

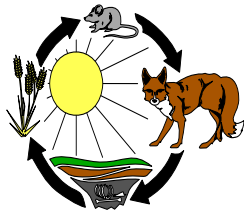
On-Board Diagnostics II (OBDII) and Light-Duty Vehicle Emission Related Inspection and Maintenance (I/M) Programs

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Transportation Systems Branch
Environment Canada

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Glossary of Terms

acceleration simulation mode (ASM)	- a dynamometer-based steady-state loaded mode emissions test that simulates acceleration.
add-on	- equipment or systems fitted to an engine or vehicle after manufacture and not as per original design or specification
administration	- government agency or person(s) in charge of or directly responsible for an HDV I/M program
aftermarket	- vehicle parts and equipment from companies that do not necessarily supply the parts and equipment installed on the assembly line by vehicle manufacturers. These parts may replace original equipment or enhance performance beyond original equipment specifications.
AirCare	- the I/M program in British Columbia
all-wheel drive or AWD	- vehicle designed to operate only in four-wheel drive mode
catalytic converter	- a catalytic converter usually comprises a metal housing filled with a hard material which is covered with a catalytic compound.
centralized I/M program and centralized test-only I/M program	- a program in which vehicle inspections are performed in a limited number of facilities. These facilities are usually operated by or under contract to state or provincial governments. These facilities are usually 'test-only' and the only function of these centralized I/M stations is the vehicle inspection or test. Ownership and operation of these facilities are separate from and not affiliated with the repair industry.
chassis-dynamometer	- a set of driven rollers that simulate road operation
clean-piping	- the practice of using the emission test readings from a 'clean' vehicle in place of those of a 'dirty' vehicle
clean-scanning	- the practice of using the OBD test scan readings from a vehicle with no OBD fault codes set in place of those of a vehicle that has OBD fault codes set.
clean-screening	- vehicles that do not have excess emissions are tested and passed with no additional test requirements. Tests are usually conducted remotely with no physical contact to the vehicle.
comprehensive components	- in the CARB OBD II regulation (section 1968.2 for 2004 and subsequent model years), section (e)(16) comprehensive components are described as any electronic input or output powertrain component that: (a) is used for any other OBD II monitor; or (b) (when malfunctioning) can cause a measurable increase in tailpipe emissions during any reasonable driving condition. The components typically monitored under these provisions include: cam sensor, crank sensor, IAT sensor, MAP sensor, MAF sensor, A/T shift solenoids, A/T input speed, A/T output speed, A/T torque converter clutch solenoid, A/T oil temp sensor, idle speed control valve, glow plugs, TPS, baro sensor, and vehicle speed sensor.

Glossary of Terms (continued)

contractor-run cutpoints	<ul style="list-style-type: none"> - a system run under contract to a government agency - chosen emission level at which a vehicle passes or fails a test or inspection
diagnostics	<ul style="list-style-type: none"> - a test run on a system or component to determine it is operating according to specifications.
diagnostic trouble code	<ul style="list-style-type: none"> - an alphanumeric code that is set in a vehicle's on-board computer when a monitor detects a condition likely to lead to (or has already produced) a component or system failure, or otherwise contribute to emissions exceeding standards by 1.5 times the certification standard.
decentralized I/M program	<ul style="list-style-type: none"> - a program where local garages act as I/M stations
decentralized test-and-repair I/M	<ul style="list-style-type: none"> - a program where I/M stations perform both inspections and repairs at the same location at local garage I/M stations
decentralized test-only I/M program	<ul style="list-style-type: none"> - a program where the only function of the I/M stations is the vehicle inspection or test
Drive Clean	<ul style="list-style-type: none"> - the I/M program in Ontario
dynamometer	<ul style="list-style-type: none"> - see chassis or engine dynamometer
dynamometer - steady-state	<ul style="list-style-type: none"> - a dynamometer that does not have the capability of simulating vehicle inertia weight beyond the basic inertia value of the rollers and flywheel. Instead, a power absorber is able to apply fixed resisting torques as specified for set or given speeds.
dynamometer - transient	<ul style="list-style-type: none"> - a dynamometer with the capability of simulating the forces that act on a vehicle in normal operation on the road. This includes simulation of inertia weight and aerodynamic drag forces proportional to speed.
enable criteria	<ul style="list-style-type: none"> - conditions necessary for a given diagnostic test to run. Each test has a certain number of conditions that need to be met before it is executed.
evaporative emissions	<ul style="list-style-type: none"> - emissions resulting from the evaporation of fuel
excess emissions	<ul style="list-style-type: none"> - emissions greater than a HDV engine's federal certification (FTP) standards
Federal Test Procedure (FTP)	<ul style="list-style-type: none"> - procedures for testing HDV engines to the federal emissions standards
fuel trim	<ul style="list-style-type: none"> - engine computer function that keeps the air/fuel mixture as close to the ideal 14.7:1 stoichiometric ratio as possible
government-run	<ul style="list-style-type: none"> - an I/M program where inspections are performed by government employees
grams/mile or grams/kilometre	<ul style="list-style-type: none"> - a mass measurement of contaminants
greenhouse gases (GHGs)	<ul style="list-style-type: none"> - gases in the atmosphere that contribute to the 'greenhouse' effect. GHGs inventoried by Environment Canada that are not covered by the Montreal Protocol include: carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons
gross emitters	<ul style="list-style-type: none"> - in general the term refers to emissions well in excess of federal standards or manufacturer specifications. However, this term is subjective and is not used in this text

Glossary of Terms (continued)

Gross Vehicle Weight (GVW)	- the maximum total weight that a vehicle is licensed to carry. It includes the tare or empty weight plus the payload weight and may be less than or equal to the GVWR.
Gross Vehicle Weight Rating (GVWR)	- the gross vehicle weight rating specified by a manufacturer as the maximum design loaded weight of a single vehicle
Heavy-Duty Vehicle (HDV)	- for Canadian Federal Emissions Standards: on-road vehicles, both trucks and buses, with a GVWR >2721.6 kg (≅6000 lbs.) to 1987 model year inclusive and >3855.6 kg (≅8500 lbs.) for the 1988 model year and newer
Heavy-Duty Diesel Vehicle (HDDV)	- an HDV that uses diesel fuel
Heavy-Duty Gasoline Vehicle (HDGV)	- an HDV that uses gasoline fuel
IM240	- a dynamometer-based transient emissions test that approximates the first 240 seconds of the FTP.
I/M or Inspection and Maintenance	- a program for the inspection and repair of in-use vehicles.
I/M ready status	- a signal flag for each emissions system test that has been set in the ECU.
idle	- the vehicle is stationary with the engine running and with no external load applied.
idle emissions test	- an emissions test conducted with the engine operating at idle.
inspection	- the examination of a vehicle in an I/M program.
in-use vehicle	- vehicle that is licensed and operating on the road.
ISO 9141	- ISO OBD II communication standard used by Chrysler and most foreign LDVs
J1850PWM	- SAE Pulse Width Modulated OBD II communication standard used by Ford domestic cars and light trucks
J1850VPW	- SAE Variable Pulse Width Modulated OBD II communication standard used by GM cars and light trucks
J1930	- SAE electrical/electronic systems diagnostic terms, definitions, abbreviations and acronyms
J1962	- SAE standard for connector plug layout used for all OBD II scan tools
J1978	- SAE standard for OBD II scan tools
J1979	- SAE standard for diagnostic test modes
J2012	- SAE standard accepted by the EPA as the standard test report language for emission tests
J2284	- SAE high speed CAN (HSC) for vehicle applications at 500 KBPS
J2534 API	- SAE standard Application Programming Interface
lambda control	- control system for regulating the excess-air factor or air ratio, lambda, in a spark-ignition engine.
light-duty vehicle (LDV)	- for Canadian Federal Emissions Standards: on-road vehicles with a GVWR <2721.6 kg (≅6000 lbs.) to 1987 model year inclusive and <3855.6 kg (≅8500 lbs.) for the 1988 model year and newer

Glossary of Terms (continued)

loaded or loaded mode test	- emissions test with the vehicle or engine operated under load
lug-down or lugging (of a HDV engine)	- at full throttle, the load is gradually increased to pull back engine speed so that the engine is labouring, or "lugging"
maintenance	- the adherence to the manufacturer's schedule for vehicle upkeep plus the repair of systems or faults that have lead to excess emissions.
Memorandum 1-A	- EPA tampering exemption policy
Northeast States for Coordinated Air Use Management (NESCAUM)	- in an effort to reduce the emission of excess smoke from Heavy-Duty Diesel engines used in highway applications, the states of Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont proposed to adopt and coordinate smoke opacity testing programs in the Northeast.
new vehicle	- vehicle as produced by the manufacturer and before first sale
on-road	- vehicles licensed to operate on the roads and highways. Vehicles licensed for road operation may vary with province and may include tracked vehicles and other construction equipment
On-Board Diagnostics – OBD (Data Link)	- a computer-controlled vehicle information system to monitor selected parameters. The system is installed on-board the vehicle in question.
OBD II	- the OBD system specified by the US EPA
OBD II drive cycle	- a specific sequence of start-up, warm-up and driving tasks that tests all OBD II functions and sets Readiness Monitors
OBD X or OBD III	- an OBD system that can perform remote interrogations and requires no physical connection to the vehicle
owner	- either the person registered as the owner of a vehicle by the provincial licensing authority or its equivalent in another state, province, or country; or a person shown by the registered owner to be legally responsible for the vehicle's maintenance
ozone (O₃)	- a gas formed as a result of chemical reactions between nitrogen oxides (NO _x) and volatile organic compounds (VOCs) in the lower atmosphere in the presence of sunlight and heat
parameters	- readings on scan tools representing functions measured by OBD II and proprietary readings
particulate matter	- any aerosol that is released to the atmosphere in either solid or liquid form
Pass-through reprogramming	- a process that allows the programming or reprogramming of a vehicle's computer without revealing proprietary information to the end user.
pre-screening	- in general vehicles undergo a test that requires no contact with the vehicle. If they pass, no additional testing is required
proprietary readings	- parameters shown by on-board computers that are not required by OBD II but are included by the manufacturer to assist in trouble-shooting specific vehicles

Glossary of Terms (continued)

Quality Assurance (QA)	- broad audit of systems to determine overall program effectiveness
Quality Control (QC)	- system audit functions performed as part of a daily routine
Readiness Code	- a status flag stored by a vehicle's on-board computer that is different from a DTC in that it does not indicate a vehicle fault, but rather whether or not a given monitor has been run, i.e. whether or not the component or system in question has been checked to determine if it is functioning properly.
Readiness Monitors	- indicators used to find out if emissions components have been evaluated. If all monitors are set to ready, the emission components have been tested.
recall or recalls	- the recall of a vehicle by the OEM to correct faults
remote sensing device (RSD)	- a system for measuring exhaust emissions that does not require physical contact with the vehicle being tested
scan tool	- computer based read-out equipment that is designed to interface with a vehicle's on-board computer for the purpose of reading DTCs and Readiness Monitor status and to display those codes and parameters.
steady-state test	- test conducted at single or multiple operational modes. Each mode is a defined combination of speed and load that is held fixed or steady throughout the duration of the mode.
stoichiometric ratio	- theoretical perfect combustion ratio of one part fuel to 14.7 parts air
tampering	- removal, modification, maladjustment, replumbing or disablement of the equipment, or the performance specifications, of emissions control systems, or other engine systems and vehicle parameters that affect emissions (Note: tampering may not include modifications that involve the retrofit of emission control systems)
test-and-repair stations	- I/M stations that perform both inspections and repairs at same location
test-only stations	- I/M stations that are permitted only to test or inspect vehicles
three-way or 3-way catalytic converter	- a catalytic converter that reduces the emissions of hydrocarbons, carbon monoxide and oxides of nitrogen.
Tier 1 emission standards	- federal HDV standards in USA that applied to 1996 through 2000 model years until NLEV program took effect in 2001
Tier 2 emission standards	- go into effect in 2004
traction control	- drive wheel responds to loss of traction by other drive wheel(s)
transient test	- a test that exercises the engine over a schedule of varying speed and/or load conditions
trip	- a key-on, key-off cycle that allows a vehicle to operate in a manner that satisfies the enable criteria to run a given diagnostic
two-speed idle test	- a stationary vehicle test that combines the idle plus a 2500 rpm (or higher speed) emissions test
Vehicle Communication Protocols	- see ISO 9141, J1850 VPW/PWM and CAN

Abbreviations and Acronyms

ABS	-	Anti-lock Braking System
A/F ratio	-	Air/Fuel ratio
AFC	-	Air Flow Control
ALDL	-	Assembly Line Diagnostic Link. Formerly GM (only) DLC
ASM	-	Acceleration Simulation Mode
BAR	-	California Bureau of Automotive Repair
CAA	-	Clean Air Act (USA)
CAL ID	-	Calibration Identification Number
CAN	-	Controller Area Network - vehicle communication protocol
CARB	-	California Air Resources Board
CFI	-	Central Fuel Injection or Continuous Fuel Injection
CO	-	carbon monoxide
CO₂	-	carbon dioxide
CVN	-	Calibration Verification Number
DDV	-	Durability Demonstration Vehicle
DLC	-	Diagnostic or Data Link Connector
DPFE	-	Differential Pressure Feedback EGR sensor (On Ford OBDII systems)
DTC	-	Diagnostic Trouble Code
dyno	-	dynamometer – may be either a chassis or an engine dyno
ECM	-	Engine Control Module - see ECU and PCM
ECT	-	Engine Coolant Temperature
ECU	-	Engine Control Unit - see ECM and PCM
EEC	-	Electronic Engine Control
EEPROM	-	Electrically Erasable Programmable Read Only Memory
EFI	-	Electronic Fuel Injection
EGR	-	Exhaust Gas Recirculation
EMR	-	Electronic Module Retard
EO	-	Executive Order (for aftermarket parts in California)
EPA	-	U.S. Environmental Protection Agency
ERMD	-	Emissions Research & Measurement Division, Enviro Canada
ESC	-	Electronic Spark Control
EST	-	Electronic Spark Timing
FLI	-	Fuel Level Indicator
FTP	-	Federal Test Procedure
g or gm	-	gram(s)
HG	-	Greenhouse Gas
GVRD -		Greater Vancouver Regional District
GVWR -		Gross Vehicle Weight Rating
HC	-	hydrocarbons
HDV	-	Heavy-Duty Vehicle
HEI	-	High Energy Ignition
HO2S	-	Heated Oxygen Sensor
hp	-	horsepower
IAT	-	Intake Air Temperature
I/M	-	Inspection and Maintenance
ISO	-	International Standards Organization
IUVP	-	In-Use Verification Program (EPA)

Abbreviations and Acronyms (continued)

kg	-	kilogram
KOEO	-	Key On and Engine Off
KOER	-	Key On and Engine Running
lb.	-	pound(s)
LDV	-	light-duty vehicle
MAF	-	Mass Air Flow
MAP	-	Manifold Absolute Pressure
MAT	-	Manifold Air Temperature
MFG	-	Manufacturer
mi.	-	mile(s)
MIL	-	Malfunction Indicator Light
mph	-	miles per hour
MY	-	model year
NESCAUM	-	Northeast States for Coordinated Air Use Management
NOx	-	oxides of nitrogen (or Nitrogen Oxides)
OBD	-	On-Board Diagnostics (Data Link)
OBD II	-	On-Board Diagnostics II
OBD X or III	-	Future remote interrogation style OBD systems
OEM	-	Original Equipment Manufacturer
OTAQ	-	Office of Transportation Air Quality (US EPA)
PCM	-	Powertrain Control Module - see ECU & ECM
PCV	-	Positive Crankcase Ventilation
PID	-	Parameter ID
PM	-	particulate matter
ppm	-	parts per million
PTC	-	Pending Trouble Code
QA	-	Quality Assurance
QC	-	Quality Control
RSD	-	Remote Sensing Device
rpm	-	revolutions per minute
SAE	-	Society of Automotive Engineers
SES	-	Service Engine Soon - dash light, now referred to as MIL
SFI	-	Sequential Fuel Injection
TBI	-	Throttle Body Injection
TPI	-	Tuned Port Injection
TPS	-	Throttle Position Sensor
TSB	-	Technical Service Bulletin
VCM	-	Vehicle Control Module
VIN	-	Vehicle Identification Number
VOC	-	Volatile Organic Compounds
VSS	-	Vehicle Speed Sensor
WOT	-	Wide Open Throttle

Table of Contents

Glossary of Terms

Abbreviations and Acronyms

Table of Contents

Executive Summary

1 Introduction to On-Board Diagnostics (OBD)

2 On-Board Diagnostics II (OBD II) Systems

- 2.1 OBD II - Basic Features
- 2.2 Malfunction Indicator Light (MIL)
- 2.3 Diagnostic Trouble Codes and Fault Codes
- 2.4 Readiness Monitors
- 2.5 OBD II Interrogation
- 2.6 Advantages for Vehicle Owners and the Repair Industry
- 2.7 OBD II and Information Requirements
- 2.8 OBD II - Some Issues and Problems

3 OBD II and I/M Programs

- 3.1 Issues Regarding OBD II Tests in I/M Programs
- 3.2 OBD II Tests - The Physical Application
 - 3.2.1 Is a Vehicle Fully OBD II Equipped?
 - 3.2.2 Operation of the MIL
 - 3.2.3 Location of the DLC
- 3.3 Test Results - The Scan Tool Readings
 - 3.3.1 Vehicle Ready or Not Ready - the Readiness Monitors
 - 3.3.2 Diagnostic Trouble Codes
- 3.4 OBD II versus Tailpipe Emissions Tests
 - 3.4.1 OBD II - The Identification of High and Low Emissions
 - 3.4.2 Lack of Overlap between OBD II and IM240 Test Results
 - 3.4.3 Catalyst Efficiency Monitoring
 - 3.4.4 NOx Emissions Monitoring
- 3.5 High Mileage Vehicles
- 3.6 Real-time Data Link
- 3.7 OBD II and Evaporative System Testing
- 3.8 Experiences with OBD Testing in I/M Programs
 - 3.8.1 OBD II in I/M Programs in the USA
 - 3.8.2 In Canada
- 3.9 Phasing-in OBD Testing
- 3.10 Costs of Incorporating OBD II into an I/M Program
- 3.11 Program Assessment

Table of Contents (continued)

4 The Potential for Fraud and Tampering

- 4.1 Potential Fraud and OBD II
 - 4.1.1 Manufacturers - Problems Related to OBD II Design
 - 4.1.2 Possible Inspector Fraud
- 4.2 Aftermarket Issues
 - 4.2.1 Part Replacement - Aftermarket Parts
 - 4.2.2 Reprogramming and Re-Calibration
- 4.3 Tampering
 - 4.3.1 OBD II Tampering Devices
 - 4.3.2 Experiences Related to OBD II System Tampering

5 Future OBD

- 5.1 OBD II - Changes in the Near Future
- 5.2 The In-Use Verification Program (IUVP)
- 5.3 OBD III

6 Discussion and Conclusions

References

Appendix A - OBD II Details

Appendix B - An OBD-I/M Test

Appendix C - States with OBD I/M

Appendix D - Canadian Vehicles

Executive Summary

Most modern spark-ignition engines installed in light-duty vehicles (LDVs) are equipped with fuel injection systems and a catalytic converter, and one of the most effective pollutant reduction combinations is the 3-way catalytic converter combined with a lambda (excess-air factor or air ratio) closed-loop control system.

In order to achieve the precise control that these modern systems require, virtually all of the automobiles and light trucks manufactured in North America since the early 1980s are equipped with an on-board computer. The vehicle's computer controls engine parameters such as the fuel injection system performance under dynamic operating conditions. These 'smart' computer systems are also known as *On-Board Diagnostics* or OBD systems.

The first OBD systems were manufacturer specific. That is the systems conformed to each vehicle manufacturer's design, hardware and software requirements. As such in order for a repair technician to interrogate the On-Board Diagnostics, the technician had to have access to the connection hardware and computer codes for each specific make and model vehicle. Also, while computerized OBD systems have been used to monitor vehicle systems since the 1980s, most of the earlier OBD systems monitored few if any emission control parameters.

