Whitehorse Emission Testing Clinic

September 20th and 21st 2007

Background

Until 2005 Environment Canada conducted regular emission testing clinics for in-use light-duty vehicles at various locations across the country. The most recent Environment Canada clinic in Whitehorse was in 2005.

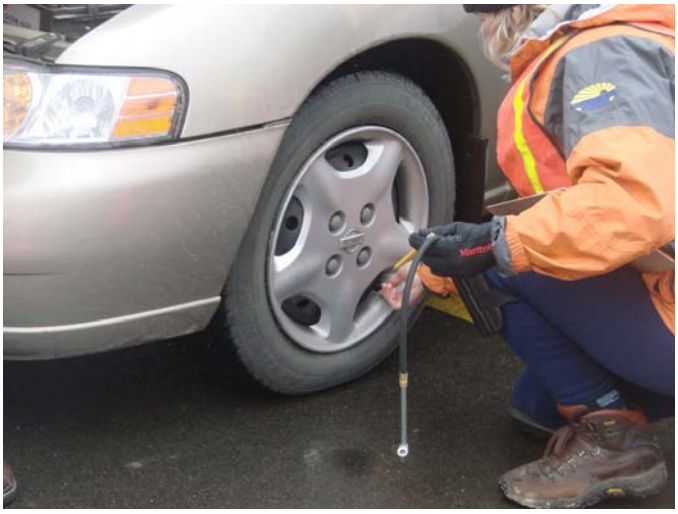
Organisation

In July this year the Yukon Government's Energy Solutions Centre contacted Pacific Vehicle Testing Technologies (PVTT), which manages the British Columbia AirCare Program, about running a clinic in September. The basic concept and intent would be the same as for those conducted by Environment Canada, and Environment Canada very helpfully provided all the available information about previous clinics to PVTT. The Environment Canada clinics performed a two-speed idle tailpipe test, and relied on paper records, which were later input for analysis. PVTT decided to create a touch-screen laptop system to enter data directly at the time of the test. PVTT also decided to include an Onboard Diagnostic (OBD) inspection as well as the two-speed idle tailpipe test, gas cap pressure test, Emission Controls Systems tampering inspection, and diesel smoke opacity measurement. The local organisation and advertising was done by the Energy Solutions Centre. The Energy Solutions Centre also conducted a small survey to determine which methods of advertising were most effective in bringing motorists to the clinic.

The clinic was held in the parking lot of the new Canadian Tire store in Whitehorse. The signage and operations were clearly visible from the main road leading to/from the Alaska Highway and Whitehorse Airport. Two complete inspection operations were set up, to provide two inspection 'lanes'. Power was provided from the Canadian Tire repair bays, and an air compressor was located between the lanes to inflate any tires that needed it.

Equipment and Testing

- **Tire Pressures** were checked using mechanical and digital gauges. However, the digital gauges were not completely reliable, and any future clinics will use all mechanical gauges. All four pressures were recorded; then, in consultation with the vehicle owner and after checking any information on the vehicle decals, the tires that needed it were brought up to the correct pressure.

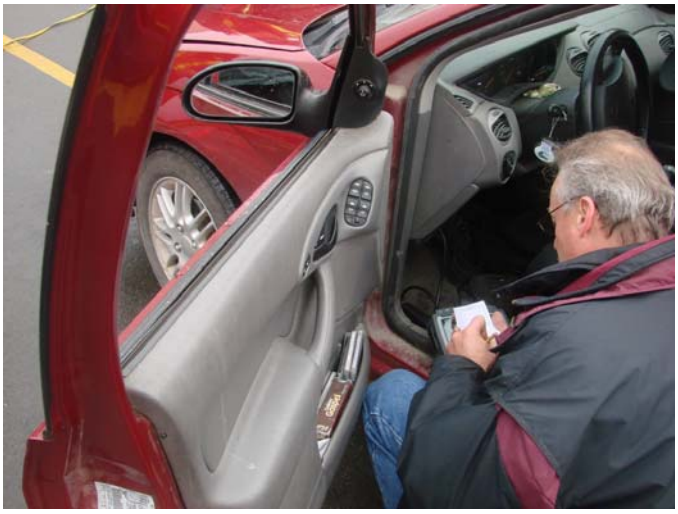


- **Gas Caps** on all 1997 and older vehicles were removed and pressure tested using Waekon hand-held testers. Diesel caps were not tested. Gas caps from 1998 and newer vehicles were not tested, because their proper operation is checked by the vehicle's OBD system.

- **Emission Control System** (ECS) components were checked on all 1997 and older vehicles. In most cases this was with reference to the under hood emissions decal. The ECS components checked for were: Catalytic Converter; Positive Crankcase Ventilation (PCV); Exhaust Gas Recirculation (EGR) valve; Air Injection System (AIS); Thermostatic Air Cleaner (TAC); and Evaporative Canister.

- **The OBD Inspection** was conducted using a Genisys scanner made by OTC, connected to the Diagnostic Link Connector (DLC). It also included visual Key-On-Engine-Off (KOEO) and Key-

On-Engine-Running (KOER) Malfunction Indicator Lamp (MIL) checks. All monitors were recorded as 'ready', 'not ready', or 'not supported'. The MIL command status was checked, and any Diagnostic Trouble Codes (DTCs) were noted.



