AirCare - Results and Observations in 2001 and 2002

(Abridged Version)

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AirCare is a community-based program represented by the following Federal, Provincial and Regional agencies:

Executive Summary

AirCare uses world-class technology to measure smog-forming and harmful substances in vehicle exhaust. A conservative estimate is that, thanks to AirCare, the amount of air pollution from vehicles was reduced by more than 46,000 metric tones in 2002. Vehicle-generated emissions were 35% lower in 2002 than they would have been if AirCare had not been operating since 1992.

AirCare inspections and resulting repairs to failing vehicles remain essential to protect the community. Although vehicle manufacturers have improved their emission control systems over the past decade, vehicles are now remaining in service longer. The typical lifespan of a vehicle exceeds the design limits of the emission control system and systems often deteriorate or fail as they age. The change to testing every two years for 1992-and-newer vehicles recognizes the improvements in new vehicle technology, but annual testing is necessary for the older vehicles in the fleet.

In the Lower Mainland, there were almost 1.2 million light-duty cars and trucks registered in 2002, up from some 1.17 million in 2001. With testing exemptions for vehicles up to two years old and alternate year testing of 1992-and-newer vehicles, the number of vehicles tested by AirCare was 778,521 in 2002 and 748,068 in 2001.

Of the vehicles tested, 127,436 (16.4%) failed their first test in 2002 and 114,819 (15.3%) failed in 2001. In both years, the majority of failures were from the 1991 and older model year group.

Vehicles from the 1991-and-older category are a major concern: They make up only about 34% of the vehicles on our roads, and account for only 29% of the total kilometees driven. But in 2002, they produced anywhere from 62-76% of the total pollutants emitted by road vehicles – and recorded 58% of the AirCare test failures.

Vehicle inspections alone do not produce emissions benefits. These come from fixing high-emitting vehicles or removing them from use.

Of vehicles that failed AirCare tests in 2002, some 24,335 were not brought back for re-inspection. The figure for 2001 was 22,604 vehicles. Investigation of a random sample of these vehicles shows that virtually all of these polluting vehicles have been taken off the roads, to the benefit of the community.

In recognition of the importance of effective repairs, and to protect the consumer, AirCare has developed special programs to train, certify and monitor repair shops. Some 1200 mechanics are now certified. AirCare provides certified shops with detailed test results to aid in diagnosing emissions defects. Mechanics can call an AirCare hotline for help and a comprehensive repair guide is available on the Internet. Consumers who have complaints about repairs done at certified shops can request an investigation of the repairs and charges, by AirCare.

Motorists who have repairs done at AirCare certified repair shops are eligible for a Conditional Pass even if their vehicle still does not meet the program standards. This may be because the needed repairs were too expensive to complete or because the repair shop failed to properly identify the defect. Approximately 30% of the repairs known to have been performed at certified repair facilities received a Conditional Pass.

Substantial reductions in emissions were found in vehicles that were re-inspected after repairs and passed. A significant portion of the successful repairs and adjustments cost less than $200. Analysis by AirCare has found that successful repairs tend to last for years, resulting in continued emissions savings.

A key goal of the AirCare program is to improve the effectiveness of repairs. With the technological improvements made to the inspection system, the program is well equipped to identify the high-emitting vehicles on our roads. The failure rate of over 15% confirms this. However, the amount and quality of repair data available to support the analysis of program benefits has been disappointing.

According to the volume of repair data submitted by AirCare certified shops, it appears they handle only about one-third of AirCare repairs. There is no information for the remainder of repaired vehicles to indicate what was done or how much it cost. A telephone survey of 100 motorists whose vehicles failed AirCare suggested that more than 70% took their vehicle to an AirCare certified shop for repairs, suggesting that certified shops do not always return repair data. Eliminating this information gap, and reducing the 15% of unsuccessful repairs that appear to be related to misdiagnosis, are targets for improvement in the coming year.

Introduction

Inspection and maintenance programs continue to be important components of air pollution reduction strategies in many cities around the world. The basic premise of all I/M programs is that a minority of excess-emitting vehicles contribute disproportionately to the inventory of smog-forming pollutants (hydrocarbons and oxides of nitrogen) and carbon monoxide. Identifying these vehicles and requiring that they be effectively repaired produces worthwhile emission reductions at a reasonable cost-benefit ratio.

In order to evaluate the effectiveness of any I/M program, there are two key factors that must be examined:

- The efficiency of the program in identifying the excess-emitting vehicles.
- The effectiveness of the repairs performed by the repair sector in reducing the emission rate of failing vehicles.

It is estimated that there are 1.2 million light-duty passenger vehicles and trucks registered in the Lower Mainland of British Columbia. Since AirCare testing is not required for vehicles less than two years old, approximately 150,000 vehicles are exempt at any given time for this reason. Due to the introduction of biennial testing for vehicles of 1992 model year and newer, the number of vehicles tested at AirCare inspection centres dropped from just under 1 million in 2000 to 748,068 in 2001 and 778,521 in 2002. With re-inspections, the total number of inspections exceeded the number of vehicles tested by 134,673 in 2001 and 176,077 in 2002. In 2001, 114,189 vehicles failed inspection and 127,436 failed in 2002. This represents 15.26% and 16.36% of the vehicles tested in each year.

Due to the electronic link between the vehicle registration system and the AirCare database, the compliance rate for the program is very high. A comparison of ICBC registration data and AirCare inspection statistics indicates that virtually every registered vehicle that required an AirCare inspection appeared at an inspection facility.