More recently, the OBD systems on LDVs have been standardized and expanded to include the monitoring of most emissions control systems. These modern OBD systems, labelled OBD II, are now subject to regulation in the USA and Canada.

Standardization was the key. In general, OBD II systems, regardless of the type of vehicle, now monitor the same components, use the same computer language, and have the same criteria for evaluating systems and indicating problems to the driver and the repair technician.

The OBD II system monitors emission control systems and key engine components. When a problem that could cause a substantial increase in air emissions is detected, the OBD system turns on a dashboard warning light, the emissions Malfunction Indicator Light or MIL, to alert the driver of the need to have the vehicle checked by a repair technician. The OBD system monitors the status of up to 11 emission control related subsystems by performing either continuous or periodic tests of specific components and vehicle conditions. Three pieces of information can be downloaded from the OBD II system in a vehicle:

- Whether the emissions MIL is commanded 'on' or 'off';
- Which, if any, fault codes or Diagnostic Trouble Codes (DTCs) are stored; and
- Readiness Monitor status.

In general, OBD II systems are designed so that the MIL light does not go 'out' until the fault is repaired and reset by a technician.

In the USA, 1996 model year (MY) and newer vehicles up to 14,000 pounds are typically equipped with OBD II systems. All 1997 MY and newer diesel fueled passenger cars and light trucks are also required to meet the OBD requirements. In Canada, OBD II was not required by federal law until 1998 MY vehicles.

OBD II systems monitor emission control system performance and provide a warning that systems are malfunctioning. This should be a great benefit in the ongoing battle to reduce 'excess' in-use vehicle emissions in most urban environments in North America. However, while OBD II systems are a powerful new weapon in that battle, in general they will only be effective in reducing excess vehicle emissions if motorists or vehicle owners react in a responsible manner to the illumination of the OBD II systems warning light, the MIL.

Unfortunately, history indicates that motorists and vehicle owners often ignore such warning lights. Therefore, while OBD II provides a method of proactive emission control system repair, its development does not necessarily obviate the need for periodic in-use vehicle inspections. In order to gain the emissions reductions that OBD II systems are capable of providing, periodic inspections, such as those provided by an Inspection and Maintenance (I/M) program, are still required.

In the USA, federal law requires that OBD II testing be implemented in all states that have 'enhanced' (areas of more serious urban air pollution) LDV emissions Inspection and Maintenance (I/M) programs. To date, 32 States plus the District of Columbia are conducting OBD II testing as part of their I/M program inspections, or are about to begin such testing.

The setup for an OBD II test in an I/M program is far less complex than for most of the modern tailpipe emission tests. There are two basic steps. With the *Key On and the Engine Off* (KOEO), the MIL is checked to verify that it works. A cable is then attached to the on-board computer connection (called a Diagnostic Link Connector or DLC) and information is downloaded. This information provides a check of the OBD II system status and reveals any Diagnostic Trouble Codes (DTCs) that may have been 'set'. A 'set' DTC usually indicates that an emission control system has failed or is about to fail.

When used in an I/M program setting, the pollution prevention approach of the OBD II system does create certain test results that will differ from those of a tailpipe emissions test. However, one of the OBD II system's great advantages is that it provides near-continuous monitoring of a vehicle's systems whereas a typical I/M tailpipe emissions test only provides a 'snapshot' of those emissions at the time of the test. Based upon OBD II testing in the USA, the Clean Air Act Advisory Committee (CAAAC), reports that OBD II testing in an I/M program provides the following benefits:

- More accurate diagnosis and repair of emission control system problems,
- Shorter inspection times, and
- OBD provides unique evaporative emissions reduction benefits in that it detects certain evaporative control system defects.

Although OBD II checks are now required to be included in I/M programs in the USA, there are concerns related to those checks or tests. The OBD Workgroup of the CAAAC reviewed the most recent information on the three areas of concern raised in a July, 2001 National Research Council (NRC)/National Academy of Sciences (NAS) report, *Evaluating Vehicle Emissions Inspection and Maintenance Programs*. These concerns were related to the:

- Effectiveness of the 'pollution prevention' approach of OBD or the difference between OBD and an emissions test;
- An apparent lack of overlap in some vehicles that fail the traditional tailpipe test and vehicles that fail OBD checks; and
- OBD failure criteria and potentially high failure rates for aging vehicles equipped with OBDII (1996 and newer vehicles).

While there are data that indicate that OBD II has been found to miss some 'high-emitters', further testing is required to assess whether these are related to manufacturer OBD II system design problems and whether the number missed is significant. In regard to the lack of overlap issue while it admits that there are some problems, the United States Environmental Protection Agency (EPA) believes in OBD II and the use of OBD II testing in I/M programs. The EPA feels that OBD II is the most efficient and effective approach to maintaining low emission levels for the future fleet of vehicles (1996 and newer model years in the USA). EPA is conducting an ongoing assessment of high-mileage vehicles to monitor the operation of the OBD systems as they age.

Regardless, the simplification provided by the OBD II test is an advance over the more complicated tailpipe, emission test approach to I/M testing. However, as with tailpipe emissions tests, OBD II does raise some concerns in regard to fraud and tampering with OBD II test results and systems.

It is currently possible for an unscrupulous inspector in a tailpipe-based emissions test program to engage in a practice known as 'clean-piping', where a 'clean' vehicle is tested while the vehicle identification information for a 'dirty' vehicle is entered into the test record. Similarly, with OBD II testing, inspectors could 'clean-scan' an OBD-equipped vehicle.

The opportunity for 'clean-scanning' exists because the Vehicle Identification Number (VIN) is not currently included in the data stored in the vehicle's on-board computer. However, there are other vehicle identifiers that could help combat clean-scanning and the California Air Resources Board (CARB) is adding a Vehicle Identification Number (VIN) requirement to OBD II systems as of the 2005 model year. This action will be universal in the USA since all manufacturers currently certify to CARB requirements.

Several recommendations have been forwarded for combating fraud in regard to OBD II testing in an I/M program. Most of these recommendations relate to the need for a well-designed and strictly enforced Quality Assurance/Quality Control (QA/QC) program similar to the recommendations listed in the CCME Code of Practice for providing adequate QA/QC in LDV tailpipe emissions test I/M programs.

Tampering with OBD II systems is also a concern. There are tampering devices on the market that can be used to bypass the OBD system, and keep the MIL from illuminating. For example, there are numerous websites that offer the 'O₂ Simulator', which can eliminate Diagnostic Trouble Codes associated with a malfunctioning catalyst. Although these websites offer the components for 'off-road use only', it is quite possible that these devices are being used on 'on-road' vehicles to pass OBD I/M inspections. In the USA, both CARB and the EPA are working together and have begun enforcement actions against several manufacturers of OBD II 'defeat devices'.

As for other vehicle systems, it is suggested that provinces make legal provisions in regard to OBD II system aftermarket parts. In the USA, there is a federal system, and also one in California, for having a device granted an exemption under their anti-tampering provisions.

However, while tampering is a concern, to date there has been little evidence, from I/M programs in both Canada and the United States, of deliberate tampering with OBD II system hardware and software.

While the IM240 tailpipe test is currently recommended as the preferred I/M tailpipe emissions test by both the EPA and by the CCME in its Code of Practice for Light Duty Vehicle Emissions I/M Programs. One difficulty with the IM 240 emissions test is its complexity. This complexity not only relates to the implementation of the I/M program by provincial or regional authorities, but to the repair industry and to the public. In some cases, that complexity has estranged both the public and the repair industry from the I/M program.

OBD II testing offers a viable alternative to tailpipe testing for detecting excess emissions, or problems that will lead to excess emissions, from LDVs in Canada. OBD II systems and OBD II testing are not futuristic. OBD II systems have been an integral part of new vehicle operating systems in this country for almost seven years, two years longer in the USA. Similarly, OBD II system interrogation has been used in various LDV I/M programs in Canada and the USA for several years.

As noted, one clear advantage of OBD II testing, as compared to a dynamometer-based tailpipe emissions test is its simplicity. The simplicity of the OBD II test, as used in an I/M program, embraces not only the consumer, but the I/M Administration and the repair industry as well.

OBD II tests are brief and uncomplicated. The consumer does not have to worry about their vehicle since it is not driven at high speed on a dynamometer. The I/M administration does not have to set up or administer test facilities with complex hardware. And finally, the repair industry is not faced with test results that may leave their repair solution open to controversy.

It would appear, from the evidence available, that OBD II testing can be used in place of an exhaust emissions test for 1998 MY and newer Canadian vehicles. However, this conclusion is not forwarded without some reservations.

OBD II systems, like any other complex operating system, are not foolproof. Studies and experience have shown that there are problems with OBD II systems and the application of OBD II testing in I/M programs. In addition, OBD II systems are changing and evolving. Most of the changes that will be incorporated into OBD II systems over the next few model years are designed to solve problems that have been encountered or to add new capabilities.

Therefore, while the general conclusion is that OBD II testing can replace an exhaust emissions test, any agency that adopts such a course of action should be aware of the problems and the impending changes. Agencies such as the EPA and CARB continue to conduct vehicle studies and to work with vehicle manufacturers in an effort to solve problems and anomalies with specific makes and models plus with OBD II systems in general.

The administration of an I/M program that adopts OBD II testing as a replacement for exhaust emissions testing should have a comprehensive, well-supervised QA/QC program. It is also recommended that they keep in close liaison with the EPA and CARB regarding changes and developments in OBD II systems. The OBD II test program they implement should be flexible enough to adapt to changes in OBD II hardware and software specifications. They should ensure that scanners and associated hardware used by the inspectors and repair technicians in their I/M program can be upgraded, quickly and relatively inexpensively, to accept new OBD II specifications and codes, as they become available.

1 Introduction to On-Board Diagnostics (OBD)

In a modern spark-ignition engine many parameters and systems are monitored and controlled by a computer or computers that are installed on, or that are on-board, the vehicle carrying the engine. Prior to 1970, most engines were designed to run on rich mixtures, then increasingly strict emissions legislation forced designers to raise air/fuel (A/F) ratios and engines began to start operating on excess air. For most gasoline-fuelled LDVs, computer control of the air-fuel ratio became necessary if vehicles were to meet the 1981 United States Environmental Protection Agency (EPA) new vehicle emissions standards.

Consequently, most modern spark-ignition engines installed in light-duty vehicles (LDVs) are now equipped with fuel injection systems and a catalytic converter. One of the most effective pollutant reduction systems is a 3-way catalytic converter combined with a lambda closed-loop control system. The 3-way catalytic converter has the capability of removing (by oxidation or reduction) large portions the tailpipe emissions of hydrocarbons (HCs), carbon monoxide (CO) and oxides of nitrogen (NOx). A 3-way catalytic converter is able to best reduce the emissions of HCs, CO and NOx if the engine operates within a narrow scatter range centred around the stoichiometric air/fuel ratio.

Lambda control is a system for regulating the excess-air factor or air ratio, lambda, in a spark-ignition engine and in these modern engines with 3-way catalytic converters; lambda control is crucial for the optimization of the emissions of all three pollutants. The lambda closed-loop system attempts to control the air/fuel mixture entering the engine.

In order to achieve the precise control that these systems require vehicles are equipped with an on-board computer sometimes known as a 'powertrain control module' (PCM) or an 'engine control module' (ECM). The vehicle's computer system controls the fuel injection system performance under dynamic operating conditions. Lambda control is achieved by monitoring exhaust gas composition and making instantaneous corrections to the air/fuel (A/F) ratio. The monitoring device in this system is the oxygen or lambda sensor. (Bosch 1999, Illinois 2003)

Once computer controlled engines became the norm for most LDVs in North America, manufacturers realised that it was also necessary to develop computer diagnostic systems that would allow repair technicians to locate and service problems with these more complex engines. The service related systems they developed became know as On-Board Diagnostic (OBD) systems. A modern OBD system is capable of monitoring a number of sensors to determine whether they are working as intended. It can detect a malfunction or deterioration of various sensors and actuators, usually well before the driver becomes aware of the problem. The sensors and actuators, along with the diagnostic software in the on-board computer comprise the On-Board Diagnostics or OBD system.

The first widespread use of OBD to monitor emissions control components and parameters was in California in the 1990s. In California, On-Board Diagnostics I (OBD I) was California's first set of OBD regulations that required manufacturers to install OBD systems that monitored some of the emission control components on vehicles. Although OBD I systems were required on all 1991 and newer vehicles sold in California, these OBD I systems were not particularly effective because they only monitored a few emission-related components and they were not calibrated to a specific level of emission performance. In addition, the computer software coding and the OBD connection hardware were not standardized. (Bordoff 2003, CARB 2003)

OBD I was relatively simple and only monitored the oxygen sensor, EGR system, fuel delivery system and the engine control module. OBD I was a step in the right direction but lacked any requirement for standardization between different makes and models of vehicles. A repair technician had to have different adapters to work on different vehicles, and some systems could only be accessed with costly OEM scan tools. Another limitation of OBD I was that it could not detect certain kinds of problems such as a dead catalytic converter. Nor could it detect ignition misfires or evaporative emission problems. Furthermore, OBD I systems had no way of monitoring progressive deterioration of emissions-related components.

Recognizing the limitations of their OBD I systems, the California Air Resources Board (CARB) developed a new set of OBD standards. A standardized 16-pin Data Link Connector (DLC) with specific pins assigned to specific functions, standardized electronic protocols, standardized Diagnostic Trouble Codes (DTCs), and standardized terminology were outlined. (CARB 2003)

In the USA, the federal government also decided to act in regard to standardizing OBD. The EPA and CARB adopted a number of OBD standards established by the Society of Automotive Engineers (SAE). This new set of federal standards was labelled OBD II.

As a result of the federal Clean Air Act Amendments of 1990 in the USA, these newer, more advanced OBD II systems were built into all vehicles manufactured in the United States since 1 January 1996. In the USA, 1996 model year (MY) and newer vehicles up to 14,000 pounds are typically equipped with OBD II systems. All 1997 and newer diesel fueled passenger cars and trucks are also required to meet the OBD requirements. In Canada, OBD II became a regulated standard for LDVs for 1998 MY and newer vehicles.

OBD II systems are more 'user-friendly' for repair technicians. OBD II systems, regardless of the type of vehicle, now monitor the same components, use the same computer language, and have the same criteria for evaluating vehicle systems and for indicating problems. (New Hampshire 2003, Oregon 2003)

One objective of OBD II is to reduce the time between occurrence of a malfunction and its detection and repair. Consequently, the illumination of a Malfunction Indicator Light (MIL) on a vehicle's dash board is intended to alert both vehicle owners and repair technicians that there is something wrong with the vehicle and that repair or servicing is required.

However, in general, this early detection and repair objective can only be met if the vehicle owner and/or the repair technician take the appropriate action when the OBD II system illuminates the MIL. Unfortunately, experience has proven that vehicle owners cannot always be relied upon to take a vehicle for servicing when the MIL illuminates. Therefore, while OBD II provides a method of proactive emission control system repair, its development does not necessarily obviate the need for periodic in-use vehicle inspections.

In the USA, federal law now requires that an OBD II testing or interrogation program be implemented in all states that currently have, or required to have, 'enhanced' (in urban areas with the most serious vehicle emissions problems) light-duty vehicle (LDV) emissions Inspection and Maintenance (I/M) programs. (EPA 2003)

This report on OBD II has two objectives, to outline OBD II in general and to discuss the most salient issues related to the introduction of OBD II testing into light-duty vehicle (LDV) emissions Inspection and Maintenance (I/M) programs in Canada.

While the impetus of this report is OBD II and how it relates to light-duty vehicles (LDVs) and LDV Inspection and Maintenance (I/M), there is interest in regard to OBD II for heavy-duty vehicles (HDVs). As noted, the Clean Air Act Amendments of 1990, in the USA, contain provisions for a portion of the HDV fleet, those vehicles in the 8,500 to 14,000 pound Gross Vehicle Weight (GVW) range. While the EPA has not yet developed OBD requirements for vehicles over 14,000 GVW (because of the greater complexity of monitoring those systems), they have begun work on the OBD II requirements for HDVs in this weight class. Presently there are no regulations in California requiring OBD II systems on heavy-duty vehicles with a Gross Vehicle Weight Rating greater than 14,000 lbs., but CARB is also developing OBD II regulations for heavy-duty vehicles. (CARB 2003, EPA 1999, EPA 2003)

2 On-Board Diagnostics II (OBD II) Systems

On-Board Diagnostics II systems have been designed to reduce in-use vehicle emissions by monitoring for failure and/or deterioration of the powertrain and its emission-control systems on an essentially continuous basis. OBD II general requirements are that: (SEMA 2003)

- Virtually all emission-control systems must be monitored,
- Malfunctions must be detected before emissions exceed standards by a specified threshold (generally 1.5 X emission standard), and
- In most cases malfunctions must be detected within two driving cycles.

The EPA defines On-Board Diagnostics (OBD) II as a system of vehicle component and condition monitors controlled by a central, on-board computer running software designed to signal the motorist when conditions exist which could lead to a vehicle exceeding its emission standards by 1.5 times the standard. (Sosnowski 2002)

2.1 OBD II - Basic Features

(A number of the basic features of OBD II systems are discussed in this section; more details are provided in Appendix A.)

When a problem that could cause a substantial increase in air emissions is detected, the OBD II system turns on a dashboard warning light, the Malfunction Indicator Light (MIL), to alert the driver of the need to have the vehicle checked by a repair technician. A repair technician can then ascertain the status of various vehicle systems by connecting a 'scan tool' to the standardized connector, the Diagnostic or Data Link Connector (DLC).

In general, three pieces of information can be downloaded from a vehicle's OBD II system with a 'scan tool':

- Whether the emissions Malfunction Indicator Light (MIL) commanded 'on' or 'off';
- Which, if any, manufacturer fault codes or Diagnostic Trouble Codes (DTCs) are stored (i.e. have been activated); and
- The status of the Readiness Monitors.

The current OBD II systems monitor the status of up to 11 emission control related subsystems by performing either continuous or periodic functional tests of specific components and vehicle conditions: (Sosnowski 2001)

The three categories monitored on a 'continuous' basis are misfire, fuel trim, and comprehensive components.

The remaining eight subsystems are only monitored after a certain set of conditions have been met, or periodically. The algorithms for running these eight, 'periodic' monitors are unique to each manufacturer and involve such things as ambient temperature as well as driving conditions. Most vehicles will have at least five of the eight monitors:

- Catalyst,
- Evaporative system or leak check,
- Oxygen sensor,
- Heated oxygen sensor, and
- Exhaust Gas Recirculation (EGR) system.

The final three systems are not necessarily applicable to all vehicles:

- Air conditioning,
- Secondary air, and
- Heated catalyst.

2.2 Malfunction Indicator Light (MIL)

While engine check lights have been installed on vehicles for a long time, the OBD II system *Malfunction Indicator Light* (MIL) has a new standard application and importance. One of the prime objectives of OBD II is to alert the driver and/or the repair technician that there is a problem with one or more of vehicle's systems. The first level of alert is achieved via the Malfunction Indicator Light (MIL). While the most common designation is MIL, this indicator has also been referred to as the *Check Engine Light* and the *Service Engine Light*.

When the OBD computer detects a problem it may illuminate the MIL on the vehicle's dashboard. This light cannot be turned off until the necessary repairs are completed or the condition no longer exists. If the MIL illuminates with a steady light, the vehicle operator should contact a repair technician and schedule a service visit to determine what is wrong. Sometimes the indicator light goes out after being illuminated for a short time. This could happen if, for example, the gas cap was not on tight, but was then tightened. Under certain conditions, the dashboard light will blink or flash. This indicates a severe problem. If this occurs, the vehicle operator should stop the car immediately and refer to the owner's manual to determine if the car can be driven or should be towed to a service station. Continued operation of the vehicle could result in damage to emission control components, specifically the catalytic converter. (Nevada 2003, New Hampshire 2003)

Although some vehicle on-board computers may monitor non-emission-related components and systems at the manufacturer's discretion, in the USA federal regulations require that the MIL only be illuminated for emission-related malfunctions. (Sosnowski 2001)

2.3 Diagnostic Trouble Codes and Fault Codes

When the OBD II computer detects a problem, it sets and stores a *Diagnostic Trouble Code* (DTC) or Fault Code. When a car is taken in for diagnosis or for an annual emissions inspection, the repair technician retrieves any set Diagnostic Trouble Codes or fault codes from a vehicle's computer using the 'scan tool'. There are now over 400 possible trouble codes that can be stored in the OBD II system. (Bordoff 2003)

Other manufacturer specific codes may also set by the OBD II system. (See Appendix A for additional information.)

