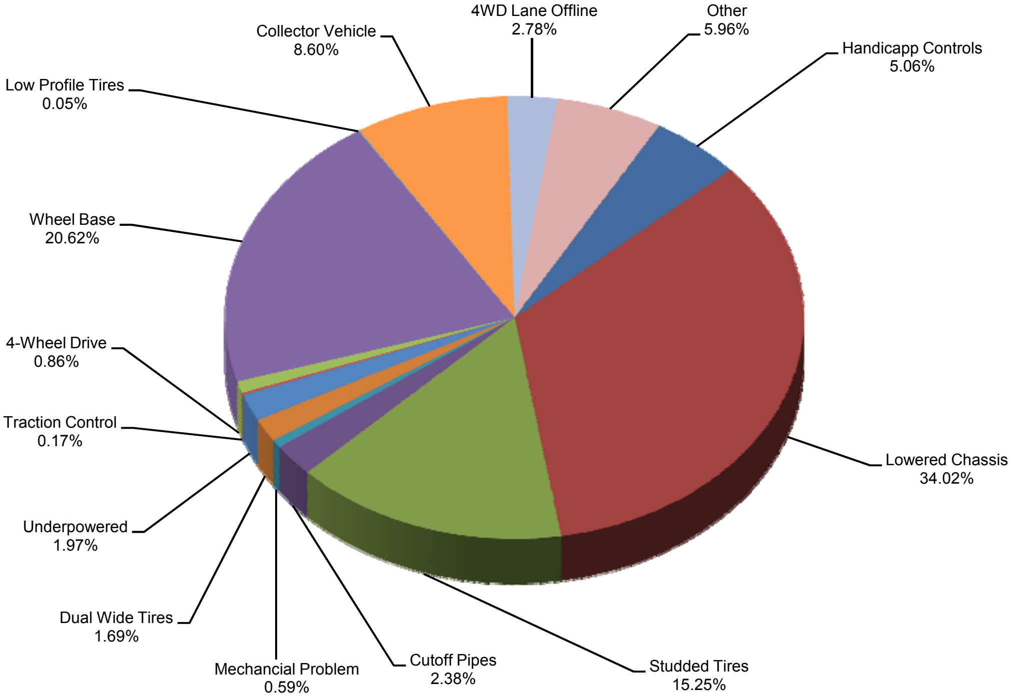


Figure 24. Reasons for Idle-Only Inspection in 2009

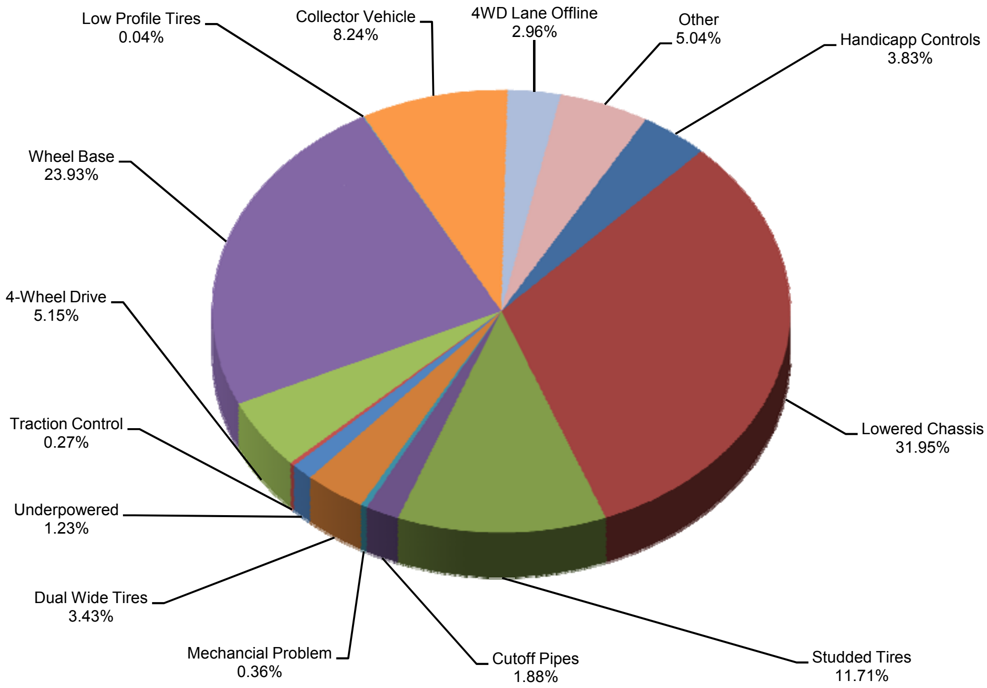


Figure 25. Reasons for Idle-Only Inspection in 2010

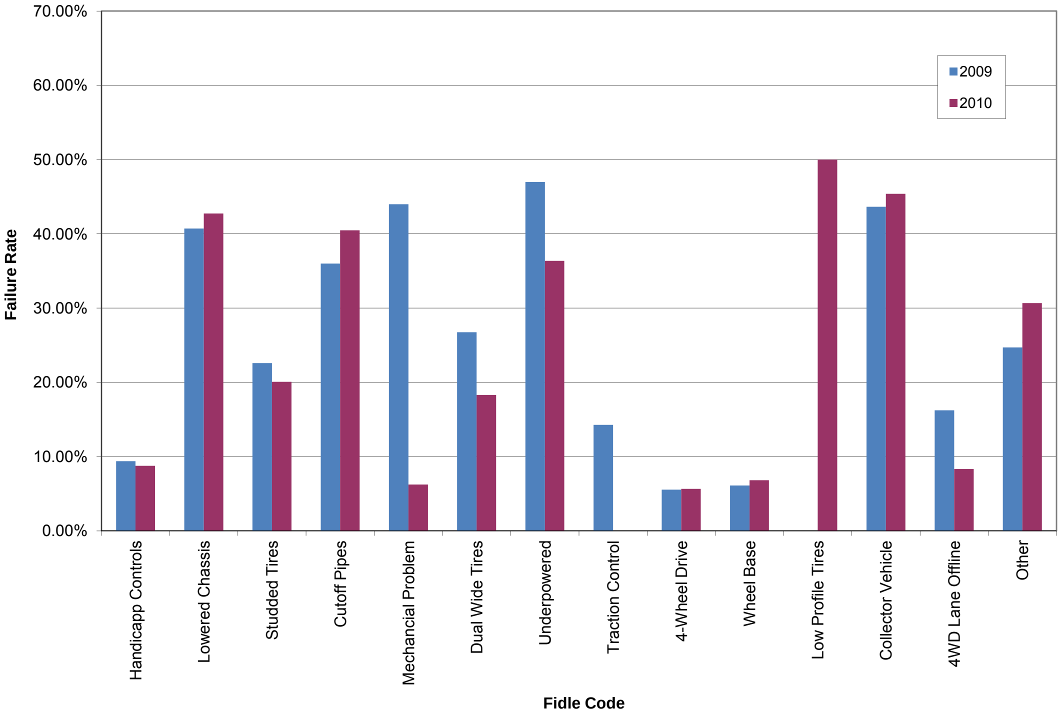


Figure 26. Failure Rates by Reasons of Idle-Only Inspection in 2009 and 2010

Figure 26 shows the failure rates by reasons of idle-only inspections in 2009 and 2010. The failure rates for most reasons were very similar in both 2009 and 2010.

In general, idle-only tests are the least desirable test type because many emission-related defects are not apparent unless the engine is under load. The excess-emitter identification rate for idle tests is much lower than for dynamometer tests and the risk of false failures due to insufficient preconditioning, even with a second-chance feature, is higher than it is for a loaded dynamometer test. Fortunately, this type of test is used in relatively few cases in the AirCare program.

2.3.5 DIESEL OPACITY INSPECTION

The number of diesel vehicles inspected in 2009 and 2010 was 7,734 and 8,877, respectively. The diesel test employs a transient dynamometer driving cycle taken from the second phase of the IM240 cycle. This phase, 147 seconds in length, has been dubbed the D147; "D" for diesel and 147 for the number of seconds in the test cycle.

Similarly to IM240 and ASM + Idle inspections, some vehicles that are not suitable to be tested on a dynamometer receive a non-loaded test. For diesel vehicles, this consists of raising the engine rpm with the transmission in Neutral or Park and measuring the opacity at the tailpipe. Without a load on the engine, failing such a test is very unlikely. As with gasoline vehicles, an unloaded test is regarded as one that is not preferred, but sometimes necessary.

The overall failure rates for D147 inspections by month in 2009 and 2010 are shown in Figure 27. The overall failure rate for diesels in 2009 was 3.14% compared to 2.57% in 2010.

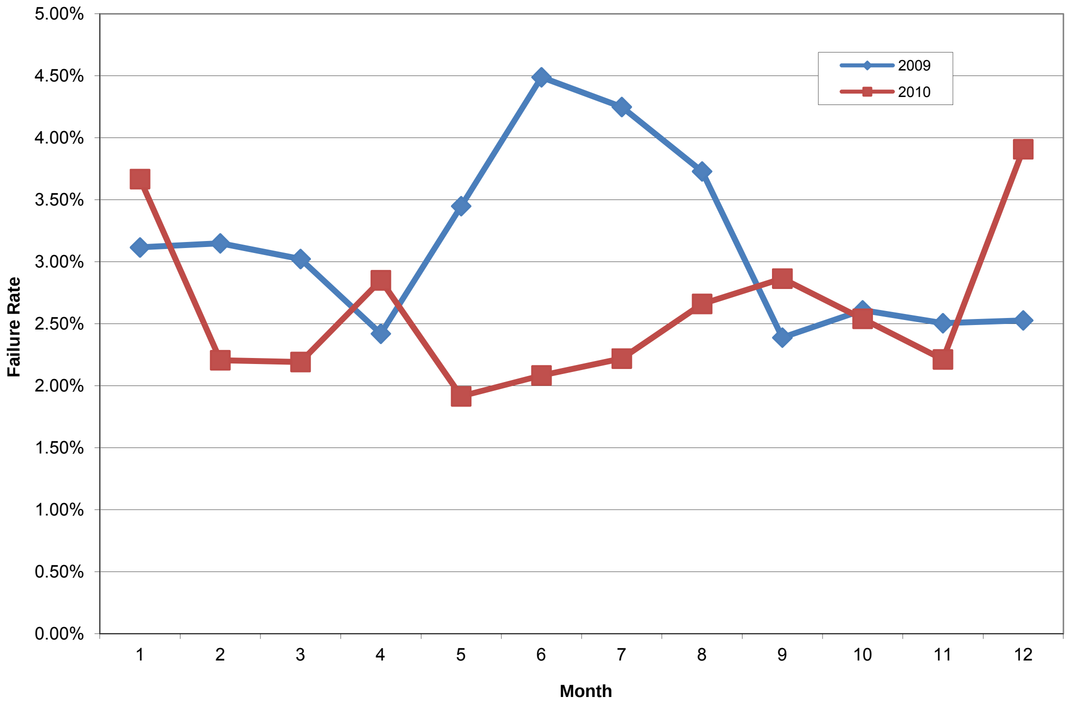


Figure 27. D147 Overall Failure Rates by Month in 2009 and 2010

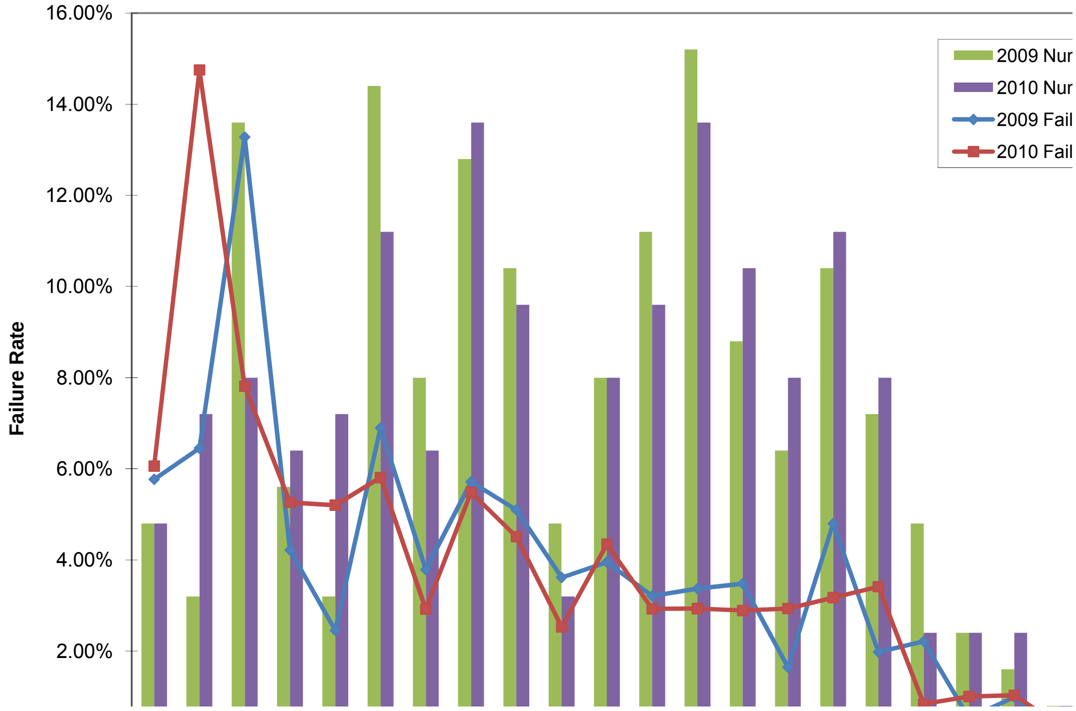


Figure 28. D147 Initial Failure Rate and Number of Failed Vehicles by Model Year in 2009 and 2010

Figure 28 shows the initial failure rate of D147 by model year in 2009 and 2010. As expected, there is a general trend to higher failure rates as the vehicles age, but even the oldest diesel vehicles fail less frequently than gasoline vehicles of the same age.

The D147 test is unique to the AirCare program and has proven to be effective at identifying malfunctioning or excessively modified diesel vehicles that emit too much smoke. Communication with diesel repair specialists has confirmed that the relatively few vehicles that fail an AirCare inspection have defects that, when corrected, significantly reduce the smoke output. Since smoke and particulate matter emissions are somewhat correlated, the reduction in opacity corresponds to a reduction in diesel particulate.

2.3.6 GAS CAP PRESSURE TEST

A functional gas cap pressure test is performed on vehicles from model years 1972-1997. The gas cap is removed from the vehicle and attached to a testing device that applies an air pressure of 28 inches water column (~1 psi) and measures the retention of that pressure. Gas caps that are not able to retain adequate pressure are tested again to confirm failure of the test.

Vehicles that fail only the gas cap portion of the test do not have to go through the whole test again. Instead, only the replacement cap is retested, and if it passes, an administrative procedure is invoked to override the failure. Thus gas cap failures may appear in the database as an overall fail, but there will be no corresponding re-inspection to follow.

Figure 29 and Figure 30 show the gas cap test fail rate by month for 2009 and 2010 respectively. The rate of failure is quite consistent throughout the two-year period.