Vehicles from the 1991-and-older age group accounted for the majority of failures in both years, despite accounting for only about one third of vehicle registrations. In 2001, 69% of failed vehicles were 1991 models or older. In 2002, the proportion was 58%. Using vehicle population and odometer reading data, it is estimated that the 1991-and-older group accounted for 33% of all vehicle-kilometres-travelled (VkmT) in 2001 and 29% in 2002. Despite accounting for a minority of the total VkmT, 1991-and-older vehicles accounted for 64% - 79% of total light-duty vehicle-related emissions of VOCs, CO and NO_x in 2001 (depending on the pollutant) and 62% - 76% in 2002.

AirCare Benefits

Direct Benefits From Vehicle Repairs

The data indicate that approximately 63,000 vehicles passed after failing their initial AirCare tailpipe emissions test in 2001 along with another 77,000 in 2002. It is assumed in this report that all of these “re-inspected to pass” vehicles experienced a reduction in emissions as a result of repairs performed after the failing inspection, even though the only vehicles for which it can be said with certainty that repairs were performed are those that went to AirCare Certified facilities and had repair data submitted on-line to the

AirCare database. In 2001, 21,295 vehicles passed re-inspection with confirmed repairs. The corresponding number for 2002 was 24,805. These totals represent only about 33% of all "re-inspected-to-pass" vehicles. It is possible that certified repair shops repaired more vehicles than this but chose not to submit repair data. Anecdotal reports from the certified repair industry suggest that some technicians submit repair data only when they believe that there is a strong possibility that a vehicle will fail the re-inspection and they want to make sure that their customer receives at least a Conditional Pass. There is little other incentive for a repair technician to submit repair data unless they are in their last year of certification (technicians are certified for 3 years at a time). In their last year of certification, technicians will be motivated to submit repair data for those vehicles that they believe will do well on re-inspection, because they can be automatically re-certified if their repair effectiveness performance meets or exceeds the overall industry average. They will be reluctant to issue too many Conditional Passes during this period as this will lower their average repair effectiveness rating.

Any vehicle repaired at a Certified AirCare repair centre is eligible for a Conditional Pass as long as repair data has been submitted. There were 9,883 Conditional Passes issued in 2001 and 11,469 in 2002. This represents about 30% of all vehicles repaired at certified repair centres and about 10% of all failing vehicles.

Substantial reductions in emissions were evident for vehicles that successfully passed re-inspection. Reductions in hydrocarbon emissions were typically the greatest, while NO_x reductions were the least. Among the oldest vehicles (pre-1972), repairs consistently increased NO_x emissions.

As a result of the ongoing sampling test program initiated in 2001 (based on full-duration IM240 testing in the inspection lanes), a database of almost 9,000 mass emission test results was available to support the calculation of program benefits. This represents an order of magnitude increase compared to the number of HOT505 emission data samples used in previous analyses. Within the mass emission sample, there were 886 failing and 766 post-repair inspection results. After subdividing the mass emission sample group by age/technology group and failure mode, corresponding post-repair results were categorized as either "good" or "marginal" depending on how post-repair emissions results compared to those of normal passing vehicles. It was then possible to apply mass emission credits to the overall population of failing vehicles by identifying the age/technology grouping, failure mode, and the noted improvement in ASM or IM240 inspection results after repair and cross-referencing to the mass emission data table. Vehicle-kilometres-travelled data were then applied to weight the improvement according to the amount of expected use the vehicle would receive in the ensuing year.

Although this is essentially the same methodology used in previous studies of program effectiveness, the use of IM240-based emission factors instead of HOT505 data changed the calculated values for total fleet mass emissions. However, an analysis of HOT505 and IM240 test results performed on the same vehicles concluded that the *relative* differences between pre- and post-repair inspections were comparable, regardless of the test type. Due to the fact that IM240 emission factors are based on a hot-start test and do not consider cold-start and off-cycle driving, the MOBILE 6 inventory model was used to generate the tonnage of each pollutant by applying percentage reductions from IM240-based data to MOBILE 6 generated inventory data.

Based on the above-mentioned methodology, the emission reductions directly related to AirCare-related repairs were calculated as shown in the next table:

Emission Reductions in 2001 and 2002

	2001	2002
HC	13% (1,262 tonnes)	15% (1,338 tonnes)
CO	8% (9,068 tonnes)	10% (10,440 tonnes)
NO_x	5% (506 tonnes)	7% (594 tonnes)

Vehicles Removed From Use

In addition to the benefits indicated by pre- and post-repair test results, there were 22,604 vehicles that failed in 2001 and did not return for re-inspection in that year. In 2002, 24,355 vehicles failed an AirCare inspection but did not appear for re-inspection within the calendar year. These vehicles are likely to have been scrapped, placed in storage, or sold outside the AirCare area. It is recognized that some portion of these vehicles may still be in use as a result of finding administrative routes around the program requirements, but the apparent incidence of registering vehicles outside the AirCare territory, yet actually continuing to operate them in the area, is negligible. Checking vehicle licensing records of a random sample of apparently-retired vehicles indicates that in virtually all cases, the vehicles were no longer licensed anywhere in British Columbia.