2.4 Readiness Monitors

As a vehicle is being driven an OBD II system performs tests on many different components to determine if the components are operating within allowable limits. *Readiness Monitors* are indicators used to find out if all of the emissions components have been evaluated by the OBD II system. Readiness Monitors can be set for the 11 systems noted in section 2.1. The EPA defines a Readiness Code set by a Readiness Monitor as: (Sosnowski 2002)

A status flag stored by a vehicle's on-board computer that is different from a DTC. This status flag does not indicate a vehicle fault, but rather whether or not a given monitor has been run, i.e. whether or not the component or system in question has been checked to determine if it is functioning properly.

In other words, the Readiness Monitor feature ensures that vehicles have had sufficient time to conduct all necessary emissions related diagnostics either: (Hyundai 2002)

- After a repair which resulted in the power to the ECM being interrupted, or
- Resulted in clearing of Diagnostic Trouble Codes (DTCs) using a scan tool.

When a vehicle's OBD II system is scanned, the Readiness Monitors can be identified by the scan tool as either:

- Ready - the monitor in question has been evaluated,
- Not Ready - the monitor has not yet been evaluated, or
- Not Applicable - the vehicle is not equipped with the component monitor in question.

In order for the OBD II system to clear the Readiness Monitors and complete its self-diagnostic checks, the vehicle must be driven under a variety of normal operating conditions. All of the self-diagnostic checks have not been completed if one or more Readiness Monitors read 'not complete' or 'not ready'. If a scan tool detects that all Readiness Monitors are set to 'ready', then all of the emission components connected to the OBD II system have been tested.

A number of factors, including emission repair work or a disconnected battery, can result in Readiness Monitors being set to 'not ready'. In most cases, the Readiness Monitors can reset to 'complete' very quickly, but in some cases, a few days of normal driving will be needed to do so. A repair technician may have to reset Readiness Monitors as part of the repair process, but generally, the car must be driven to reset Readiness Monitors. (BAR 2003) (See Appendix A.)

The status of the Readiness Codes is important for OBD II interrogations in regard to I/M programs. (See Chapter 3.)

2.5 OBD II Interrogation

Compared to a dynamometer-based exhaust emissions test, the equipment for and the test procedures for an OBD II interrogation are rather simple. An EPA guidance document provides the seven elements of an OBD I/M check. (Sosnowski 2001) (See Appendix B.) To provide additional assistance with OBD II interrogation procedures, in 2002, CARB published an OBD I/M Testing Flowchart for conducting an OBD II I/M test. (McCarthy 2002-1, ETOOLS 2003)

In general, there are two basic steps to the OBD test. With the *Key On and the Engine Off* (KOEO), the MIL is checked to verify that the bulb is working. Next, a cable from a 'scan tool' is attached to the on-board computer via the Diagnostic Link Connector or DLC, and the scan tool 'scans' the software or checks the OBD II system status. (Illinois 2003)

2.6 Advantages for Vehicle Owners and the Repair Industry

From an environmental perspective, the benefit of OBD II over its predecessors is that the OBD II system monitors and reports on the status of most of the systems in a vehicle that relate to and control emissions. Not only are components related to exhaust emissions included in the overall OBD II package, but the monitoring of the ability of the fuel storage tank seal to maintain pressure or vacuum, i.e. a type of leak check, provides an indication of possible excess fuel tank evaporative emissions.

Since the presence of faults or potential faults that could lead to excess emissions are relayed to drivers by the illumination of the MIL, the OBD II system provides motorists with the ability to be more proactive in regard to correcting emissions problems with their vehicles. Most conventional exhaust emission I/M programs features a once per year or biennial opportunity for a motorist to have emissions problems detected and repaired. In contrast, an OBD II system provides the opportunity for a motorist to have emissions problems (or potential problems) corrected before or soon after they occur.

One of the basic pillars of the OBD II system, compared to its predecessors, is standardization. As noted, the standard items include fault codes, communication protocol, connection hardware and the scan tools used to check the system. The service and repair industry benefit from the standardization provided by OBD II. The universal application of diagnosis to all makes and models that is provided by OBD II results in a significant reduction in the complexity and cost of instrumentation hardware for repair facilities.

The OBD II system also provides a measure of real-time diagnostic information, since the OBD II system monitors vehicle performance while the vehicle is being operated. The OBD II system also stores engine operating conditions and parameters upon the detection of a malfunction. These performance measurements, and the reporting of performance via stored codes, provides a repair technician with on-road engine parameter data that may not be available via tests conducted at a repair facility.

In California, vehicle owners can benefit when OBD II is used as part of a manufacturer's Warranty Reporting Program. In 2002, CARB reported on their Emission Warranty Reporting Program. Warranty claims in this program are usually triggered by the OBD II system on a vehicle. The features of this program are: (McCarthy 2002)

- The program uses warranty data to identify defective emission controls,
- Manufacturers must report when warranty claims for any one part exceed 1%,
- Additional reporting and assessment are required when claims reach 4%, and
- Corrective action required when true failure rate exceeds 4%.

In addition, CARB staff checks the accuracy of submitted data by performing field audits of dealership warranty records.

For areas that employ Inspection and Maintenance (I/M) programs as a tool for reducing excess emissions from in-use vehicles, OBD II testing or interrogation can provide benefits for both the motorist and the repair industry. From experiences with OBD in I/M programs in the USA, as of November 2002, an OBD Working Group concluded that OBD II provided the following benefits: (CAAAC 2002)

- Accurate diagnosis and repair – OBD minimizes trips back for second and third inspections which can be a problem in programs with emission-only I/M tests,
- Short inspection times of five to ten minutes, and
- OBD provides unique evaporative emissions reduction benefits in that it detects evaporative control system defects.

The use of OBD II testing in LDV I/M programs is discussed in detail in Chapter 3.

2.7 OBD II and Information Requirements

One of the reasons for the standardization of OBD codes, hardware, etc. was because first generation OBD systems were manufacturer specific, and the manufacturer's retained proprietary rights to those systems. However, the introduction of standardized OBD II systems did not necessarily open up the choice of repair options. The initial OBD II legislation did not require the vehicle manufacturers to provide all the essential information in regard to their OBD II systems. Also, anti-tampering features in the systems that were designed to assist in the maintenance of federal anti-tampering legislation limited certain repair functions.

However, the aftermarket parts industry in the USA felt that it needed detailed OBD II information in order to service or rebuild systems. This was in direct conflict with the manufacturers (the OEMs) that wished to restrict information access for what they claimed were proprietary reasons and to prevent tampering. Regardless, as a result of lobbying, both the EPA and CARB adopted new information requirements for OBD II systems.

In December 2001, the California Air Resources Board approved a series of regulations concerning On-Board Diagnostic II systems. CARB now requires that car companies permit independent aftermarket access to all service information and tools necessary to provide service and parts for late model vehicles equipped with OBD II systems. The Information Act, that became effective in April 2003, covers all 1994 and later model-year motor vehicles equipped with On-Board Diagnostic systems. (CARB 2003)

EPA's new Service Information Rule came into effect in 2003. That Rule contains a requirement that each vehicle manufacturer maintain all emissions-related information on an Internet web site that is accessible at a reasonable price to anyone who needs the information (EPA 2003)

Another information tool is the manufacturer's Technical Service Bulletin (TSB). Despite access to the codes provided by the standardized OBD II system, in many cases it has been reported that repair technicians could not repair certain vehicles without the information provided by a TSB. The experts at Colorado State University have stated that it is critical that technicians working on OBD II equipped vehicles have access to all TSBs. (CSU 2003)

2.8 OBD II - Some Issues and Problems

In general, OBD II systems work. In the USA, the federal Clean Air Act Advisory Committee (CAAAC), reported that in relation to OBD II system's ability to detect vehicle faults that 'OBD does appear to work': (CAAAC 2002)

In 2001, there were about 961 thousand vehicles recalled. 74% of the vehicles recalled were directly related to successful OBD operation in the field. 23% were non-OBD related recalls. 3% were software problems discovered and corrected by the manufacturer.

While OBD II does provide a number of advantages for vehicle owners and repair technicians, there are also a number of issues or problems related to OBD II systems and their interrogation. The OBD II software problems listed above are an example of one of the issues that have surfaced with respect to OBD II systems. Many of the problems or anomalies associated with OBD II systems apply to their application in LDV I/M programs and are discussed in Chapter 3.

3 OBD II and I/M Programs

OBD II systems monitor and report on the condition of vehicle emissions control systems. As such OBD II system interrogation has a place in, and should be a benefit to, a modern light-duty vehicle emissions Inspection and Maintenance (I/M) program.

However, I/M administrators should be aware that OBD II interrogation in an I/M program represents a major change in vehicle emission control system evaluation and monitoring. The tailpipe emission tests that have been employed in I/M programs for decades provide a 'snapshot' of emissions at the time of the test whereas OBD II interrogation provides a report from a system that monitors emission control system performance on a near continuous basis.

In addition, OBD II systems identify deteriorated components or systems that, if allowed to further deteriorate, will result in higher emissions. One OBD II system goal is to identify components in need of repair before emission standards are exceeded. (CAAAC 2002)

Although there is some controversy in regard to specifics, by their nature OBD II interrogations have a place in I/M programs. In the USA, EPA regulations require states to include OBD system checks within the so-called 'enhanced' I/M programs and both the EPA and CARB have provided guidance on how to perform such tests. (Sosnowski 2001, Sosnowski 2002, McCarthy 2002-1)

In regard to the vehicles to be included in the OBD II interrogation portion of an I/M program, in the USA the EPA requires all 1996 MY and newer vehicles be included in the OBD inspection. In Canada, LDVs were not required to be OBD II compliant until the 1998 MY. Therefore, the 1998 MY is the likely cutoff model year in a Canadian I/M program. (The EPA guidance for 1996 and 1997 MY Canadian vehicles is reprinted in Appendix D.)

3.1 Issues Regarding OBD II Tests in I/M Programs

Although OBD II checks are now required to be included in I/M program in the USA, there are concerns related to those checks or tests. The OBD Workgroup reviewed the most recent information on three areas of concern raised in the July, 2001 National Research Council (NRC)/National Academy of Sciences (NAS) report, *Evaluating Vehicle Emissions Inspection and Maintenance Programs*. These concerns were related to the: (Sosnowski 2001)

- Effectiveness of 'pollution prevention' approach of OBD. That is the difference between an OBD II interrogation and a tailpipe emissions test;
- The detection of a lack of overlap in some vehicles that fail the traditional tailpipe test and vehicles that fail OBD checks; and
- OBD failure criteria and potentially high failure rates for aging vehicles equipped with OBDII (1996 and newer vehicles).

Other concerns in regard to OBD II testing in I/M programs include the physical application of the OBD II test, including the operation of the Malfunction Indicator Lamp (MIL) and the interpretation of the Readiness Monitor codes. Another issue in regard to the use of OBD II in I/M programs concerns possible difficulties in evaluating OBD II test program effectiveness. (Holmes 2001)

3.2 OBD II Tests - The Physical Application

An OBD II interrogation or test is a relatively simple procedure. The EPA's seven elements of an OBD II I/M check and their five reasons for failure or rejection as a result of an OBD II test are listed in Appendix B. (Sosnowski 2001)

In regard to the use of OBD II interrogations in I/M programs, a number of questions and issues arise with respect to their physical application.

3.2.1 Is the Vehicle Fully OBD II Equipped?

Before a vehicle can undergo an OBD II interrogation, one must establish whether the vehicle is OBD II equipped. Two factors can assist this determination: (B&B 2003)

- 1) There will be an OBD II specific connector - the Diagnostic Link Connector (DLC), and
- 2) There will be a note on a nameplate under the hood that states that the vehicle is 'OBD II compliant'.

Since OBD II was not regulated in Canada until the 1998 MY, there may be difficulties related to 1996 and 1997 MY vehicles. The EPA has published a list of Canadian vehicle makes and their status in regard to OBD II testing in the USA. (Sosnowski 2002) (See Appendix D)

In addition, experience has shown that not all vehicles have all OBD II sensors. For example from a Colorado State University case study regarding evaporative system sensors: (CSU 2003)

On OBD II equipped vehicles, many vehicles have CARB (California Air Resources Board) approved evaporative emission system exemptions. These exemptions are allowed due to the design problems caused by large capacity fuel tanks (and their large vapor space). In fact, most vehicles with large capacity fuel tanks are built without evaporative system monitors.

A technician can pick out these exemptions by checking the monitor list on a scan tool. If a vehicle does not have an evaporative system monitor, the non-continuous evaporative monitor will be marked N/A, or some such equivalent. In this case, the OBD II system has no monitor to look for an evaporative emissions leak.

Also, regulated requirements for OBD II systems are changing. For example, in 2002 CARB adopted NOx catalyst monitoring as part of their OBD II requirements. This NOx conversion efficiency monitoring requirement will begin to be phased in on 2005 MY vehicles with full implementation on all cars by the 2007 MY. (McCarthy 2004) (See Chapter 5 for additional regulated changes.)

Therefore, a key to successful OBD II interrogation will be for inspectors and repair technicians to ensure that the software incorporated into their scan tools is up-to-date and contains all of the latest notifications, regulations and requirements in regard to the OBD II systems installed on each make and model.

3.2.2 Operation of the MIL

While the concept on the Malfunction Indicator Lamp (MIL) is relatively simple, there are a number of issues related to its use or operation.

Motorist MIL Awareness

For OBD II to serve its purpose, that of detecting and identifying emissions control system problems, an illuminated MIL is only of use if the motorist takes the appropriate action to correct the problem that caused the MIL to illuminate.

The motorist should not only take action in regard to an illuminated MIL but should be aware that with OBD II systems the MIL does not go out until the fault is repaired and reset by a repair technician. It is important that the motorist be aware of the Malfunction Indicator Light (MIL) and what an illuminated MIL signifies. Taking action in regard to an illuminated MIL should lead to the repair of potential or existing problems.

MIL Bulb Check

While it may seem trivial, one of the first steps in an OBD II test is to check to ensure that the bulb in the MIL is functioning, i.e. that the bulb has not burned out. Regardless, CARB has concluded that a burned out MIL bulb is not common: (McCarthy 2002-1)

MIL bulbs should rarely ever 'burn out'. Most vehicles that are identified as failing the bulb check are likely not due to bulb 'burn out'. They are more likely to be inspector error such as, did not see the MIL illuminate, or did not cycle the key off for a long enough period of time.

Incorrect MIL Identification

In I/M programs, vehicles have 'failed' because the MIL was 'on' for what are originally reported as 'undetected reasons'. However, evidence appears to indicate that it is likely that many of these difficulties relate to motorists and repair technicians being unfamiliar with the OBD II system. In some cases an illuminated dashboard light other than the MIL has been incorrectly identified and reported as an illuminated MIL.

The CARB OBD II interrogation flow chart contains a second test loop based upon a bulb check failure. This test loop requires an inspector to verify that the bulb did indeed fail to illuminate in the KOEO position. (McCarthy 2002-1)

If the MIL is commanded 'off' but the inspector failed the car for the bulb check or visual MIL on, it is probably worth having the technician verify the fail again. Many inspectors have falsely failed vehicles for maintenance reminder lights, ABS lights, or other non-MIL lights... cars that legitimately fail the bulb check should be something like 0.01% of all cars.

MIL problems related to refuelling.

Problems have arisen when the MIL is set because of a loose gas cap. If this happens, the MIL will not go out when the cap is tightened: (CSU 2003)

Several rental fleets have encountered problems with the MIL lamp coming on because motorists and fleet personnel have not been using the correct refueling procedure when filling the fuel tank with gas. On these cars, the OBDII system applies vacuum to the evaporative emissions control system to check for air leakage. If the gas cap is not tight or the tank is filled while the key is on or the engine is idling, it can trigger a false P0440 code causing the MIL light to come on.

For this reason it is important for motorists to switch off the engine before refuelling.

'Bad' gasoline has also been discovered to cause MIL illumination.

Colorado State University has also reported problems related to fuel quality. In one case, when a vehicle was diagnosed, a technician found a P0300 random misfire code. This code would normally be set by a lean misfire condition due to a vacuum leak, low fuel pressure, dirty injectors, etc., or by an ignition problem such as fouled plugs, bad plug wires, weak coil, etc. However, it was discovered that: (CSU 2003)

Water in the gas, or variations in the additive package in reformulated gasoline in some areas of the country, can increase the misfire rate to the point where it triggers a code.

Misfire and MIL problems

In designing OBD II misfire monitors, manufacturers are aware that misfire occurs as part of normal engine operation. All engines experience some misfire during normal operation. The OBD II system self-diagnostics track misfire by individual cylinder, and considers up to a 2% misfire rate as normal. (CSU 2003)

Therefore, a misfire monitor cannot simply look for misfire. What the misfire monitor must do is identify abnormal or excessive misfire. Obviously, this presents big engineering challenge. OBD II codes formatted P0300 through P0312 refers to engine misfire, with the last two digits indicating random misfire or the misfiring cylinder. Typically, the misfire is monitored using a crankshaft position sensor, with the computer monitoring crankshaft acceleration. However, Colorado State University has discovered other sources of MIL illumination due to false misfire signals: (Case Study 8 - CSU 2003)

Outside conditions can cause false misfire signals, with gravel roads or railroad tracks transmitting unusual accelerations back through the driveline to the crankshaft. Obviously, this is one potential source for false MIL illumination.

3.2.3 Location of the DLC

Problems have been detected in regard to the physical location of and connection to the OBD II Diagnostic or Data Link Connector (DLC) in specific makes and models. Many of these have been (and continue to be) dealt with by both the EPA and CARB in investigations and discussions with individual manufacturers. In addition, the EPA publishes guidance in regard to the location of the DLC, and manufacturers will publish DLC location for certain models in their Technical Service Bulletins (TSBs). (Sosnowski 2001, Sosnowski 2002)

The EPA OBD II guidance advises I/M administrators to be aware that some vehicles have atypical OBD configurations and should take steps to avoid unfairly penalizing motorists. An I/M inspector may incorrectly suspect motorist tampering for certain vehicles that were manufactured with the DLC in a hard-to-find location.

3.3 Test Results - The Scan Tool Readings

In addition to the physical application of the OBD II interrogation in an I/M program, there are a number of concerns regarding scan tool readings and the information that is downloaded as a result of the interrogation.

3.3.1 Vehicle Ready or Not Ready - the Readiness Monitors

In an I/M program, Readiness Monitor information is retrieved from the vehicle as part of the OBD II interrogation. As noted, the OBD system monitors the status of up to 11 emission control related subsystems by performing either continuous or periodic functional tests of specific components and vehicle conditions. When a vehicle is scanned at an OBD-I/M test site, these monitors can appear as either 'ready', 'not ready', or 'not applicable'.

As noted in Chapter 2 and Appendix A, following a repair procedure or a battery disconnection, an OBD II vehicle's computer will set the status of its monitors to 'not complete' or 'not ready'. The computer must then review the status of its emission control systems within the vehicle.

In an OBD II equipped vehicle, a Readiness Monitor determines whether a vehicle's on-board computer has completed its check of a specific emission control device. The tests are performed on many different components while the vehicle is being driven to determine if the components are operating within allowable limits. A limitation of the current OBD II systems is that, as presently designed, the on-board computer cannot run some of these tests or readiness checks until certain driving conditions are met.

During a normal I/M interrogation, the scan tool would count the completed Readiness Monitors to determine whether the vehicle meets the minimum requirements. Currently the US EPA requires the I/M program inspection to fail a vehicle if an insufficient number of readiness monitors are not completed.

How Many Readiness Monitor 'Not Ready' Flags are Acceptable?