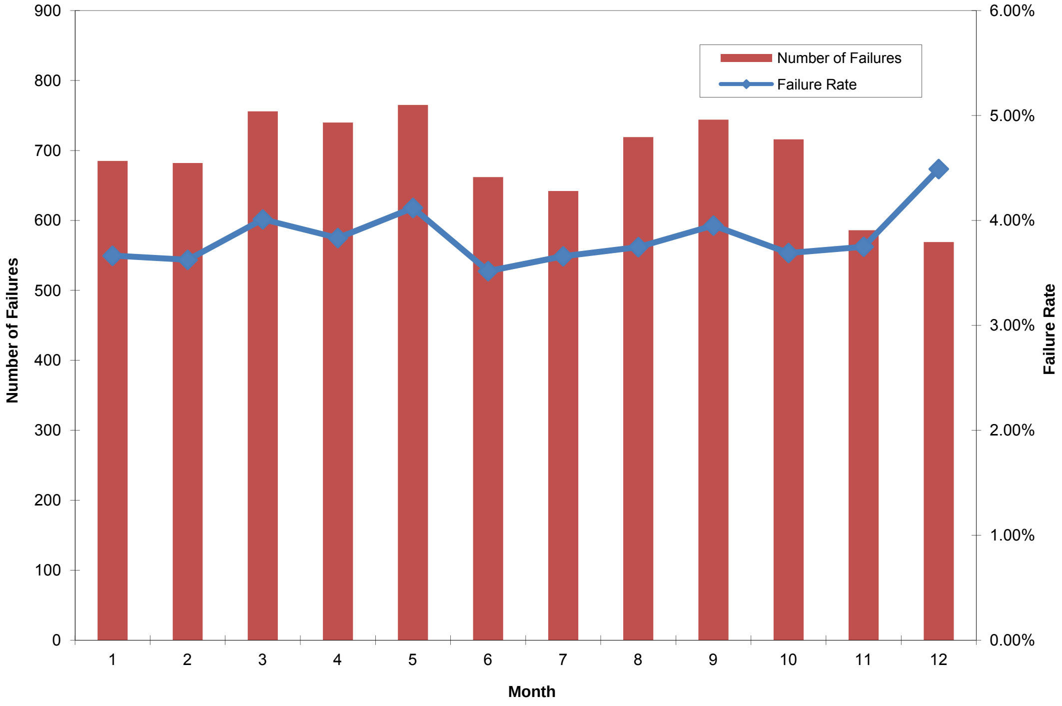


Figure 29. Gas Cap Overall Failure Rates and Number Failed by Month in 2009

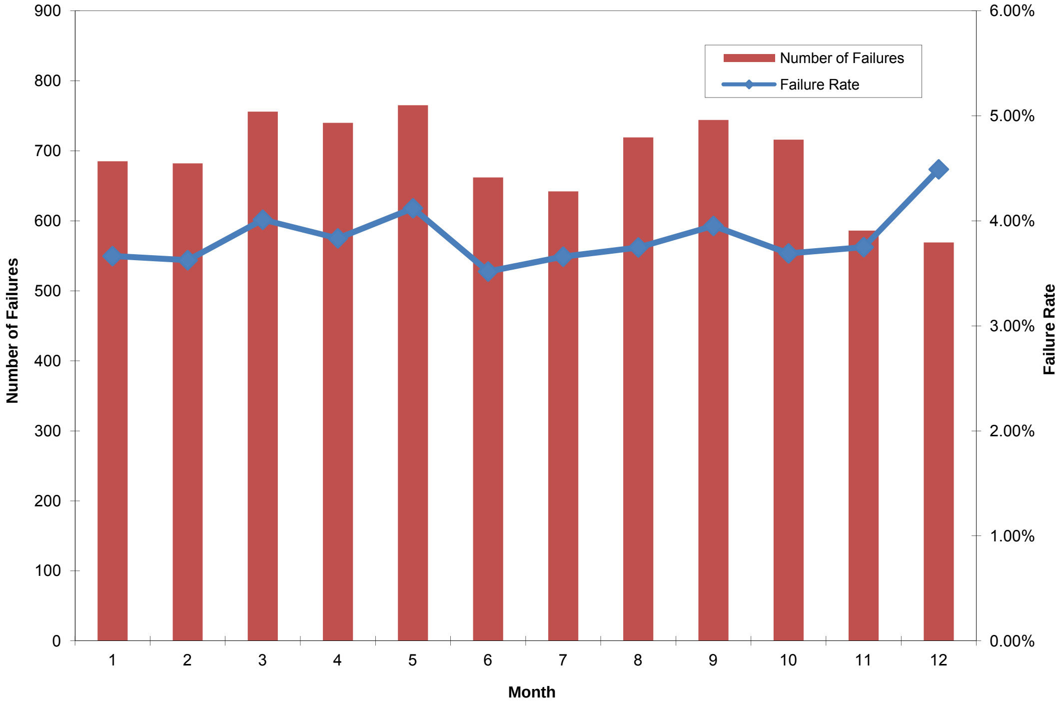


Figure 30. Gas Cap Overall Failure Rates and Number Failed by Month in 2010

2.3.7 VISUAL INSPECTION OF EMISSION COMPONENTS

Visual inspection of emission control components is limited to catalytic converters and gas caps. In both cases, the inspection is to confirm the presence of these devices and not necessarily their functionality.

2.3.7.1 Visual Inspection for Catalytic Converter

The catalytic converter is arguably the most important emission control device on a vehicle. For vehicles built between 1975 and 1987, an advisory is issued if a catalytic converter was originally fitted to the vehicle (a number of Canadian vehicles in this period were not) and it is not present when the inspector checks the exhaust system. The advisory has no bearing on the test result as long as the vehicle is able to pass the tailpipe test. On 1988-and-newer vehicles, however, the lack of a catalytic converter will result in an automatic failure.

There were 1,190 detected cases of a missing catalytic converter in 2009, or 0.26% of all inspected vehicles. The corresponding values for 2010 were 867 and 0.18%. The distributions by model year for both 2009 and 2010 are shown in Figure 31.

In Figure 31, a sharp increase is evident in the number of detected cases of a missing catalytic converter for vehicles older than 1988 model year. It is clear from this data that the AirCare inspection is a factor in keeping catalytic converters in place on 1988-and-newer vehicles. Once the catalytic converter is not absolutely necessary to pass the inspection, it appears that some motorists will drive without one. It is important to keep in mind that the data regarding Advisory results issued for missing catalytic converters on 1987-and-older vehicles may not be accurate as there is no real consequence for entering an incorrect result. Inspectors may err to the side of issuing an Advisory if there is uncertainty about whether the vehicle was originally catalyst equipped or if the converter was removed.

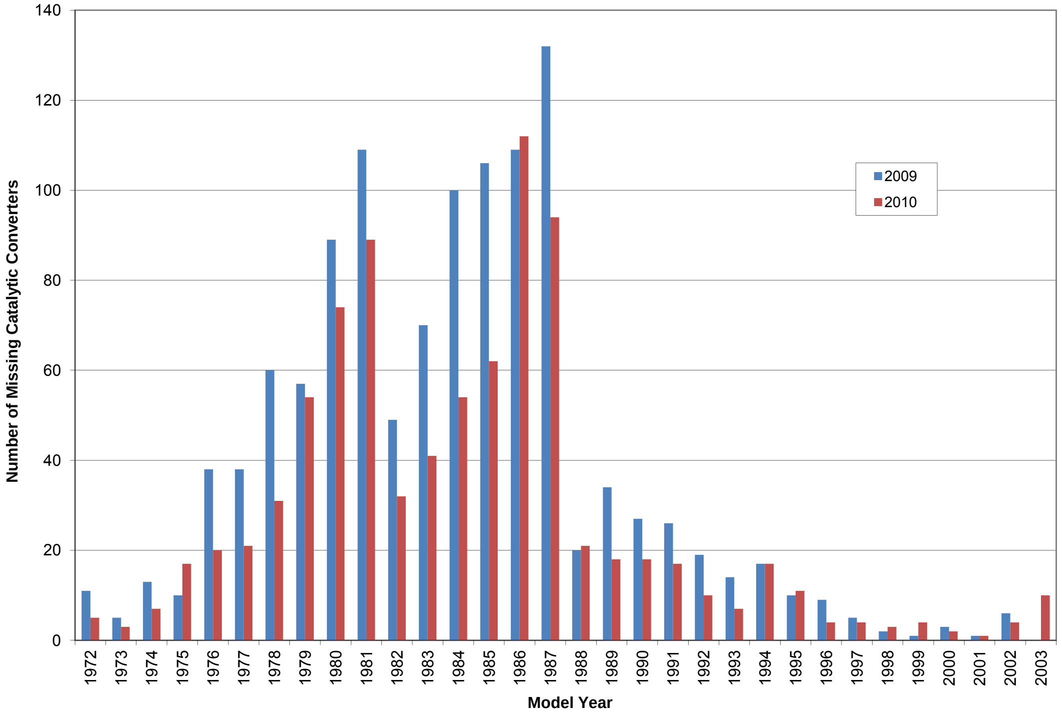


Figure 31. Number of Vehicles with Missing Catalytic Converter in 2009 and 2010 Combined

2.3.7.2 Missing Gas Cap

In 2009, there were 1,278 instances where vehicles appeared for inspection with no gas cap. In 2010, the number was 791. The percentage rate works out to be 0.18 % for 2009, and 0.15 % for 2010.

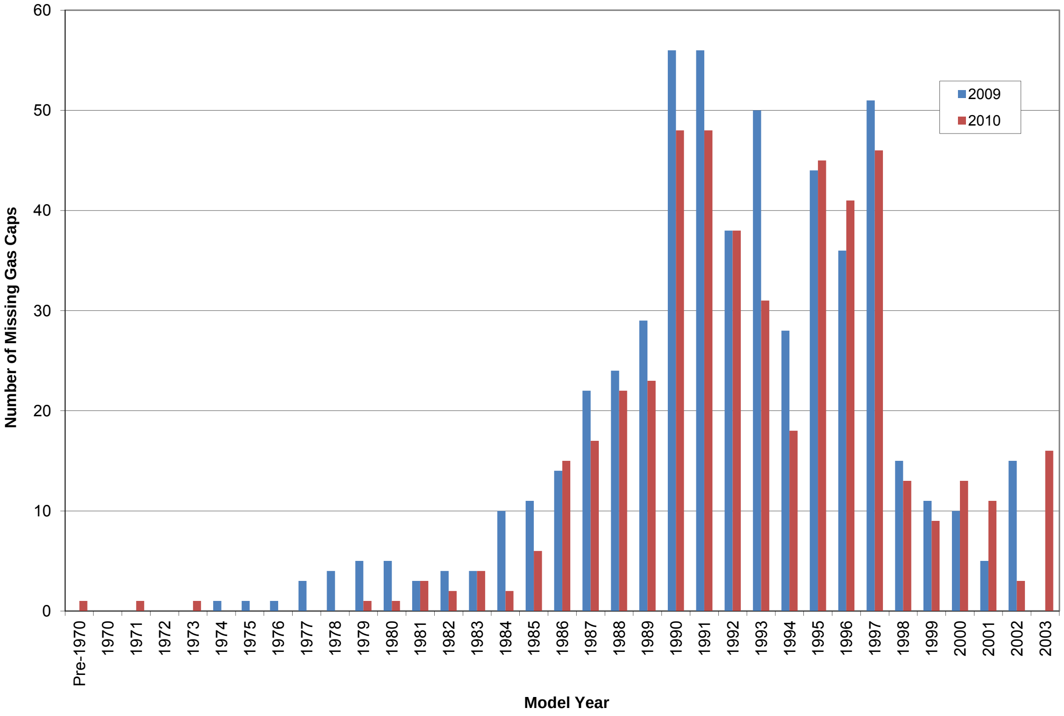


Figure 32. Number of Vehicles with Missing Gas Cap by Model Year in 2009 and 2010

Figure 32 shows the number of vehicles with missing gas caps by model year in 2009 and 2010. For the most part, driving a vehicle without a gas cap is the unintentional result of forgetting to replace it after refuelling. The number of vehicles identified with missing gas caps at AirCare inspection facilities is likely representative of the fact that a small percentage of vehicles operate for some period without a gas cap at any given time.

3.0 AUDITING AND QUALITY ASSURANCE

AirCare is a mandatory program that may require vehicle owners to spend hundreds of dollars on repairs in the event of a failure. Therefore, it is vital that the test be administered correctly and that all analytical equipment be calibrated correctly for optimum accuracy.

Numerous performance standards are specified in the contract between the AirCare contractor and TransLink. In order to ensure that the appropriate service levels are being delivered, PVTT performs regular audits at all inspection facilities. Each inspection facility and every lane is audited once per month. Deficiencies noted are identified to the facility manager during the audit and many are corrected prior to completion of the audit. In some cases, it may be necessary to close a lane until the necessary calibrations or maintenance work can be performed.

The PVTT auditor prepares a monthly report summarizing the results of the audit checks performed, the status of corrective actions in response to any deficiencies and recommendations for remedies in the event of contract violations. Regular meetings are held with the AirCare contractor to discuss performance issues such as excessive wait times, incorrect test procedures and customer complaints.

The auditor schedules visits to each inspection centre once per month. No warning is given to the AirCare contractor prior to the audit. The standard procedure followed by the auditor is as follows:

1) Arrive at inspection centre, note the estimated wait time indicated on the sign at the station entrance, call the telephone hotline to determine the wait time being reported and count the number of vehicles in each queue. All of the wait time data should be consistent and accurate.
2) A visual audit of station cleanliness and upkeep is done.
3) The audit vehicle is then tested in each lane, waiting in the queue in the same way that a regular customer would. This provides another measure of wait time. Upon entry to the station, data entry and the gas cap test are performed as normal. The auditor uses a known failing cap or “master” pass or fail caps to verify the accuracy of the gas cap testing equipment.
4) After the gas cap audit is complete, the audit vehicle is run through one of the inspection test types. Using a scan tool, data are collected from the audit vehicle’s on-board computer to assess the amount of load being applied by the dynamometer. Parameters such as throttle position, vehicle speed, engine RPM, mass airflow sensor voltage, and calculated load are used to determine that the dynamometer load being applied is consistent across all lanes and centres. Significant deviations from normal readings suggest a fault with the dynamometer load application and result in the lane being shut down until corrective maintenance is performed.
5) At the dynamometer position, an “EMS Audit” (Emissions Measurement System) is then performed on the ASM testing equipment. This audit uses a tailpipe simulator and a cylinder of compressed gas mixture containing known quantities of each emission that is measured by the EMS. The gas for auditing purposes has a stated accuracy of ±1%, traceable to NIST (National Institute for Science and Technology) standards. NIST is the North American reference for materials such as calibration gas and can be considered absolutely accurate. The tailpipe probe is inserted in the simulator and gas is sampled from the cylinder. The indicated readings are compared to the certified

values on the cylinder label. If the indicated readings from the analyzers deviate by more than ±5% from the stated cylinder concentrations, the EMS system is re-calibrated and the check done again. If the reading does not fall within the allowable tolerance after calibration, the lane is locked out from use until maintenance has been performed and the audit has passed. Cylinder concentrations of HC, CO, CO_2 and NO_x are chosen to be representative of the vehicles being tested and are varied throughout the year in order to confirm the accuracy of the gas analysis equipment over its typical operating range. As a rule, audit gases are chosen so that they test the equipment accuracy in the area of the pass/fail standards where any inaccuracy would have the biggest impact on test outcomes.

6) IM240 EMS checks are performed in a similar manner to the ASM system audit using a cylinder of compressed gas mixture containing known quantities of HC, CO, CO_2 and NO_x. Because the IM240 test uses a Constant Volume Sampler, the concentrations of gases measured by the IM240 analyzers is much lower than those for an ASM test. The calibration gases used are of typical concentrations for the types of vehicles tested based on expected tailpipe concentrations and the amount of dilution taking place. The gas is introduced directly through an audit port on the analyzer bench, which feeds the gas to the THC, CO/CO_2 and NOx analyzers. As with the ASM audit, the concentrations of the audit gas constituents are referenced to NIST and the tolerance of accuracy used are specified in the published Guidance for IM240 inspections as published by the U.S. EPA. A secondary procedure used thus far by PVTT has been to subject the audit vehicle to a full-duration IM240 test in each lane and to evaluate the consistency of results achieved in all lanes, for regulated emissions, CO2 and carbon balance fuel consumption. This method has proven effective in that the test results for the audit vehicle have been consistent and have suggested that the test apparatus is working properly when equipment self-check criteria have been satisfied. In order to evaluate the accuracy of dynamometer loading, which is much more complex for an IM240 test because of the transient driving cycle, data stream information from the audit vehicle's on-board computer is downloaded during the IM240 test. The objective is to determine an acceptable range of critical parameters for the purpose of identifying potential malfunctions. Useful indicators include "Percent Load" "throttle Position" and "Mass Air Flow Rate" as these all vary in response to changes in dynamometer loading.

7) The OBD system is checked by means of an OBD simulator. The simulator allows the Auditor to create pass/fail situations with readiness monitors, trouble codes and MIL status that are similar to actual situations encountered in the test lanes. The auditor confirms that the lane software correctly identifies the pre-selected trouble code, MIL status and readiness monitor information.

8) The auditor writes a monthly report outlining the results of each station audit on a lane-by-lane basis. Any deficiencies are noted along with any known corrective action. Outstanding issues are flagged with the expectation that the AirCare contractor will correct them in short order.

As shown in Table 9 and Table 10, in 2009, there were 385 lane audits conducted as shown above. The numbers in brackets indicate that a problem was detected during the month at that facility. Sometimes, a single lane can receive multiple audits and therefore a four-lane station could have more than four audits in a month. In 2009, there were seven problems identified during functional testing of the lane equipment. Three cases involved a problem with the gas analyzer, another three concerned the OBD connector cable and one involved dynamometer.

Table 9. Number of Lane Audits and Failures in 2009

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	(Fail)
1	3	3	3	4(1)	3	3	3	3	3	3	3	3	37	1
2	4	4	4	4	4	4	4	4	4	4	4	4	48	0
3	3	3	3	3	3	3	3	3	3	3	3	3	36	0
5	4	4	4	4	4	4	4	4	8	0	4	4	48	0
6	4	4	4	4	4	4	4	4	4	4	4	4 (1)	48	1
8	2	2	2	2	2	2(1)	2	2	2	2	2	2	24	1
9	3	3	3 (1)	3	3	3	3	3	3	3	3	3	36	0
10	3	3(1)	3	3	3	3	3	3	3	3	3	3	36	2
11	2	2	2	2	2	2	2 (1)	2	2	2	2	2	24	1
12	4	4	4	4	4(1)	4	4	4	4	4	4	4	48	1
Totals	32	32	32	33	32	32	32	32	36	28	32	32	**385**	**7**

Note: Station:1 – North Vancouver,2 – East Vancouver,3 – Richmond,5 – Coquitlam,6 – North Surrey,8 – Maple Ridge,9 – Langley,10 – Abbotsford,11 – Chillwack,12 – South Vancouver.