- **The Tailpipe Test** was a Two-Speed Idle: 2000 rpm followed by a curb idle. Concentration measurements were taken using a Vetronix portable 5-gas analyser. The cut points used to determine PASS or FAIL for the curb idle were the same as would be used for idle tests in the Aircare program: they varied by vehicle type, model year and engine size. For the 2000 rpm high idle the cut points were set at 220 parts per million (ppm) Hydrocarbons (HC) and 1.2% Carbon Monoxide CO).

- **The Smoke Opacity** of diesel exhaust was measured using a Wager full-flow Opacimeter. The clinic was not really directed at diesel vehicles, but the intention was to test any that did show up.

Vehicles Tested

The total number of vehicles tested over the two days was 181. The clinic was intended for light-duty vehicles, up to about 11,000 lb Gross Vehicle Weight (GVW); so in the following sections, 'heavy truck' refers to trucks over 8500 lb GVW. All tests were voluntary, and no attempt has been made to compare the following profile with the fleet profile of all vehicles operating in Whitehorse, but it is likely that the in-use fleet contains a higher proportion of newer vehicles than were tested in the clinic. One thing that was not expected was the number of right-hand-drive vehicles, recently imported as used vehicles from Japan.

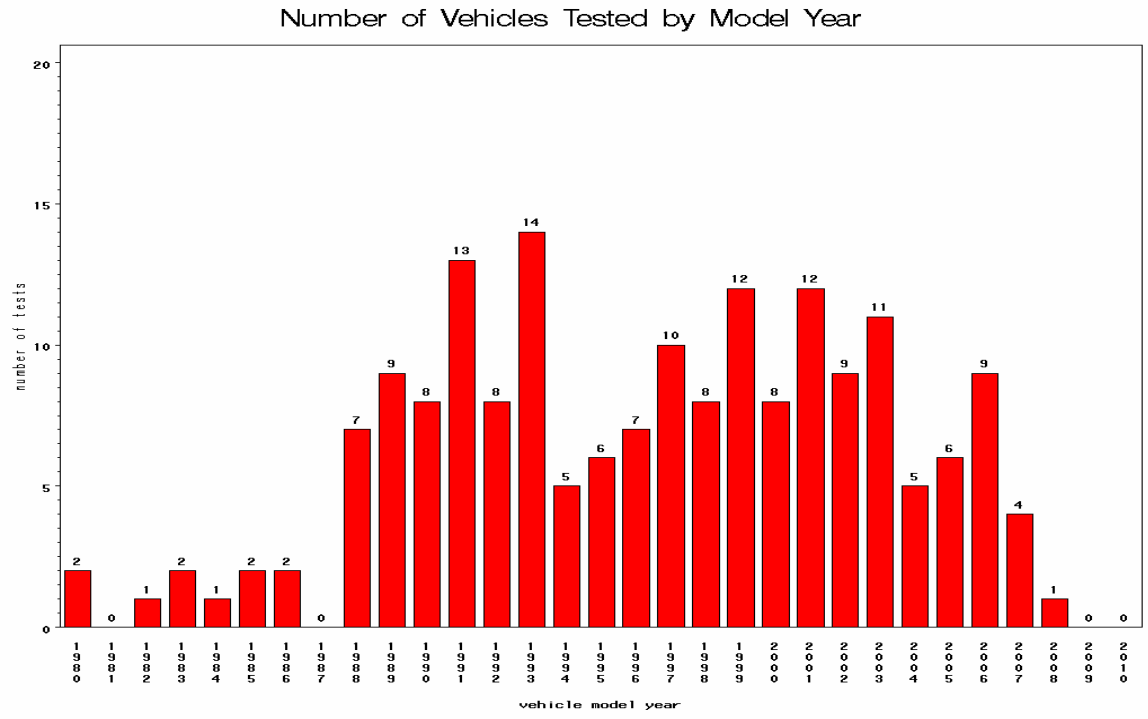
Vehicle Types and Fuel

92 gasoline passenger vehicles
66 gasoline light trucks
9 gasoline heavy trucks
1 motorcycle
2 diesel passenger vehicles
5 diesel light trucks (2 of these were using a biodiesel blend)
6 diesel heavy trucks

Model Years

Passenger Vehicle	median model year = 1996,	(range from 1976 to 2007)
Light Truck	median model year = 1998,	(range from 1965 to 2008)
Heavy Truck	median model year = 2001,	(range from 1985 to 2006)

In the following chart all the 1980 and older vehicles are counted as 1980.