Initially the EPA required a vehicle to be rejected if any of the Readiness Monitor codes were found set to 'not ready' during an I/M test. However, they found that this decision created too much motorist inconvenience. Therefore, they relaxed their initial requirement and allowed two Readiness Monitor codes to be set: (Sosnowski 2001)

- 1996 to 2000 model year vehicles can have 2 unset readiness codes
- 2001 model year vehicles can have 1 unset readiness code

In other words, in an I/M test, a vehicle should be rejected if it is MY 1996-2000 and has three or more unset, non-continuous readiness codes or is MY 2001 or newer and has two or more unset, non-continuous readiness codes.

The I/M program administration can set the number of systems it chooses to allow to indicate a 'not ready' status before the vehicle is rejected from I/M test. It seems that for rejection, it is important to set a higher number of unset Readiness Monitors particularly upon program startup. For example, in California, the state authorities decided to phase-in OBD II Readiness Monitor requirements: (BAR 2003)

On November 12, 2002, the Bureau of Automotive Repair phased-in the OBD II functional inspection readiness requirements by setting the Smog Check system's overall OBD II readiness threshold to 5. What this meant was that some vehicles did not pass their Smog Check if more than 5 of the 11 OBD II readiness monitors had not run to completion.

However, in an effort to comply with US EPA requirements, California gradually reduced the allowable number of incomplete monitors. CARB reports that as of September 2003, the failed Readiness Monitor code threshold was down to 3 before a vehicle automatically fails or is rejected from the test. (CARB 2003-1)

Regardless, in an I/M program the Readiness Monitor issue creates friction in regard to the communication of a Readiness Monitor count problem to a motorist. A Readiness Monitor set to 'not ready' may not necessarily be an indication that there is an emissions related fault with a motorist's vehicle, but a vehicle may be rejected for having too many 'not ready' monitors. Therefore, there is concern that Readiness Monitors may cause undue customer inconvenience. Customer annoyance is inevitable if there is an unnecessary 'ping-pong' effect as a vehicle is rejected from testing because of problems with Readiness Monitor codes.

In the USA, the report of the OBD Working Group listed concerns about the Readiness Monitor problem. In particular they worried about the implications for the I/M program if an excessive number of vehicles are rejected because of unset Readiness Monitors. (CAAAC 2002)

AirCare officials in British Columbia have expressed concern in regard to Readiness Monitors and the time taken for them to set and indicate that all monitors are 'ready'. Most Readiness Monitors reset almost immediately, but others will not reset unless the vehicle is driven over a 'drive cycle'. But how much time, or how long a drive cycle, is required for the Readiness Monitors to all indicate 'ready' and how much time is likely to be acceptable to motorists?

From experience in at least one state, if the OBD system senses that certain components are 'not ready' for testing during the inspection, the vehicle owner may be asked to complete a short drive cycle prior to testing. The purpose of a drive cycle is to give the OBD II computer in the vehicle a chance to review most of the systems and, if the vehicle was properly repaired, reset each system's status to 'ready'. (New Hampshire 2003)

One EPA suggestion is that in the case of a vehicle rejected for unset Readiness Monitor codes (which does not otherwise meet the failure criteria described in this guidance), the motorist should be given the option of operating the vehicle for a week under normal operating conditions. This prolonged driving cycle is an attempt to allow the on-board computer time evaluate the necessary monitors without being required to visit a repair facility prior to re-testing. Then if the monitors still have not performed an evaluation by the first retest, the motorist should then be advised to visit a repair facility where the monitors can be set based upon vehicle-specific, manufacturer guidance.

Since August 1998, Wisconsin's I/M program contractor has been sending the EPA OBD scanning and IM240 test results data collected on MY 1996 and newer vehicles coming through the Wisconsin I/M test lanes. In analyzing the Wisconsin data, EPA made the following observations regarding the readiness status of the OBD-equipped vehicles presented for testing: (Sosnowski 2001)

- The majority of vehicles showing up at the I/M lane with readiness codes reading 'not ready' were from the 1996 MY. The data collected to 2002 indicated that the 'not ready' rate for 1996 MY vehicles was approximately 5.8%,
- The frequency of vehicles with readiness codes reading 'not ready' dropped off with each successive model year to 2.2% for MY 1997 and 1.4% for MY 1998, and
- If an exemption were allowed for up to two readiness codes to read 'not ready' before a vehicle is rejected, the rejection rate drops to 2.2% for 1996 MY and to 0.2% for 1997 MY 1997 and 1998 MY, for a three model year average of 0.9%.

The EPA feels that state I/M administration authorities should make it clear to motorists that a vehicle rejected from the test because of Readiness Monitor codes is not necessarily an indication that it is a 'dirty' vehicle. The lack of readiness is a special status particular to OBD II systems and a vehicle is not necessarily producing excess emissions. Instead, the vehicle's emissions status is officially 'unknown' due to a failure to meet certain monitoring conditions prior to the inspection. (Sosnowski 2001)

The EPA has also suggested that alternatively, states may decide to have vehicles with a continued Readiness Monitor problem default to a tailpipe test. (Sosnowski 2001)

Regardless, none of these suggested solutions is likely to mollify a motorist or endear them to the I/M program. Especially if they are told that their supposedly 'short' OBD II test will either take considerably longer than expected (time for a prolonged drive cycle) or that they must return for another test. I/M program administrators should be aware of the potential for customer inconvenience that may be created by the Readiness Monitor problem. They will need to seek a solution to the 'not ready' for test vehicle problem that they feel is the best for their program.

Problems with the Readiness Monitors for Certain Manufacturers

The EPA recognizes that at present certain manufacturers have OBD II Readiness Monitor issues. A number of Readiness Monitor problems, for specific makes and models, have been published in the latest appendix to the EPA guidance. Some vehicles may have a high degree (relative to other vehicle families) of 'not ready' for catalyst, evaporative monitors or other monitors, depending on vehicle operation. Suggestions for handling these vehicles in an I/M program are published in the latest appendix to the guidance. (Sosnowski 2002)

Currently the EPA recommends that I/M programs waive the readiness requirement or otherwise accommodate specific makes, models, and model years of vehicles with known readiness design problems, in accordance with applicable Technical Service Bulletins and/or EPA guidance. (Sosnowski 2002)

Continuous Monitors

The EPA has also found that a small number of vehicles may be flagged as 'not ready' or 'not supported' for one or more of the continuous monitors i.e., misfire, fuel trim, and/or the comprehensive components. According to the EPA, this situation makes no sense because continuous monitors are designed to run continuously (as their name implies) and therefore should always be flagged as 'ready'.

In its investigation of this issue, the EPA has determined that the problem is the result of incompatibility between the vehicle and scanner software and is not indicative of a fault with the vehicle's OBD system.

However this is a serious issue since having an inappropriate number of Readiness Monitors set as 'not ready' can result in a vehicle being rejected from an I/M test. As a result of this discovery, the EPA recommends that programs disregard these continuous monitors when establishing the readiness status of the vehicle. However, the EPA stresses that this exclusion is for readiness determination purposes only and does not apply to a vehicle with a MIL commanded 'on' for a continuous monitor based DTC:

A vehicle with the MIL commanded 'on' for a continuous monitor based DTC should continue to be failed...EPA is working with state programs and OBD software suppliers to address this issue and will issue revised guidance as warranted. (Sosnowski 2001)

3.3.2 Diagnostic Trouble Codes

The EPA guidance recommends that if a vehicle fails the OBD II interrogation the test report given to the motorist should include the status of the MIL illumination command and the alphanumeric fault code(s) listed along with the DTC definition(s) as specified per SAE J2012 and J1930.

DTCs and the MIL Commanded 'On'

The EPA's 4th criterion for failure in an OBD II test (see Appendix B) states that a vehicle fails if any DTCs are present *and* the MIL status, as indicated by the scan tool, is commanded 'on', regardless of whether or not the MIL is actually illuminated. In other words, a computer scan revealing that a MIL is commanded 'on' takes priority over a non-illuminated MIL. However: (Sosnowski 2001)

Do not fail the vehicle if DTCs are present and the MIL status, as indicated by the scan tool, is *off*, because such non-MIL-triggering DTCs are considered 'pending' and frequently self clear without requiring repair of the vehicle. MIL command status must be determined with the engine running.

The EPA has also found cases where the MIL is commanded 'on' but no 'set' DTCs are detected. The reasons for this include: (Sosnowski 2001)

- X Communication problems related to the ECM reading MIL command status,
- X Some manufacturers indicate MIL commanded 'on' during the KOEO bulb check (i.e., status of the light is tied to the MIL command
- X Some early-build 1996 MY vehicles are incorrectly programmed to send a computer-commanded MIL 'on' message even if the dashboard MIL is not illuminated and there are no DTCs present (subject to recall under Emissions Recall Bulletin #EMR-02-001, November 2002), and
- X For some 2000 and 2001 MY vehicles, if the scan is initiated before the vehicle is running, the scanning equipment can receive a MIL commanded 'on'.

These anomalies or manufacturer specific OBD II system issues illustrate that in any I/M program the administration must ensure that the scanners used by their inspectors and repair technicians are equipped with the latest software updates. They must also have access to the latest information regarding specific problems as supplied by the EPA, CARB and the vehicle manufacturers.

Non-emissions Related Codes

The EPA revised OBD II test failure criteria require that a vehicle be failed for the presence of any Diagnostic Trouble Code (DTC) that results in the MIL being commanded 'on'. Some reviewers felt that this change could result in vehicles being failed for non-emission-related components or systems, such as the brakes or suspension. However, although some vehicle on-board computers may monitor non-emission-related components and systems at the manufacturer's discretion, the federal regulations in the USA require that the MIL only be illuminated for emission-related malfunctions. (Sosnowski 2001)

Other dashboard lights may be illuminated to indicate the need for service of a non-emission-related component or system, but the presence of such lights does not constitute grounds for failing the OBD-I/M check. Furthermore, the EPA claims to have examined data from over 300,000 OBD-I/M checks performed in actual I/M lanes and has not found a single instance of the simplified failure criteria leading to the failure of a vehicle for a non-emission-related component or system. (Sosnowski 2001)

The latest CARB and EPA OBD II information regulations require that manufacturers provide all Diagnostic Trouble Codes (DTCs) and the information for reprogramming of systems. This information must be published on individual Internet sites. (See Section 2.7.)

Additional Scanning Issues

The EPA guidance documents lists a number of other issues related to DTCs including:

- X Internal communication problems when DTCs are not being correctly relayed,
- X Trouble codes without an MIL commanded 'on' related to:
 - Reading pending codes,
 - Reading history codes, or
 - An Equipment Problem
- X Power down time - some vehicle makes require a longer computer shutdown time to reset,
- X Some makes will illuminate MIL on the dashboard when a scan-tool is connected, and
- X A mismatch in communications timing between ECM and Transmission Control Module (TCM) causes tester to display a 'No Response' or similar non-communication message.

For more information on these issues, the reader is referred to the EPA guidance documents and their appendices. (Sosnowski 2001, Sosnowski 2002)

3.4 OBD II versus Tailpipe Emissions Tests

Exhaust emission tailpipe tests of one type or another have been used for evaluating in-use vehicle emissions in I/M programs for decades. Therefore, it is inevitable that the results of OBD II interrogations would be compared to the results of tailpipe tests. However, as noted by the EPA, OBD and tailpipe testing are two different approaches to identifying vehicles in need of repair. The OBD system looks for broken or malfunctioning emissions control components on a continuous basis while the vehicle is operating on the roads and highways. The I/M tailpipe test takes a 'snap-shot' or sample of a vehicle's exhaust to see if it is above or below certain pre-scribed limits at the time of the test.

In regard to current I/M programs, comparison is being made between the IM240 exhaust emission test recommended by the EPA, and forwarded as the 'benchmark' in the CCME's Code of Practice in Canada. (CCME 1998) The California Air Resources Board (CARB) published the following comparison between IM240 and OBD II. (McCarthy 2000)

IM240 Objectives

- Simulate/predict FTP emission levels,
- Identify vehicles clearly not meeting certification FTP standards - roughly more that 2 times the standards, and
- Work in a test lane environment as part of an annual/biennial inspection.

OBD II Objectives

- Keep all vehicles at or below a level of 1.5 times the standards for the life of the vehicle,
- Reduce the time between the occurrence of a malfunction and its detection and repair by monitoring for failures whenever the vehicle is driven,
- Identify emission increases that occur during any driving condition, not just an FTP type driving segment, and
- Assist in the diagnosis and repair of emission-related problems.

In other words, OBD II identifies individual failures of components on a vehicle whereas IM240 identifies the cumulative impact of all failures or deterioration currently on the vehicle.

A major difference between an OBD II test and a tailpipe emissions test such as the IM240 is the impact that they have on the repair industry. While an IM 240 emissions test may identify a vehicle with excess emissions, the repairs required to reduce those emissions are not set but largely left to the discretion of the repair technician. However, the repairs required to correct an OBD II failure are more fixed.

When a vehicle fails an OBD II test because the MIL is 'on' and trouble codes are stored, there is a high probability that some form of repair action is needed and will be taken. The success of the repair will be easily verified by the MIL remaining 'out' following repairs and reset. However, with a vehicle that fails a tailpipe emissions test, the solution is not a clear cut and the outcome may not be as positive: (AirCare 2003)

In the case of an IM 240 failure where there are no stored codes, a technician must perform a number of diagnostic tests and apply considerable judgement to determine an appropriate repair strategy. Unless a clear fault is discovered during diagnosis, the outcome of the process might be that the vehicle be re-tested without repairs or that a generic solution is applied such as a new catalytic converter, oxygen sensor or both.

Therefore, of major concern for I/M programs is any differences between an exhaust emissions test and an OBD II interrogation that could make it is possible for a vehicle to pass a tailpipe emission test but fail an OBD test and vice versa.

While a number of problems and anomalies related to the issue of tailpipe test versus OBD II test are discussed in this Section, data submitted by the EPA indicates that failure rates for tailpipe versus OBD II tests in I/M program are similar: (CAAAC 2002)

Data from 1999 through 2001 from 534,000 OBD, I/M tests in Oregon and Wisconsin revealed an overall failure rate for OBD equipped vehicles was about 2.5 %. Failure rates for the oldest OBDII equipped vehicles, 1996 MY vehicles, were about 7%. These overall failure rates are consistent with what would be expected with the traditional tailpipe

3.4.1 OBD II - The Identification of High and Low Emissions

The results from some studies have shown that OBD II systems may either fail to detect vehicles with emissions well in excess of standards, errors of omission, or activate DTCs for vehicles with emissions that are below standards, errors of commission.

High Emitters - Errors of Omission

The Colorado Department of Public Health and Environment (CDPH&E) has an ongoing study to assess the performance of its IM240 lane emission test results and compares that performance to OBD II results: (CAAAC 2002)

In the course of their research a number of vehicles have been uncovered which are above the (1.5 x certification) OBD trigger threshold as measured on the Federal Test Procedure. In all cases these vehicles should have been identified by the OBD II system as in need of repair and the MIL commanded 'on'. However this has not always been the case in this study. Colorado has found vehicles with high emissions where the OBD II system has not indicated a malfunction.

Similarly, in Canada, AirCare officials have expressed concern in regard to vehicles that fail and IM240 but do not have lit MILs. (AirCare 2003)

One can understand that a MIL could come on before emissions have been affected enough to fail an IM 240 test, but why would a vehicle that has high emissions not have a MIL set?

A consistent problem for tailpipe emission tests is the lack of adequate preconditioning. This is particularly true for the IM240 test where the IM 240 test may produce a false failure if preconditioning is insufficient. However, while AirCare officials feel that preconditioning problems may explain some of the anomalies they have detected, preconditioning problems do not appear to explain all cases.

In Colorado, the I/M Administration found that some of the high emitting vehicles that were not detected by their OBD II systems were the result of manufacturer's OBD II design problems and these problems were being addressed by the manufacturers. (CAAAC 2002)

The findings of the OBD Workgroup in the USA confirmed that there have been cases of manufacturer OBD II design faults. The OBD II systems installed by some manufacturers have been found to be 'under-sensitive'. These under-sensitive OBD systems have failed to detect malfunctions at the proper levels. Both the EPA and CARB have taken action in these cases. Penalties have been assessed and remedial action taken. (CAAAC 2002)

However, while some vehicles with 'high' emissions were missed by the OBD II system, there is evidence that OBD II may perform as well or better than IM240. The NRC/NAS report on I/M claims that EPA data showed that of 21 vehicles with emissions two times greater than certification standards, 19 were identified by OBD and only 13 were identified by IM240. While 19 out of 21 illustrates that OBD II can be successful, the two vehicles that were missed also illustrate that high-emitters may not be identified by OBD II. (Holmes 2001, CAAAC 2002)

In British Columbia, AirCare indicates that their data show that OBD II has performed well. While the AirCare data also suggest that OBD II is not 100% effective in identifying all vehicles that have excess emissions, it was found that: (AirCare 2003)

More of the vehicles that had the MIL illuminated were found to be genuine high emitters and the total emission reductions achieved by successfully repairing these vehicles were greater than those achieved from the IM240 group.

While the ability of OBD II to identify high emitters must be monitored, there appears to be evidence to support its ability to capture high emitters. Anomalies in the OBD II systems produced by some manufacturers may account for some of the unidentified high emitters.

Low Emitters - Errors of Commission

The 2001 NRC/NAS report in the USA also reported data for vehicles with MILs illuminated that had low emissions: (Holmes 2001)

- The EPA reported 70% of OBD IM failures had emissions below certification standards,
- The EPA also reported 17% of OBD IM failures had a malfunction that could not be reproduced, and
- Durbin et al. (2001) found 63% of OBD IM failures had emissions below standards.

When it addressed the concerns of the NRC/NAS report, the OBD Workgroup in the USA felt that much of the problem in regard to these perceived errors or commission was do to a lack of understanding of OBD II system design. (CAAAC 2002)

The OBD II system is designed to identify malfunctioning emissions control components before emissions standards are exceeded. Therefore, OBD systems can identify deteriorated or broken components or systems that 'lead' to higher emissions. OBD systems identify repairs needed to prevent further deterioration of broken emission control components.

The current specification for OBD II systems is that the MIL will illuminate if a problem is detected that results in, or could potentially result in, emissions higher than 1.5 times vehicle's emissions certification standard. Studies show that if OBD II were used to decide whether a vehicle passes or fails an I/M inspection, most OBD II failing vehicles would have emissions less than 1.5 times the standard. That is because the emission control system malfunction that the OBD II detects may not yet have resulted in increased emissions.

Also many current I/M programs have much higher cutpoints than 1.5 times the vehicle's certification standard. Therefore, since OBD II is designed to detect problems and not to measure emissions, it is not necessarily a sign of an OBD II system malfunction that an MIL light is illuminated on a vehicle whose emissions are within set standards.

3.4.2 Lack of Overlap between OBD II and IM240 Test Results

Central to the issue of differences between OBD II and the IM240 emission test results is what appears to be a certain lack of overlap between OBD II and IM240 test results. This is a contentious issue particularly for the AirCare program in British Columbia that currently employs IM240 for its pass/fail decisions.

In regard to this lack of overlap, the NRC/NAS report expressed concern about the results of an assessment of Wisconsin I/M program lane data: (Holmes 2001, CAAAC 2002)

- The EPA...Wisconsin Lane Data results show - 1,479 OBD failures, 1,344 IM240 failures, and only 173 vehicles that failed both (out of 116,667 vehicles tested),
- Colorado Department of Public Health and Environment results show - 2,835 OBD failures, 393 IM240 failures, and 66 vehicles that failed both, and
- The EPA test results that show - 21 vehicles with emissions 2 times greater than certification standards, 19 identified by OBD and 13 identified by IM240.

The AirCare program in Vancouver, British Columbia has performed OBD II checks, for information purposes only, on vehicles entering their centralized I/M stations since January 2001. Their data also reveal a similar lack of overlap between IM240 failures and OBD II failures: (AirCare 2003)

During calendar year 2001, 60,929 OBD II interrogations were successfully completed.