In 2010, there were 387 lane audits conducted as shown below. There were four problems identified. Three involved a problem with the OBD cable, and one involved an oxygen sensor.

Table 10. Number of Lane Audits and Failures in 2010

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	(Fail)
1	3 (1)	3	3	3	3	3	3	3	2	3	3	3	35	1
2	4	8	4	4	4	4	4	4	4	4	4	4	52	0
3	3	3	3	3	3	3	3	3	3	3	3	3	36	0
5	4	4	4	4	4	4	4	4	4 (1)	4	4	4	48	1
6	4	4	4	4	4	4	4	4	4	0	8	4	48	0
8	2	2	2	2	2	2	2	2	2	2	2	2	24	0
9	3	3	3	3	3	3	3	3	3	0	6	3	36	0
10	3 (1)	3	3	3	3	3	3	3	3	3	3	3	36	1
11	2	2	2	2	2	2	2	2	2	2	2	2	24	0
12	4	4	4	4	4	4 (1)	4	4	4	4	4	4	48	1
Totals	32	36	32	32	32	32	32	32	31	25	39	32	387	4

Note: Station:1 – North Vancouver,2 – East Vancouver,3 – Richmond,5 – Coquitlam,6 – North Surrey,8 – Maple Ridge,9 – Langley,10 – Abbotsford,11 – Chillwack,12 – South Vancouver.

4.0 SERVICE LEVELS

4.1 INSPECTION WAIT TIMES

An important measure of customer service is the average wait time. Wait time is defined as the amount of time that passes between the time that a motorist arrives at an inspection centre and the time that the inspection is initiated.

During normal operating hours, wait times are estimated for each inspection centre based on the number of vehicles currently queued, and the current rate of vehicle throughput. This information is posted at the entrance to each inspection centre and is also available on the telephone hotline and the program website.

Wait time data is compiled monthly to monitor seasonal trends and to ensure adequate service levels. Figure 33 shows the averages inspection wait time in 2009 and 2010.

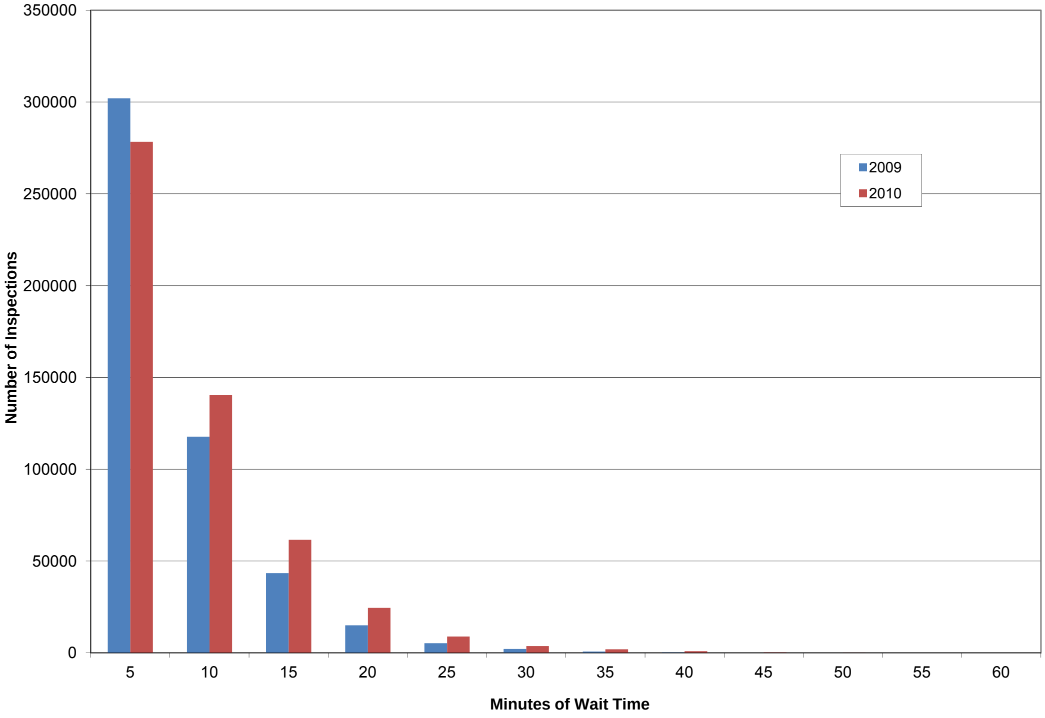


Figure 33. Average Wait Time per Inspection in 2009 and 2010 Combined

Figure 33 shows the percentage of time that the reported wait time fell into the intervals specified for both 2009 and 2010. It can be seen clearly that wait times were typically less than five minutes and the 15-minute service standard was exceeded very rarely. In fact, over 95% of all inspections had a wait-time less than or equal to 15 minutes.

4.2 MYSTERY SHOPPER PROGRAM FOR INSPECTION CENTRES

To evaluate the performance of the AirCare contractor on a covert basis, a separate contractor has been engaged to take vehicles through the inspection process on a regular basis. The mystery shopper notes the adherence of contractor employees to standard operating procedures and also evaluates the quality of customer experience provided based on the comportment and demeanour of the employees and consistent adherence to standard operating conditions when performing the test.

The summary of results from 2009 and 2010 is shown in Table 11.

Table 11. Results of Mystery Shopper for Inspection Centres in 2009 and 2010

Cycle	Centres Tested	Wait Time Range (min)	Pass	Fail / Reject	# of Issues Identified
2009-1	4	5-15	3	1	7- Name tags not visible, turn off accessories, etc.
2009-2	5	12-25	3	2	11 – accessories, name tags, insufficient staff, etc.
2009-3	5	6-11	5	0	9-turn off accessories, enter signs, etc.
2009-4	6	5-24	5	1	8 – turn off accessories, enter sign, etc.
2010-1	6 (9 tests)	3-18	7	2	13 – accessories, odometer checks, visual inspections not performed, etc.
2010-2	6	5-35	3	3	12 – accessories, no fail booklet provided (2 out of 3), enter sign, lack of courtesy to customer
2010-3	6 (8 tests)	4-44	1	7	11 – No fail booklet, no “Reject” pamphlet, accessories
2010-4	5	2-13	2	3	5- No fail booklet(2 out of 3), accessories

The mystery shopper contractor obtains vehicles from local used car lots and an employee takes the vehicle through the test, posing as a regular customer. Prior to 2010, the mystery shopper noted any instances of apparent deviation from standard operating procedures. Starting in 2010, a checklist was devised for the benefit of the mystery shopper, listing the specific areas of evaluation required and clearly stating the conditions to be met to meet the definition of a proper test. A copy of the checklist is included in the Appendix.

For the most part, tests are being done correctly and customers are not encountering excessive wait times. The longest wait time was 44 minutes, which exceeds the objective of less than 15 minutes, but this was a unique occurrence and was likely beyond the control of the contractor. Sudden rushes of customers occur from time to time, and issues with lane equipment calibrations can often slow down throughput and extend wait times.

A copy of the inspection centre mystery shopper report is provided to the Operations Manager at the AirCare contractor head office for follow-up and corrective action. Some of the deficiencies noted in 2009 such as failing to wear or clearly display a name tag, have been largely corrected. Instructing customers to turn off accessories such as air conditioning has been a consistent issue. Although the impact on the test result may be undetectable, it is better to have consistent conditions at the time of each test and emission testing procedures generally prescribe that all accessories be turned off. Another concerning deficiency is that, when a vehicle fails or is rejected from testing, the lane inspector is supposed to provide the customer with a booklet or pamphlet describing what they are supposed to do. In a high proportion of cases, these materials are not being provided to the mystery shopper. This is a situation that needs to be corrected as there is valuable information in those publications that the motorist needs.

The AirCare contractor responds promptly to the reports with operations alerts to field staff or direct intervention with employees involved. The goal is to provide better customer service and a more effective program.

5.0 REPAIR INDUSTRY

5.1 CERTIFIED REPAIR INDUSTRY STATISTICS

Although the inspection side of a vehicle inspection and maintenance program tends to receive most of the attention, the benefits of any I/M program are derived almost entirely from corrective maintenance performed on failing vehicles by the repair industry.

In recognition of the importance of the repair industry to the effectiveness of the AirCare program, the original program design included a repair industry certification program to encourage more effective repairs. To be certified, repair shops were required to have diagnostic equipment and reference materials at their disposal, while repair technicians were required to demonstrate their understanding of emission-related diagnosis and repair procedures by passing an examination. Passing the exam resulted in a technician being certified for a three-year period. Later on, a recertification examination was developed for technicians wishing to renew their certification. Alternatively, technicians that had consistently demonstrated competency at repairing emission failures could be re-certified automatically if they performed a minimum number of repairs while maintaining a sufficient level of Repair Effectiveness Index (REI). The REI is calculated for each repair performed by an AirCare Certified Technician. The REI is based on the indicated reduction in emissions between a vehicle's failing test and its re-test as well as on a comparison of the re-inspection result to the "Average Passing Vehicle" reading.

5.1.1 NUMBER OF AIRCARE CERTIFIED TECHNICIANS

Table 12 shows the number of active AirCare technicians (i.e. technicians that submitted at least one Repair Data Form) at year-end in both 2009 and 2010.

Table 12. Active AirCare Certified Technicians Summary

2009	2010
483	442

5.1.2 NUMBER OF AIRCARE CERTIFIED REPAIR CENTRES

Table 13 below shows the number of AirCare Certified Repair Centres as of December 31st 2009 and 2010.

Table 13. Number of Certified Repair Centres in 2009 and 2010

2009	2010
281	259

5.2 REPAIR DATA FORM STATISTICS

In 2009, there were 8,525 Repair Data Forms (RDFs) submitted to PVTT. This represents 17% of the vehicles that failed for emissions in that year.

In 2010, there were 7,684 RDFs submitted. This represents 16% of the vehicles that failed in that year. Vehicles that passed the re-inspection, but had no repair data, could have experienced the following actions:

- repair was performed by the owner;
- repaired by a non-certified shop,
- repaired by certified shop but no RDF submitted; or
- no repair was done at all.

Analysis of the repair data provided indicated that the top five items replaced during AirCare repairs were as shown in Table 14. In each year, pre-1992 and 1992-and-newer vehicles are treated separately.

Table 14. Top 5 "Replaced" Items in 2009 and 2010

2009		2010	
Pre-1992	**1992-and-Newer**	**Pre-1992**	**1992-and-Newer**
Catalytic Converter	Catalytic Converter	Catalytic Converter	Catalytic Converter
Front Oxygen Sensor	Front Oxygen Sensor	Front Oxygen Sensor	Front Oxygen Sensor
Spark Plugs	Spark Plugs	Spark Plugs	Spark Plugs
Oil Contamination	Ignition Wires	Vacuum/ Air Leak	EGR Value
Air Filter	Warm Up Catalyst	Ignition Wires	Rear Oxygen Sensor

Table 15. Top 5 "Serviced" Items in 2009 and 2010

2009		2010	
Pre-1992	**1992-and-Newer**	**Pre-1992**	**1992-and-Newer**
Idle Mixture	Combustion Deposit	Idle Mixture	Combustion Deposit
Idle Speed	EGR Passage	Ignition Timing	Ignition Timing
Ignition Timing	Ignition Timing	Idle Speed	EGR Passage
Carburetor	Air Flow Sensor	Carburetor	Air Flow Sensor
Combustion Deposit	EGR System	Combustion Deposit	EGR System

Table 15 above lists the most common items that were serviced. "Serviced" refers to the act of adjusting, cleaning or otherwise repairing a component. Vehicles manufactured prior to 1988 have more parameters that can be adjusted.

Table 16. Top 5 "Defective but not Repaired" Items in 2009 and 2010

2009		2010	
Pre-1992	**1992-and-Newer**	**Pre-1992**	**1992-and-Newer**
Catalytic Converter	Catalytic Converter	Catalytic Converter	Catalytic Converter
Engine Mechanical Other	Engine Mechanical Other	Engine Mechanical Other	Engine Mechanical Other
Carburetor	Warm Up Catalyst	Compression	Combustion Deposit
Compression	Bank 2 Main Catalyst	Carburetor	Bank 2 Main Catalyst
Cylinder Head	Combustion Deposit	Cylinder Head	Compression

Table 16 shows that the type of repair that is NOT being done is generally complex and/or expensive. Repair cost limits may prevent vehicle owners from authorizing such repairs or parts may simply not be available for certain vehicles in order to address their specific problem. Catalytic converters can usually be replaced with cheaper, aftermarket units, but occasionally, only an OEM fitment will do. These are often prohibitively expensive or are no longer available.

All of the above tables are essentially identical to those published for earlier years. So we can conclude that the same types of repairs continue to be performed; and, by inference, that the inspection failures continued to be caused by the same types of deterioration and defects.

5.3 COST OF REPAIRS

Table 17 shows the median cost of repairs reported on RDF's in 2009 and 2010. The average appears to be stabilizing with little increase between 2009 and 2010. (The 2007 and 2008 results were $400 and $428, respectively.)

Table 17. Median Cost of Repairs in 2009 and 2010

Calendar Year	Median Cost
2009	$425
2010	$430

A frequency distribution of reported repair costs is shown below in Figure 34. The data indicates that some motorists spent much more than the repair cost limit on their vehicles. The most common repair cost reported in both 2009 and 2010 is $500. Repair costs reported with $0 or more than $1,000 are also quite significant as shown in the figure. Caution is urged in the use of this information. It is possible that inaccurate information could have been submitted on the RDF. Anecdotally, in cases where it is has been possible to compare the actual Work Order with the submitted repair data, the numbers frequently do not agree.

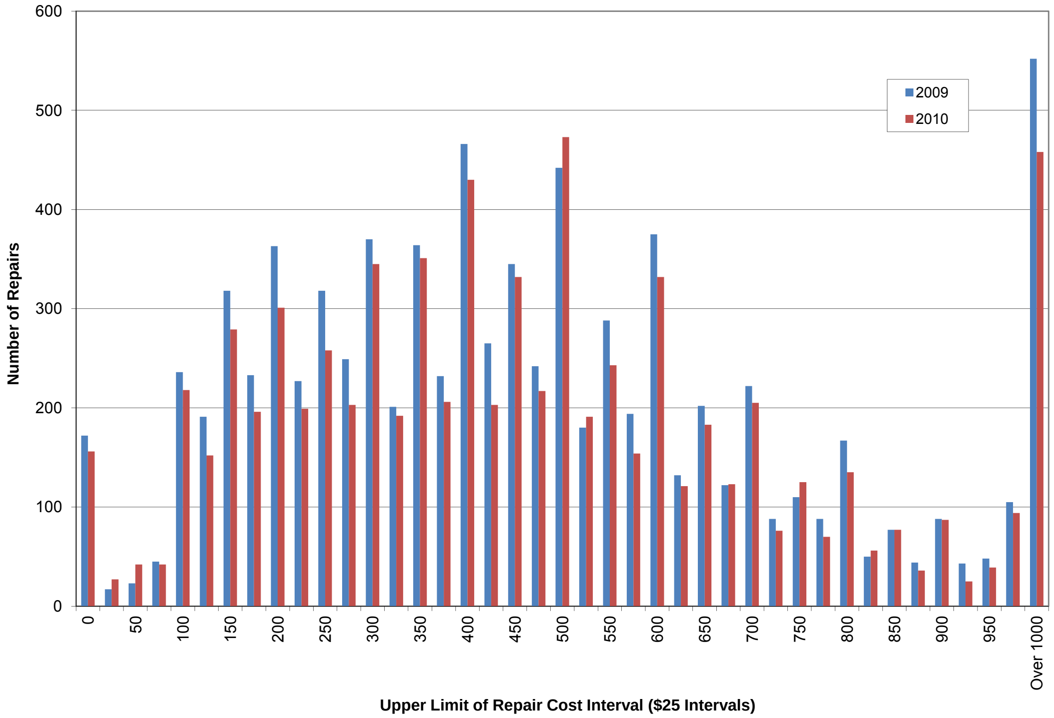


Figure 34. Repair Cost Distribution for 2009 and 2010

5.4 CONDITIONAL PASSES (WAIVERS)

Due to a policy called a Conditional Pass, the AirCare program allows motorists to continue operating vehicles that do not meet the AirCare pass/fail criteria on re-inspection provided that they have taken their vehicle to an AirCare Certified Repair Facility for repair. It is not necessary that the estimated cost of the repairs exceed the repair cost limit. In some cases, the certified repair shop will not have identified items that require repair and therefore expects the vehicle to pass – but the vehicle still fails on re-inspection. In these cases, the motorist is not penalized by failing again and having to have additional work performed on the vehicle because the motorist met their obligations by entrusting their vehicle to a certified repair shop.