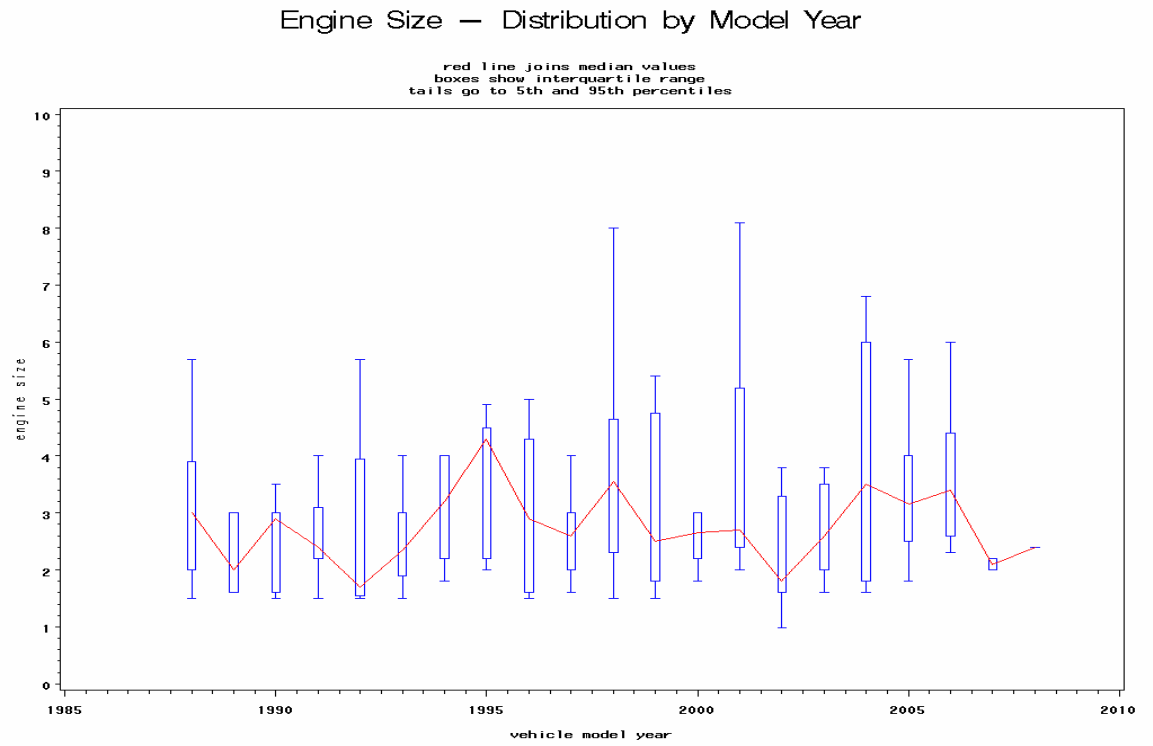


Engine Size (gasoline only)

Passenger	mean=2.2L,	(range from 1.0 to 5.9)
Light Truck	mean=3.7L	(range from 2.0 to 5.8)
Heavy Truck	mean=6.4L,	(range from 5.2 to 8.1)

In the following and subsequent charts, the red line connects the median values for each model year; the boxes extend from the first quartile value to the third quartile; and the whiskers show the locations of the 5th percentile and the 95th percentile. So as well as indicating how average values relate to model year, the charts also show how much spread the actual values have above and below the average.

There is clearly a wide range of engine sizes from all model years, with no clear trend over time.