- Overall, 466 vehicles were discovered to have the MIL commanded 'on' (or 0.76% of the vehicles tested).
- There were 493 vehicles in the sample that failed the IM240 test, but only 41 of these vehicles also failed the OBD II check.
- In other words, although 452 vehicles exhibited tailpipe emissions in excess of the IM240 cut points, for 90% the OBD II system was not indicating any fault. Conversely, of the 466 vehicles where the OBD II system had illuminated the MIL, 425 were still able to pass the IM240 test, despite the fact that the OBD II system had detected a fault within the vehicle.

In calendar year 2002, the number of OBD II interrogations increased significantly, due to the fact that both 2000 and 1998 model year vehicles required testing.

- In total, 143,146 OBD II interrogations were performed, 63,307 from the 1998 model year, and 71,296 from the 2000 model year. Overall, 2,039 were determined to have the MIL commanded 'on' (or 1.42% of the vehicles tested).
- Of these, only 328 also failed the IM240 test, and
- There were 2,865 vehicles that failed the IM240 test even though the OBD II system indicated a clean bill of health.

The lack of overlap between IM240 tailpipe emissions test and OBD II test results is of also of concern in Colorado, since their I/M program uses the IM240 emissions test. To verify the Colorado concerns the EPA procured 17 vehicles from the Colorado I/M program inspection lanes that were observed to have high tailpipe emissions according to an IM240 test but did *not* have the MIL illuminated: (CAAAC 2002)

When subjected to an IM240 test in the laboratory, 15 of the 17 were observed to pass. The study did manage to obtain 8 vehicles that had bona fide high emissions when tested to the IM240 cycle in the laboratory. Five out of these 8 vehicles failed the FTP test. When repaired, the vehicles that failed the IM240 test exhibited greater emission reductions on average than the vehicles repaired following an OBD II failure, however, more vehicles were identified using OBD screening than IM240 testing.

Therefore, while this lack of overlap between IM240 tailpipe emission test and OBD II test results is of concern, some of the incidents can be explained. In the case of the Colorado I/M program vehicles, it was found that some of the overlap came from vehicles misidentified as high-emitters by the IM240 tailpipe test. The Colorado study data suggests this could be as high as 15% of the vehicles seen to date. (CAAAC 2002)

A certain amount of the lack of overlap can also be explained by different nature of the OBD II tests. Obviously, if an OBD II system has commanded the MIL 'on' for a detected fault that has not yet resulted in excess emissions, that vehicle will fail an OBD II I/M test but not a tailpipe emission test.

As noted, OBD II also monitors parameters continuously whereas IM240 provides an emissions 'snapshot'. Therefore, an emission control component or system may have malfunctioned at some time prior to being brought for an emissions test. A fault detected and registered by the OBD II system may not be malfunctioning at the time of the 'snapshot' emissions test. Therefore, the vehicle would fail an OBD II test but not the IM240 emissions test. For example, a component failure that results in higher NO_x emissions only during highway driving would not necessarily be detected by an IM240 tailpipe test.

The EPA feels that given the robust nature of today's emissions control components, it is entirely possible for an individual component to malfunction without leading to an immediate increase in emissions at the tailpipe. It may also be possible for a component like the catalytic converter to temporarily compensate for an increase in emissions from a component that is broken: (EPA 2002)

It is because of this 'early warning' capability that OBD II will sometimes fail a vehicle that would otherwise pass a tailpipe test. In addition, OBD also monitors for leaks and other malfunctions in the fuel system, problems that traditional tailpipe tests were not designed to identify.

Another explanation for the lack of overlap is the issue of NOx emissions. The current OBD II sensors are designed to produce failure responses that are related to malfunction of a catalytic converter and excess HC emissions. Therefore, high NOx emissions may not trigger an OBD II fault response, but an IM 240 tailpipe test may discover those high NOx emissions and fail a vehicle that the OBD II system was not designed to detect. (See Section 3.4.4)

The OBD Workgroup offered a number of reasons for a lack of overlap: (CAAAC 2002)

- OBD systems identify repairs needed to prevent further deterioration of broken emission control components. Data from EPA and other studies indicate that half or more of the OBD I/M test failures identify vehicles in need of repair before they exceed the emissions standard (explaining half or more of the lack of overlap in OBD and tailpipe failures).
- The OBD-I/M inspections also identify evaporative system purge and pressure failures; the IM240 tailpipe inspections do not. Therefore, it is logical that there would not be an overlap in regard to evaporative emissions failures.
- OBD systems are designed to identify vehicle emissions-related failures occurring during all types of operating conditions, in real-time. IM240 and other tailpipe test methods are designed to identify vehicle emissions-related failures occurring during a representative set of operating conditions at a one-time inspection every one or two years.

Recently, CARB began a test program to study vehicles that fall into a group that can be labelled 'fail tailpipe, pass OBD'. Based on earlier studies, they feel that vehicles in the 'fail tailpipe, pass OBD' group will fit into three categories: (CARB 2003-1)

- Dirty cars that OBD misses,
- Clean cars that the tailpipe falsely says are dirty, and
- Dirty cars that are slipping through the I/M test because of the Readiness Monitor loophole (up to two monitors incomplete is ok to pass).

However, based upon previous studies, CARB officials think they will likely find that the number of dirty cars that are missed by OBD will be small. These studies also suggest that the total number of vehicles falling into the 'fail tailpipe, pass OBD' category is getting smaller and smaller. CARB is concentrating upon the 'fail tailpipe, pass OBD' group because it is felt that the other categories all have logical answers (including 'fail OBD, pass tailpipe') based on the design of these two different systems.

Regardless, the state of Colorado is sufficiently concerned in regard to OBD II versus emission test anomalies that it has set a new MIL or *Check Engine Light Policy* in regard to failing vehicles in the I/M program. The state has effectively deleted OBD II testing as a pass/fail tool: (Colorado 2002)

Effective April 1, 2003, an illuminated *Check Engine Light* is no longer a mandatory pass/fail component of the emissions testing process. If the *Check Engine Light* is illuminated, it is noted on the vehicle inspection report each motorist receives at the end of the emissions testing procedure. However, it is an informational tool for the motorist, rather than a reason for failure.

The OBD Workgroup agreed that the data show that of 2,823 On-Board Diagnostics (OBD) and IM240 tailpipe test failures (1,479 and 1,344 respectively), only 173 vehicles failed both tests. They also acknowledged that similar results have been reported in other studies by Colorado, Illinois and the EPA. However, the OBD Workgroup looked at the positive side with respect to these apparent anomalies: (CAAAC 2002)

The 2,823 failures were a subset of a total of 116,667 vehicles tested, meaning that, for the purpose of identifying clean vehicles, the OBD-I/M test and the IM240 tailpipe test agreed more than 97% of the time.

In summary it would appear that one or more of the following may account for the lack of overlap in I/M test failures that has been observed between OBD II and IM240:

- An inherent difference in system design and purpose,
- OBD II system fault related to a specific manufacturer's design problem,
- OBD II detecting a driving cycle fault not seen during an IM240 emissions 'snapshot',
- An OBD II design loophole that currently does not register high NOx emissions related to a catalytic converter fault, and
- OBD II detecting an evaporative control system fault that is not a part of an IM240 test.

The issue of the lack of overlap between OBD II and IM240 emission test results has not been resolved, however, the test data that have been collected to date appear to indicate that the problem may not be as serious as first indicated. I/M administrators should be aware of the problem and should monitor the latest data published by the EPA, CARB plus state and provincial I/M programs in regard to the problem.

3.4.3 Catalyst Efficiency Monitoring

A Colorado State University research team feels that from an engineering standpoint the misfire, evaporative and catalyst monitors are unique and new to OBD II systems. Because of this, the manufacturers have had the hardest time developing these monitors. (CSU 2003)

In particular, problems were discovered in regard to the effectiveness of the OBD II catalyst efficiency monitoring on a group vehicles tested at Colorado State University (CSU). The following is an example of what appears to be a 'glitch' in regard to catalyst efficiency DTCs that were set on three vehicles: (CSU Case Study 7 - CSU 2003)

After scanning three vehicles with lit MILs, the CSU team discovered that they all had a set catalyst efficiency Diagnostic Trouble Code, either a P0420 or P0421. A Federal Test Procedure (FTP) was performed on each vehicle. In each case, the vehicle came out of the test with 'clean' exhaust. However, all three vehicles had manufacturer Technical Service Bulletins that required reprogramming of the Powertrain Control Module (PCM). For these three vehicles, dealerships performed a reflash of the PCM and the MIL was extinguished without catalyst replacement

While problems of this nature are serious, they are indicative of problems with individual manufacturer system design and do not necessarily signal an inherent fault with OBD II in general. Since the manufacturers involved issued Technical Service Bulletins for the models in question, they were obviously aware of technical problems with their software. Both the EPA and CARB have ongoing investigations regarding possible problems with OBD II software on certain makes and models.

3.4.4 NO_x Emissions Monitoring

The catalyst efficiency monitors in the present OBD II systems are largely HC-based. The present catalyst monitors are only required by California regulation to indicate a catalyst malfunction when tailpipe emissions increase to 1.75 times FTP HC standards, unlike other monitors that are required to indicate a malfunction before a vehicle exceeds 1.5 times FTP standards which includes HC, CO, and NO_x. As a result, for the present catalyst efficiency monitors the vehicle manufacturers are only required to calibrate to HC conversion efficiency. When OBD II was adopted, HC conversion seemed to best correlate with oxygen storage and HC emissions were a priority in California. (McCarthy 2004)

For current OBD II systems catalyst efficiency is monitored by comparing pre and post-catalyst O₂ sensor waveforms to determine if the converter is functioning correctly. While the current catalyst monitors are not necessarily solely HC-based, as noted by CARB, they are calibrated to be sensitive to increases in HC emissions.

Colorado State University testing has also revealed limitations related to catalyst efficiency monitoring, particularly in regard to NO_x emissions. While engine control systems are designed to illuminate the MIL when any exhaust pollutant exceeds 1.5 the applicable Federal standard, the existing catalyst monitors are only required to illuminate the MIL when HC emissions exceed the standard. For example, FTP tests on one vehicle revealed that it had slightly elevated HC and NO_x emissions, but the CO emissions were almost two times the federal standards, and yet the MIL was not lit. However, after examining the evidence, the CSU team concluded that the OBD II system on the vehicle in question had performed exactly as designed. Because the OBD II system only had to set a DTC when the HC emissions were high, the OBD II system on this particular vehicle was working fine despite the excessive tailpipe CO emissions. (CSU 2003)

The AirCare program also has evidence that supports the issue that elevated NO_x emissions may go undetected or not be registered by an OBD II system: (AirCare 2003)

The program administration office has encountered cases where NO_x emissions have been well above certification standards. The data are from a tailpipe emission test and with no accompanying indication of a vehicle fault from the OBD II system. Due to the sensitivity of NO_x conversion in the catalytic converter to air-fuel ratio, the OBD II system may not detect a slight lean shift that would be enough to have a significant impact on NO_x output. These cases would appear as tailpipe failures but OBD II passes.

This lack of NO_x emissions monitoring likely accounts for some of the lack of overlap between OBD II test results and those from IM240 emissions tests as discussed in Section 3.4.2.

However, as noted, OBD II systems are evolving and the situation in regard to NO_x emissions is changing. In California, NO_x emissions have become a priority and technology advances now show that NO_x conversion also correlates very well with oxygen storage, thus enabling the use of a monitor calibrated to NO_x conversion efficiency. NO_x conversion efficiency monitoring has been adopted and will begin to be phased in on 2005 MY vehicles. The OBD II systems on all 2007 MY vehicles will be required to monitor for NO_x conversion efficiency. (McCarthy 2004)

3.5 High Mileage Vehicles

OBD II was introduced to provide real-time data on the performance of emissions control systems, however, there has been some concern expressed as to how the OBD II systems will react as the vehicles and their emissions control systems age. In the USA, a July 2001 report of the National Research Council (NRC)/National Academy of Sciences (NAS) titled *Evaluating Vehicle Emissions Inspection and Maintenance Programs* expressed concern regarding OBD failure criteria and potentially high failure rates for aging vehicles equipped with OBDII. (Sosnowski 2001)

Recently officials from the AirCare program in Vancouver also express concern that the OBD II system may be too sensitive and therefore is likely to lead to expensive repairs for vehicles once they reach advanced age and mileage. (AirCare 2003)

Unfortunately, it would appear that there is little information on the long-term use of OBD II in I/M programs or on how the OBD II systems will react once they have been installed on vehicles for a long period of time. There is also a lack of information regarding the performance of OBD II systems in detecting faults in vehicles that accumulate high mileage. While evidence indicates that OBD II systems work, the EPA also has questions regarding the impact of OBD II I/M failures as vehicles age or accrue significant mileage.

This concern, in part, reflects the fundamental difference between how an OBD II system alerts a technician that repairs are required versus how a traditional tailpipe emission test triggers repairs. In general, I/M programs that feature an exhaust emissions test provide little additional information that can be used to target the component or system failure that has led to the high emission reading. While most of the tailpipe test programs offer some information on repair possibilities, in such programs, repair technicians have a fair degree of discretion when it comes to the repairs that are needed to address high emissions. OBD II systems, on the other hand, identify specific components and/or systems in need of repair or replacement.

As a result, the EPA foresees the possibility that some advanced-aged OBD-equipped vehicles could be failed for DTCs for which the only available repair option would cost substantially more than the fair market value of the vehicle itself. Under such a scenario, a repair cost waiver option does not offer much consumer protection, since such repairs tend to be all-or-nothing propositions. In their OBD II guidance document, the EPA acknowledged that it is possible that the EPA may need to limit the criteria for failing OBD-equipped vehicles after such vehicles reach an as-yet undetermined age and/or mileage. (Sosnowski 2001)

However, to fairly assess this issue it should be separated into two distinct problems or concerns:

- The correct function of OBD II systems as they age, and
- The problem of older high emission vehicles in an I/M program.

OBD II System Function with Age

Linked to the issue of aging vehicles and systems is the durability of the OBD II systems themselves. In general, the characteristics of most electro-mechanical systems will change to some degree as they age. The question in regard to OBD II systems is, will the aging of the on-board computer or computers and the associated monitoring hardware cause problems that will result in errors with respect to the setting of Diagnostic Trouble Codes and the illumination of the MIL? This problem will then become one of who or what monitors the monitors?

In regard to the computers that are a part of an OBD II system, in non-vehicle applications, modern computers and sensors have proven to be relatively durable. In general, if a personal computer and its associated systems are going to 'break' or otherwise malfunction, they seem likely to do so within the first six months of operation. Applying this same discovery to vehicle-based computers and sensors, it is likely that problems with OBD II system computers will occur during the period of the new vehicle warranty.

However, an OBD II system also relies on input from a large number of sensors to correctly assess the performance of the vehicle's emissions control systems. However, not only is the performance of these sensors likely to alter as they age, but they may break or otherwise malfunction. For example, oxygen sensors can be problematic and most OBD II systems employ more than one.

In the USA, a Workgroup under the Mobile Source Technical Review Subcommittee, provides policy advice to the EPA and various States to help facilitate effective implementation of OBD II testing in vehicle Inspection and Maintenance (I/M) programs. In a recent report, that Workgroup listed OBD durability as one of the issues that it is studying. (CAAAC 2002)

Older High Emission Vehicles in an I/M Program

However, if an OBD II system is functioning as designed as it ages, then the issue of how OBD II systems handle high mileage and older vehicles is neither unique nor new to I/M programs.

If the purpose of vehicle testing I/M program is to detect and repair vehicles with significant excess emissions, then the OBD II system should not be faulted for detecting those vehicles even if those vehicles are old and not worth much money. If the OBD II systems in aging, high mileage vehicles are performing as designed then the issue is how to handle older, high emitting vehicles in LDV I/M programs and not how to compensate for OBD II systems as they age.

All I/M programs must confront the issue of older, high-emitting vehicles. A simple solution would be to take all older, high-emitting vehicles off the road, but this solution ignores the economic impact of such a policy on a large number of lower income citizens.

Solutions

For an in-use I/M program, the OBD Workgroup in the USA recognized that the OBD II failure point might be too stringent for a cost-effective and publicly acceptable I/M program especially for older OBDII vehicles. They suggested that an alternative approach, such as tailpipe testing, might be needed for those vehicles. The NRC/NAS report also forwarded a suggestion that tailpipe emission testing might be needed for older OBD II vehicles if failure rates become unacceptable. The EPA also feels that traditional tailpipe I/M testing will still play an important role as the means of accurately identifying vehicles that need emission-related repairs for 1995 and older vehicles, and may be needed for OBD-equipped vehicles as they age. Overall, the Agency believes that both OBD and tailpipe testing remain important components of I/M programs. (CAAAC 2002, Holmes 2001)

However, one of the purposes of OBD II system interrogation in an I/M program is to act as an alternative to complex dynamometer emissions tests. Therefore, is it likely that an I/M program administration that has selected OBD II for its primary I/M test would then decide to initiate emissions tests for older vehicles? One of the main reasons for a switch from I/M emissions testing to OBD II interrogations is the comparative simplicity that the latter offers for motorists, repair technicians and I/M administrators.

Another solution proposed by the OBD Working Group in the USA was to exempt certain DTCs on older vehicles, and only require repair for the most significant trouble codes. (CAAAC 2002)

The EPA is currently conducting an ongoing assessment of high-mileage vehicles in order to monitor the operation of the OBD systems as they age. (CAAAC 2002)

However, if the issue is how to handle high-emitting older vehicles in an I/M program, then the administration of an I/M program must develop a policy that is consistent with their overall goals. If the true objective of their program is to eliminate or repair high-emitting vehicles, then the age of the vehicle or its mileage should be of little concern.

3.6 Real-time Data Link

In regard to OBD II testing in an I/M program most of the essential operating principals for centralized and decentralized programs would remain the same. One of the most important features of a modern I/M program is a real-time data link between test instrumentation and the I/M administration.

While most I/M program inspection facilities are likely to be equipped with the more expensive stand-alone OBD II scanners, some may attempt to use the less expensive hand-held units. The latter is particularly true for decentralized test and repair programs.

The EPA has concerns about the use of hand-held OBD II scanners in I/M programs and those concerns relate to hand-held scanners not being linked to the recommended real-time data-link system: (Sosnowski 2001)

Hand-held scanners usually do not generate automatic test reports and are not tied to a real-time data-linked system. While the use of stand-alone scanners is not barred by I/M regulations...EPA nevertheless sees several drawbacks to the stand-alone approach to OBD-I/M testing.

The EPA feels that if there is no real-time data link to the main I/M program computer then oversight of the program will be more difficult. One of the main reasons for instituting a real-time data-link was to attempt to reduce the possibility of fraud in relation to I/M test results. There is also the possibility of data corruption during the manual transfer of data from a hand-held unit to an I/M computer. Losing the real-time data link would therefore be a step backward.

At a minimum, the EPA believes that for an OBD-I/M test program to be most effective, whether centralized or decentralized, it should be designed in such a way as to allow for: (Sosnowski 2001)

- Real-time data link connection to a centralized testing database;
- Quality-controlled input of vehicle and owner identification information (preferably automated, for example, through the use of bar code); and
- Automated generation of test reports.

However, it would seem that these are likely short-term concerns. In this era of burgeoning wireless communication it will surely not be long before hand-held units will be available that will have a wireless real-time link to an I/M central computer.

3.7 OBD II and Evaporative System Testing

While OBD II testing is recommended for I/M programs, the EPA's analysis of the Wisconsin I/M lane data suggests that OBD-I/M testing can be supplemented by including a separate gas cap check.

The EPA compared the failure rates for the evaporative portion of the OBD-I/M test to the failure rate for the stand-alone gas cap test. They found that the separate gas cap test was able to identify a substantial number of leaking gas caps that were not identified by the OBD II monitors due to the different failure thresholds. (Sosnowski 2001)

The stand-alone gas cap test was designed to detect a leak as small as 60 cubic centimeters per minute (cc/min) at a pressure of 30 inches of water, while OBD systems were designed to detect leaks equal to a circular hole 0.040 inches in diameter. The 0.040 inch hole equates to a flow rate in excess of 2,600 cc/min at 10 inches of water column (i.e., the maximum allowable internal tank pressure using the enhanced evaporative emission test). As a result, an OBD system can reliably detect a loose or missing gas cap, while a properly tightened but leaking gas cap that can easily be identified by the gas cap test will probably not be identified by OBD.