The removal of high-emitting vehicles from the fleet produces a significant emissions benefit. Some portion of this emission reduction should be counted as part of the AirCare program benefits, but only a portion – not all. Since some or all of the retired vehicles might have dropped out of the fleet anyway, even with no AirCare program, it is difficult to say precisely what proportion of the benefit should be attributed to the program. In the extreme, the benefits attributable to the retirement of all of the vehicles in 2001 amounts to 2,338 tonnes of HC, 20,847 tonnes of CO and 1,284 tonnes of NO_x. The numbers for 2002 are 2,102 tonnes for HC, 19,412 tonnes for CO and 1,405 tonnes of NO_x. These estimates are derived by taking the assumed emission rates of these vehicles multiplied by the expected mileage they would have been driven over the ensuing 12-month period.

The “removed from use” reductions are somewhat larger than those attributable to repairs. This is because the vehicles involved are assumed to have zero emissions after retirement, while repaired vehicles have a benefit equal to the difference in pre- and post-repair emission levels.

Pre-AirCare Repairs

Anecdotal reports from the public and the repair industry suggest that there is a certain amount of maintenance work that is performed on vehicles prior to AirCare inspections, with a view to avoiding the inconvenience of repairing and re-inspecting the vehicle in the event that it fails. Logically, this practice must exist but it has been difficult to quantify since the vehicles involved simply pass their initial inspection. In the absence of a program, it is likely that some portion of this preventative maintenance would not occur and would therefore result in increased fleet emissions. However, even if the program administrators were aware of the number and nature of pre-inspection repairs, it would be difficult to determine how many vehicles would have failed the emission test without

pre-test repairs. Due to the uncertainty regarding this program effect, no attempt has been made to quantify the emission reductions attributable to it.

"With AirCare" Scenario Compared to "Without AirCare"

After ten years of operation, the cumulative effect of repairs made to excess-emitting vehicles has been significant. In every year, carryover benefits from previous cycles are apparent in that vehicles that failed one two or more years ago are still passing. In the absence of a program, it is quite likely that these vehicles would have continued to degrade from the point of failure, rather than being corrected and restored to normal emissions performance. These effects combined with accelerating the retirement of older, high-polluting vehicles has resulted in a significant emissions benefit. By comparing the actual vehicle-related emissions inventory for 2002 with the amount that would have occurred in the absence of AirCare testing, the indicated reduction is 35%.

AirCare II vs. AirCare I

As vehicle emission control technology has evolved, the task of identifying "excess-emitting" vehicles has become more difficult. Levels of emissions from malfunctioning current-technology vehicles may actually be lower than "as new" emission levels for vehicles built in the 1970s or early 1980s. In order to take full advantage of new emission control technologies, faults in newer vehicles must be detected and repaired as expeditiously as possible. The ability to distinguish between normal and abnormal emitters among new technology vehicles requires more rigorous test procedures. In order to maintain the effectiveness of the AirCare program in the period up to August 31, 2006, new measurement equipment was installed and new inspection procedures were implemented.

On January 2, 2001, many changes to the test regime became effective, most significantly the adoption of the IM240 transient emission test for all 1992 and newer vehicles. In conjunction with this change, the frequency of testing for these newer vehicles was reduced to biennial from annual. Annual testing was retained for 1991 and older vehicles.

The changes to the program were made to address known deficiencies in the 1992-2000 AirCare program and to keep pace with technological developments in the inspection industry. AirCare is the only I/M program to offer both ASM and IM240 testing in the same lanes and is likely the only program in the world using a transient dynamometer diesel opacity test. Cut points are strict with EPA final cut points being used for IM240 testing and AirCare-derived limits being used for ASM testing. With advanced testing methods, stringent cut points and a high rate of compliance, it must be concluded that the AirCare program is one of the most effective programs in existence in terms of identifying excess-emitting vehicles in the fleet.

The next table summarizes the key differences between AirCare II and the version that operated from 1992 to August 31, 2000 (AirCare I).

Differences Between AirCare II and AirCare I

	AirCare I	AirCare II
Test Procedures	ASM 2525/Idle Idle Tests for All-Wheel Drive Vehicles or Other Non-Testable Vehicles on Dynamometer Steady-state Diesel test (50 km/hr, 10.0 hp)	IM240 Test for 1992-and-newer vehicles ASM/Idle Test for 1991 and older All-Wheel Drive vehicles tested on 4WD dynamometers. Idle tests only for non-testable vehicles Transient driving cycle for diesel vehicles
Testing Frequency	Annual	1992 and newer – Biennial 1991 and older – Annual
Test Fee	$16.05 - $24	1992 and newer - $48 1991 and older - $24 1992+ Re-inspection - $24
Gas Cap Pressure Test	None	All 1972 – 1995 vehicles
On-Board Diagnostic Check	None	All 1998 and later vehicles
Visual Inspection	Gas Cap for all, Catalytic Converter on 1988 and newer vehicles, other underhood components advisory only for 1987 and older, mandatory for 1988 and newer	Gas Cap for all, Catalytic Converter on 1988 and newer vehicles. No underhood inspection
On-Line Repair Data Collection	None. Hard copy form only with 34 items.	Repair Net. Electronic repair information entry with 91 possible entries and comments field. On-line collection of oxygen sensor min/max voltage, response time and cross counts along with catalytic converter efficiency test results.
Data Collection	Two test types - "I" and "R". "R" applied only to vehicles with submitted Repair Data Form. Ad hoc reporting capability only for previous six months of data	Test counter indicates multiple tests. Counter re-sets with Pass or Conditional Pass. All test data since 1992 available at all times. Data queries and standard reports available on line as desired. Emission data collected on a second-by-second basis and graphs made available for failing vehicles on "Diagnostic Trace Report"
Wait Time Monitoring	Manual Only	Automated calculation of wait time with display on electronic sign at station entrance
Test Lane Monitoring	Audit Only	Electronic surveillance using video cameras
Calculation of Program Benefits	Separate laboratory test program for failing vehicles, yielding HOT 505 mass emission data before and after repairs. Approximately 375 vehicles per year tested.	Ongoing Sample Test program selecting a representative sample of 8000 full-duration IM240 tests per year on both passing and failing vehicles

Inspection Statistics

The next table summarizes the tailpipe emission and diesel opacity inspection data from 2001 and 2002.