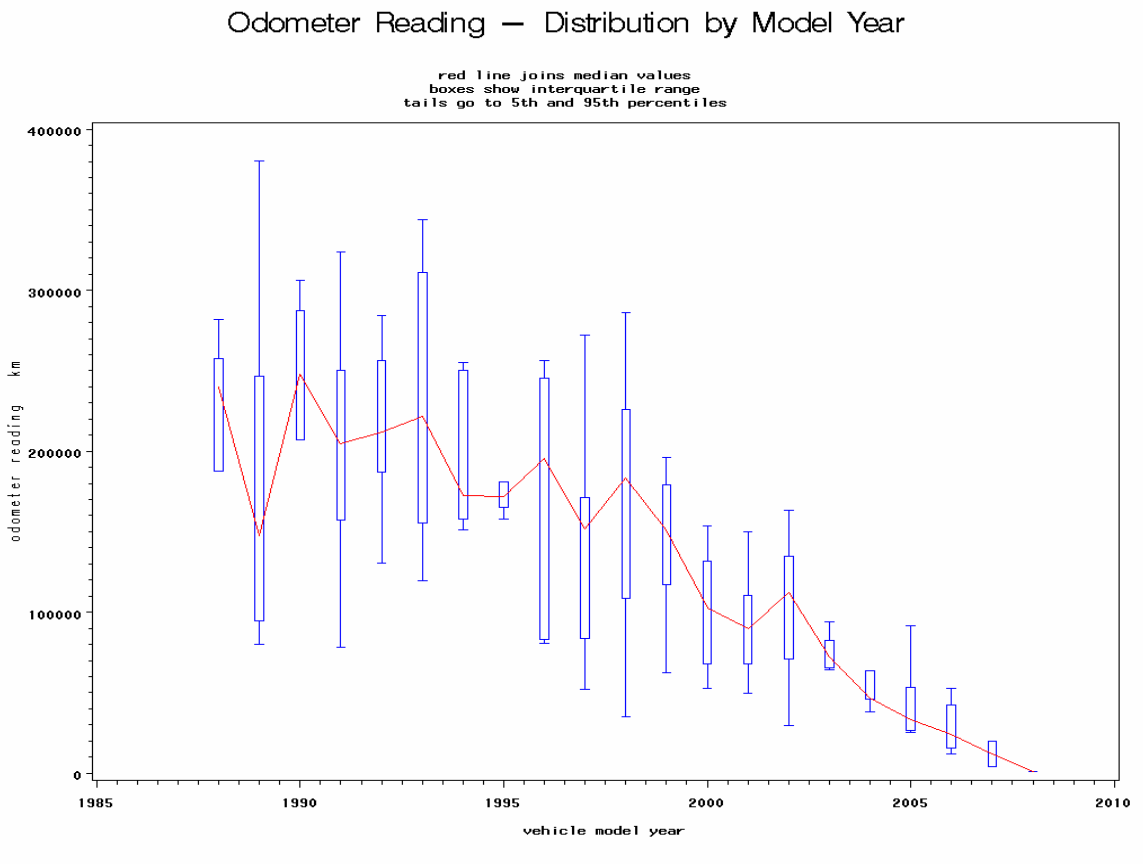


Odometer Readings

Passenger	mean= 155,816 km,	(range from 4,284 to [1]800,000)
Light truck	mean=156,473 km,	(range from 1,284 to 425,628)
Heavy truck	mean=134,371 km,	(range from 26,418 to 380,572)

The slope of the following chart suggests that annual mileage averages around 19,000 km/year over the first 10 years of life and then drops off a little. This is higher than in the Vancouver region, so in their first ten years of life vehicles in Whitehorse appear to be driven further than vehicles in Vancouver.

[1] The 800,000 km vehicle was a taxi on its third engine, and can be considered an outlier.



OBD II vehicles

In Canada all 1998 and newer light-duty vehicles are required to have second generation On-Board Diagnostics (OBD II). There were 80 gasoline vehicles and 5 diesels of model years 1998 or newer. All the gasoline vehicles except the motorcycle were OBD II compliant. Motorcycles are not required to comply. Although OBD is not actually required yet for heavy-duty vehicles, all 5 of the heavy duty diesels were compliant. OBD is a system by which the vehicle's own computer monitors a number of systems which are essential for controlling emissions. When a system shows a fault, it stores a Diagnostic Trouble Code (DTC) and when the fault is serious enough it lights the Malfunction Indicator Lamp (MIL) on the dash to alert the driver to the need for attention. OBD can help ensure that malfunctions are repaired sooner rather than later (if ever) and provide the repair mechanic with much useful diagnostic information that can help pinpoint the problem.

38 gasoline passenger vehicles
34 gasoline light trucks
7 gasoline heavy trucks
5 diesel heavy trucks

Used Japanese Imports

There were nine vehicles that were recent used imports from Japan. One of these was a 1988 Mercedes that had started life in Belgium. The others were a Nissan Fairlady; a Nissan MPV; a 4WD Toyota Tercel; a diesel Nissan Terroa, a diesel 4WD Toyota Hiace; and three diesel Toyota Landcruisers. These vehicles are becoming increasingly available. The importers take advantage of

the availability of good used vehicles from Japan, and Canada's easy import regulations for vehicles over 15 years old. It is unlikely that the full Yukon fleet contains such a high proportion of these vehicles.

Results

Tire Pressures

Of the 181 vehicles tested, there were 72 vehicles (40%) that had at least one low tire pressure, and 30 vehicles (16%) that had at least one high tire pressure.

36 had one tire low
19 had two tires low
6 had three tires low
11 had all four tires low

15 had one tire high
2 had two tires high
4 had three tires high
9 had all four tires high

On average, those tires which were low, were low by about 6 psi, and those that were high were high by about 5.5 psi. The vehicle with the lowest pressures all round was a 1992 Nissan Sentra, with values of 5, 10, 15 and 20 psi, which were all then inflated to 30 psi.

The mean difference between lowest and highest pressures on an individual vehicle was 8.6 psi or 23.6% of the high value. However, the maximum difference was 30 psi on a 1998 RAM 2500 which had a left-rear pressure of 64 psi and a right-rear pressure of 34 psi. Another extreme example was a 1998 Mazda Protege that had 32 psi on both left side tires, but only 10 psi on the right-front and 20 psi on the right-rear.

Two-Speed Idle Test

Failure rate

The tailpipe test was conducted on all 168 gasoline vehicles, and of these there were 31 vehicles (18.5%) that failed one or more parts of the test.

Across the different vehicle types the failure rates were:

20	passenger vehicles failed out of 92	(22%)
8	light trucks failed out of 66	(12%)
2	heavy trucks failed out of 9	(22%)
1	motorcycle tested failed	

There were not really enough cases to allow an analysis of failure rate by model year, but it is worth defining two age groups: the pre-1998 vehicles and the 1998 and newer vehicles. This allows comparison of tailpipe results with OBD results.

For the pre-1998 vehicles:

20	passenger vehicles failed out of 54	(37%)
8	light trucks failed out of 32	(25%)
2	heavy trucks failed out of 2	(100%)

So the overall failure rate for these older vehicles was 34%.

None of the 79 vehicles of 1998 model year and newer (OBD) failed the tailpipe test.