However, from their experience, AirCare officials in British Columbia have reservations about a test that requires the gas cap to be removed from the vehicle. In effect, such a procedure violates the basic tenet of OBD, that is, to test systems on-board the vehicle. Their data also indicate that the stand-alone gas cap test can produce a high rate of test variability and false readings that result from problems with the test equipment. While, due to the EPA recommendation, the gas cap pressure should still be considered as a compliment to OBD II testing, agencies may wish to investigate this additional test more closely before adding it to their I/M program.

3.8 Experiences with OBD Testing in I/M Programs

The I/M programs in Canada and the USA that currently include (or will soon include) OBD II testing are listed in Table 3.1. The majority of these programs also feature some form of emissions testing, but a few rely almost solely on pass/fail decisions that result from OBD II interrogations.

3.8.1 OBD II in I/M Programs in the USA

As noted, the EPA requires OBD II testing to be integrated into 'enhanced' I/M programs in the USA. As a result 32 States plus the District of Columbia now incorporate OBD II interrogation into their I/M programs. The timing for the introduction of those tests has varied. While some have only recently begun (or are soon to begin) OBD II testing on a pass/fail basis, others have been doing so for several years. (EPA 2003)

The data show that most programs now confine their tailpipe emissions tests to 1995 MY and older LDVs. (Additional details are presented in Appendix D.)

Of the states that feature OBD II testing, four do not require vehicles to undergo any form of exhaust tailpipe test:

- One state, Vermont, features an OBD II test for 1996 MY and newer vehicles and that is the only test requirement for vehicles in their I/M program,
- Two other states, Louisiana and Maine supplement their OBD II test with a visual catalyst inspection and a gasoline cap pressure test, and
- When New Hampshire begins pass/fail OBD II testing in mid-2004 they plan to supplement that test with a tampering inspection for 1980 MY and newer vehicles.

Six other states, Alaska, Delaware, Nevada, New Mexico, North Carolina, and Tennessee, employ the OBD II test for 1996 MY and newer vehicles and test older vehicles using a combination of a simple idle or a two-speed idle test.

While Vermont employs only the OBD II test in their I/M program, California is at the other end of the spectrum. Currently in California, in the 'enhanced' I/M program areas of the state, vehicles must undergo OBD II testing, an ASM dynamometer-based emissions test and various visual and function tests. OBD II equipped vehicles are required to undergo all of these tests and can fail the I/M inspection if they fail any one of those tests. (CARB 2003-1)

In addition to California, nine other states employ the OBD II test for 1996 MY and newer vehicles and a form of the ASM test for 1995 MY and older vehicles.

Six states complement the OBD II test by employing an abbreviated transient emissions test, which conforms to a portion of the IM240 test, to test older vehicles.

Six states indicate that they employ the full IM240 test. Of those six, four states, Washington DC, Illinois, Maryland, and Wisconsin, do not require the 1996 MY and newer vehicles that receive an OBD II test to undergo the IM240 test. However, the fifth, Missouri does use the IM240 test as a second chance test for 1996 MY and newer vehicles that fail the OBD II test.

The sixth state using the full IM240, Kentucky, employs some interesting test procedure variations. As in parts of Missouri, in the Louisville area of Kentucky if a vehicle fails an OBD II test it is required to undergo an IM240 test as a second chance test. If it passes the IM240, although it failed the OBD II test, it is still considered to have passed. In the northern part of the state officials decided not to use the OBD II test as the initial test. However, if a vehicle fails an IM240 test it is required to undergo an OBD II test, presumably as a check for emission control component problems.

Program Test Results

In December 2001, the EPA reported on OBD data from two centralized I/M programs in Oregon and Wisconsin and from three decentralized I/M programs in Vermont, Utah and Maine. The general conclusion was that the success and failure data from five programs looks similar: (Gardetto 2001)

- overall success ~98%,
- overall fail rate ~2.5%,
- overall "not ready" ~1.0%,
- OBD test takes less time ~5 minutes,
- MY 1996 fail rate of ~7%, and
- Less "ping-pong" on repairs.

Following a review of the OBD test data from I/M programs that were available up to the end of 2001, the EPA concluded the following: (Gardetto 2001)

- OBD can be effectively performed in an I/M program,
- OBD does miss some 'dirty' vehicles,
- OBD does identify 'clean vehicles' that are broken,
- OBD can identify evaporative problems, and
- OBD identified repairs are easier to repair than I/M tailpipe only identified repairs.

Some of the Experiences of OBD and I/M as of November 2002 have been summarized by the OBD Working Group, of the Clean Air Act Advisory Committee (a US Federal Advisory Committee): (CAAAC 2002)

- Oregon and Wisconsin data show that the average OBD failure rates are similar to tailpipe testing, at final cutpoints for the same model year vehicles, when all three pollutants (HC, NOx, and CO) are measured by both tests.
- Oregon and Wisconsin data also show an overall failure rate for the OBD fleet of approximately 2.5%, and 1996 and 1997 model year failure rates are 7% and 3.4% respectively.
- The most frequent causes of OBD failures include oxygen sensors, misfires, exhaust gas recirculation (EGR), and evaporative codes (over 65% of codes from combined Oregon/Wisconsin OBD failure data). EPA high mileage study data agrees with these data showing 70% of OBD failures for the same systems.
- OBD I/M scan tool (used by an inspector to query a vehicle's OBD system) communications rates of 99% and higher can be expected in operating programs.
- Rejection of vehicles for being 'not ready' is low (4.8% in MY 1996 and 1.2% in MY 1997) assuming the program uses the recommended guidance.
- Average repair costs are about the same for OBD and tailpipe testing at about \$270 [Oregon study]. Average repair costs at high-mileage, or over 100,000 miles, are statistically the same for OBD and tailpipe testing, averaging around \$370 in the EPA High-Mileage Study.
- Average emissions reductions are statistically the same between OBD-based repairs and tailpipe testing-based repairs. This does not include any future emissions reductions resulting from repairs based on early detection of emission control component failures.
- Cumulative emissions reductions are similar between OBD identified repairs and tailpipe identified repairs.

However, not all of the experiences related to OBD II tests in I/M programs have been positive. In Colorado, their 1994 and newer vehicles are checked for OBD computer codes in the I/M program. Because of questions in regard to OBD II testing, OBD test results are now considered to be advisory only. In the Colorado I/M program an illuminated MIL is no longer a reason for a pass/fail decision on a vehicle.

3.8.2 In Canada

In Vancouver, over a decade ago during the first phase of the AirCare, the I/M program included the gathering of OBD information from vehicles so equipped. However, the lack of standardization of those first generation OBD systems caused testing difficulties. For those early systems it was often difficult to locate the Data Link Connector and it was found to be impractical to attempt interrogation of the many different OBD systems. Largely for the reasons that OBD II was developed, these early OBD interrogations were dropped because they were too time consuming and largely unrewarding from an emissions reduction standpoint.

As of 1 January 2001, the second phase of AirCare began OBD II interrogations on 1998 and newer vehicles. As of the date of publication, AirCare has accumulated data from close to 200,000 interrogations. However, to date, these OBD II data are gathered for information and advisory purposes only. AirCare is presently involved in an analysis of the various alternatives for the next stage of their I/M program. This analysis includes the possible use of the OBD II test for making pass/fail decisions in regard to the emissions worthiness of a vehicle. (AirCare 2003)

The Drive Clean program in Ontario features an OBD II interrogation for 1998 and newer LDVs, but while the OBD II system output is monitored, no information is downloaded or recorded.

Table 3.1 Data Related to Current I/M Programs that Feature OBD II*

	State or Province***	OBD II Check**	IM 240	Other Dyno Test	Other Tests
C1	British Columbia - centralized	Yes - info only, 98 MY & newer	yes 1992 MY and newer	ASM 1991 and older	gas cap test 1972 to 1995 MY
C2	Ontario - decentralized	Yes - 98 MY and newer, but no info recorded	no	ASM 25/25 - 20 MY old and newer	
1	Alaska	yes	no	no	96 & newer also visual component + function tests, must pass all 3 tests 68 to 95 visual, function plus BAR 90 2-speed idle test
2	Arizona - centralized	yes	no	IM 147 - 1981 to 1995; Steady State Loaded and Idle 1967 to 1997 in Tucson and 1967 to 1980 MY in Phoenix	visual tampering plus evap system integrity (pressure) test
3	California - centralized and decentralized	yes	no	BAR-97 loaded-mode ASM 50/15 & 25/25 dynamometer test - all vehicles	visual, functional, and gas cap pres - all vehicles
4	Connecticut - decentralized	yes	no	ASM 25/25 - 1980 to 1995 MY	two-speed idle test - certain 1980 to 1995 MY
5	Delaware - centralized	yes	no	no	idle test - 1968 to 1980 2-speed idle test - 81 to 95 gas cap and evap tests
6	DC - centralized	info since 2002 start Feb 2004	yes 1981 to 1995 MY	no	idle test - 1968 to 1980 gas cap pressure test - all MY
7	Georgia - decentralized	yes	no	ASM 25/25 + 50/15 1979 to 1995 MY	2 speed idle if fail OBD test cat visual - 79 to 95 MY fuel cap - 79 and newer
8	Idaho - decentralized	yes	?	?	idle test - 65 MY & newer visual tampering - 84 & newer
9	Illinois - centralized	yes	yes - 1981 to 1995 MY	no	idle test - 68 to 80 MY gas cap pres - all 71 & newer
10	Indiana - centralized	yes	no	IM93 - transient 0 to 30 mph for up to 93 seconds - 1981 to 1995 MY	idle test - 76 to 80 MY cat visual 81 to 95 MY gas cap pres test - 81 to 95
11	Kentucky - centralized	yes, Louisville program closes Jan 2004 yes, if fail other tests N. Ken.	yes, 2nd chance test in Louisville	no	visual ins. - 1975 & newer idle test - 1968 and newer evap pres test - 81 & newer
12	Louisiana - decentralized	yes	no	no	visual cat ins. - 1980 & newer gas cap pres - 80 & newer
13	Maine - decentralized	yes	no	no	visual ins. - 83 & newer gas cap pres - 74 & newer
14	Maryland - centralized	yes	yes - 84 to 95 MY and all 96 MY and newer 8,501 to 10,000 lbs.	no	idle test - 77 to 83 MY gas cap pres - all MY
15	Massachusetts - decentralized	yes for 'fast pass' until Jan 2004	no	Mass 99/BAR31 - 1984 to 1995 MY and 1996 and newer if they fail OBD	2-speed idle - if cannot be dyno tested gas cap integrity test
16	Missouri - centralized	yes	yes - 81 to 95 MY 2nd chance test 96 MY and newer	no	vehicles can pass remote sensing test & avoid other tests idle test - 71 to 80 MY gas cap pres test

* Tests referred to gasoline-fuelled vehicles unless otherwise noted.

** OBD II checks are on 1996 MY and newer vehicles unless otherwise noted.

*** Not all programs are statewide. In certain states test requirements vary by region. The most demanding set of tests is listed.

Table 3.1 Data Related to Current I/M Programs that Feature OBD II* (continued)

	State or Province***	OBD II Check**	IM 240	Other Dyno Test	Other Tests
17	Nevada - decentralized	yes	no	no	2-speed idle test - 1968 MY to 1995 MY
18	New Hampshire - decentralized	mid-2004	no	no	tampering inspection - 1980 and newer
19	New Jersey - centralized and decentralized	yes	no	ASM5015 1981 & newer	idle test - pre 81 MY gas cap pres - all MY visual cat - 75 and newer
20	New Mexico - decentralized	yes - in 2004 in Albuquerque	no	no	2-speed idle test - 75 to 95 visual ins - 75 to 95 for cat, smoke and cap pres test
21	New York - decentralized	yes	no	yes - NY Short Transient Test - 81 MY and newer in NY City Metro area	idle test - 81 MY and older gas cap check - all MY visual tampering - all MY
22	North Carolina - decentralized	yes	no	no	idle test - 25 years old up to 1995 MY
23	Ohio - centralized	yes	no - to ASM in 2001	ASM2525 - last 25 MY	idle test - if cannot dyno test gas cap pres test - all MY
24	Oregon - centralized	yes	no	enhanced BAR 31 transient test - 1981 - 1995 MY	2-speed idle - 75 to 80 MY
25	Pennsylvania - decentralized	yes to begin Dec 2003	no	ASM test - 1981 to 1995 MY in the Philadelphia region.	2-speed idle test - Pittsburgh evap system function - 81 to 95 gas cap pres - 75 & all newer visual tampering - 75 to 95
26	Rhode Island - decentralized	yes	no	RI2000 test (3 BAR 31 transient) - 25 years old to 1995 MY - owners choice	gas cap pres test - all MY 2-speed idle test if cannot be dyno tested
27	Tennessee - centralized	yes	no	no	2-speed idle test - 75 to 95 MY gas cap leak - 96 & newer visual cat, restrictor, gas cap - 1995 and older
28	Texas - centralized and decentralized	yes	no	ASM2 - 1995 and older	2-speed idle test - El Paso visual cat - all MY gas cap pres test - all MY
29	Utah - decentralized	yes	no	ASM2 in Salt Lake county DC98 in Davis county	2-speed idle test - Weber and Utah counties on 1995 and older MY
30	Vermont - decentralized	yes	no	no	
31	Virginia - decentralized	yes	no	ASM 15/25 - 81 to 95 MY	2-speed idle test - 80 to 25 yrs. gas cap pres test - all MY visual tampering - all MY
32	Washington - centralized	yes	no	ASM2525 - 1995 and older MY	2-speed idle - if cannot be dyno tested - 95 and older MY gas cap pres test - all MY
33	Wisconsin - centralized	yes	yes - 1968 to 95 MY	no	idle test + 9 point component if I/M 240 cannot be done gas cap pres - 71 and newer
a	Colorado - centralized and decentralized	yes - info only	yes - 1982 MY and newer	no	2-speed idle test - 1981 MY and older
b	Michigan	cancelled program			

* Tests referred to gasoline-fuelled vehicles unless otherwise noted.

** OBD II checks are on 1996 MY and newer vehicles unless otherwise noted.

*** Not all programs are statewide. In certain states test requirements vary by region. The most demanding set of tests is listed.

3.9 Phasing-in OBD Testing

If an I/M program in Canada were to decide to use OBD II testing for pass/fail decisions, there are several options that could be used to phase-in that testing. In the USA even though the use of OBD II testing was a regulated requirement, states were allowed to phase-in the introduction of OBD II testing.

States could delay startup for up to 12 months based on the need for additional training, outreach etc. Several states chose this method of phase-in and used OBD II testing as an information tool until they were ready to begin OBD II testing on a pass/fail basis.

States could also phase-in the OBD testing by using OBD as a clean-screen in tandem with a tailpipe test. In the latter case, if a vehicle passed OBD II it passed the I/M test. If it failed it was required to undergo a tailpipe test. If the vehicle also failed the tailpipe test it failed the I/M inspection. This 'second chance' method of phase-in was employed by several states and, as noted in Section 3.8, is still in use in use in Kentucky and Missouri.

A province may wish to phase-in OBD II testing in an I/M program by progressive model years. For example, in Rhode Island, during at the beginning of the phase-in period, only Light Duty Vehicles built in model year 2000 or newer were OBD II tested. Throughout the course of the phase-in period, the model year coverage was adjusted until model year 1996 was reached.

As noted in Section 3.3.1, the EPA relaxed its requirements in regard to Readiness Monitor codes. They also allowed some leeway in regard to introducing stricter rules in regard to those codes. Consequently, in California, the state authorities decided to phase-in OBD II Readiness Monitor requirements: (BAR 2003)

On November 12, 2002, the Bureau of Automotive Repair phased-in the OBD II functional inspection readiness requirements by setting the Smog Check system's overall OBD II readiness threshold to 5. What this means is that some vehicles will not pass their Smog Check if more than 5 of the 11 OBD II Readiness Monitors have not run to completion.

During the phase-in California gradually reduced the allowable number of incomplete monitors. By the beginning of December 2003, to comply with U.S. EPA requirements, BAR decreased the maximum number of incomplete OBD Readiness Monitors allowed when passing a Smog Check to two.

3.10 Costs of Incorporating OBD II into an I/M Program

The introduction of OBD II testing in an I/M program will require the purchase and installation of OBD II scanners by inspection and repair facilities. In Canada, while neither is presently using OBD II for pass/fail decisions, the I/M programs in Ontario and British Columbia already include OBD II interrogation as part of their inspection procedures. While I/M system software may have to be upgraded to accommodate the use of OBD II interrogation data for pass/fail emissions decisions, that change should not require any additional hardware expenses for inspection facilities in those two I/M programs.

In order to correctly diagnose and repair 1998 and newer Canadian vehicles in Canada, most modern repair facilities should already be equipped with OBD II scanners. However, changes to OBD II system requirements are coming. Therefore, inspection and repair facilities may require system upgrades to allow the scanning of the latest OBD II systems. (See Section 5.1.)

In California, a CARB report listed their estimates of the costs of incorporating OBD II interrogation using the new CAN protocol into their existing Smog Check program: (CARB 2003)

It is anticipated that licensed I/M stations will experience a one time cost of approximately \$500 (US dollars) to upgrade existing equipment to test vehicles equipped with the Controller Area Network (CAN) OBD II communication protocol.

3.11 Program Assessment

The main purpose of a LDV emissions I/M program is to identify vehicles with excess emissions and to initiate repairs that are designed to reduce those excess emissions. However, OBD II is also capable of detecting system faults that 'could eventually' cause a significant increase in emissions. This early detection and repair feature is a progressive step, but can also be considered a disadvantage.

In the USA, the NRC/NAS report on OBD in I/M programs recognized this problem and felt that it would be difficult to assess effects and benefits of OBD II testing: (Holmes 2001)

The OBDII system does not actually measure emissions. Because this system does not measure emissions, but rather alerts drivers that there is a problem that might result in excess emissions, evaluating the benefits of such a system is not straightforward.

The OBD Working Group in the USA also restated that the goal of OBD II is to identify components in need of repair before emission standards are exceeded, instead of the traditional emphasis on detecting and repairing vehicles with excess emissions after the vehicle is polluting over the standard. OBD systems identify repairs needed to prevent further deterioration of broken emission control components. The Workgroup believes it is very important to quantify this benefit and to include it in any evaluation of program effectiveness. (CAAAC 2002)

However, since OBD II systems can provide the potential for the detection and repair of emission control systems before they falter and cause excess emissions, OBD II provides no immediate indication as to the overall affect on emissions of those repairs. In other words, if you repair a system before it increases emissions, how much has your program reduced emissions? Therefore, if OBD II interrogation is the sole test in an I/M program, how does an agency evaluate the effectiveness of their I/M program?

The answer may be to shift the focus in regard to I/M program evaluation. Programs may have to accept faults detected and faults repaired as a measure of program effectiveness rather than measured emission reductions.

4 The Potential for Fraud and Tampering

Compared to more complex, and hardware intensive, tailpipe emission tests OBD II testing proffers a simplification of the testing process for I/M programs. However, as with tailpipe emissions tests there are a number of operational issues in regard to the potential for fraud and tampering with OBD II systems and test results.

4.1 Potential Fraud and OBD II

The potential for fraud in relation to I/M program testing is always a concern for I/M administrators, and OBD II testing is no exception. In regard to OBD II tests in an I/M program environment there are issues related to possible dealer, manufacturer and inspector fraud.

4.1.1 Manufacturers - Problems Related to OBD II Design

Both the EPA and CARB have discovered problems related to faulty OBD II system design. One type of fraud, whether accidental or intentional, has been in the form of 'under-sensitive' OBD II systems. Under-sensitive OBD II systems are considered to be those that do not set trouble codes during the warranty period.