Conditional Passes issued in cases where the cost of necessary repairs would exceed the applicable repair cost limit are referred to as “Cost” Waivers and are denoted by the Result “C”. Vehicles where the repair shop appeared to misdiagnose or overlook the cause of a failure are issued a “Qualified” or “Q” Waiver.

In 2009 there were a total of 2,010 inspections with a result of Conditional Pass out of 8,115 inspections with RDF information entered into the system as shown in Table 18. This means that 24.8% of certified repairs were not successful in repairing the vehicle well enough to pass re-inspection. In 2010, there were 1,606 inspections with a result of Conditional Pass out of 7,105 re-inspections with repair data. This represents 25.9% that were not effective in achieving a Pass

Table 18. Certified Repair Re-Inspection Results in 2009 and 2010

Result	2009		2010	
	Pre-1991	1992-and-Newer	Pre-1991	1992-and-Newer
Pass	2,249	3,856	1,686	3,813
Cost Waiver	422	376	279	332
Qualified Waiver	395	817	302	693
Total Conditional Passes	817	1,193	581	1025
% Conditional Passes	26,6%	23.6%	25.6%	21.2%
Total	**3,066**	**5,049**	**2,267**	**4,838**

5.5 REPAIR EFFECTIVENESS INDEX

As mentioned earlier in this section, each certified repair is subject to a calculation that numerically ranks its effectiveness. The calculation is based on two main factors – one that compares the amount of indicated emission reduction from the initial failing test to the re-inspection result and one that compares the final re-inspection result to the "Average Passing Vehicle" reading. An "ideal" repair would be represented by a case where a vehicle with extremely high failing emission results goes through the re-inspection with emissions that are equal to or better than the "Average Passing Vehicle" readings. In such a case, the difference between the initial and the final test result would be greatest and the comparison to the "Average Passing Vehicle" reading would be highly favourable.

Table 19 shows the REI results for all the RDFs submitted in 2009 and 2010 based on a scale of 0-10 where higher is better.

Table 19. Average REI in 2009 and 2010

Year	Average REI
2009	7.25
2010	7.60

An improvement in repair effectiveness is evident in 2010. Since the inception of the REI calculation, the average value has improved steadily from year to year.

For the most part, the REI seems to be effective at identifying both the most successful and the least effective technicians. However, its primary purpose is still to provide feedback on the effectiveness of each individual repair.

5.6 REPAIR INDUSTRY PERFORMANCE MONITORING

A shop must have a 70% average success rate on 10 or more repairs over a 12-month period to be listed in the "What to do if Your Vehicle Doesn't Pass" booklet handed out at the Inspection Centres. The success rate is a relatively simple calculation based on the number of repairs that pass re-inspection expressed as a percentage of the number of vehicles repaired. Presumably, the public will be inclined to select the most competent repair shops, based on the number of AirCare repairs they have done and how successful they have been at passing re-inspection. Hopefully this translates into a strong incentive for shops to do effective repairs. According to the booklet published in Aug, 2010, there were 11 shops with a 100% success rate. Aside from those, there were 27 shops with success rates greater than 90% and 122 shops with success rates ranging between 70% to 90%.

Shops not meeting the criteria are subject to a performance audit visit by PVTT staff. During these audits, the shop's performance is reviewed with the owner or manager and all of the AirCare Certified Repair Technicians working at the facility. Areas needing improvement are pointed out and suggestions are given to aid the shops in increasing their success rate. This system has come to be known as the "Three-Strike System".

A committee selects shops for site visits in order to discuss their repair record and to talk about the possible reasons for low success rate. The tone of these visits is always positive, emphasizing the shared goal of having a high success rate. Regular shop visits to discuss performance concerns began in 2009. Totals for each month in 2009 and 2010 are shown in Table 20 below:

Table 20. Number of Performance Audits

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
2009	6	7	8	3	2	1	2	1	2	0	6	7	45
2010	3	3	0	0	0	12	6	0	2	4	5	2	37

After visiting a shop with low indicated success and discussing possible countermeasures, their performance is monitored for two to six months and, if no improvement is observed, a second visit is scheduled and the shop is taken to "Strike Two". If no improvement is seen after another 2-6 months, a third visit is scheduled. At this point, the shop may be taken to "Strike Three". At Strike Three, the shop's ability to qualify customers for a Conditional Pass is taken away and the shop is listed in the "What to do if Your Vehicle Doesn't Pass " booklet as "limited due to performance concerns". As of December 31, 2010, only one shop has remained at Strike Three, eight shops were at Strike Two, and 11 were at Strike One.

Regular face-to-face visits with repair shops have turned out to be a very effective way to exchange information and to discuss issues of concern to the industry. More frequent interaction with PVTT usually leads to immediate improvement in shop performance. In fact, 16 shops were once the candidates for performance monitoring but have now improved their results and are repairing vehicles successfully. Occasionally, PVTT also recognizes a shop with excellence repair records with a "doughnut" visit and there were 8 such recognitions in 2009 and 2010.

5.7 MYSTERY SHOPPER PROGRAM FOR REPAIR FACILITIES

In addition to the performance monitoring program described in last section, repair shops are also subject to a mystery shopper program. Each year, four vehicles are selected and deliberately implanted with one or more emission-related defects that cause them to fail an AirCare inspection. Approval of the vehicle selection and the decision as to what sort of defect to create are the responsibility of PVTT. Prior to sending the vehicle out for a round of mystery shopper testing, a thorough review of the vehicle is made to ensure that no other major faults are present and that the sole cause of failing AirCare is the defect(s) purposely placed in the vehicle.

The vehicle is then taken by an employee of the mystery shopper contractor to six repair facilities to get a diagnosis of the reason for failure. If the diagnosis of the shop correctly identifies the nature of the problem causing the AirCare failure, a follow up visit is scheduled to apprise them of the fact that they were mystery shopped and that they were successful. Shops that fail to correctly identify the cause of the failure or don't follow the recommended diagnostic and customer service procedures will also receive a follow-up visit to point out areas that need improvement.

The mystery shop process is carried out quarterly, meaning that 24 repair shops are visited each year in order to obtain diagnoses. In each quarterly cycle, one shop is chosen to actually perform the repair. Usually, this is the shop that has misdiagnosed the problem, or, if more than one shop has done so, the shop that is the furthest off base. Once the repair is done and the vehicle goes back through the re-inspection, appropriate follow-up is taken with the shop involved. The mystery shopper also reports on their experience with every repair shop and provides a subjective evaluation on a scale of 0-5 in three key areas- Service, Knowledge and Cost. A summary report is shown in Table 21.

Table 21. Results of Mystery Shopper for Repair Facilities in 2009 and 2010

Cycle	Number of Visits	Number Correct	Diagnostic Cost Range	Range of Scores	Repair Cost	Correct Repair?
2009-1	6	6	$44.50 - $120.00	8-11	N/A	N/A
2009-2	6	0	$87.81 - $181.44	7-12	$458.97	No
2009-3	6	4	$57.11 - $122.08	6-14	$1080.50(refused by PVTT)	No
2009-4	6	6	$70.00 - $115.25	9-12	$355.99	50% Correct
2010-1	6	5	$80.69 - $164.81	5-13	$304.19	50% Correct
2010-2	6	6	$53.09 - $167.16	10-14	$414.34	Yes
2010-3	6	6	$82.32 - $149.99	9-15	N/A	N/A
2010-4	6	6	$84.00 - $115.25	9-15	$329.18	No

It bears mentioning that the defects planted in the mystery shop vehicles are not exotic or particularly difficult to find. The objective is to create a problem that any competent technician, following a logical diagnostic procedure, should be able to identify. The results shown in Table 21 above indicate that in most cases, the majority of shops were able to identify the actual problem. In 2009-2, there were *two* defects placed in the vehicle, both simple. The reason that zero shops were shown as having correctly diagnosed the problem is that no one correctly diagnosed both problems. It appears that diagnosis proceeded until one problem area was found and then the focus shifted to repairing that one problem. The diagnosis should have continued, noting additional problems that might be identified. When shops were selected to do repairs (when every shop correctly diagnosed the problem, we chose not to do this step to the repair cost), the problem was generally corrected, but additional repairs were often included that were unnecessary. For example, to repair a faulty oxygen sensor on one bank of a V-8 engine, both sensors were replaced.

The mystery shopper component of repair centre monitoring has been generally well-received and most shops like receiving feedback on how they are serving their customers. From PVTT's perspective, it gives valuable insight into the way the public are being treated by the repair industry when seeking repairs to their vehicles.

5.8 CONSUMER PROTECTION AND DISPUTE RESOLUTION

Because the AirCare program recommends to the public that they have repairs done at certified repair shops, there is a responsibility on the part of the program administration to intervene in cases where the customer is not satisfied with the service received.

Upon receiving a complaint about an AirCare Certified Repair Centre, the complainant is informed that the first step is to contact the repair shop to try and resolve the issue. It is hoped that the customer and the repair shop can resolve the issue to each other's satisfaction without involvement by PVTT. In most cases, that is exactly what happens.

In the event that the repair shop and the customer are unable to resolve the dispute, PVTT will conduct an investigation. In 2009, there were 19 formal repair complaints that were investigated on behalf of motorists. In 2010, the number decreased to 10.

In most cases where the complaint is related to a vehicle failing re-inspection, an important aspect of the investigation is the determination of what is actually wrong with the vehicle. A PVTT diagnostic specialist examines the vehicle to identify the root cause of the re-inspection failure. Once the cause has been identified, it is easy to determine if the repair shop should have been able to identify and correct the fault. At the same time, any repair work performed by the shop can be evaluated to determine if it was necessary. Once the needed repairs are known, it is much easier to negotiate a solution between the repair shop and the customer.

In most cases, the resolution involves either performing the needed repairs at no labour charge or refunding money to the customer. To the credit of the certified repair industry, most disputes are settled voluntarily without involvement by PVTT.

6.0 EVALUATING EMISSIONS REDUCTIONS

The usual way of calculating the emissions output of a motor vehicle is to use an emission factor, expressed in grams per kilometre, for each exhaust gas constituent, and then multiply the emission factor by the annual kilometres driven. For example, a vehicle that is assumed to emit hydrocarbons at a rate of 0.5 g/km and is driven 15,000 km per year would produce 7.5 kg of hydrocarbon emissions. If that vehicle happened to develop a defect that resulted in its emissions increasing to 1.0 g/km, the annual emission output would increase to 15 kg. If the vehicle failed an emissions test due to its abnormal emission output and was repaired, restoring its emissions to the normal level of 0.5 g/km, the resulting reduction in emissions would be 15 kg – 7.5 kg = 7.5 kg.

In order to calculate the total emission benefits attributable to AirCare, it is necessary to specify the gram-per-kilometre emission rate for *all* of the vehicles in the fleet, in various operating states – passing, failing and post-repair. Given that the in-use vehicle fleet consists of passenger cars, light-duty trucks, heavy–duty trucks of ages ranging from brand new to 30 years old or more, the matrix needed to contain all of these emission rates becomes very large. In addition, it is necessary to know exactly how a vehicle failed the test in order to characterize its emission output prior to repair. Given that there are many modes of failure possible, the matrix size increases again. Similarly, the after-repair state will depend on the effectiveness of the repairs performed, which is indicated by the post-repair test result. Repairs that result in a pass may correspond to different degrees of emission reduction, depending on the change from the pre-repair to the post repair state. Also, since the AirCare program allows for vehicles to operate on a Conditional Pass, some of the post repair results are still in excess of the AirCare standards.

The availability of mass emission data is central to the calculation of program benefits. Since 2001, mass data has been based on full-duration IM240 tests performed in the inspection lanes. For exempt newer vehicles, new vehicle certification standards are used as a reference to estimate IM240 emission output.

6.1 MASS EMISSION SAMPLE NUMBER EIGHT (MES8)

The total number of observations in MES8, collected between January 2009 and December 2010, was 67,000, compared to 85,000 for the 2007 and 2008 review (MES7). The decrease is due to the reduction in the overall number of vehicles tested.

Regular IM240 inspections are usually fast-pass tests, and a fast pass can occur as early as 30 seconds into the driving cycle. The purpose of allowing fast pass is to improve the rate of inspection lane throughput, and to ease the time burden on motorists. Fast-pass is technically justified because the purpose of the inspection is only to determine whether the vehicle is operating properly or has a problem that should be repaired. If a vehicle is obviously very clean early in the inspection cycle, this determination can be made without going through the full 240 seconds. However, the combination of accelerations, cruise, decelerations and other transients in a fast-pass test will not be the same as the standard full-duration driving cycle, and, because vehicle emissions are very sensitive to such conditions, it is not valid to compare the emissions measured on fast-pass tests with other fast-pass results of different duration or with full duration measurements. For older vehicles (pre-1992) that are inspected using ASM and idle tests, the full-duration IM240 data is obtained by performing an IM240 test immediately following the ASM/Idle test. This test is called a Sample test. Sample tests are for information only and do not affect the pass/fail status of the vehicle.

For 1992 to1997 model year vehicles that *passed* their first attempt at inspection (usually a fast-pass IM240), the MES8 data is taken from a second, full-duration IM240 test performed immediately after the regular inspection. For 1992 to 1997 vehicles that *failed* inspection, the MES8 data is derived directly from the failed inspection itself, which is always a full-duration test. For *post-repair* 1992 to 1997 vehicles the data is from the re-inspection test, which is also always full duration.

For 1998-and-newer vehicles that were inspected using OBD, the mass emission data is derived from Sample full-duration IM240 tests performed immediately after the OBD inspection.

The full-duration inspection data is categorized by the result (Pass or Fail for each of HC, CO and NOx) corresponding to the initial inspection. Thus, for 1991-and-older vehicles, the mode category reflects the outcome of the ASM+Idle inspection. These vehicles can fail for numerous possible test conditions - HC, CO and NOx on the ASM test, HC and CO on the idle test or a number of combinations of pollutants and test modes. For 1992-1997 model year vehicles, mode category is determined from the initial IM240 test. A vehicle can fail the IM240 test for HC, CO, NOx or combinations of those three. For vehicles inspected using OBD, the mode is defined as simply Pass or Fail.

6.1.1 PRE-1992 VEHICLES IN MES8

The lane control software automatically selects for sample testing certain vehicles that match a pre-defined sample profile when they first arrive for inspection. Selected vehicles undergo a full duration IM240 test immediately after their regular ASM/Idle inspection. If one of these vehicles fails its initial inspection and has to be re-inspected, it will automatically receive a full duration IM240 after each re-inspection, until it finally passes or receives a Conditional Pass (waiver). The full-duration IM240 test has no effect on the pass/fail determination – this being entirely based on the ASM/Idle result.

For 2009 and 2010, the full-duration IM240 (IM240FD) sample for 1991-and-older vehicles consisted of 2,383 vehicles that passed the regular ASM/Idle inspection, and 305 that failed. Of these, 210 failed one or more parts of the ASM test and 95 only failed part of the idle test. The full data set is shown in Table 22 to Table 24, broken into categories by vehicle type and age group, and showing how many passed or failed each element of the inspection.

Table 22. Numbers of Initial Pre-1992 Vehicles in MES8

Vehicle Type	Model Year	Initial Result	ASM HC	ASM CO	ASM NO$_x$	Idle HC	Idle CO	Pass
All	Pre-1972	F	1	3	0	0	8	
All	Pre-1972	P	10	8	11	8	0	15
P	1972-81	F	1	1	1	4	1	
P	1972-81	P	5	5	5	0	3	37
T	1972-81	F	4	4	2	10	11	
T	1972-81	P	24	24	26	9	8	84
P	1982-87	F	4	7	9	4	1	
P	1982-87	P	17	14	12	0	3	232
T	1982-87	F	4	10	5	7	9	
T	1982-87	P	26	20	25	6	4	209
P	1988-91	F	40	30	35	21	12	
P	1988-91	P	46	56	51	1	10	841
T	1988-91	F	31	33	54	23	5	
T	1988-91	P	92	90	69	2	20	965
Total			**305**	**305**	**305**	**95**	**95**	**2383**

There were 245 full-duration IM240 sample vehicles with a re-inspection pass, and 15 where the final re-inspection result was a waiver (Conditional Pass). For the vehicles that received waivers, this is a relatively small sample – too small to be divided into the various sub-samples for each vehicle category and modal result. Moreover, these waivers are commonly very variable. Some are a reflection of poor or non-existent repairs that delivered little or no emission benefit, but some waivers are achieved after repairs that did reduce emissions substantially, even though they did not reach the levels necessary to pass re-inspection.

Vehicles that failed re-inspection but received a waiver were found to have average emissions comparable to those of initial failures, suggesting little to no emission reduction benefits from this group. Therefore, for the purpose of this analysis, the assumption is that, as a group, the emissions from vehicles that received a Conditional Pass are about the same as the overall average for all failed initial inspections.