Failure Modes

The most common mode to fail was curb idle HC. Most of those which failed only failed one mode, but 3 vehicles failed all four modes.

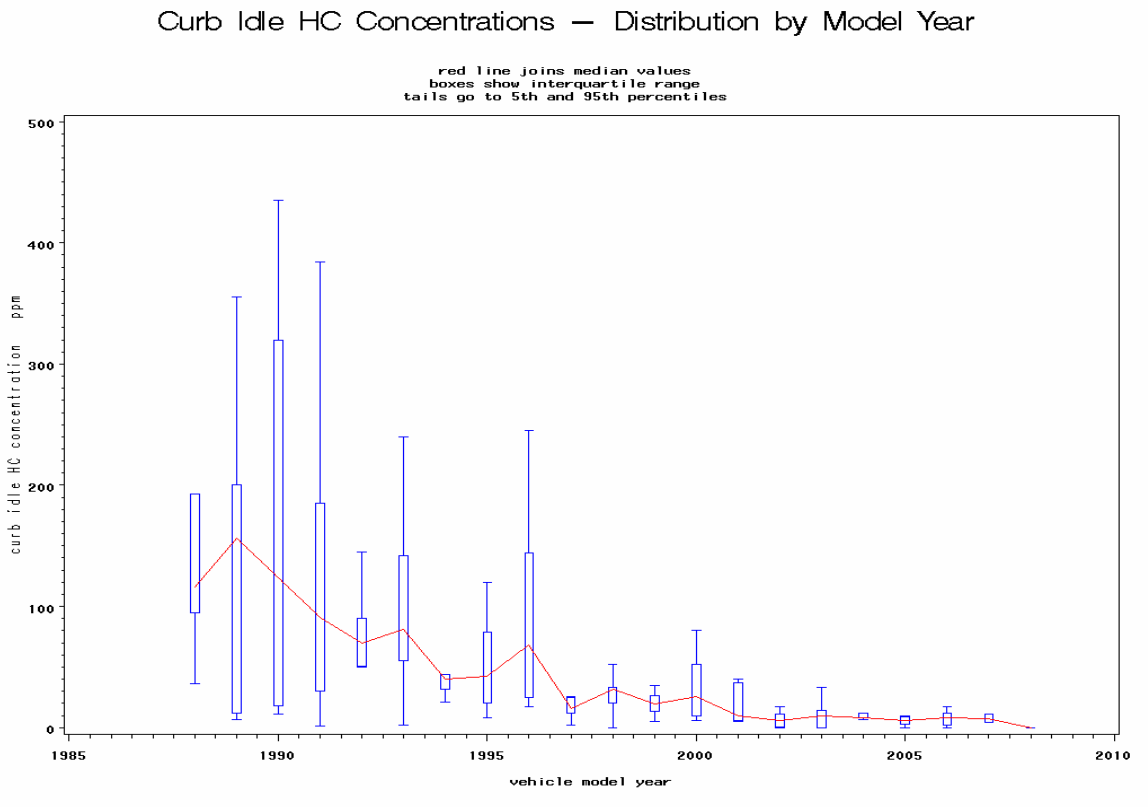
25	failed curb idle HC
10	failed curb idle CO
10	failed high idle HC
11	failed high idle CO

Tailpipe Readings

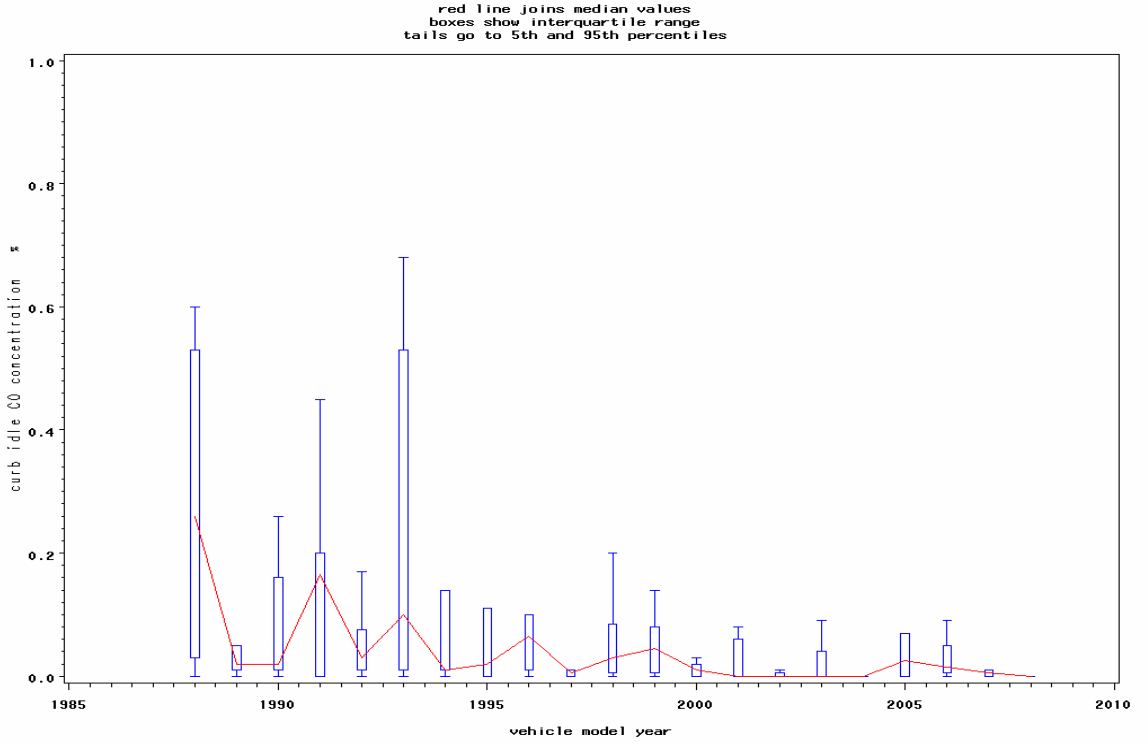
The following charts show the distributions of HC and CO readings by model year. The median values for each year are joined by the red lines; therefore this red line indicates the average readings. The spread of readings above and below the line are indicated by the size of the interquartile boxes and the lines extending from the boxes which go from the 5th to the 95th percentile values.