The data suggest that the introduction of IM240 testing had a dramatic effect on the failure rate for newer vehicles. Prior to 2001, the failure rate for 1992-and-newer vehicles was less than 3%. In 2002, the failure rate for 1992-and-newer vehicles reached 9.6%. This was primarily due to high failure rates for 1992 model year vehicles and 1994 and 1995 model year trucks.

Summary of Inspection Data in 2001 and 2002

	2001	2002
Number of Inspections Performed	882,741	954,598
Number of Vehicles Inspected	748,068	778,521
Number of Vehicles Failed Initial Test for all Reasons Combined	114,189 (15.3%)	127,437 (16.37%)
Number of Vehicles Failed Initial Test for Emissions Only	93,468 (12.5%)	110,830 (14.2%)
Number of Vehicles Tested According to ASM/Idle Test	446,544	397,902
Number Failed ASM/Idle Test	78,295 (17.5%)	74,112 (18.6%)
Number of Vehicles Tested According to IM240 Test	283,777	359,974
Number Failed Initial IM240 Test	13,044 (4.6%)	34,419 (9.6%)
Number Failed Idle Test	595	1,198
Number of Diesel Vehicles Inspected	13,830	13,503
Number Failed Diesel Opacity Inspection	1,069 (7.7%)	760 (5.6%)
Number Failed Unloaded Diesel Opacity Inspection	1	0

The table below summarizes the results of the various non-tailpipe tests

Observations of Non-Tailpipe Tests

	2001	2002
Number of Gas Cap Pressure Tests Conducted	631,077	587,313
Number Failed Gas Cap Pressure Test	29,446 (4.67%)	23,237 (3.96%)
Number Failed Gas Cap Presence Test	1,342	1,410
Number of 1998 and Newer Vehicles Interrogated for OBD-II	60,470	145,988
Number Failed OBD- II Inspection	466 (0.77%)	2,039 (1.40%)
Number Failed Catalytic Converter Presence Test (1988 and Newer Only)	189	232
Number of Catalytic Converter Advisories (1987 and Older Only)	3,143	4,949

The gas cap pressure test failure rate ranged from 4% to 7% throughout the reporting period. A comparison of the failed vehicles from 2002 against the 2001 group resulted in very little indicated overlap between the two populations. There have been reports of

brand new caps failing the re-inspection, suggesting problems with some replacement caps. In some cases, multiple replacements have been found to be unable to pass the test. To a large degree, the automotive parts sellers have responded to the demand for replacement caps with products of the necessary quality.

Response to Failed Inspection

The table below shows the actions taken in response to failing inspections:

Observations on Actions Taken after Failing Inspections

	2001	2002
Number of Vehicles Not Returning for Re-inspection	22,604 (24.2%)	24,335 (22.0%)
Number of Vehicles Repaired to Pass by Certified AirCare Repair Facilities	21,295 (22.8%)	24,805 (22.4%)
Number of Vehicles Re-Inspected to Pass Without Repair Information	41,839 (44.8%)	52,432 (47.3%)
Number of Diesel Vehicles Passing Re-Inspection	738	543
Number of Gas Cap Replacements	Not Measured	19,212
Number of Vehicles issued Conditional Pass	9,883 (10.6%)	11,469 (10.3%)

According to the data, approximately two thirds of the vehicles that satisfied the following three conditions:

1. failed for emissions,
2. returned for re-inspection,
3. passed re-inspection,

did not have any associated repair information. This suggests that they were repaired by a non-certified repair facility or possibly by a “Do-It-Yourself” amateur mechanic, but it is impossible to say for certain that repairs were actually performed in all cases. It is possible that some portion of this group would have attempted another test without repairs and managed to pass or made temporary repairs to secure a passing result. However, there are twice as many non-certified repair shops in the Vancouver area than certified shops and, since these facilities cannot qualify their customers for a Conditional Pass, they must repair vehicles to fully pass the inspection. We believe that the incidence of successful non-certified repairs greatly outnumbers the number of illegitimate passes. The ratio of certified repairs to non-certified repairs is consistent with the ratio of non-certified repair shops (approx. 900) to certified repair shops (approx. 450).

Effectiveness of Repairs

The only data available to evaluate the effectiveness of repairs comes from the certified repair industry. Unfortunately, as mentioned above, only 33% of failing vehicles have associated repair data returned to the program administrators. Furthermore, it is

possible that the vehicles taken to certified repair shops are not representative of the overall failing-vehicle population. Owners of vehicles in poor condition may purposely seek out certified repair shops so as to take advantage of repair cost limits and continue driving their vehicle without having to fully repair it. Therefore, certified shops may deal with a higher proportion of vehicles that require costly repairs.