Table 23. Numbers of Repaired-to-Waiver Pre-1992 Vehicles in MES8

Vehicle Type	Model Year	Initial Result	ASM HC	ASM CO	ASM NO_x	Idle HC	Idle CO
All	Pre-1912	F	0	0	0	0	0
All	Pre-1972	P	0	0	0	0	0
P	1972-81	F	0	0	0	0	0
P	1972-81	P	0	0	0	0	0
T	1972-81	F	1	2	1	0	0
T	1972-81	P	2	1	2	0	0
P	1982-87	F	2	2	0	0	0
P	1982-87	P	0	0	2	0	0
T	1982-87	F	0	0	0	0	0
T	1982-87	P	0	0	0	0	0
P	1988-91	F	0	0	2	0	0
P	1988-91	P	2	2	0	0	0
T	1988-91	F	4	4	1	1	0
T	1988-91	P	3	3	6	0	1
Total			**14**	**14**	**14**	**1**	**1**

Table 24. Numbers of Repaired-to-Pass Pre-1992 Vehicles in MES8

Vehicle Type	Model Year	Initial Result	ASM HC	ASM CO	ASM NO_x	Idle HC	Idle CO
All	Pre-1912	F	1	2	0	0	4
All	Pre-1972	P	5	4	6	4	0
P	1972-81	F	0	1	2	1	2
P	1972-81	P	5	4	3	1	0
T	1972-81	F	0	1	1	7	6
T	1972-81	P	14	13	13	5	6
P	1982-87	F	3	4	6	2	1
P	1982-87	P	12	11	9	0	1
T	1982-87	F	2	6	4	8	9
T	1982-87	P	22	18	20	5	4
P	1988-91	F	25	21	21	12	6
P	1988-91	P	28	32	32	1	7
T	1988-91	F	16	23	28	11	5
T	1988-91	P	53	46	41	2	8
Total			**186**	**186**	**186**	**59**	**59**

6.1.2 1992 TO 1997 MODEL YEAR (IM240 TEST) VEHICLES IN MES8

The bulk of the mass emission data for this group was taken directly from failed initial inspections, because all such tests are naturally full-duration IM240's. For the purpose of this review, there were 59,287 such test results available. Table 25 shows their breakdown by cut-point category (nine categories) and combination failure mode (seven possible modes).

Vehicles that pass their IM240 inspections usually do so early in the test, i.e. they fast-pass. Therefore, the lane inspection data for passing vehicles cannot be reliably used as a source of valid mass emission information about this type of vehicle. However, the pre-defined IM240FD sample, identified by the lane control software, selects some passing vehicles for full duration tests immediately after their regular inspection. Of the 36,907 1992-1997 vehicles selected for sample testing in 2009 and 2010, there were 6,409 that passed their initial inspection, leaving 30,498 from the failing group.

Since April 2004, it has been required that all re-inspections must be full-duration tests, regardless of whether any fast-pass criteria have already been met. The reason for this policy is to enable direct comparison of before and after-repair inspection readings. It also means that mass emission reductions for re-inspected vehicles that pass can be derived directly from the test readings. In 2009 and 2010 there were 21,483 vehicles that passed re-inspection after having initially failed. This represents 70% of the failed vehicles in the sample.

Data on 1992-1997 vehicles where the final re-inspection result was a waiver can also be derived directly from the lane inspections, because, like all re-inspections, they are naturally full-duration tests. In 2009 and 2010, there were 897 of these vehicles that only achieved a re-inspection waiver, after having initially failed in the same period.

Table 25. Numbers of 1992-1997 Vehicles in MES8 by Cut Point Category and Inspection Result Mode

Initial Failure Mode	Cutpoint Category								
	Initial Failure								
	1	2	3	4	5	6	7	8	9
FFF	97	548	60	277	364	165	50	53	11
FFP	96	2607	114	192	1018	30	37	288	301
FPF	120	2828	46	505	677	147	100	295	30
FPP	91	4601	44	241	455	73	76	617	414
PFF	16	77	34	51	156	15	3	2	0
PFP	134	859	337	114	782	14	4	33	104
PPF	309	3789	215	1801	3174	273	89	408	37
PPP	0	2701	169	636	939	196	141	476	1151
Initial Failure Mode	Repaired-to-Waiver								
	1	2	3	4	5	6	7	8	9
FFF	1	20	4	8	18	4	1	2	11
FFP	1	64	7	3	39	1	1	22	1
FPF	7	85	0	15	23	2	5	9	9
FPP	2	146	2	5	14	1	3	17	2
PFF	0	0	1	3	6	1	0	0	2
PFP	2	22	13	1	18	0	0	0	0
PPF	8	101	9	66	70	8	2	9	0
Initial Failure Mode	Repaired-to-Pass								
	1	2	3	4	5	6	7	8	9
FFF	62	303	37	178	205	105	38	23	8
FFP	74	1724	84	143	646	17	27	173	195
FPF	84	1845	36	336	413	104	70	201	26
FPP	64	3339	35	180	319	50	60	425	281
PFF	11	51	28	34	109	14	3	0	0
PFP	110	663	288	95	597	11	3	29	78
PPF	229	2769	163	1374	2334	192	56	294	38

Note: 1) Failure Mode is in the following order: HC | CO | NOx. 2) Refer to Section 3. 2 – Standards for information on Cutpoint Category

6.1.3 1998-AND-NEWER VEHICLES IN MES8

For 1998-and-newer vehicles that were OBD-tested, the mass emission data was derived from the full-duration IM240 sample tests performed in parallel with the OBD interrogation. For 2009 and 2010 there were 5,576 sample tests available. Table 26 shows their breakdown by vehicle type and test type. There were 2,743 initial tests that passed, 1,265 initial tests that failed; 1,525 re-inspection passes and 43 re-inspection waivers. To evaluate the emission reductions from OBD repairs the approach was to scale up the reductions from this sample group to the total number of OBD repairs. This avoided the need to allocate emission factors to different failure modes as might be characterised by the DTCs present in OBD failures. The sample group is relatively large compared to the total, and various checks indicated that it is representative in terms of its age and manufacturer profile and the frequencies of DTCs present.

Table 26. Numbers of 1998-and-Newer Vehicles in MES8

	Vehicle Type		
	P	T	Total
Initial Failed	550	423	974
Waivered	22	12	34
Repaired to Pass	516	365	881
Pass	1664	1079	2743

6.2 FLEET MASS EMISSION EVALUATION

The basic method for calculating the total mass of light-duty vehicle emissions has been described in previous reports. Simply put, it allocates emission rates in grams/km and annual kilometres driven to all the light-duty vehicles licensed for use in the AirCare region. The emission rates used in this report are derived from MES8. The vehicles whose emissions changed in the calendar year as a result of the program are allocated two possible sets of emission factors – one pre-repair, and the other post-repair. Calculating the total emissions from all of the repaired vehicles in their pre-repair (failing) state establishes the baseline emission level. Subtracting the emissions for these same vehicles in the post-repair condition yields the emission reduction attributable to repairs. The annual kilometres driven for all vehicle types are derived from odometer readings recorded at the time of inspection, adjusted to a 12-month period.

Since the IM240 test does not include vehicle operating modes such as cold-start, high-speed cruise, climbing and descending hills, rapid acceleration, operation with the air conditioner in use, etc., data from the tests cannot correctly be used to represent the annual average emission rate for vehicles under the full range of driving modes and environmental conditions encountered in real-world driving. More sophisticated emission factors are available from the EPA MOBILE emission inventory model with suitable corrections for temperature, speed and other factors.

The percentage change in emissions indicated from the pre- and post-repair IM240 emission factors is applied to the MOBILE emission factors to derive real-world emission rates and total emissions. The total inventory value for light-duty vehicle emissions is taken from the Lower Fraser Valley Light-Duty Mobile Source Emission Inventory as published by Metro Vancouver. The inventory is updated every 5 years, and the updates include forecasts and backcasts from the reference year. This is necessary because each time the MOBILE model is revised, (previous versions include MOBILE 2.5, MOBILE 4, and MOBILE 5) it may give a different result for a year that was previously inventoried using an earlier version. For example, MOBILE 6 predicts higher emissions than MOBILE 5 in all years. The present version of the model is MOBILE 6.2C, but for some time now the US EPA has been developing a new model that is to completely replace MOBILE. The new model is called MOtor Vehicle Emission Simulator (MOVES), and at the time of writing, Metro Vancouver is working with MOVES to develop the 2010 inventory on the usual five year cycle.

It appears that the inventory estimates from MOVES, compared to MOBILE 6.2C, will be little different for HC and CO, but somewhat higher for NOx. However, the results will not be finalized or published until mid 2012. When they are finalized, it will be necessary to re-examine the AirCare emission reduction estimates and make any adjustments that are required. The estimates in this report continue to be based on previously published inventories.

6.2.1 INVENTORY REDUCTIONS FROM REPAIRS

The estimated quantitative benefits of AirCare for calendar years 2009 and 2010 are presented in Table 19 and Table 20. The reductions achieved in 2009 from repairs in that year were 488 tonnes for HC, 7,334 tonnes for CO, and 299 tonnes for NO_x. In 2010, the reductions achieved from repairs in that year were 391 tonnes for HC, 5,765 tonnes for CO, and 278 tonnes for NO_x. These results are lower than those reported for 2007 and 2008. The reason for this is the changing age profile of the fleet, and decreasing failure rates. Also, the absolute difference between passing and failing emission levels has becomes less as emission control technology has improved allowing for less potential emission reductions from repairs.

Most of the emission reductions due to repairs have previously come from 1991-and-older model year vehicles. However, as the older vehicles drop out of use and the 1992-and-newer vehicles deteriorate with age, the proportion of the reductions due to repairs on the 1992-and-newer age group has risen steadily, and in 2010 this group accounted for more than half of the total reductions due to repairs.

Compared with the ASM/Idle and IM240 groups, only a small number of OBD-repairs were observed during the review period. Although MES8 included more than 1,200 failed OBD test results, the sample size for any given DTC turned out to be fairly small, given the plethora of DTC's possible. For the most frequently-observed DTC's the sample size was large enough to provide usable information about the tailpipe emission reductions that could be expected from eliminating a DTC. In general, repairs related to failed oxygen sensors, insufficient EGR flow and low catalytic converter efficiency yielded the most significant tailpipe emission reductions. Not unexpectedly, some OBD repairs had no measurable effect on tailpipe emissions because the DTC was related to an issue with the monitoring system itself and not a problem with the engine/emission control system.

6.3 REMOVAL FROM USE AFTER FAILURE

Some vehicles do not appear for re-inspection after failing and may be considered as having been removed from use. Some of the emission reduction benefit derived from removing these vehicles from the road can reasonably be attributed to the AirCare program.

However, there is no reliable method to estimate what that proportion is, so Table 27 and Table 28 simply indicate the total emissions that would have been generated by the continued operation of those vehicles, without attempting to estimate what proportion is a direct result of the program. This estimate, like the previous ones, is only intended to illustrate the fact that emission reductions from the removal of older vehicles from use can be very significant, even though the number retired after failing inspection is small compared to the number that are repaired.

Table 27. In-Use Light-Duty Vehicle Mass Emission Inventory in 2009

		BASE			With REPAIRS			With RFUAF		
Vehicle Type	Age Group	Emission (Mg/Year)			Emission (Mg/Year)			Emission (Mg/Year)		
		HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
All	Pre-1982	764	11,438	379	781	10,017	370	670	8,321	336
All	1982-1987	470	4,929	442	436	4,600	422	387	4,029	393
All	1988-1991	874	11,161	911	722	9,362	845	617	7,993	786
All 1991-and-Older		2,108	27,528	1,732	1,940	23,979	1,636	1,674	20,342	1,514
P	1992-1995	701	9,440	760	590	8,184	701	534	7,522	668
P	1996-1997	254	4,125	376	231	3,830	364	221	3,721	359
T	1992-1995	691	8,329	718	570	6,983	653	511	6,344	620
T	1996-1997	195	2,962	355	164	2,549	322	152	2,431	309
All 1992 - 1997		1,840	24,856	2,208	1,555	21,545	2,040	1,419	20,017	1,957
P	1998-2001	334	6,666	579	320	6,495	565	316	6,434	560
TP	1998-2001	379	5,432	757	365	5,250	744	360	5,186	738
All 1998 - 2001		713	12,099	1,336	685	11,744	1,309	676	11,620	1,298
P	Post-2001	265	10,053	972	262	9,983	969	261	9,965	968
T	Post-2001	178	3,390	463	175	3,340	459	175	3,330	458
All Post-2001		444	13,443	1,435	437	13,323	1,428	435	13,295	1,425
TOTAL		5,105	77,926	6,712	4,617	70,591	6,412	4,204	65,273	6,194
Reduction in Year					488	7,334	299	901	12,652	518
Reduction in Year from RFUAF								413	5,318	218
Reduction from 2006 Base		5,324	66,254	4,636	5,812	73,589	4,935	6,225	78,907	5,153

Table 28. In-Use Light-Duty Vehicle Mass Emission Inventory in 2010

		BASE			With REPAIRS			REPAIRS + RFUAF		
Vehicle Type	Age Group	Emission (Mg/Year)			Emission (Mg/Year)			Emission (Mg/Year)		
		HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
All	Pre-1982	713	10,336	348	735	9,144	339	641	7,739	311
All	1982-1987	360	3,665	342	336	3,509	327	300	3,117	304
All	1988-1991	689	8,601	730	577	7,367	676	490	6,258	624
All 1991-and-Older		1,762	22,601	1,421	1,648	20,020	1,342	1,431	17,114	1,239
P	1992-1995	543	7,140	626	456	6,229	571	403	5,651	539
P	1996-1997	216	3,472	331	195	3,225	319	185	3,116	312
T	1992-1995	601	7,187	646	505	6,165	589	453	5,599	558
T	1996-1997	185	2,839	334	155	2,434	301	142	2,291	289
All 1992 - 1997		1,545	20,638	1,937	1,311	18,053	1,781	1,183	16,657	1,697
P	1998-2001	321	6,308	544	304	6,094	527	299	6,026	522
TP	1998-2001	374	5,367	739	355	5,117	721	349	5,038	713
All 1998 - 2001		695	11,675	1,283	659	11,211	1,248	649	11,064	1,235
P	Post-2001	298	11,130	1,072	294	11,050	1,068	293	11,033	1,067
T	Post-2001	190	3,607	488	187	3,553	483	186	3,540	481
All Post-2001		488	14,738	1,559	481	14,603	1,551	479	14,573	1,548
TOTAL		4,490	69,652	6,200	4,099	63,887	5,922	3,742	59,408	5,719
Reduction in Year					391	5,765	278	748	10,244	481
Reduction in Year from RFUAF								357	4,479	202
Reduction from 2006 Base		5,939	74,528	5,147	6,330	80,293	5,425	6,687	84,772	5,628

6.4 MASS OF EMISSIONS PREVENTED BY REPAIRS

The mass of emissions prevented within a one-year period is one half of the difference between the base inventory and the inventory calculated using post-repair emission results for the vehicles that returned for re-inspection. This essentially assumes that the repairs are evenly spread throughout the year and therefore, the nominal failing vehicle would operate for 6 months in the post-repair state. In 2009, the mass of emissions prevented by new repairs was 244 tonnes of HC; 3,667 tonnes of CO; and 150 tonnes of NO_x. In 2010 the mass of emissions prevented by new repairs was 195 tonnes of HC; 2,882 tonnes of CO; and 139 tonnes of NO_x. These are one half of the values reported in section 6.2.1.

6.5 PERCENTAGE REDUCTIONS DUE TO REPAIRS

Overall, the percentage emission reduction achieved by repairs only changes a little each year. There were very few failures, and therefore very few repairs, for the 1998-2001 vehicles, that were inspected using OBD, so their overall emissions were not reduced very much. The largest percentage reductions now come from the 1992-1997 age group. But the percentage reductions from the pre-1992 age group are still only very slightly less than in previous years.

Table 29. Percentage Emission Reductions Due to Repairs

Vehicle Type	Age Group	2009			2010		
		HC	CO	NOx	HC	CO	NOx
All	Pre-1982	-2%	12%	2%	-3%	12%	3%
All	1982-1987	7%	7%	5%	7%	4%	4%
All	1988-1991	17%	16%	7%	16%	14%	7%
All 1991-and-Older		8%	13%	6%	6%	11%	6%
P	1992-1995	16%	13%	8%	16%	13%	9%
P	1996-1997	9%	7%	3%	10%	7%	4%
T	1992-1995	18%	16%	9%	16%	14%	9%
T	1996-1997	16%	14%	9%	17%	14%	10%
All 1992 - 1997		15%	13%	8%	15%	13%	8%
P	1998-2001	4%	3%	2%	5%	3%	3%
TP	1998-2001	4%	3%	2%	5%	5%	2%
All 1998 - 2001		4%	3%	2%	5%	4%	3%
P	Post-2001	1%	1%	0%	1%	1%	0%
T	Post-2001	2%	1%	1%	2%	1%	1%
All Post-2001		2%	1%	1%	2%	1%	1%
TOTAL		10%	9%	4%	9%	8%	4%

6.6 INVENTORY CONTRIBUTIONS

The inventory contributions by age group are shown in Table 30 and Table 31. The pre-1992 vehicles now contribute less than a third of the inventory, because their numbers continue to decrease and their VkmT contribution is low.