The two most important observations from these charts are: that newer vehicles have much lower average tailpipe concentrations than older vehicles; and that the variability of readings for the older vehicles is much higher than for newer vehicles. This means that we can confidently expect a newer vehicle to have low readings, with very little probability of being wrong. However, an old vehicle will usually have high readings, but it may have low readings, or it may have very high readings.

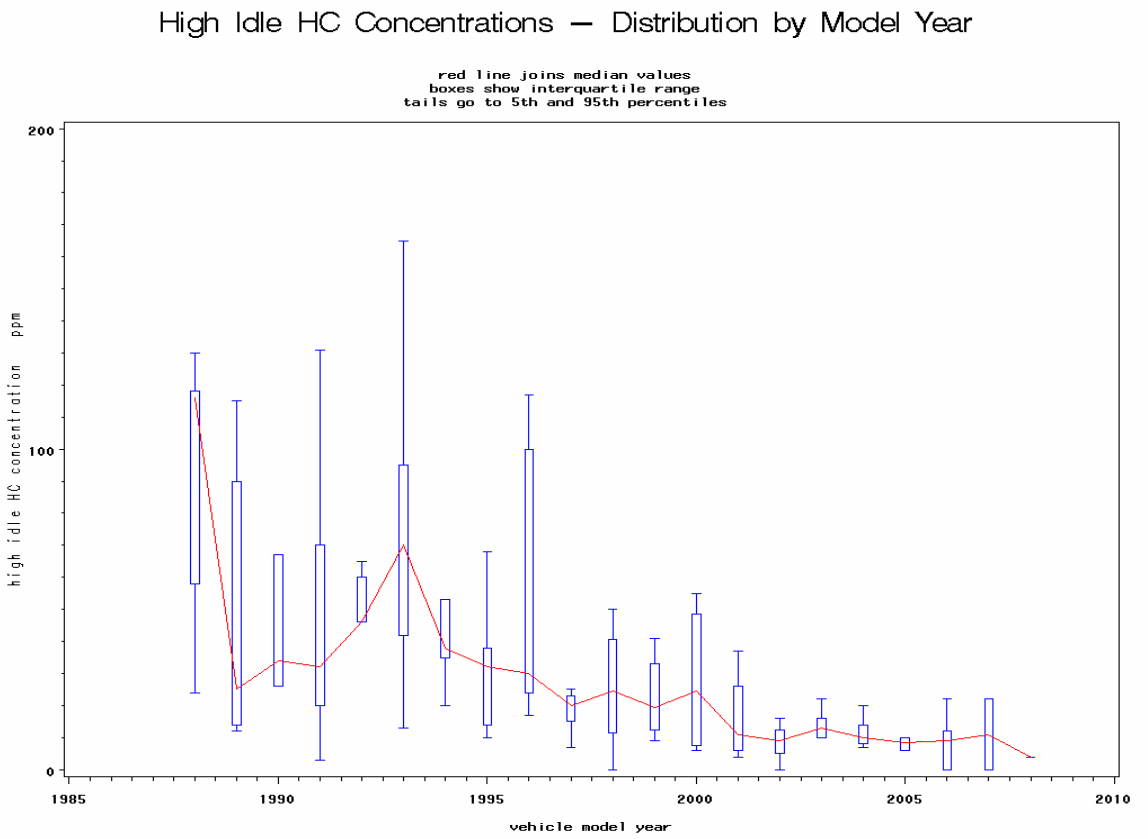
Curb Idle HC Concentrations — Distribution by Model Year