Nevertheless, the certified repair industry was able to successfully repair about 70% of the vehicles for which they submitted repair data. This effectiveness rate has been quite consistent since AirCare began in 1992. Analysis of repair data in two groups - 1992-and-newer vehicles and 1991-and-older vehicles - suggests that a slightly higher percentage of newer vehicles were not successfully repaired (33.5% in 2002), perhaps reflecting unfamiliarity of the repair industry with the IM240 test procedure. It is concerning to note that a high rate of Conditional Passes continues to exist for 1991-and-older vehicles (30.5% in 2002). These vehicles are tested according to the simpler ASM/Idle test that the repair industry has been exposed to for the past ten years. The increasing age and deteriorating condition of this older vehicle group may be the reason that the success rate of repairs has hit a plateau.

In 2001 and 2002, more than 50% of the Conditional Passes issued were “Q” waivers, meaning that the estimated cost of repair was less than the repair cost limit and no items were indicated as remaining defective. These cases may be characterized as misdiagnoses. For 1992-and-newer vehicles, the ratio of “Q” waivers to “C” waivers was greater than 2:1, suggesting that improper diagnosis, rather than the cost of repairs, was the limiting factor in achieving a full repair.

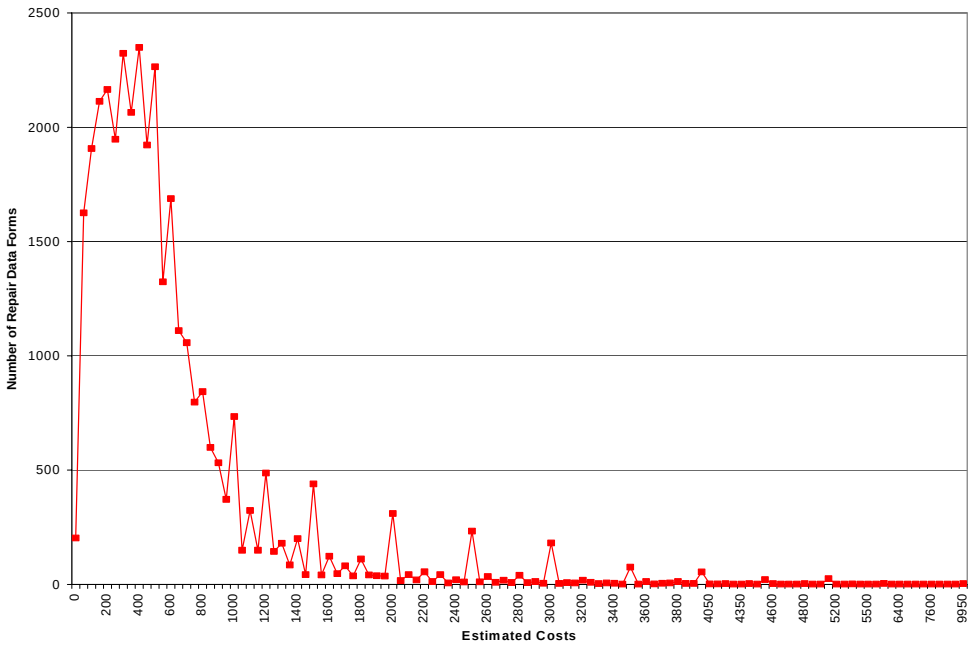
The most common repairs involved the replacement of the oxygen sensor, catalytic converter, spark plugs, air filter and EGR valve. In terms of adjustments, cleanings and other repairs, combustion chamber deposit removal and other chemical and physical cleaning actions were most prevalent. Ignition timing and idle mixture adjustments were common repair actions on older vehicles. Such adjustments are not possible on newer vehicles. Engine mechanical defects, low-efficiency catalytic converters and defective carburetors were the items most frequently mentioned as being required but not repaired, usually due to the cost involved.

The number of AirCare-certified repair facilities has declined slightly since 2000. The reasons for this are not known, but it is possible that the requirement to enter repair information through the Internet proved to be a disincentive for some shops. The number of AirCare-certified repair technicians has remained fairly stable at about 1200. Approximately 50% of technicians whose certification is expiring are automatically re-certified by virtue of having a Repair Effectiveness Index (REI) higher than the industry average in their last year of certification. Of technicians not eligible for automatic re-certification, the pass rate on the re-certification exam is approximately 60%. The remaining technicians must complete a training course and successfully pass the exam to retain their certification. A significant portion of the technicians in this position appear to let their certification lapse.

The AirCare administration office provides technical support to the repair industry through a telephone hotline. In 2002, 4795 calls were made to the hotline. It is believed that this technical support is critical in helping the repair industry deal with emission failures. Further support was provided to the industry through quarterly newsletters and a complete revision of the Repair Centre Manual which was posted online at the AirCare web site.

Cost of Repairs

The average actual cost of repairs reported by certified AirCare repair facilities was $343 in 2001 and $377 in 2002. Performing a frequency distribution of the data suggests that a significant portion of repairs cost less than $200. Although certified repair centres frequently cite repair cost limits as a constraint on their ability to perform effective repairs, 85% of the time, the estimated cost of repair was less than the applicable repair cost limit. The figure below illustrates the frequency distribution of estimated repair costs from Repair Data Forms submitted in 2002.



Distribution of Estimated Repair Cost in 2002

The frequency distribution of estimated repair costs indicates that the median cost is $450. By comparison, 25 percentile is at $250 and the 75 percentile is at $701. The peaks on the above figure indicate the estimates were very often rounded up to multiples of $500, e.g. $1,500, $3,000 and so on.