In the USA, the OBD Workgroup recognized the potential for OBD II fraud related to system design and in their report listed measures that are used by the EPA and CARB to counter possible manufacturer fraud or OBD II design problems. For example, during a vehicle's warranty period, the CARB and/or EPA can require manufacturers to submit OBD II systems to an extensive certification process. This process includes in-use testing and durability tests. If a manufacturer is found to have an 'under-sensitive' OBD system, then EPA and/or CARB can take action. (For details see Appendix A - CAAAC 2002)

For vehicles after the warranty period there is also concern about 'over-sensitive' OBD II systems. This relates to the concern that OBD II systems may trigger too many DTCs once the vehicle is older or has accrued considerable mileage. While an 'over-sensitive' OBD II system may be an accident of design rather than planned, the discovery of an 'over-sensitive' OBD system may result in EPA enforcement action.

For high mileage vehicles after the warranty period, the CARB certification process requires that a *Durability Demonstration Vehicle* (DDV) show OBD II system compliance testing at 100,000 miles. The EPA is also has an on-going 'high mileage' vehicle study to monitor OBD performance at 100,000 miles and higher.

Regulations require manufacturers to submit any defect reports related to OBD II systems to the EPA. The EPA also reviews independent service facilities letters, email, and telephone calls concerning warranty, performance, fuel economy, and emission problems. In addition, other sources track and rate reliability and durability of vehicles. (CAAAC 2002)

4.1.2 Possible Inspector Fraud

The potential for fraud related to an OBD II inspection is similar to that for the other tests in any I/M program. In general, fraud can be limited by closely monitoring I/M programs on an ongoing basis to ensure fraudulent activity is not taking place. In other words an I/M program must have a well-funded Quality Assurance/Quality Control and audit program that applies equally to OBD II test procedures and test results.

Dealers

There is concern in relation to OBD II tests performed at dealer-owned and operated inspection facilities in decentralized I/M programs. A dealer operating an I/M inspection facility may have an incentive not to properly test and fail their own brand of vehicles in order to minimize manufacturer's warranty expenses. In addition, as often stated for decentralized test-and-repair I/M programs, there is an incentive not to fail vehicles owned by long-time clients and 'good' customers.

However, while this concern was noted, in their 2002 report, the OBD Workgroup in the USA indicated that as of the date of their report there was little evidence to support or refute this concern. The auto manufacturers and several other OBD Workgroup members provided the following reasons why they felt that concerns in regard to dealer fraud were unwarranted: (CAAAC 2002)

- Nearly all car dealers are independent businesses not controlled by the auto manufacturers,
- The dealers, like independent shops, profit from vehicle repairs, and have an incentive to perform the repair, and
- Collusion between an auto dealership and a manufacturer to manipulate inspection results could result in enforcement action, including severe financial and possible criminal penalties.

The OBD Workgroup report also noted that in the USA there are safeguards in regard to potential dealer/manufacture fraud in regard to warranties: (CAAAC 2002)

- The EPA can (and has) audit a manufacturer's warranty records when a defect report indicates a possible emission failure. This action can lead to a vehicle recall.
- CARB routinely performs unannounced inspections and audits of dealership warranty records and compares the records to the manufacturer's reported warranty rates.

Provincial I/M program administrators may wish to consider the implementation of similar audit systems for their programs.

Inspectors

As noted, in decentralized I/M programs there is always concern in regard to potential inspector fraud. This has been a historic problem in regard to decentralized test-and-repair programs in the USA. The potential for inspector fraud was also one of the reasons that the CCME LDV I/M Code of Practice, and the EPA I/M regulations, leaned heavily toward the more controlled environment of centralized test-only I/M programs. As is the case with all other I/M test types, the OBD-I/M check is vulnerable to inspector fraud, and program managers need to be on guard to limit the opportunities for this kind of activity.

Administrators in I/M programs based on a tailpipe exhaust emissions test are familiar with the practice referred to as 'clean-piping'. This form of fraud is when a 'clean' vehicle is tested, but vehicle identification information for a 'dirty' vehicle is entered into the test record. The 'dirty' vehicle then passes the test and is neither tested nor repaired. Similarly, inspectors performing an OBD II test can 'clean-scan' an OBD-equipped vehicle. The EPA feels that the opportunity for 'clean-scanning' exists because the Vehicle Identification Number (VIN) is not currently included in the data stored in the vehicle's onboard computer. (Sosnowski 2001)

In an effort to foil this practice, CARB is adding a Vehicle Identification Number (VIN) requirement to OBD II systems as of model year 2005 and all manufacturers currently certify to CARB requirements. Having the VIN downloaded, as part of an OBD II interrogation, will make vehicle switching for clean-scanning during inspections much more difficult. (CAAAC 2002)

The CARB OBD II I/M test flow chart contains suggestions for two checks that are designed to assist in the detection of vehicles that may have undergone either a 'clean-scan' or that may have tampered or corrupted OBD II system software. (McCarthy 2002-1, McCarthy 2004)

CAL ID is a calibration identification number (similar to a software version number) for the software and calibration installed in a vehicle's ECU. CAL ID indicates the exact emission software/calibration set installed in a vehicle.

CVN is the calibration verification number and is the result of a type of 'check-sum' calculation performed on the calibration values stored in a vehicle's ECU. If the calibration values have not been changed or corrupted, the CVN will always provide the same sum for a given software-calibration set in an ECU. If somebody has modified or corrupted any of the calibration values, the CVN calculation will generate an incorrect 'sum'.

CAL ID looks to see if the correct software is installed in the inspected vehicle and CVN verifies the software has not been corrupted or altered. A given CAL ID will have a given CVN.

All OBDII equipped vehicles (California and EPA) will support CAL ID and CVN. CAL ID was required by the 2002 MY, and CVN will be required by 2005 MY.

These two values can be downloaded and recorded at the time of inspection and then be used to look for signs of tampering and fraud. While CAL ID is not the complete solution in regard to preventing 'clean-scanning', it should at least ensure that the vehicle scanned is of the correct make, model and engine type.

The EPA believes that there are also a number of methods available to counter 'clean-scan' fraud using other identifiers that are already part of an OBD II system: (Sosnowski 2001)

Programs can limit the potential for fraud via 'clean-scanning' by comparing the *Parameter Identifications* (PID) count and/or the *Powertrain Control Module* (PCM) diagnostic address to the other vehicle information in the test record. EPA is working with manufacturers and states currently implementing the OBD II I/M inspection to gather the data necessary to interpret PID count and PCM diagnostic address information so it can be used for this purpose.

The OBD Workgroup had recommendations for additional preventative measures in regard to fraud. These recommendations focus on the prevention and detection of fraud in decentralized I/M programs. (CAAAC 2002)

- The EPA should crosscheck data between centralized and decentralized I/M areas as well as dealership and non-dealership inspections to look for anomalies in pass/fail rates.
- States should be aware of the many different technologies and approaches available to them to detect inspection fraud including the following:
 - Measures to ensure inspections are being conducted by authorized persons, such as video auditing cameras in each facility to allow the State or contractor to observe and communicate with technicians, or other measures to prevent lane operators from sharing user ID codes,
 - Bar codes to track inspection stickers,
 - Audits of inspection data by the State to detect anomalies,
 - Unannounced inspection or audit of facilities,
 - 'Undercover' failing cars to verify proper inspection, and
 - Third party testing at decentralized inspection stations where repair work is also performed.

Many of the OBD Workgroup recommendations, as listed above, that are designed to prevent fraud in relation to OBD II testing are similar to those listed in the CCME Code of Practice for preventing fraud in I/M programs in Canada that feature tailpipe exhaust emissions tests. (CCME 1998)

Readiness Monitors - Possible Fraud

The issue of Readiness Monitors and the clearing of Readiness Monitor codes are unique to OBD II and OBD II testing in an I/M program. Not only do Readiness Monitor codes present problems, but according to the EPA the presence of unset Readiness Monitor codes among the non-continuous monitors could be a sign of attempted fraud. Therefore, it is important that all OBD-equipped vehicles be checked to confirm that all Readiness Monitor codes have been set to 'ready' as one of the pre-requisites for a valid OBD-I/M inspection (Sosnowski 2001)

AirCare officials in British Columbia have expressed some concern in regard to Readiness Monitors. One of their concerns was the possibility of cheating on a re-inspection if a repair technician has simply cleared the codes with a scan tool.

According to the EPA OBD II guidance documents, some reviewers raised similar concerns. They worried that it could be possible for repair technicians to selectively clear DTCs without performing repairs and without setting the remaining Readiness Monitors (i.e., those without DTCs recorded) to 'not ready'. If this were possible then vehicles that should be failed could be fraudulently passed on the retest (even without receiving repairs) because of the Readiness Monitor exemptions allowed by EPA. This assumes that the number of DTCs resulting in the initial failure did not exceed the number of allowed Readiness Monitor exemptions. The EPA allows two Readiness Monitors to be 'not ready' and some states allowed up to five to be 'not ready' as they phased-in their programs. (Sosnowski 2001)

The EPA feels that many of the concerns in regard to Readiness Monitors are unnecessary. According to the current design requirements, it is not possible to selectively clear DTCs or to only set some Readiness Monitors to 'not ready' while leaving the remaining monitors 'ready'. As currently designed the feature that allows the clearing of DTCs is an all-or-nothing proposition. The regulations governing OBD II systems were specifically designed to produce systems that would avoid this type of fraud. (Sosnowski 2001)

4.2 Aftermarket Issues

In relation to OBD II, there are a number of issues that could be considered to be 'tampering' in regard to vehicle systems. The first is required or legitimate part replacement and/or the reprogramming or re-calibration of components and systems. While these acts may be performed for legitimate reasons, unless redefined in anti-tampering legislation, these actions could be viewed as tampering. The second issue is vehicle modification by enthusiasts. The third is deliberate tampering that is designed to defeat the OBD II system.

4.2.1 Part Replacement - Aftermarket Parts

An issue for all I/M programs is whether the use of aftermarket parts on vehicles inspected in their program constitutes tampering. In the USA, following the tradition of the 'backyard mechanic', the issue of aftermarket part replacement is huge.

The advent of OBD II systems and the associated hardware/software was no different. The Automotive Parts Rebuilders Association (APRA) lobbied hard to ensure that OBD II system repairs were not restricted to the vehicle manufacturers (OEM) only. If OBD II system repairs had been restricted to OEM then all aftermarket parts and aftermarket non-OEM actions to repair OBD II systems would have been considered tampering.

The APRA efforts, and those of other similar associations, were successful and have resulted in new and revised EPA and CARB Information Acts. Under their new OBD II information rules, the EPA requires auto manufacturers to make available to aftermarket service providers any and all information needed to make use of the vehicle's emission control diagnostic system. (EPA 2003) (See Section 2.7.)

Therefore the issue of the use of aftermarket parts related to OBD II systems and OBD II testing is similar to that for any other emissions control system and I/M test. The I/M administration must set up, or otherwise recognize, a system for the certification and verification for aftermarket parts that may be used in their program. (See Section 4.3.1.)

4.2.2 Reprogramming and Re-Calibration

Similar to the aftermarket parts issue discussed in Section 4.2.1 is the reprogramming or re-calibration of OBD II systems following repair or adjustment. When they passed their initial OBD II legislation, the EPA agreed with the OEMs. They both felt that the universal release of reprogramming information would result in a significant increase in tampering or misuse of calibrations and re-calibrations. (EPA 2001)

As with the issue of aftermarket parts, several associations including the Automotive Parts Rebuilders Association (APRA), the Specialty Equipment Market Association (SEMA), and the Coalition for Auto Repair Equality (C.A.R.E.) campaigned for fewer restrictions. They felt that that in regard to OBD II parameters, overly broad anti-tampering features could make legitimate reprogramming by any independent repair facility impossible. (APRA 2003)

The EPA found no evidence to indicate that abuses in regard to OEM confidentially or other similar tampering had occurred in regard to OBD II systems. Therefore, the EPA passed their revised Service Information Rule that requires manufacturers to make available emissions-related reprogramming and re-calibration events to aftermarket technicians. They stated that performing a recall is not considered tampering, if it is installed properly and into the proper vehicle. (Gardetto 2003)

Starting with the 2004 model year, the EPA requires vehicles to be equipped with the SAE J2534 API (Application Programming Interface). Using the J2534 API all 'car communications' hardware will look the same. In regard to the adoption of the J2534 API, some feel that for car enthusiasts, performance-enhancing firmware will be easier to install. (SEMA 2003)

However, due to the nature of the system, the EPA feels that fears in regard to tampering via performance-enhancement with the J2534 should not be an issue: (Gardetto 2003)

The J2534 or 'pass-thru' reprogramming will be required by the Service Information Rule. However, the J2534 is just a translator, it does not negatively affect whatever reprogramming security a particular manufacturer has in place. Security resides on the OEM software on the PC. Through many security procedures...incorrect, unauthorized, or outdated calibrations are prevented from being installed. All J2534 does is allow one reprogramming box to be used on all makes and models.

One industry expert agrees with the EPA. His assessment, in regard to the adoption of the J2534 standard Application Programming Interface, is that for ordinary car users your car can now be fully serviced in any garage. (DeMaggio 2003)

4.3 Tampering

As with any other system, tampering with OBD II systems is possible. In the USA, unauthorized changes to an OBD II system and its components is a violation of their federal anti-tampering legislation. OBD II system tampering may include: (EPA 2002, Sosnowski 2001)

- A deliberate attempt to overriding the OBD system through the use of high-tech defeat devices, and non-certified computer chips, and
- Any action taken to clear the DTCs or MIL illumination without performing the prescribed maintenance. This includes any fraudulent attempt to avoid I/M program requirements by clearing OBD codes just prior to OBD-I/M testing. By, for example, temporarily disconnecting the battery. Following such action, a vehicle may arrive for testing without the required Readiness Monitor codes set.

An OBD system may, however, be repaired back to its original certified configuration with certified 'performance chips' and approved aftermarket parts.

In regard to tampering, OBD II systems have a big advantage over earlier on-board computer systems. The earlier systems had chips that could be replaced to adjust engine parameters for extra speed and power. However, OBD II systems must be sealed. These sealed systems do not allow for easy single chip replacement.

Regardless, tampering with OBD II systems is still likely to occur since the ability to modify vehicles and engines to increase performance is a hobby and a passion for many. The following is an example of the mindset of certain automobile enthusiasts: (Bohacz 2003)

Within a few years, all...manufacturers had employed some sort of electronic management on their engines, and the death knell was sounded for the performance enthusiast.

One expert listed the effects of certain engine modifications on OBD II on an Internet site. The following describe how common modifications can evoke a MIL illumination: (Bohacz 2003)

Higher fuel pressure or larger injectors:

A potential problem with a fuel trim diagnostic failure exists when changes are made to the flow rate of the injectors or the fuel pressure. The criteria that are needed or, in other words, the amount of correction that is allowed, will determine the success of this modification. In all fairness, on a totally stock vehicle there's no reason to change either one of the above-mentioned areas. A highly modified engine would probably evoke trouble codes in other areas first.

Cat-back Exhausts:

There should be no problem with cat-back exhaust systems since their improvement to airflow is not monitored. There may be a possible problem area in EGR function if mufflers are not used.

Increased Rocker Arm Geometry:

There is no interference with OBD II functioning by increasing lift with rocker arms of a different ratio. Even though increased lift through rocker arm geometry has a slight effect on duration, its more dominant area is in valve moment.

Camshafts:

This is major area of concern with possible problems all over the map. Valve event timing will have a drastic effect on hydrocarbon generation, which will affect both heated oxygen sensors, HO₂s, time to activate and response time. It may also have an effect on converter efficiency due to the increased hydrocarbon load placed on the converter. Another area of concern is in idle stability and misfire detection. The roughness that we all like in a cammed engine most likely will be interpreted as a misfire, which will be confirmed by the lack of converter conversion efficiency. Camshafts with slightly increased durations and lobe separations angles of at least 112 degrees will most likely be tolerated.

Cooler Thermostats:

Without letting the engine reach normal operating coolant temperatures, the OBD II drive cycle will not be completed.

Cylinder Heads:

It appears that increased volumetric efficiency through better-flowing heads and a slight raising of the fuel pressure to keep the fuel trim in check should go totally undetected.

Headers:

Emissions-legal headers will have no effect on OBD II.

Superchargers:

In theory, since WOT (Wide-Open Throttle) is not monitored, the only possible problem arises with fuel trim under closed-loop boost and idle stability with the air being forced into the throttle body. Even though superchargers do not affect idle quality, there will be fewer counts of the IAC to achieve the same idle. This should not pose a problem. The increased volume of air passing through the MAF (Mass Air Flow) will most likely be detected and recorded. Since it will only be for a short period of time, the system should respond like Ford's EEC-IV by seeing an uncalculated amount of air and illuminate a MIL.

Nitrous Oxide Injection:

It looks as if nitrous is the safest bet for adding performance on OBD II vehicles. This is almost a contradiction in itself; since nitrous is only operated at WOT; the ECU will not care.

While not necessarily advocating tampering, information such as that shown above does provide instructions for changing engine specifications in an OBD II environment. Instructions such as these are readily available to the general public. They may be why the EPA feels that there is potential for deliberate tampering with OBD II systems. To that end, the EPA reports that it has undertaken an investigation of tampering in relation to OBD II system interrogations and has requested that state's provide their experiences with tampering. (EPA 2003)

4.3.1 OBD II Tampering Devices

The OBD Workgroup in the USA reported concern in regard to the availability of tampering devices that can be used to bypass the OBD system, and to keep the MIL from illuminating. Although AirCare officials report that they have not discovered any of these OBD II defeat devices during their OBD II tests, they have heard of these devices: (AirCare 2003)

Since repairs related to OBD II test failure can be expensive, an industry has sprung up to provide 'fixer boxes' that send the appropriate signal to the ECM in order to keep the MIL from coming on or from setting a code. These boxes cost as little as \$40.

The OBD II Workgroup in the USA claims claim that there are numerous websites that offer an 'O₂ Simulator', which can eliminate Diagnostic Trouble Codes associated with a malfunctioning catalyst. Although these websites offer these devices for 'off-road use only', the Workgroup feels that it is quite possible that these devices are being used on 'on-road' vehicles to pass OBD I/M inspections. (CAAAC 2002)

The aftermarket parts industry indicated that the use of add-on or modified parts is not a form of tampering if a product has been granted a CARB EO number or meets the requirements of EPA's anti-tampering policy document Memorandum 1-A. Hundreds of products of all types, for thousands of applications, have been granted EO numbers and many specialty products sold by OEMs also have EO numbers. (SEMA 2003)

As noted by SEMA, there is a federal system and one in California for having a device granted an exemption under the anti-tampering provisions. Companies can apply for recognition of their aftermarket components by either the EPA or CARB.

EPA Memorandum 1-A (Gardetto 2003)

The Clean Air Act amendments of 1990...prohibit individuals from tampering with the emission control devices on in-use vehicles. But EPA's enforcement policy is to not initiate enforcement proceedings against a regulated party who installs a retrofit device if that person has a reasonable basis for knowing that the use of the device will not adversely affect emissions performance. This policy is set out in memorandum 1-A

EPA Memorandum 1A provides information as to what tampering is and provides guidance as to what needs to be shown to establish a reasonable basis to believe that a modification will not adversely effect emission performance. It should be noted that although a CARB EO for an aftermarket part could be used as a 'reasonable basis' to show no adverse emissions effects, it may not necessarily mean that it is not tampering. It should also be noted that the Federal anti-tampering law applies to California as well as the other 49 states.

CARB Executive Orders (EOs) for Legal Add-on or Modified Parts (CARB 2003)

Exempted parts are add-on or modified parts that have undergone a CARB engineering evaluation. If the part or modification is shown to *not increase* vehicle emissions, it is granted an exemption to emission control system anti-tampering laws. This exemption is called an Executive Order (EO) and allows the modification to be installed on specific emission controlled vehicles. Every EO part or modification has an assigned number that can be verified by Smog Check stations, BAR Referee stations, or by CARB. For example, replacement computer chips must be an Original Equipment Manufacturer (OEM) part, or aftermarket computer chips must have an EO to be legal for street use.

4.3.2 Experiences Related to OBD II System Tampering

Many of the 33 I/M programs in the USA that feature OBD II testing have only recently introduced (or are soon to) OBD II testing on a pass/fail basis. Therefore, experience related to tampering with OBD II systems is limited.

When questioned, several states admitted that the amount of tampering information related to OBD II systems and testing is limited because their I/M program inspectors and software are not set up to look for tampering related to OBD II systems.