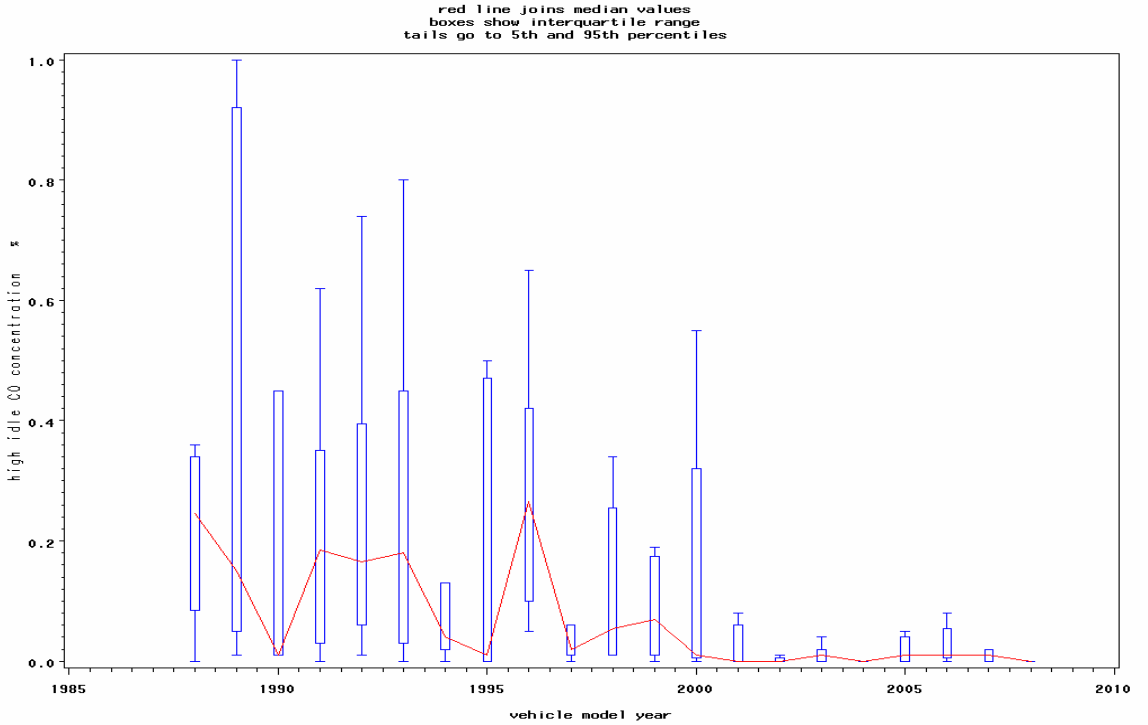
Curb Idle CO Concentrations — Distribution by Model Year



High Idle HC Concentrations — Distribution by Model Year



High Idle CO Concentrations — Distribution by Model Year



Gas Cap

The gas caps were tested from 87 of the 88 pre-1998 gasoline vehicles. The cap from the 1965 Mercury truck was not tested because caps from that era are simply vented to the atmosphere. Six of the caps failed the test, which is 8%.

Emission Control System Inspection

The inspections did not reveal much evidence of intentional tampering. Only two gasoline vehicles were identified as definitely tampered. They were a 1988 Dodge Dakota, where all Emission Control System (ECS) components had been tampered (pictured below) and a 1991 Audi with a tampered Exhaust Gas Recirculation (EGR) valve.

Seven other gasoline vehicles were missing ECS components. Two were heavy trucks, one was a light truck, and four were passenger vehicles. Two were missing catalysts; one Positive Crankcase Ventilation (PCV) valve was missing; two air injection systems were missing; and four Thermostatic Air Cleaners (TACs). Some people would define these vehicles as tampered; but we consider these missing components to simply be a reflection of reality in a context where ECS component replacement is not enforced.

Two of the heavy duty diesels were tampered. One was a 1995 Ford F350 7.3L which had been fitted with an aftermarket turbocharger, intake system and exhaust, and a performance chip. The other was a 2001 GMC Sierra 6.6L fitted with a performance chip.

Onboard Diagnostics Inspection

Except for the one motorcycle, all of the 79 gasoline vehicles of 1998 or newer model years were OBD compliant. The monitors which were interrogated were:

- COMP Comprehensive Component Monitors (includes anything not covered by other specific monitors)
- FUEL Fuel System
- MISF Misfire
- CAT Catalytic Converter Efficiency
- EGR Exhaust Gas Recirculation System

- EVAP Evaporative Emissions Control System
- OXY Oxygen Sensors
- HOXY Oxygen Sensor Heaters
- PCV Positive Crankcase Ventilation
- SAIR Secondary Air Injection
- THER Thermostat
- HCAT Heated Catalyst
- ACSYS Air Conditioning System

The first three monitors (COMP, FUEL and MISF) are known as Continuous Monitors and are present on all OBDII vehicles (except that vehicles with more than 8 cylinder engines do not require the misfire monitor). All gasoline vehicles also have CAT, EVAP, OXY, HOXY, PCV and THER monitors, and will have EGR and SAIR monitors if those systems are fitted. Diesel vehicles have the three continuous monitors plus the EGR monitor, if an EGR is fitted. The HCAT and ACSYS monitors are not required by any existing production vehicles.

Most vehicles had all supported monitors shown as 'ready'. Three Toyota passenger vehicles (2004 Corolla, 2003 Matrix, and 2002 Corolla) showed 'not ready' for CAT, EVAP, OXY and HOXY. One 2006 Toyota Sienna was 'not ready' for CAT, EVAP, and OXY.