Table 30. Percentage Contributions in 2009

Vehicle Type	Age Group	BASE			with REPAIRS		
		HC	CO	NOx	HC	CO	NOx
All	Pre-1982	15%	15%	6%	17%	14%	6%
All	1982-1987	9%	6%	7%	9%	7%	7%
All	1988-1991	17%	14%	14%	16%	13%	13%
All 1991-and-Older		41%	35%	26%	42%	34%	26%
P	1992-1995	14%	12%	11%	13%	12%	11%
P	1996-2000	5%	5%	6%	5%	5%	6%
T	1992-1995	14%	11%	11%	12%	10%	10%
T	1996-2000	4%	4%	5%	4%	4%	5%
All 1992 - 2000		36%	32%	33%	34%	31%	32%
T	1992-1995	7%	9%	9%	7%	9%	9%
T	1996-2000	7%	7%	11%	8%	7%	12%
All 1992 - 2000		14%	16%	20%	15%	17%	20%
P	Post-2001	5%	13%	14%	6%	14%	15%
T	Post-2001	3%	4%	7%	4%	5%	7%
All Post-2001		9%	17%	21%	9%	19%	22%
TOTAL		100%	100%	100%	100%	100%	100%

The increased percentage contribution attributable to 2002-and-newer vehicles is because of their increased numbers and greater annual distance driven.

Table 31. Percentage Contributions in 2010

Vehicle Type	Age Group	BASE			with REPAIRS		
		HC	CO	NOx	HC	CO	NOx
All	Pre-1982	16%	15%	6%	18%	14%	6%
All	1982-1987	8%	5%	6%	8%	5%	6%
All	1988-1991	15%	12%	12%	14%	12%	11%
All 1991–and-Older		39%	32%	23%	40%	31%	23%
P	1992-1995	12%	10%	10%	11%	10%	10%
P	1996-2000	5%	5%	5%	5%	5%	5%
T	1992-1995	13%	10%	10%	12%	10%	10%
T	1996-2000	4%	4%	5%	4%	4%	5%
All 1992 - 2000		34%	30%	31%	32%	28%	30%
T	1992-1995	7%	9%	9%	7%	10%	9%
T	1996-2000	8%	8%	12%	9%	8%	12%
All 1992 - 2000		15%	17%	21%	16%	18%	21%
P	Post-2001	7%	16%	17%	7%	17%	18%
T	Post-2001	4%	5%	8%	5%	6%	8%
All Post-2001		11%	21%	25%	12%	23%	26%
TOTAL		100%	100%	100%	100%	100%	100%

Table 32. Number of Vehicles and VkmT in 2009 and 2010

		2009				2010			
Vehicle Type	Age Group	Number of Vehicles	Percentage of Population	VkmT 1,000	Percentage of VkmT	Number of Vehicles	Percentage of Population	VkmT 1,000	Percentage of VkmT
All	Pre-1982	22,997	2%	185,108	1%	21,716	2%	170,430	1%
All	1982-1987	25,493	2%	235,361	1%	20,044	1%	180,363	1%
All	1988-1991	83,610	6%	859,274	4%	67,575	5%	677,622	4%
All 1991-and-Older		132,100	10%	1,279,743	7%	109,335	8%	1,028,415	5%
P	1992-1995	99,325	7%	1,119,761	6%	82,571	6%	908,281	5%
P	1996-2000	57,649	4%	700,517	4%	51,442	4%	609,749	3%
T	1992-1995	47,506	3%	536,996	3%	43,227	3%	476,656	2%
T	1996-2000	34,538	3%	420,368	2%	32,664	2%	387,772	2%
All 1992 - 2000		239,018	17%	2,777,642	15%	209,904	15%	2,382,458	12%
T	1992-1995	153,923	11%	2,019,575	11%	144,213	10%	1,846,229	10%
T	1996-2000	97,670	7%	1,280,409	7%	95,579	7%	1,222,460	6%
All 1992 - 2000		251,593	18%	3,299,984	17%	239,792	17%	3,068,689	16%
P	Post-2001	599,156	44%	9,464,596	50%	670,694	48%	10,366,287	54%
T	Post-2001	150,503	11%	2,277,829	12%	161,748	12%	2,400,848	12%
All Post-2001		749,659	55%	11,742,425	61%	832,442	60%	12,767,135	66%
TOTAL		1,372,370	100%	19,099,794	100%	1,391,473	100%	19,246,697	100%

The percentage contribution from these newest vehicles will grow, however, because their absolute emissions are much lower than those from older vehicles, their percentage contribution to the inventory does not increase at the same rate as do their numbers and VkmT as shown in Table 32.

6.7 VEHICLE NUMBERS AND KILOMETRES TRAVELLED

Two thirds of the total VkmT (66%) is from the 2002-and-newer age group, but their emissions contribution is only 20%. The OBD vehicles (1998-2003) contributed 16% of VkmT, and their emission contribution was 18%. The IM240 vehicles (1992-1997) contributed 12% of VkmT, but their emission contribution was 30%. The oldest group (pre-1992) contributed only 5% of VkmT, but with an emissions contribution of 31%. The relationships between vehicle numbers, VkmT and emission contributions are illustrated in Figure 35.

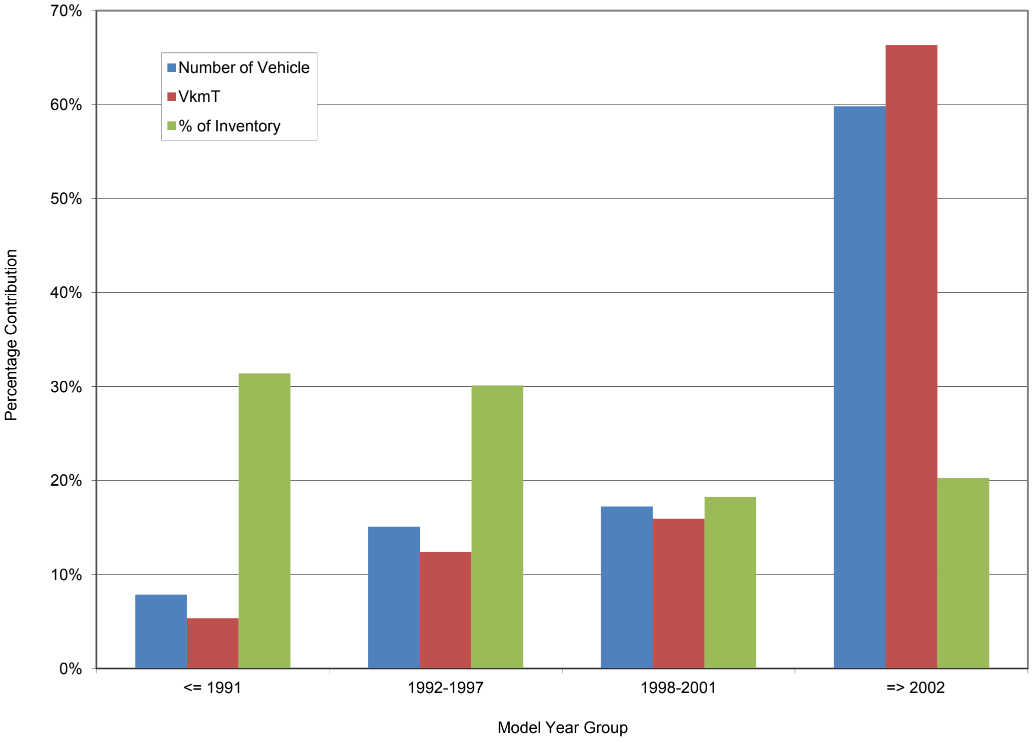


Figure 35. Relationship Between Fleet Size, VkmT and Emission Contributions

6.8 ASM SPACE AND IDLE SPACE

For the purposes of evaluating the amount of emission reductions that have been achieved by an inspection and maintenance program, it is essential to work entirely in terms of the mass of emissions in the mobile source inventory, and the amount that inventory has been reduced as a consequence of the program. This has been attempted, and is described in the previous section. It required consistent mass emission factors to be assigned to all the vehicles in the fleet, however they were inspected, and even though many of them were not actually inspected. The raw ASM and idle inspection readings can not be directly converted into mass emission values, because of the other factors that contribute to the overall mass emissions, such as engine size, vehicle weight, transmission efficiency, etc. However, it can be informative to simply examine how mean ASM and idle emission readings have changed over time and as a result of repairs.

The mean readings for ASM and idle inspections on 1991-and-older vehicles are shown in Table 33 to Table 35. In all cases there is very little difference between 2009 and 2010 mean readings. They are also very close to the mean readings published previously, so the observations made in the previous reports continue to apply.

There are two main things to observe. The first is that mean readings are higher for older age groups. This is mostly a reflection of the continued improvements that have been made to the federal new vehicle emission standards over the years. Each time the standards have changed, they have required new vehicle manufacturers to reduce emissions by improving engines and emission control technology, and to warrant that those emissions will stay low for longer. Natural deterioration with age would also contribute to the higher readings from older vehicles.

The second observation is that failed inspections have higher mean readings than passing inspections, but that after repair, the re-inspection readings are comparable to those vehicles which passed at their first attempt. This is an important observation. It suggests that those vehicles repaired to pass re-inspection are achieving the same emissions performance as vehicles that initially passed inspection at their first attempt.

Table 33. Average ASM and Idle Results for Vehicles that "Passed at First Attempt"

	Vehicle Type	Age Group	ASM HC (ppm)	ASM CO (%)	ASM NOx (ppm)	Idle HC (ppm)	Idle CO (%)
2009	P	Pre-1981	81	0.68	880	184	1.51
	T	Pre-1981	70	0.48	1263	166	1.65
	P	1982-1987	58	0.26	895	76	0.38
	T	1982-1987	63	0.28	876	93	0.51
	P	1988-1991	24	0.10	366	23	0.04
	T	1988-1991	38	0.13	415	42	0.06
2010	P	Pre-1981	79	0.65	878	191	1.47
	T	Pre-1981	71	0.43	1276	174	1.57
	P	1982-1987	55	0.22	874	74	0.32
	T	1982-1987	62	0.26	889	94	0.47
	P	1988-1991	25	0.10	379	23	0.04
	T	1988-1991	39	0.13	422	42	0.06

Comparison of the these tables with the corresponding versions published earlier reveals that the average ASM and Idle readings for the various age and vehicle type groups have not changed much over a 10-year time span. Generally, it is believed that overall mean readings for particular groups of vehicles will increase over time as a result of deterioration with age. However, the tabulated values indicate that, for a particular modal result, there is little change in the mean readings with age. It appears that the mechanism by which a group of vehicles deteriorates does not involve each vehicle sharing an equal amount of deterioration. Instead, some vehicles continue to perform with little or no change, whereas others experience component or system failures that have a serious effect on emissions performance. For example, if a vehicle, which had previously had no problems and had received ASM results of 'PPP', developed a serious CO problem, its ASM result would change to 'PFP'. This would reduce the fraction of the age group that achieved 'PPP' and increase the fraction that received

'PFP'. This would increase the overall mean CO readings, which would appear as a deterioration of the group as a whole.

Table 34. Average ASM and Idle Readings for Vehicles that "Failed at First Attempt"

	Vehicle Type	Age Group	ASM HC (ppm)	ASM CO (%)	ASM NOx (ppm)	Idle HC (ppm)	Idle CO (%)
2009	P	Pre-1981	197	2.17	795	788	4.47
	T	Pre-1981	208	1.65	1125	723	3.98
	P	1982-1987	152	1.45	1429	387	2.23
	T	1982-1987	156	1.33	1223	477	2.40
	P	1988-1991	101	0.96	912	201	1.18
	T	1988-1991	126	1.09	917	274	1.27
2010	P	Pre-1981	204	2.10	772	848	4.52
	T	Pre-1981	207	1.45	1239	837	3.60
	P	1982-1987	141	1.21	1461	392	1.78
	T	1982-1987	152	1.15	1341	512	2.28
	P	1988-1991	97	0.89	963	187	0.99
	T	1988-1991	127	0.94	952	256	1.11

Table 35. Average ASM and Idle Readings for Vehicles "Repaired to Pass"

	Vehicle Type	Age Group	ASM HC (ppm)	ASM CO (%)	ASM NOx (ppm)	Idle HC (ppm)	Idle CO (%)
2009	P	Pre-1981	86	0.93	736	243	1.84
	T	Pre-1981	74	0.69	1081	189	1.90
	P	1982-1987	60	0.33	927	92	0.58
	T	1982-1987	66	0.39	959	111	0.81
	P	1988-1991	29	0.12	403	30	0.06
	T	1988-1991	41	0.13	421	48	0.10
2010	P	Pre-1981	84	0.89	746	257	1.92
	T	Pre-1981	72	0.65	1123	211	1.81
	P	1982-1987	60	0.28	956	98	0.51
	T	1982-1987	64	0.30	975	115	0.75
	P	1988-1991	30	0.12	432	30	0.05
	T	1988-1991	41	0.13	447	51	0.11

The overall effect is for the mean performance to deteriorate as the number of vehicles that have experienced failure increases. However, when we consider the pass and fail conditions separately, there is very little change with time, and this is what is shown by the mean readings for specific modal results which have not changed significantly from 2001 to 2010

Another effect that tends to mitigate against overall deterioration of the mean with age is that the worst vehicles, which have experienced failure, and have high mileage, are those most likely to be retired from use. Only the better-condition, lower-mileage vehicles continue in use, and their emissions are lower than the emissions of the retired vehicles.

6.9 IM240 SPACE

As was explained for ASM and idle readings, the raw IM240 readings cannot be used as a basis for a proper evaluation of mass emission reductions. Although the IM240 results are expressed in the same units as mass emission factors, they are derived from inspections which are mostly fast pass, and therefore, incomplete inspections. These inspections are ended early, and therefore do not include the same proportions of accelerations, cruise, decelerations and other transients as does a standard full duration IM240. Because emission rates are very sensitive to these conditions, this means that the fast pass reading is not always a reliable indication of what the full duration reading would be. However, as for ASM and idle tests, the raw readings can be easily examined, and it can be interesting to see how overall mean IM240 reported readings have changed with time and in response to repairs.

Mean readings for IM240 inspections on 1992-1997 vehicles are shown in Table 36 to Table 38. The vehicles have been grouped by their inspection cut-point categories. Of course, the same two general observations hold true as for older vehicles: mean readings are higher for older age groups; and failed inspections have higher mean readings than passing inspections, while repairs lower the readings to about the same level as for first-time-pass vehicles.

Table 36. Average IM240 Readings for Vehicles that "Passed at First Attempt"

	Cutpoint Category	Vehicle Type	Age Group	IM240 HC (g/km)	IM240 CO (g/km)	IM240 NOx (g/km
2009	2	LDV	1992-1997	0.19	4.01	0.55
	3	LDT1	1996-1997	0.12	4.91	0.44
	4	LDT2	1996-1997	0.15	2.98	0.66
	5	LDT	1992-1995	0.33	5.98	0.86
	6	LDT3	1996-1997	0.22	3.50	0.66
	7	LDT4	1996-1997	0.20	3.96	0.70
	8	LDTH	1992-1995	0.57	7.34	1.26
	9	HDV	≥ 1992	0.34	6.16	1.40
2010	2	LDV	1992-1997	0.19	3.86	0.58
	3	LDT1	1996-1997	0.14	4.54	0.49
	4	LDT2	1996-1997	0.16	2.98	0.68
	5	LDT	1992-1995	0.34	5.82	0.89
	6	LDT3	1996-1997	0.23	3.21	0.67
	7	LDT4	1996-1997	0.22	4.13	0.71
	8	LDTH	1992-1995	0.58	7.05	1.27
	9	HDV	≥ 1992	0.31	5.89	1.24

For non-heavy-duty vehicles tested using the IM240 test, there is essentially just one age group, which approximately corresponds to Tier 0 certification requirements. Tier 1 was introduced in 1996, but its requirements were not fully implemented in Canada until the 1998 model year. So cut-point category 2 roughly correspond to Tier 0 passenger vehicles. Because we have moved to OBD inspection for 1998-and-newer vehicles, the former cut-point category 1 is now obsolete. The situation for trucks is complicated by their various weight classifications, but the same general observation holds true, that the Tier 1 certified vehicles have lower emissions than the older, Tier 0 vehicles.