Sample Test Data

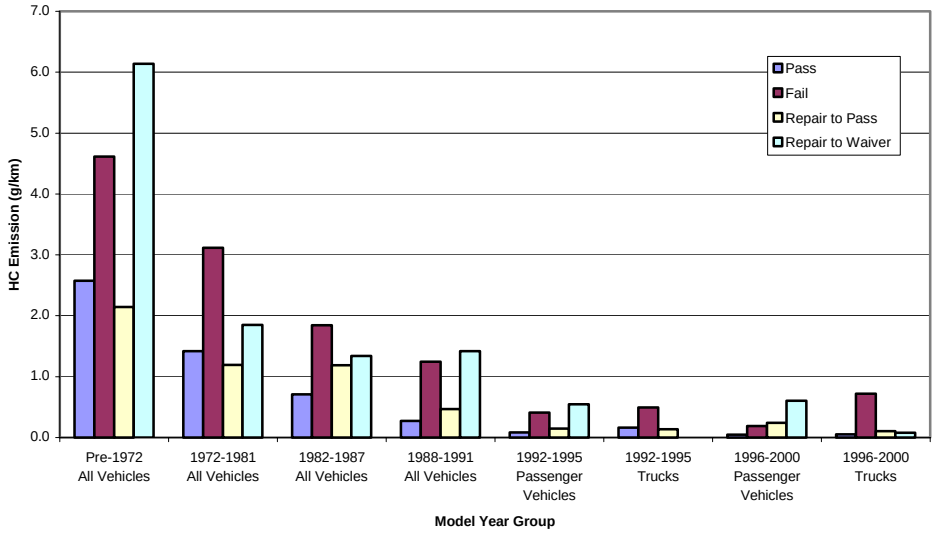
In simplest terms, the benefit of an inspection and maintenance program is equal to the difference in total vehicle emissions with an I/M program compared to the expected amount that would have occurred without it. In order to construct a model of fleet emissions, it is necessary to obtain mass emission data for all types and ages of vehicles in the fleet.

In March of 2001, a mass emission sampling test program was initiated with a target of 8,000 full-duration IM240 tests per year. The 8,000-vehicle sample was designed to include representative quantities of cars and trucks by age, type and manufacturer. In order to fulfil the requirements of the program, even vehicles normally subject to ASM/Idle tests were required to undergo full-duration IM240 testing.

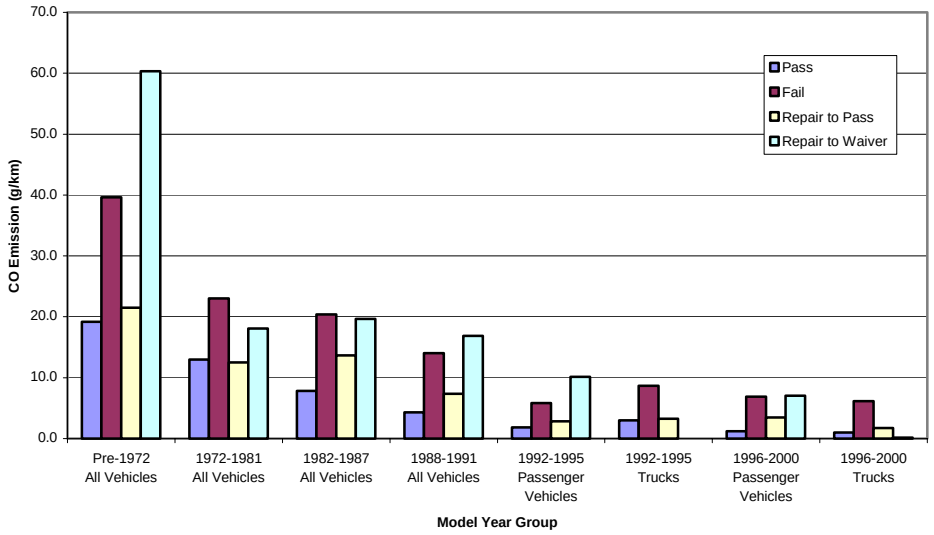
The program did not get fully underway until mid-2001 and, as a result, the sample size as of December 31, 2002 was limited to 8,872 initial tests. Of these, 7,986 were passes and 886 were fails. There were 766 after-repair tests recorded among the failed vehicle group. The data made available by the sample test program is extremely valuable in that it provides information on the passing portion of the fleet. In previous years, it was necessary to rely on a parallel testing program wherein HOT505 mass emission tests were performed on a voluntary sample of failing vehicles. This program was useful but was limited to about 400 vehicles per year and suffered from the fact that the participating vehicles were not necessarily representative of all failing vehicles because the owners volunteered to participate.

The sample group was divided into 8 sub-populations; all pre-1972 vehicles, all 1972-1981 vehicles, all 1982-1987 vehicles, all 1988-1991 vehicles, 1992-1995 cars, 1992-1995 trucks, 1996-2000 cars and 1996-2000 trucks.