Only the four vehicles listed below had any Diagnostic Trouble Codes (DTCs):

- 1999 Ford F150, with the MIL=ON and DTC P0156 which is for the Bank 2 Sensor 2 oxygen sensor.

- 1998 GMC Jimmy, with the MIL=OFF and DTC P0300, which is a random misfire. The owner did confirm that the MIL had recently been ON.

- 1999 VW Jetta, with the MIL=ON and DTC P1582 which is a manufacturer code for the idle fuel trim being at its limit. This vehicle also had a Pending P0507 which means the idle air control is high.

- 1999 Ford Windstar, with the MIL=OFF had a Pending P0171 which means it has a lean long term fuel trim.

All the Key-On-Engine-Off (KOEO) bulb checks passed, and the only Key-On-Engine-Running (KOER) visual MIL checks that failed were the F150 and the Jetta listed above. However, although we did not perform OBD checks on any pre-1998 vehicles, it was noticed that some of the 1996 and 1997 vehicles did have the MIL ON. In at least two cases, conversation with the motorists indicated that they had experienced trouble finding the necessary expertise to correct the problem that caused the MIL to light.

Using the BC AirCare OBD failure criterion of the MIL being commanded ON, would have failed just two vehicles from the 79, for a failure rate of 2.5%.

Five of the heavy duty diesels appeared to be OBD compliant, but only four were checked. All passed the KOEO and KOER visual checks, and none had the MIL commanded ON, or any DTCs. However, the meaning or validity of the readiness monitor data is not so clear. They appear at best to only support the three continuous monitors; COMP, FUEL; and MISF. A 2007 Dodge RAM was 'ready' for all three monitors; a 2006 RAM was 'not ready' for COMP and MISF monitors; a 2003 F350 was 'ready' for COMP and MISF, but showed 'not supported' for FUEL; the 2001 Sierra that was tampered with a performance chip showed 'ready' for COMP and 'not supported' for FUEL and MISF.

Diesel Smoke Opacity

The intention was to measure the opacity of diesel smoke using the Wager Opacimeter. But unfortunately, partway through the first day it developed a fault, so subsequent opacity estimates were visual. These visual assessments were made by people who had previously held EPA Method 9 visual smoke opacity certification, and the results were also fairly obvious.

- All of the diesels showed almost no smoke opacity at steady speed.
- The two tampered vehicles (2001 Sierra and 1995 F350) which had been modified for power were also given snap-acceleration tests and both blew 100% opacity solid black exhaust.
- Three of the five recent, used Japanese imports showed no visible smoke. One of these was actually using 8% biodiesel, and at the owner's request, it was also checked with the 5-gas analyser, obtaining very low readings.
- The other two used Japanese imports showed about 15% opacity, and one of these was using 10% biodiesel.
- A 1996 VW Passat showed about 20% opacity when snapped.
- A 1983 Audi showed about 50% opacity when snapped.

Advertising

Motorists reported that they had learned of the clinic through the following methods:

- 40% through a newspaper advertisement or article
- 18% noticed the tents and banners when driving by
- 17% through word of mouth
- 14% via a radio interview
- 8% through Yukon Government web sites
- 3% via a CBC TV report and posters

Motorists said that they came to the clinic for the following reasons:

- 61% wanted to learn more about their vehicle's performance
- 18% were concerned about the impact their vehicle had on the environment
- 15% said they were "just curious"
- 6% came for a variety of other reasons

Over 2/3's of the motorists at the clinic were men.

Conclusions

- The clinic clearly confirmed the message that low tire pressures are a common problem.

- The tailpipe emissions failure rate for the pre-1998 vehicles was more than double the rate currently experienced in the Vancouver area. It appears that emission issues are not normally part of regular maintenance in Whitehorse. Anecdotally, it was reported that only one dealership in Whitehorse even owns a gas analyser at present, and that staff at the dealership have not used it in years.

- The 1998 and newer OBD equipped vehicles have a very low incidence of emission problems. The few cases where OBD indicated a problem have not yet developed so far as to increase emissions. However, when OBD is indicating a problem, vehicle owners have had trouble finding the necessary expertise to correct the problem.

- There appeared to be very little intentional tampering with emission controls. The vehicles most likely to be tampered are late model diesels which can easily be tampered to produce more power, on-demand.

- Used Japanese imports seem popular in Whitehorse, especially diesel 4WD models that were never offered for sale in Canada.

- It was not really possible to conclude anything about the two used Japanese imports that were running on biodiesel blends.

- Overall the clinic was a great success. The clinic appeared to appeal to men more than to women and radio advertising appeared to be the most effective way of making the public aware of the clinic. Staff and volunteers were kept busy throughout the two days by a continuous stream of vehicles for testing, therefore public interest, and the perceived need for the clinic is still there. The high number of vehicles found with low tire pressures, or with high tailpipe emissions indicates that there is little else in place to effectively bring these problems to the public attention.

Acknowledgements

PVTT and the Yukon ESC wish to thank the following companies for providing test equipment free of charge:

- Snap-on TOOLS
- Lordco AUTO PARTS
- EnviroTest Canada

Their contribution to the success of the clinic was invaluable.