Table 37. IM240 Space for Vehicles which "Failed at First Attempt"

	Cutpoint Category	Vehicle Type	Age Group	IM240 HC (g/km)	IM240 CO (g/km)	IM240 NOx (g/km
2009	2	LDV	1992-1997	0.74	8.63	1.24
	3	LDT1	1996-1997	0.56	14.22	1.11
	4	LDT2	1996-1997	0.50	5.49	1.60
	5	LDT	1992-1995	0.99	12.91	1.76
	6	LDT3	1996-1997	0.64	6.51	1.74
	7	LDT4	1996-1997	0.66	7.12	1.62
	8	LDTH	1992-1995	1.71	15.71	2.01
	9	HDV	≥ 1992	2.11	25.51	2.68
2010	2	LDV	1992-1997	0.74	8.63	1.24
	3	LDT1	1996-1997	0.56	14.22	1.11
	4	LDT2	1996-1997	0.50	5.49	1.60
	5	LDT	1992-1995	0.99	12.91	1.76
	6	LDT3	1996-1997	0.64	6.51	1.74
	7	LDT4	1996-1997	0.66	7.12	1.62
	8	LDTH	1992-1995	1.71	15.71	2.01
	9	HDV	≥ 1992	2.11	25.51	2.68

For vehicles in the newest age group it is still too soon to expect any significant deterioration of emission readings over time. Vehicles in the newest age groups (categories 3, 4, 6, and 7) that passed on their first attempt show approximately the same mean readings in 2009 and 2010. In this age group, there is little difference from 2007 to 2008 in the mean readings for vehicles that failed inspection.

Table 38. IM240 Space for Vehicles that were "Repaired to Pass"

	Cutpoint Category	Vehicle Type	Age Group	IM240 HC (g/km)	IM240 CO (g/km)	IM240 NOx (g/km
2009	2	LDV	1992-1997	0.21	2.15	0.53
	3	LDT1	1996-1997	0.15	3.42	0.42
	4	LDT2	1996-1997	0.15	1.36	0.60
	5	LDT	1992-1995	0.30	3.56	0.74
	6	LDT3	1996-1997	0.18	1.51	0.53
	7	LDT4	1996-1997	0.20	1.73	0.50
	8	LDTH	1992-1995	0.45	4.75	1.00
	9	HDV	≥ 1992	0.54	5.72	1.61
2010	2	LDV	1992-1997	0.21	2.15	0.53
	3	LDT1	1996-1997	0.15	3.42	0.42
	4	LDT2	1996-1997	0.15	1.36	0.60
	5	LDT	1992-1995	0.30	3.56	0.74
	6	LDT3	1996-1997	0.18	1.51	0.53
	7	LDT4	1996-1997	0.20	1.73	0.50
	8	LDTH	1992-1995	0.45	4.75	1.00
	9	HDV	≥ 1992	0.54	5.72	1.61

The older age group shows slightly increased readings in 2010 for vehicles that passed inspection at their first attempt. This could be deterioration with age. The vehicles that failed on their first attempt showed slightly more increase in mean IM240 readings. However, after repair, the mean readings in 2010 were all lower than the corresponding mean readings in 2009, which suggests that 2010 repairs were more effective at reducing emissions.

Heavy-Duty vehicles (category 9) that passed inspection had slightly lower mean readings in 2010 than in 2009. The mean readings for those that failed were about the same in both years. The mean readings after being repaired to pass were slightly lower in 2010 than in 2009

7.0 THIRD PARTY REVIEW OF THE AIRCARE PROGRAM

7.1 BACKGROUND

The U.S. Clean Air Act of 1970 set ambitious targets for the reduction of emissions from motor vehicles, which were recognized as the principal source of smog-forming pollutants in urban areas. Vehicle manufacturers were tasked with reducing emissions by 90% compared to pre-control vehicles by 1975/76. The U.S. EPA was established to implement a certification process and enforcement system to ensure that all vehicles intended for sale in the U.S. market complied with the standards. Without an official certificate of compliance, a vehicle could not be sold. In Canada, emission standards were incorporated into the Motor Vehicle Safety Act for the 1971 model year, mirroring the U.S. standards through 1974. The 1975 standards, however, were set at a less stringent level than the United States. Parity with the U.S. standards did not return until the 1988 model year.

Although the vehicle manufacturers designed and built vehicles that met the new-vehicle emission standards when they rolled off the assembly line, those same vehicles, if checked a year or two later, would often not meet the standards and a small subset of this group would be emitting far more than the allowable amounts. Inspection and Maintenance programs like AirCare were proposed in the mid-1970's to address this problem of in-use vehicles not delivering the promised emission reductions in the real world. Studies of in-use vehicles across the U.S. and Canada showed consistently that a minority of poor-performing vehicles (10%-15% of the fleet) accounted for up to 50% of total vehicle emissions. If these high emitters could be weeded out of the overall fleet and made to run properly, total vehicle-generated emissions could be reduced significantly. Inspection and Maintenance programs were intended to screen the fleet so as to pick out the worst emitters (Inspection) and then require that they be repaired to restore normal emissions performance (Maintenance).

Throughout the 1970's and 1980's, sampling programs and surveys were conducted in both the U.S. and Canada to determine the reasons for the discrepancy between certification test emission levels and typical in-use performance. Most often, the reasons for excess emissions included improper adjustment of ignition timing and the carburettor idle mixture. Failure to perform scheduled engine maintenance and the deliberate removal or disabling of emission control components further worsened the problem. In truth, many of the early emission-controlled vehicles suffered from reduced performance and fuel efficiency compared to their uncontrolled forebears and tampering with emission controls and engine settings was seen as a means of restoring lost power and economy. Furthermore, it was not uncommon for repair shops to ignore repairs to or replacement of emission control hardware such as air pumps, EGR valves and catalytic converters. If these parts broke, they were either removed or bypassed. The combination of improper engine settings and non-functioning emission controls meant that many of the early emission-controlled vehicles performed like uncontrolled vehicles or worse for much of their useful lives.

Over the decades that I/M programs have been in operation, vehicle technology has evolved to fundamentally address many of the causes of excess emissions from in-use vehicles. For example, the use of electronic fuel injection has eliminated the need for idle mixture and idle speed adjustments and cold-start enrichment no longer requires the use of a mechanical choke device. An oxygen sensor and on-board computer allows for continuous monitoring and adjustment of the air-fuel ratio so, as long as the system works properly, the air-fuel ratio is maintained at the design point. The catalytic converter benefits from the proper control of the mixture, enhancing its efficiency and ensuring a long life. Ignition systems have evolved to completely eliminate distributors and ignition wires in many cases and spark plug life has been extended beyond 10 years. By making engines more durable and eliminating the need for periodic adjustments and component replacements, manufacturers have made it so that a vehicle built at some time in the past 20 years will generally comply with its new-car emission standards unless something has broken. Current I/M programs should more correctly be called I/R programs, for Inspection and Repair, because lack of preventive maintenance is rarely the cause of excess emissions in modern vehicles.

One problem that vehicle technology cannot address, however, is the unwillingness of some owners to attend to problems that may crop up in their vehicles. This is especially true of emissions-related defects, because the vehicle will often continue to run well, despite producing more pollutants. Although the illumination of a "Check Engine" light will motivate many owners to seek advice from a repair shop, others will resist attending to the problem until forced to do so. Until vehicle technology reaches the point where the engine and emission control system is immune from the effects of owner neglect, there will continue to be vehicles operating in the real world with uncorrected problems and excess emissions. The question is: 'How many, and to what effect?'

7.2 PROGRAM REVIEW

The superior power output, driveability and fuel efficiency of engines built since the 2001 model year (full implementation of the National Low Emission Vehicle (NLEV) Program) has led to the impression in some people that the reasons for I/M are no longer applicable to modern vehicles. As the proportion of vehicles from the 2001-and-later model years makes up more and more of the in-use fleet, the opinion that programs like AirCare are no longer necessary or effective is heard more often.

Although it cannot be denied that the emissions performance of vehicles has improved dramatically since the early days of I/M, data from AirCare testing confirms that emissions-related defects are still occurring, even in new technology vehicles. However, the probability of failure within the first five to seven years of ownership has been greatly reduced. Over time, AirCare has increased the exemption period for new vehicles in recognition of the improved durability and effectiveness of engines and control systems. The seven-model-year exemption that took effect in 2007 is the longest of any program in existence in North America.

The inspection half of the AirCare program is delivered by a private company under contract to TransLink. Since 1992, there have been three contracts - two of seven-year duration and the current five-year contract that will expire at the end of 2011. Historically, prior to each contract renewal, there has been a consultant's review performed to consider the projected benefits of continuing the program for a further term. Factors such as emissions reductions, human health protection and cost efficiency are key elements in the decision-making process.

In order to determine if the time to end AirCare testing had arrived, a review of the AirCare program was commissioned in 2009. The review was overseen by a committee consisting of representatives of the federal, provincial and regional governments as well as ICBC and TransLink. The committee established terms of reference for the review and selected Sierra Research of Sacramento and SENES Consultants of Vancouver to perform the analysis. The consultants submitted their report in June, 2010 with the conclusion that the program would continue to provide meaningful emission reductions in the 2010-2020 time period and that the value of the avoided health costs related to improved air quality would outweigh the cost of program.

As expected, one of the most important questions related to the review concerned the long-term emissions performance of "new technology" vehicles – those vehicles certified as meeting U.S.

EPA Tier 1 (1996), NLEV (2001) or Tier 2 (2004) standards. When predicting vehicle emissions for calendar year 2020, for example, it is necessary to estimate emission rates for vehicles that have yet to be built. Even for vehicles already in existence, such as those from the 2010 model year, there is no data available to indicate how these vehicles will perform over the 15 years that they are likely to remain in service. It is necessary to make educated guesses of these rates of deterioration.

Forecasts of vehicle emission inventories are made using computer models that establish the fleet composition for any future year based on historical trends for fleet growth and the distribution of registrations by vehicle age. Using emission factors for each model year based on the original certification emissions and the expected degradation that has occurred over time, the inventory number can be calculated by multiplying the number of vehicles in each model year by the number of kilometres-travelled and the appropriate emission factors. The U.S. EPA developed the first MOBILE emission model in the 1970's to calculate on-road vehicle emission inventories for areas in the United States. Environment Canada has modified the U.S. model, adding the suffix "C" to denote the Canadian version. The most recent versions of the MOBILE model in the U.S. and Canada are MOBILE 6.2 and MOBILE 6.2C, respectively. MOBILE is in the process of being replaced with the MOVES model but this was not ready for use at the time of the most recent review.

One of the selectable parameters within the MOBILE model is whether or not the area being modelled has an I/M program in force. If so, the calculated inventory value is reduced to reflect the benefits of the program. How much reduction depends on factors such as the type of program, the stringency of standards, the mechanism of ensuring motorist compliance and the waiver rate. Without going into the details of the calculation, MOBILE 6.2C would credit AirCare with a 14.8% reduction in vehicle-generated emissions for 2010, on a health-impact-weighted basis (HC+CO/7+NOx+25PM). In 2020, the predicted benefit would be a 22.6% reduction. The percentage benefit increases in future years because the program generates fairly consistent benefits on an absolute basis each year while the overall vehicle-related inventory is declining each year. Therefore, on a percentage basis, the I/M-attributable reductions increase.

In performing its review of AirCare, Sierra Research made modifications to MOBILE 6.2C to reflect a higher rate of emissions degradation for newer technology vehicles than originally built into the model. The degradation rates implicit in MOBILE 6.2 were established at a time when no data existed to support the assumptions made about how 1996-and-newer model year vehicles would perform in 2006, for example. Sierra was able to obtain data from roadside emission inspections in California in which vehicles were randomly pulled over by Highway Patrol and Air Resources Board personnel and subjected to an emissions test. This was an extensive study involving thousands of vehicles over a number of years, including a representative sample of the new technology vehicles of interest. In short, the roadside test results indicated a much higher failure rate for U.S. EPA Tier 1 vehicles than what would be predicted by the MOBILE model. Sierra Research adjusted the deterioration rates for the 1996-and-newer vehicles to more closely match the real world data. Using the revised assumptions, the MOBILE model yielded benefits of 21.6% in 2010 and 36.6% in 2020.

Figure 36 shows the difference between the "With AirCare" and "Without AirCare" scenarios for 2010 and 2020, using the basic assumptions in MOBILE 6.2C and the revised assumptions as per Sierra Research.

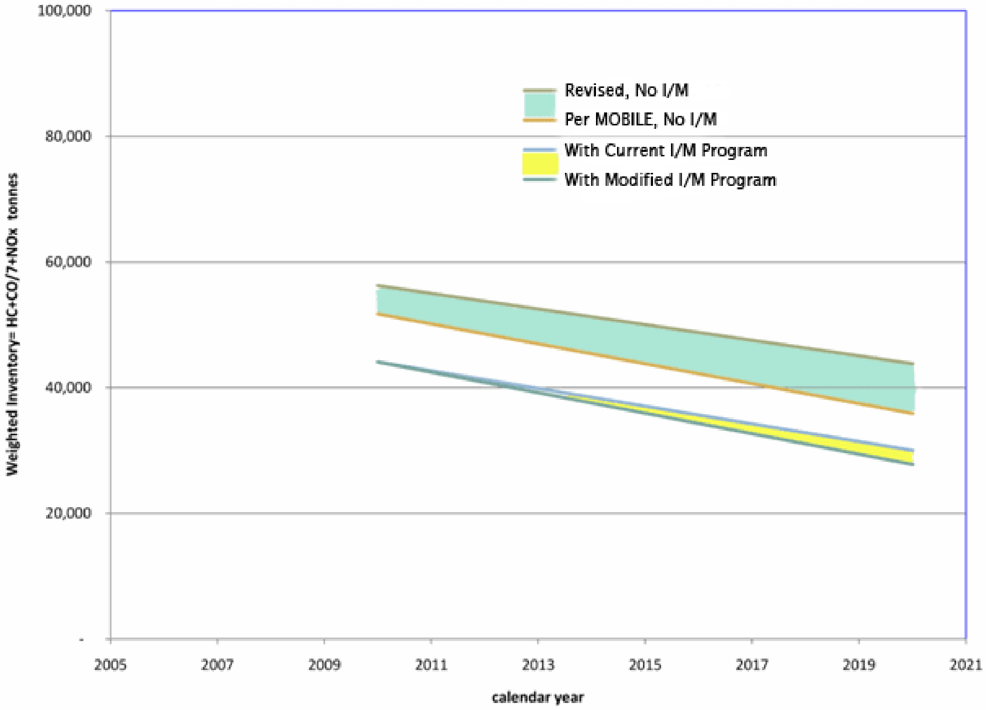


Figure 36. Range of Future Outcomes - With and Without AirCare

The figure clearly shows that, no matter which version of the model you use, the AirCare program is currently generating significant emission reductions and will continue to do so in the foreseeable future. If one accepts that the California roadside data is representative of vehicles in the Lower Mainland, the benefits of the program appear to be much greater. Figure 36 shows shading between the upper and lower pairs of lines to illustrate the potential uncertainty in the projection. It is probably accurate to say that the MOBILE 6.2C model would have been overly optimistic about the long-term performance of 1996-and-newer vehicles and that the experience in California confirms that these newer vehicles are still susceptible to component failure, owner neglect and even emission system tampering. It should also be mentioned that the California roadside data reflects a fleet that is required to be emission-tested every two years after 6 years of age, so if there were no I/M program in place, the failure rate in roadside testing would be even higher. Regardless, for the purpose of this report and the AirCare review, it was assumed that Sierra's revised assumptions represent the upper bound of the projected benefits of AirCare and the base MOBILE 6.2C assumptions represent an overly-conservative estimate. The true value rests somewhere between these bounds.

The final step of the review was to take the emission reductions predicted for 2020 and calculate the difference that such a reduction would make to human exposure to ozone and particulate matter. Using the Air Quality Benefits Assessment Tool (AQBAT), the health outcomes were evaluated and monetized.

The annual cost of the AirCare program was calculated by the consultants based on the amount paid in inspection fees (approximately $19 million dollars per year), the amount spent on pre-AirCare and post-AirCare repairs (approximately $35 million per year) with an adjustment of $9 million to account for fuel savings due to the improved operating state of the overall fleet. Overall, the assumed annual cost (test fees + pre and post AirCare repairs – cost of fuel savings) ranged from $45 million in 2010 to $47 million in 2020.

From Figure 36, the emission reductions in the conservative scenario were 7,635 tonnes in 2010 and 8,109 tonnes in 2020. Sierra Research's modified estimates suggest benefits of 12,120 tonnes in 2010 and 16,028 tonnes in 2020. The cost effectiveness of the program ranged from $3,712 to $5,893 per tonne for 2010 depending on whether Sierra's modified or MOBILE 6.2C's conservative benefit numbers were used. For 2020, the cost-benefit calculation ranged from a low of $2,932 to a high of $5,796 per tonne depending on whether the most conservative or most optimistic benefits were used. Even at the high end, the cost/tonne for a continued AirCare program is well within accepted limits for emissions reduction measures.

Health benefits were assessed and monetized for calendar year 2020. The value of avoided medical costs due to improved ambient air quality in 2020 were estimated at $45 million to $77 million dollars, again based on the magnitude of emission reduction assumed. In the most conservative case, the health benefits do not outweigh the program cost, but the discrepancy is small. Using the Sierra Research upper bound numbers, the health benefit value greatly exceeds the cost of running the program.