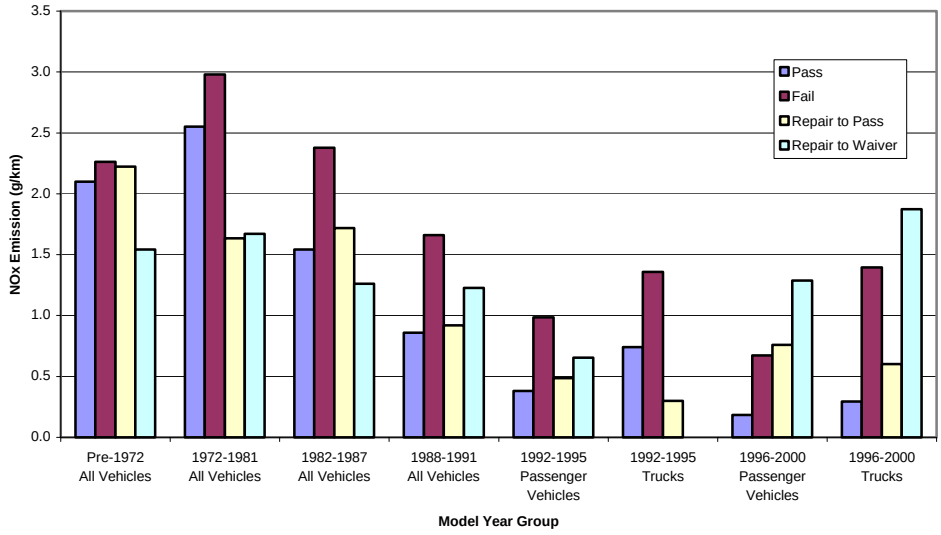
The following figures illustrate the comparison of passing, failing and post-repair emission rates for all 8 groups separately for HC, CO and NO_x.



HC Emission Factors by Model Year Group



CO Emission Factors by Model Year Group



NO_x Emission Factors by Model Year Group

The figures show clearly that older vehicles have much higher emission rates than newer ones.

They also confirm that the emission output of failing vehicles is much higher than corresponding passing vehicles and that the typical “repaired to pass” emission rate is much lower than the failing rate. In all but 4 cases, however, the average emission rate

of a “repaired-to-pass” vehicle is not quite as good as that of an “initial passing” vehicle. Hydrocarbon emissions from repaired 1981-and-older vehicles are better than initial-passing vehicles, while NO_x emissions from 1972-1981 vehicles are better after repair. Significantly, the post-repair NO_x emission levels for 1992-to-1995 trucks are considerably lower than those of initial-passing versions.

Aside from the above-mentioned exceptions, vehicles that have failed inspection and have been repaired do not achieve the same average emissions performance as their passed-first-time counterparts. This effect has been observed in other analyses of I/M programs. It suggests that repairs are sometimes incomplete or that there are non-reversible effects of some emission-related defects. For example, a misfire condition that causes a hydrocarbon emission failure can cause thermal damage to the catalytic converter. When the misfire is repaired, HC emissions will be reduced, but not to the extent that they would have occurred if the converter had not experienced collateral damage from the misfire.

Vehicles that received a Conditional Pass had much higher post-repair emission results than vehicles that passed. In some cases, Conditional Pass recipients had even worse results on average than they did before they were “repaired”. For pre-1972 vehicles, Conditional Pass recipients had worse HC and CO emissions than the average failing vehicle. For the newest vehicles (1996-2000), post repair NO_x emissions tended to be worse than the average failing level. Conditional Pass recipients from this group had NO_x emissions many times higher than passing vehicles and considerably worse than failing vehicles. There were, however, only 550 1996-or-newer vehicles that received a Conditional Pass.

Calculation of Program Benefits

The significant progress made by the automotive industry in lowering vehicle tailpipe emissions is evident in the way that the passing vehicle emission rates have declined significantly for the newer vehicles. The emission rates indicated in the figures represent hot-start, IM240 emissions and are therefore not completely representative of emission factors that would be used in emissions inventory modelling, but should provide a reasonable relative indication of the performance across age and technology groups.

The IM240 mass emission sample provides a sufficient number of passing, failing and re-inspected vehicles to derive emission factors with which percentage emission benefits due to repairs can be calculated. The basic approach involves choosing the most common failure modes within different groupings of vehicles and matching these modes to data in the mass emission sample. For example, it is assumed that all trucks from model years 1992-1995 that failed for excessive hydrocarbons and excessive NO_x would have the same emission rate as the matching failed and post-repair average emissions of all 1992-1995 trucks in the mass emissions sample.

Overall, for the 4 categories of vehicles subject to ASM/Idle testing, the top six failure modes were selected. Although 32 possible outcomes are possible, the top six modes accounted for 67% to 78% of all failures. For vehicles tested to the IM240, there are only 8 possible outcomes and therefore every failure mode was considered.

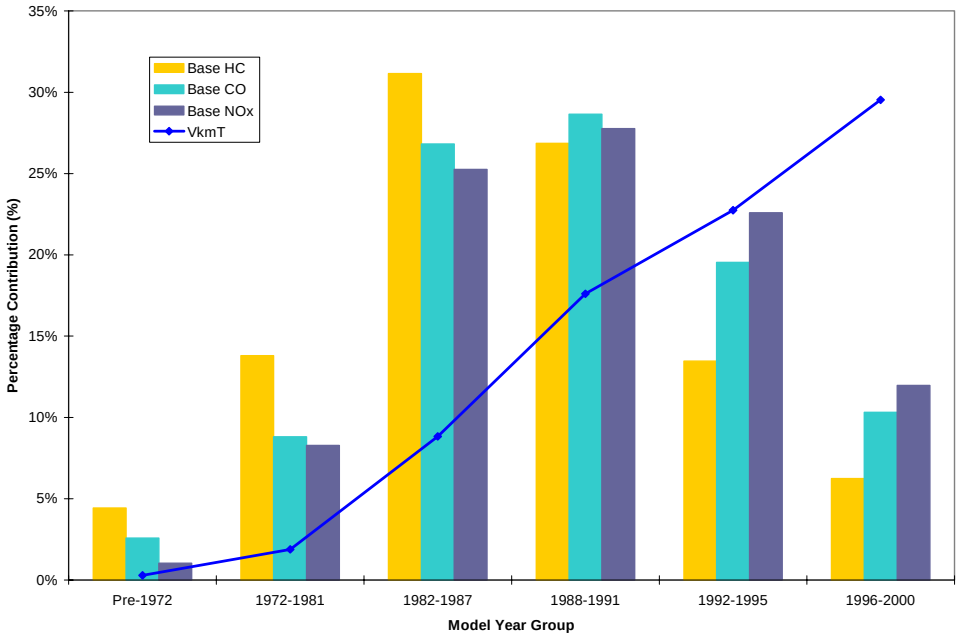
Using data on the number of vehicles in each group and their annual kilometres travelled, it was possible to compute the total grams of emissions generated by vehicles in each of the 8 categories for the baseline scenario with no repairs and for the post-repair case. The reductions attributable to repairs were then calculated as a percentage

of the base case. A further estimate of the effect of the "disappeared" vehicles was calculated by assuming that the "Removed From Use After Failure" vehicles would have continued to operate at failing vehicle emission rates in the absence of a test program. This effect was calculated separately from the repair effect.

The mass emission rates from the IM240 testing are different from the factors used in inventory models like MOBILE 6, making it necessary to apply the calculated percentage reductions to the inventory results computed by MOBILE 6 in order to derive the tonnage of emission reductions that can be assigned to the program. Data were provided by the Greater Vancouver Regional District for calendar year 2000 and were calculated using the MOBILE 6 inventory model.

Contribution by Age Group to Overall Emissions

Using the IM240 emission factors from the 9,000-vehicle sample, it was possible to calculate the relative contributions of different age and technology groups on overall emissions. The chart below indicates that 1996 and newer vehicles, despite accounting for more than 30% of the total vehicle-kilometres-travelled (VkmT), accounted for only 8-12% of the total emissions generated. At the other extreme, 1972 and older vehicles accounted for only 0.6% of the VkmT but contributed almost 5% of all vehicle-generated HC emissions. In general, pre-1992 vehicles accounted for less than 50% of the VkmT, but produced 67%-76% of total emissions.



VkmT Vs. Emissions Contribution by Model Year Group

Conclusions

- The changes made to the AirCare program, in particular the move to IM240 testing, have significantly boosted the program's ability to identify excess-emitting

vehicles with more than 200,000 test failures noted within the two-year review period.

- Repair data was available for only 43,000 of the 140,000 vehicles that were successfully re-inspected in the two calendar years combined.
- One third of the vehicles for which repair data is available were unsuccessful in achieving a passing re-inspection. In over half of these cases, it appears that misdiagnosis was the reason rather than limitations imposed by the repair cost limits.
- According to "Estimated Cost of Repair" data submitted by certified repair shops, 25% of vehicles repaired would require more than $750 of work to fully address all deficient items.
- Repairs to failing vehicles that resulted in a passing re-inspection showed a significant decrease in ASM and Idle emission readings for 1991-and-older vehicles and in IM240 emission results for 1992-and-newer vehicles. The Idle and ASM Space (ie, differences in ppm and % volumetric emission results for re-inspections compared to initial inspections) reductions associated with repairing a vehicle to pass are shown in the table below for calendar year 2002:

ASM/Idle-Space Emission Reductions

Age Group	Idle HC	Idle CO	ASM HC	ASM CO	ASM NO_x
Pre-1972	61%	57%	52%	55%	3%
1972-1981	74%	64%	61%	66%	29%
1982-1987	73%	74%	57%	74%	40%
1988-1991	80%	92%	68%	87%	58%

- The IM240-space reductions for 1992-and-newer vehicles are shown in the Table below:

IM240-Space Emission Reductions

	HC	CO	NO_x
1992-1995 Cars	66%	61%	50%
1992-1995 Trucks	60%	57%	50%
1996+ Cars	72%	70%	57%
1996+ Trucks	67%	64%	56%

- The most common repairs were related to the replacement of catalytic converters and oxygen sensors, particularly for vehicles tested to the IM240 test. According to the repair data submitted, there were 5,779 catalytic converters replaced in 2001 and a further 10,678 in 2002. For oxygen sensors, there were 8,328 replacements in 2001 and an additional 11,803 in 2002. It should be kept in

mind that these figures reflect only repairs for which repair data was submitted. If these repairs are representative of the overall failing vehicle population, the number of catalytic converters and oxygen sensors replaced as a result of the program would be triple these amounts.

- There continues to be a significant amount of spark plug and air filter replacements (7,304 and 5,008 respectively in 2002) associated with repairs to failed vehicles. These are basic maintenance items that are unlikely to be the main cause of an emissions failure. The high instance of these types of repairs suggests a continued misunderstanding of diagnostic and repair procedures by some repair facilities.
- Over 40,000 gas caps failed the functional pressure test in the review period. Confirmation of a successful gas cap re-inspection occurred in about 24,000 cases. No benefits from gas cap testing were calculated or included in this report.
- In calendar year 2002, interrogation of the OBD-II system on 1998-and-newer vehicles was successful in 143,146 cases. Of these, 2,039 (1.4%) were found to have the MIL commanded ON. Of these, 1,711 passed the IM240 test. The remaining 328 failed the IM240 as well as the OBD-II test. 2,865 vehicles failed the IM240 test (2.00%), but had no MIL illuminated. This effect is consistent with results observed in other programs.