Based on the analysis, a recommendation was made by the AirCare Review Committee to the regional and provincial governments to support an extension of the AirCare program for 5-7 years with another review to be initiated circa 2015. As the date of this report, a final decision has not been made on the future of AirCare.

APPENDICES

A. **Glossary**
B. **Mystery Shopper Program Checklist**

A. GLOSSARY

Advisory	A notice concerning a fault with a vehicle. AirCare advisories pertain to missing or tampered catalytic converters for pre-1988 model year vehicles, and to OBD DTCs for 1998-and-newer vehicles. An advisory does not constitute a Fail on an inspection.
AirCare I	The inspection and maintenance program established for Light-Duty Vehicles in GVRD and FVRD effective September 1st, 1992
AirCare II	Implementation of changes to the AirCare I Program begun September 1, 1999 and becoming fully effective January 1st, 2001
AirCare Research Centre	A mass-emissions laboratory used for research, vehicle diagnostics and conflict resolution.
AirCare-eligible	Vehicle requires an AirCare emissions inspection prior to re-licensing.
AirCare staff	Refers to employees of PVTT or Envirotest Canada
ASM 2525	Acceleration Simulation Mode test procedure, also referred to as simply ASM. It consists of driving the vehicle on a dynamometer at a constant speed of 25mph, with a constant load equal to 25% of the maximum FTP load, while monitoring the exhaust emissions.
ASM space	The expression of emissions performance and reductions entirely in terms of concentrations measured as part of an ASM test.
Audit	A quality control process to check and determine if the inspection centre equipment is properly calibrated and maintained
Average passing vehicle	Values represents the average readings for passing vehicles of the same year, type (car or truck), make and engine as inspected vehicle, calculated from actual AirCare test results.
BAR 97	The BAR (Bureau of Automotive Repair) 1997 specification is for equipment used to perform steady-state, loaded-mode emissions tests (ASM 2525, ASM 5015). BAR 97 establishes performance criteria for the equipment used to perform the test.
Base inertia	The mechanical inertia of a dynamometer in the absence of any electrically simulated inertia.
Beer-Lambert Law	The Beer-Lambert law is the linear relationship between absorbance of light and the concentration of an absorbing species
BIRD	Before Inspection Repair Data
Bureau of Automotive Repair	The Bureau of Automotive Repair (BAR) is part of the California Department of Consumer Affairs. BAR manages the implementation of the motor vehicle Inspection and Maintenance Program.
C waiver	Cost Waiver, a conditional pass based on required repair costs exceeding the repair cost limits for the vehicle
Calibration	A set of procedures to ensure an instruments accuracy and provide quality control assurance

Calibration gas	Pressurized gas containing exhaust gas components blended to exact tolerances and certified to be accurate within a specified tolerance. Gas analysers used by AirCare inspection centres and AirCare Certified Repair Centres are required to be calibrated at regular intervals with calibration gas to ensure accurate measurements.
Certification test	EPA75 or FTP, the test that certifies a vehicle conforms to its federally- mandated emission design limits
Check engine light	An illuminated light on the dashboard warning the driver that a problem exists with the vehicle. Also known as the Malfunction Indicator Lamp, or MIL.
Chemilluminescence	A process used in NO_x analysers, where NO and ozone are mixed in a reaction chamber producing light in proportion to the amount of NO
Closed-loop fuel control	System in which the fuel/air ratio in the engine is carefully controlled to optimize emissions performance. A closed-loop system uses oxygen sensor(s) to provide a feedback control signal.
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Coastdown	A check to ensure a dynamometer is accurately correcting for parasitic losses in bearings, belts and other sources of friction.
Cold start	Starting of a vehicle after a predetermined cold soak period
Collector	Licensing status issued by ICBC. To qualify for collector status, a vehicle must be at least 25 years old for most cars, or; at least 15 years old if it's a limited production vehicle or; at least 15 years old and from a source which has not manufactured vehicles of any kind for at least five years.
Composite standards	Cut-points which apply to a full-duration IM240 inspection cycle
Conditional Pass	Conditional passes are waivers that are granted on the basis of repair and cost information submitted by a certified repair centre.
Constant Volume Sampler (CVS)	A constant volume sampling system, which maintains a constant total flow rate of vehicle exhaust plus dilution air. A normal part of a mass-emissions measuring system.
Cut point	For each pollutant, the emissions level above which a car is considered to have failed the emissions test for that pollutant.
D147	Enhanced diesel emissions test, measures opacity during a transient drive cycle
Driving cycle	A driving schedule to simulate real world conditions, periods of acceleration, deceleration, cruise, and idle
DTC	Diagnostic trouble code stored by the OBD II system
Dynamometer	A treadmill-like device that simulates vehicle inertia and road load to derive results under conditions similar to normal driving.
EGR	Exhaust Gas Recirculation. A method of reducing NO_x emissions by recirculating some of

	the exhaust gas into the intake charge.
Emission factors	For mobile source emissions, emission factors are mass of each pollutant per unit distance (e.g. grams per kilometre)
EMS	Emissions measuring system
Excess-emitting	Vehicles that produce emissions higher than established AirCare emission cut-points.
Exempt	Vehicles that do not require an AirCare inspection
Expiry date	The last day an AirCare test is valid for re-licensing.
Failure modes	The various manners or areas that a vehicle can fail an emissions inspection
Fast pass	A protocol that allows vehicles operating well within their allowed limits to terminate inspection early to increase throughput
FID	Flame ionization detector, an analyzer that measures total hydrocarbon emissions
Fidle code	A code number that corresponds to a specific reason for performing an idle test on a vehicle rather than a dynamometer inspection.
First generation OBD	First vehicle's equipped with an onboard engine control computer to provide diagnostic data to assist a technician in determining were a fault probably lies in any monitored circuit
FTP test	Federal Test Procedure. A certification test for measuring the tailpipe and evaporative emissions from new vehicles
Full duration IM240	An IM240 inspection that went 240 seconds without fast-passing
FVRD	Fraser Valley Regional District
GVRD	Greater Vancouver Regional District, currently known as Metro Vancouver
GVWR	Gross Vehicle Weight Rating
HC	Hydrocarbons
Heavy duty truck	Vehicle with GVWR greater than 8500 lb, curb weight greater than 6000 lb and frontal area greater than 45 square feet.
High idle	An idle speed typically between 2000&2500 rpm
ICBC	Insurance Corporation of British Columbia
Idle space	The expression of emissions performance and reductions entirely in terms of concentrations measured as part of an idle test.
Idle test	An emissions test performed under idle conditions. (maximum 1150 rpm)

IM240	A transient emission test procedure established by the U.S. EPA, and derived from the Federal Test Procedure.
IM240FD	See Full duration IM240
IM240 space	The expression of emissions performance and reductions entirely in terms of reported IM240 readings.
Light duty truck	Vehicle with GVWR less than or equal to 8500 lb, curb weight less than or equal to 6000 lb and frontal area less than or equal to 45 square feet designed for the transportation of goods or the carriage of more than 12 passengers.
Malfunction indicator lamp	The instrument panel light used by the on-board diagnostic system to notify the vehicle operator of an engine or emission control related fault.
MAP sensor	Manifold Absolute Pressure sensor, informs PCM of engine load
Mass emissions inventory	Estimates of the amount of pollutants emitted into the atmosphere from major mobile, stationary, area-wide, and natural source categories over a specific period of time such as a day or a year.
Master pass cap	A gas cap calibrated to consistently pass a leak test.
MES5	Mass Emission Sample Five, a resource which enables the evaluation of mass emission reduction.
Megagram (Mg)	1 Mg = 10^6g = 1,000kg = 1 tonne
MMT	Methylcyclopentadienyl manganese tricarbonyl, is a manganese compound which, when burned in automobile engines, results in manganese air pollution and O2 sensor and/or catalyst contamination. It is used as an octane rating enhancer.
Mode length	The time taken to complete a phase of an inspection test
Model year	Vehicles are certified for sale, marketed and later registered as certain model year that indicates the year a vehicle was produced and offered for sale. A model year run must include the January 1st of the calendar year corresponding to the model year but cannot extend so as to include two January 1st dates.
N_2	Nitrogen
NDIR	Non-Dispersive Infra Red
NIST	National Institute of Standards & Technology
NO_x	Oxides Of Nitrogen
O2	Oxygen
OBD II	On-Board Diagnostics II. This system continuously monitors the emission control and emission-related systems and records any defects in up to 50 different components. This allows Service Technicians to diagnose intermittent engine problems, to help reduce

service time and cost.

Off-cycle operation	Operating a vehicle at a speed and load condition not included in the FTP driving cycle.
On-board computer	Microprocessor that controls engine and emission control functions.
Opacity	The amount of light obscured by particulate matter. Clear window glass has zero opacity, while a brick wall is 100 percent opaque. Opacity is a surrogate for particulate matter emissions.
Oxygen sensor	A device used to measure the oxygen content of vehicle exhaust gases. The signal is fed to the on-board computer which regulates the fuel-air mixture for optimum exhaust gas reduction.
Passenger vehicle	A motor vehicle designed for moving people
Phase 2	The second part of IM240; starts at 94 second and lasts for 147 seconds
Phase-in standards	Temporary standards used during a set period of time in order to monitor the performance of the fleet prior to implementing the final standards.
PM	Solid or liquid particles of soot, dust, smoke, fumes, and aerosols.
ppm	Gas concentration measured in parts per million
Program Administration Office	Organization that administers the AirCare program. Currently as a subsidiary of Translink, named PVTT
PVTT	Pacific Vehicle Testing Technologies, an operating subsidiary of TransLink. PVTT administers the AirCare program.
Q waiver	Qualified waiver, a conditional pass where the Repair Data Form indicates no remaining emissions related defects on the vehicle
Quality Repair Award	Award given to technicians whose repair efficiency meets a predetermined standard
Registered GVW	The gross vehicle weight that the vehicle has been registered and licensed for
Regulated pollutants	CO, HC, NO_x, and PM are the regulated pollutants for motor vehicles
Repair Advisory Committee	RAC, a committee comprising repair industry and AirCare representatives that discuss issues involving the repair industry
Repair cost limit	The maximum dollar amount needed to be spent on repairs at a certified shop to qualify for a cost waiver
Repair data form	An on-line form completed by repair technician to report the repairs performed and outstanding items still in need of repair.
Repair Effectiveness Index	An objective assessment of the effectiveness of an emissions repair based on emissions reductions achieved

RepairNet	An Internet-based application providing certified repair centres and technicians with access to all vehicle inspection and repair records. Within the RepairNet, AirCare technicians and repair centres also submit vehicle repair data on-line.
Sample dilution	Dilution of an exhaust gas sample to the point where the sample cannot be considered valid.
Sample test	A full-duration IM240 test performed after a mandatory AirCare inspection. Vehicles that meet an established set of criteria receive a sample test in order to gather more comprehensive vehicle emission data and to calculate AirCare benefits.
Scan tool	A hand held device that is plugged into a vehicle's data link connector allowing a technician to read diagnostic trouble codes, readiness status, and other information collected by the OBD system.
Scrap-it program	A vehicle retirement program that recycles vehicles in exchange for various incentives.
Second-by-second readings	Readings recorded every second of an emissions test and used to observe trends and provide technicians with valuable diagnostic data
Show cause hearing	Part of a process for suspending on decertifying a technician and/or repair facility
Tampering	The removal or disabling of any emission control device, that would potentially increase a vehicle's exhaust emissions
Test trace	The on-screen representation of the required driving cycle
Three-way catalytic converter	A catalytic converter that contains the elements to both reduce oxides of nitrogen and oxidize both hydrocarbons and carbon monoxide.
Tier 0	Tailpipe standards beginning with model-year 1981in the United States and were phased out by model-year 1995 for passenger cars and most light duty trucks.
Tier 1	Tailpipe standards that were phased in for 40% of 1994 models, 80% of 1995 models and 100% of 1996 models.
Transient inspection	An emissions test performed under loads and speeds that vary from second to second during the test.
Trouble code	A code number generated by a vehicle's onboard computer that corresponds to a specific fault.
U.S. EPA	The United States Environmental Protection Agency. The mission of the U.S. EPA is to protect human health and to safeguard the natural environment--air, water, and land--upon which life depends.
Vehicle type	Description used to determine the primary use of a motor vehicle and to determine it's emission classification
Vintage	Licensing status issued by ICBC. The vehicle must be: at least 30 years old, owned as a collector's item, maintained as close as possible to its original condition with original parts, and mechanically sound.
VkmT	The product of the number of vehicles multiplied by their annual distance driven in kilometres

Void	Rendering a test result invalid for the purposes of re-licensing.
Volatile Organic Compounds	Hydrocarbon compounds that exist in the ambient air. VOCs contribute to the formation of smog and/or may, themselves, be toxic. VOC emissions are a major precursor to the formation of ozone.
Waiver	Waivers for emissions compliance are granted when the vehicle fails re-inspection after having been repaired at a certified repair centre
Zeroing	Calibration procedure to ensure the accuracy of an instruments zero point

B. MYSTERY SHOPPER PROGRAM CHECKLIST

Inspection Centre Observation Report

Date		Inspection Centre	
Investigator		Lane Number	
Vehicle Year, Make & Model		Arrival Time	
Vehicle Registration No.		Departure Time	
Vehicle Inspection No.			

AIRCARE LOCATIONS

BC01	North Van - 1333 McKeen Ave
BC02	East Van - 3608 Charles St
BC03	Richmond - 11115 Silversmith Pl
BC05	Coquitlam - 1316 United Blvd
BC06	North Surrey - 7910 - 130th St
BC08	Maple Ridge - 11469 Kingston St
BC09	Langley - 5958 - 205A St
BC10	Abbotsford - 3380 McCallum Rd
BC11	Chilliwack - 45730 Airport Rd
BC12	South Van - 728 E. Kent Ave

ARRIVAL AT INSPECTION CENTRE		Comments
1. Displayed wait time vs. Actual wait time		
2. Number of available lanes		
3. Number of lanes open		
4. Number of Vehicles ahead in your lane		
5. “Wait/Enter” sign illuminated when entered	☐ Y ☐ N	
6. Hand gestures from Inspector to enter	☐ Y ☐ N	

INSPECTION POSITION 1		Comments
7. Greeted by Inspector	☐ Y ☐ N	
8. Instructed to turn-off accessories, place in park mode and apply parking brake	☐ Y ☐ N	
9. Inspected underside of vehicle with mirror	☐ Y ☐ N	
10. Requested registration documents & odometer reading	☐ Y ☐ N	
11. Gas cap checked for presence or pressure	☐ Y ☐ N	
12. Requested payment	☐ Y ☐ N	
13. Payment method – Cash, Debit, Credit Card		
14. Verified odometer reading visually	☐ Y ☐ N	
15. Verified VIN with registration documents	☐ Y ☐ N	
16. Returned registration documents or placed on dash	☐ Y ☐ N	
17. Instructed to move to Position 2	☐ Y ☐ N	

INSPECTION POSITION 2		Comments
18. Instructed to place vehicle in park and apply parking brake	☐ Y ☐ N	
19. Guided into booth and activated appropriate audio test description	☐ Y ☐ N	
20. Type of audio test played – IM240 or OBD or ASM 2525 (*pre 1992*)		
21. Conducted test efficiently and treated vehicle with due care and respect	☐ Y ☐ N	
22. Invited to return to vehicle and advised that vehicle engine is running	☐ Y ☐ N	
23. Instructed to move to Position 3	☐ Y ☐ N	

INSPECTION POSITION 3		Comments
24. Confirmed VIN on dash to registration documents on dash	☐ Y ☐ N	
25. Advised of test results and returned the vehicle registration documents	☐ Y ☐ N	
26. If failed, provided RDF and booklet, "*What to Do if Your Vehicle Doesn't Pass*"	☐ Y ☐ N	Booklet "Valid Until" date: Booklet Inserts date:
27. Offered diagnostic advice or speculated the cause of failed test	☐ Y ☐ N	

INSPECTOR PRESENTATION

Inspector #1		Inspector #2		Inspector #3	
Name on tag		Name on tag		Name on tag	
Name tag legible	☐ Y ☐ N	Name tag legible	☐ Y ☐ N	Name tag legible	☐ Y ☐ N
AirCare shirt or jacket	☐ Y ☐ N	AirCare shirt or jacket	☐ Y ☐ N	AirCare shirt or jacket	☐ Y ☐ N
Overall uniform presentation	☐ Satisfactory ☐ Unsatisfactory	Overall uniform presentation	☐ Satisfactory ☐ Unsatisfactory	Overall uniform presentation	☐ Satisfactory ☐ Unsatisfactory
Inspector IDs listed at bottom of VIR					
Comments					

COMMENTS	**** REPORT ONLY DEFICIENCIES ****
Inspectors • Impression of staff • verbal communications • body language • attitude	
Inspection Centre • impression of property • cleanliness	
Overall Customer Service	