However, a number of states did indicate that they have detected OBD II related tampering in connection with their I/M program:

- The Vehicle Emission Testing (VET) program in Louisville, Kentucky reported that in regard to OBD II testing that they have experienced some 'light' tampering. (VET 2003)
- Officials with the Anchorage Alaska I/M program reported a case of tampering in which a vehicle owner had removed the catalysts from a vehicle and had also replaced the PROM in a vehicle's computer. (Alaska 2003)
- Officials with the I/M program in Davis County, Utah reported that they have detected some tampering in vehicles testing in their program. One type of tampering was MIL disconnection. However, they reported that their biggest problem was a number of cases of 'clean-scanning'. (Utah 2003)
- The State of Maine reported that they have detected tampering in relation to OBD II testing. They feel that most of the tampering has involved individuals who they refer to as members of the 'fast and furious' group. They report that they are trying to deal with the problem. (Maine 2003)

- The latest information on OBD II tampering from California I/M program experience indicates that few incidents have been reported. The only device they are aware of is designed to disable the catalyst monitor. CARB and EPA are working together and have begun enforcement actions against several manufacturers of these devices. However, while CARB has not yet discovered their use in the I/M program, there is no special inspection process in place to look for these devices. (CARB 2003-1)

Two other I/M programs in the USA indicated that they had not detected tampering with OBD II systems in their programs:

- In Utah County, Utah, OBDII testing on 1996 MY and newer vehicles has been used as a Pass/Fail test since March 2001. However, officials in that state report that no OBDII system tampering has been detected or discovered to date. (Utah 2003)
- The state of Washington also reports that to date they have not seen significant tampering with the OBD systems. However they state that they do expect tampering to become more of an issue in the future as more vehicles are tested. (Washington 2003)

As noted, in Canada, the AirCare I/M administrators in British Columbia have heard rumours of OBD II system defeating hardware, but to date they have not discovered any such devices as part of their inspections and tests. (AirCare 2003)

However, as noted, OBD II tampering and the use of OBD II tampering devices may not have been detected because the current test procedures in most I/M programs have not been designed for, and the inspectors not trained to, locate and identify this type of tampering.

As an aside, California's engine change and rebuild requirements represent what could almost be described as tampering in reverse. California's special provisions in regard to engine changes and rebuilds require OBD II systems to be fully functional if a computer-controlled engine is installed in what was originally a non-computerized vehicle. The MIL, the OEM DLC, plus all sensors, switches, and wiring harnesses that are needed to make the system fully functional must also be installed. (BAR 2003)

Regardless, provinces with I/M programs must address the issue of tampering with OBD II systems. It is recommended that provinces with I/M programs that include OBD II testing ensure that their anti-tampering legislation covers all of the forms of tampering that are likely to be encountered with OBD II system testing.

5 Future OBD

OBD II systems are evolving. Over the next three or four years, in almost every new model year the vehicles produced will have a slightly different OBD II system. In addition, there are a number of innovations that are being suggested for a new generation of OBD systems.

5.1 OBD II - Changes in the Near Future

As noted in the early Chapters, a number of changes to OBD II have already been legislated or allowed.

CAN (Controller Area Network)

The CAN (Controller Area Network) vehicle communication protocol for OBD II will be allowed by EPA in 2004-2007 model years along with the existing protocols. However, as of the 2008 model year, CAN will be the only allowed protocol and the existing protocols, SAE J1850, ISO 9141 and 14230-4, will be eliminated. (Gardetto 2003)

Vehicle Identification Number (VIN)

In an attempt to foil the practice of 'clean-scanning', CARB is adding a Vehicle Identification Number (VIN) requirement to OBD II systems as of the 2005 model year. This action will be universal in the USA since all manufacturers currently certify to CARB requirements.

Calibration Verification Number (CVN)

CVN is the Calibration Verification Number and is the result of a type of 'check-sum' calculation performed on the calibration values stored in a vehicle's ECU. The CVN calculation verifies that OBD II software has not been corrupted or altered. All OBDII equipped vehicles, both California and EPA certified, will support CVN by the 2005 MY.

NOx Catalyst Conversion Efficiency Monitoring

In California, NOx conversion efficiency monitoring has been adopted and will begin to be phased-in on the 2005 MY vehicles. The OBD II systems on all 2007 MY vehicles will be required to monitor for NOx conversion efficiency. (McCarthy 2004)

Vehicle manufacturers by the 2007MY will have to indicate a catalyst malfunction (MIL 'on') before the catalyst deteriorates to the point that tailpipe emissions reach (a) 1.75 times the FTP HC standard or; (b) 1.75 times the FTP NOx standard; whichever occurs first. Criteria (a) will be the limiting factor on some cars and criteria (b) will be the limiting factor on others. For the phase-in, for the 2005 and 2006 MY, some cars will implement NOx conversion efficiency monitoring to a higher interim threshold of 3.5 times the FTP NOx standard in lieu of the final 1.75 times FTP NOx standard.

J2534 API (Application Programming Interface)

Starting with the 2004 model year, the EPA wants anyone (including auto repair shops and car enthusiasts) to be able to upgrade their car for a reasonable cost. To accomplish this, the EPA asked SAE to create the J2534 API (Application Programming Interface). (DeMaggio 2003)

Using the J2534 API all 'car communications' hardware will look the same. The EPA is forcing car manufacturers to release software that updates the firmware on their cars. The application must run on Windows and use the J2534 API to talk to the car. A J2534 device plugs into a car's OBD connector on one side, and a computer on the other side. Under the hood, the device must speak a myriad of different vehicle protocols (ISO9141, J1850VPW/PWM, CAN, etc.)

5.2 The In-Use Verification Program (IUVP)

The EPA has announced the In-Use Verification Program (IUVP). The IUVP will provide a substantial new source of data on OBD II system performance and will be available in the near future. Beginning in 2004, the EPA will require, via the IUVP, manufacturers to test a number of customer-owned and operated vehicles. (CAAAC 2002)

One year-old and 5 year-old vehicles (minimum 50,000 miles) are to be tested. The EPA will start receiving test data in the 2005 calendar year on 2001 MY high (50,000 miles and greater) and 2004 low-mileage (10,000 miles and greater) vehicles. This will be an invaluable data source, in that it will provide about 2000 FTP emissions data points per year, with OBD II information that includes MIL illumination ('on' or 'off'), Diagnostic Trouble Codes (DTCs), and 'not ready' codes

The EPA will also conduct confirmatory in-use tests on about 150 vehicles per year to verify the results of the manufacturer in-use testing. These data will provide laboratory-quality emissions tests to help to monitor whether OBD MILs are illuminating when emissions are being exceeded. In addition, these data will help to identify problematic vehicles for recall purposes.

5.3 OBD III

California is studying future OBD systems that will increase customer convenience regarding their Smog Check program: (CARB 2003)

These ideas are focusing on eliminating the need for properly working cars to go to a Smog Check station and are intended only to require cars with malfunctioning components to be tested at fixed installations. These ideas...include the use of remote transponders as a means of identifying only those cars which have malfunctioning components.

The remote interrogation of OBD information has been labelled OBD X or OBD III. The concept involves the use of wireless techniques to query the OBD computer installed on-board a vehicle. This type of remote sensing of emissions control system information could be done from any of a number of roadside locations. The overall concept is to allow a 'hands off' approach to the in-use testing of a large fleet of vehicles. It is hoped that such a system would be both simple and convenient for motorists.

In 2000 CARB published the results of a field study into the feasibility of wireless OBD. The conclusions from that study were: (CARB 2003)

The feasibility of incorporating radio communications into On-Board Diagnostic (OBD) systems for new cars and light trucks has been demonstrated through the successful completion of a field study using five vehicles equipped with prototype systems. Referred to as 'OBD III', OBD systems interfaced with radio communications would be a cost-effective alternative to the current California vehicle Inspection and Maintenance program, 'Smog Check'.

One roadblock to the introduction of OBD III systems is likely to be considerable public opposition in relation to what may be perceived as a 'Big Brother' approach to vehicle inspections. The 'right to privacy' is likely to be a large issue in relation to the implementation of OBD III.

6 Discussion and Conclusions

OBD II System Summary

On-Board Diagnostic systems featuring OBD II software and hardware have been required on new vehicles sold in Canada since the 1998 MY (since the 1996 MY in the USA). Therefore, OBD II systems are not futuristic; they have been an integral part of new vehicle operating systems in this country for almost seven years, two years longer in the USA. Similarly, OBD II system interrogation has been used in various LDV I/M programs in Canada and the USA for several years. In the USA urban centres with the most serious ambient air pollution problems, so-called 'enhanced' I/M program areas, are required by federal regulation to incorporate OBD II testing into their I/M programs.

From an environmental perspective, the benefit of OBD II over previous OBD systems is that OBD II systems monitor and report on the status of most of the systems in a vehicle that relate to emissions and emissions control. Not only are components related to exhaust emissions included in the overall OBD II package, but monitoring the fuel storage tank's ability to maintain pressure or vacuum, i.e. a type of leak check, allows the system to provide a measure of fuel tank evaporative emissions integrity.

Another great benefit of OBD II, in regard to testing in an I/M program is that, when compared to most of the latest exhaust emissions, tailpipe tests, OBD II testing is relatively simple. OBD II interrogation in an I/M program is not onerous and the test hardware or instrumentation that is required to conduct an OBD II system interrogation is relatively inexpensive. Scanners for interrogating OBD II systems should be standard equipment in any modern repair facility.

The IM240 test is currently recommended as the preferred I/M tailpipe emissions test by both the EPA and by the CCME in its Code of Practice for Light Duty Vehicle Emissions I/M Programs. However, one drawback of the IM 240 emissions test is its complexity. This complexity not only relates to the implementation of the I/M program by provincial or regional authorities, but to the repair industry and to the public. In some cases, that complexity has estranged both the public and the repair industry from the I/M program.

AirCare officials in British Columbia agree that one clear advantage of OBD II testing is its simplicity. The simplicity of the OBD II test in an I/M program setting embraces the consumer, the I/M Administration and the repair industry. OBD II tests are brief and uncomplicated. The OBD II test removes customer worry about vehicle damage since their vehicle will not be driven at high speed on a dynamometer. The I/M administration does not have to set up or administer inspection facilities with complex, maintenance intensive, hardware and the repair industry can duplicate the OBD II test using relatively inexpensive equipment.

One of the basic pillars of the OBD II system, compared to its predecessors, is standardization. The standard items include fault codes, communication protocol, connection hardware, and the scan tools used to check the system. This standardization allows the universal application of OBD II system diagnosis to all makes and models. Standardization also allows a reduction in the complexity and cost of the I/M test equipment.

Since OBD II systems monitor vehicle performance while the vehicle is being operated, OBD II systems also provide real-time diagnostic information. The OBD II system stores emission information plus engine operating conditions and parameters. These performance measurements and the reporting of that performance via stored codes provides a repair technician with on-road engine parameter data that may not be available via the older style tests that were conducted at most repair facilities

From experiences with OBD II testing in I/M programs, as of November 2002, the OBD Working Group in the USA concluded that application in an I/M program OBD II provided the following benefits: (CAAAC 2002)

- Accurate diagnosis and repair – OBD II minimizes trips back for second and third inspections which can be a problem in programs with emission-only I/M tests,
- Short inspection times of five to ten minutes, and
- OBD provides unique evaporative emissions reduction benefits in that it detects some evaporative control system defects.

AirCare officials also thought that OBD II should make I/M testing possible in areas where the vehicle population base may not support a tailpipe-testing program. In such areas, OBD II testing should provide a viable alternative.

The hardware required for a complex tailpipe emissions test such as the IM240 is expensive and therefore few, if any, local repair facilities are unlikely to be equipped with the hardware that would be required to duplicate that type of emissions test. Therefore, a further benefit of OBD II testing is that it removes the problem of separation between a testing facility (usually in a centralized I/M program) and a repair facility. The repair industry is not faced with test results that it can not duplicate and repairs that are open to controversy. As noted, most modern repair facilities are already likely to be equipped with OBD II interrogation hardware.

OBD II Tests - As the Sole Test for 1998 MY and Newer Vehicles

Experience to date has shown that OBD II systems work. While they are not trouble free, in general OBD II systems appear largely to operate as designed. Therefore, in respect to OBD II and OBD II testing in I/M programs, the principal issue is not a question as to whether OBD II tests should be employed, but how should they be used.

Two LDV I/M programs are currently operating in Canada, one in Ontario and the other in British Columbia. Both of these programs focus on the use of a dynamometer-based tailpipe emissions test to evaluate vehicles. However, in British Columbia, AirCare has been downloading OBD II data for information and analysis since 1 January 2001, but to date, they have not employed OBD II testing in a pass/fail capacity in their program. The AirCare program in British Columbia is now in the process of evaluating options for what is referred to as AirCare 3. Since the centralized AirCare stations are already equipped and are conducting OBD II tests, it would seem logical that a future move would be the integration of OBD II testing into the pass/fail decisions for vehicles. The scope of that integration and whether OBD II tests would be the sole I/M test procedure used on certain model year vehicles needs to be decided.

In Ontario, the Drive Clean program has the capability to perform OBD II interrogations and the majority of facilities in their decentralized program are likely to be equipped with OBD II scanners. Regardless, to date, the Drive Clean program does not use OBD II testing as part of their emissions pass/fail decisions for the vehicles tested in their program.

Therefore, the status of OBD II testing in I/M programs in Canada and the USA is markedly different. In the USA, the EPA believes in OBD II and states that while: (CAAAC 2002)

Overall, the EPA has confidence in both OBD and tailpipe testing as vehicle inspection and maintenance tools. OBD is the most efficient and effective approach to maintaining low emission levels for the future fleet of vehicles (1996 and newer model years).

The EPA stance on OBD II for testing 1996 MY and newer vehicles in the USA was stated even more strongly in 2002 when from the results of their high mileage study test data, the EPA concluded that for I/M programs: (Gardetto 2002, CAAAC 2002)

Adding a tailpipe test to an OBD test does not offer any real emissions benefits.

Consequently, as a result of the EPA's strong stance on OBD II testing for 1996 MY and newer vehicles, the 33 'enhanced' I/M program areas in the USA feature (or will soon feature) OBD II testing for making pass/fail decisions. In the majority of these I/M programs, if an OBD II test is performed, they do not perform an emissions test on the same vehicle (although many perform other tests such as a gas cap pressure test and/or a visual component inspection).

Currently, California is an exception. As noted, in that state all of the OBD II equipped vehicles are also required to undergo an emissions test plus evaporative system tests and a visual inspection. However, state officials have expressed the feeling that the exhaust emissions test may not be required for OBD II equipped vehicles.

However, despite the EPA's strong support of OBD II testing and the penetration of that testing into I/M programs in the USA, at least one state, Colorado, disagrees. After experiencing problems related to the lack of overlap between OBD II and their IM240 test results, the state relegated OBD II testing back to a role of information gathering only. Colorado continues to study OBD II testing in comparison to IM240 tailpipe tests.

Similarly, in Ontario, the Drive Clean program's publicly stated position on OBD II testing is that: (Ontario 2004)

The technology has not yet matured to the point where a tailpipe emissions test is not required.

The EPA and Ontario positions are examples of the two ends of the spectrum in regard to OBD II testing. However, both contain a certain bias. The EPA wishes to show support for the system that they have regulated into I/M programs and the Ontario Drive Clean program wishes to support the continued use of dynamometer-emissions tests in their decentralized I/M program.

Therefore, the question still remains - is an OBD II interrogation a replacement for a convention I/M exhaust emission test in an I/M program? Or conversely, why would it not be considered as a replacement for a tailpipe exhaust emissions test?

The major concerns in regard to OBD II test results appear to be a lack of total overlap with the previously favoured IM 240 emissions test plus some evidence that appears to suggest that an OBD II check may miss certain high-emission vehicles.

However, from the evidence gathered, it appears that much of the lack of overlap that has been detected can be explained. Some lack of overlap is created by the major differences in the design and intent of the two systems, OBD II and the IM240 emissions test. Another portion of this perceived lack of overlap results from OBD II design or system faults attributed to certain vehicle makes and manufacturers. Other problems, such as the issue of high NOx emissions not being detected by OBD II catalyst monitors, are being corrected by latest regulated changes to OBD II system design.

While additional testing, such as underway in California, is required, the overall conclusion in regard to the lack of overlap, is that the EPA believes in OBD II and its use in I/M programs.

Recent test results also appear to indicate that the percentage of high-emission vehicles missed by OBD II systems may be low. Also, a number of the regulated changes to OBD II systems that will be required in the next few years should correct some of the problems that have been experienced.

While there still are a number of problems and anomalies related to the issue of tailpipe versus OBD II testing, data submitted by the EPA indicates that failure rates for tailpipe versus OBD II tests in I/M programs are similar. Evidence from ongoing studies, and from I/M programs, also appears to indicate that perceived problems with OBD II testing may not be as serious as first suspected.

Therefore, it would appear, from the evidence available, that OBD II testing can be used in place of a tailpipe exhaust emissions test for 1998 MY and newer Canadian vehicles.

However, this conclusion is not forwarded without some reservation. OBD II systems, like any other complex operating system, are not foolproof. Studies and experience have shown that there are problems with OBD II systems and the application of OBD II testing in I/M programs. In addition, OBD II systems are changing and evolving. The changes that will be incorporated into OBD II systems over the next few model years are designed to solve problems that have been encountered or to add new capabilities.

Therefore, while the general conclusion is that OBD II testing can replace an exhaust emissions test, any agency that adopts such a course of action should be aware of the problems and the impending changes. The EPA and CARB are continuing with a number vehicle studies, and to work with vehicle manufacturers, in an effort to solve problems and anomalies with specific makes and models plus with OBD II systems in general.

The administration of an I/M program that adopts OBD II testing as a replacement for exhaust emissions testing should have a comprehensive, well-supervised QA/QC program. It is also recommended that they keep in close liaison with the EPA and CARB regarding changes and developments in OBD II systems. The OBD II test program they implement should be flexible enough to adapt to changes in OBD II hardware and software specifications. They should ensure that scanners and associated hardware used by the inspectors and repair technicians in their I/M program can be upgraded, quickly and relatively inexpensively, to accept new OBD II specifications and codes, as they become available.

Retaining the Tailpipe Emissions Test

The other major issue or question, in regard to the application of OBD II interrogations in I/M programs in Canada, is whether I/M programs should maintain, or implement, exhaust emissions tests for non-OBD II equipped or older OBD II equipped vehicles?

In the USA, the EPA's position is that traditional tailpipe I/M testing still plays an important role as the means of accurately identifying vehicles that need emission-related repairs for 1995 and older vehicles. Overall, the Agency believes that both OBD and tailpipe testing remain important components of I/M programs. (CAAAC 2002)

Currently, in the USA, while OBD II testing is the norm for 1996 MY and newer vehicles, the majority of I/M programs perform some type of tailpipe emissions test on 1995 MY and older non-OBD II equipped vehicles.

In regard to the design of I/M programs, one of the historic debates has focused on whether programs should test 'newer' vehicles. The argument has been that if evidence shows that older vehicles with older technology are responsible for most of the excess emissions from in-use vehicles in a particular area, then why test newer technology vehicles? While not all evidence supports this claim, a considerable amount does.

OBD II testing appears to be an ideal solution to this 'newer' vehicle, testing problem. OBD II provides a rather simple, and comparatively rapid, method for testing the 'newer', 1998 MY and newer, vehicles in an I/M program. However, many feel that 'older' vehicles cause much of the 'excess' in-use vehicle emission problem. Therefore, it is unlikely that an I/M program would drop its tailpipe exhaust emissions test program, since it is one of the few proven methods for the detection and repair of emissions problems in 1997 MY and older Canadian vehicles.

The EPA considers OBD II tests as a replacement for exhaust emission tailpipe tests for model year 1996 MY and newer vehicles. However, it also realizes that States that currently operate I/M programs will need to continue tailpipe testing for 1995 and older vehicles for about seven to ten years, until the fleet 'turns over', and OBD-equipped vehicles become predominant in the fleet. (CAAAC 2002)

Since both of the operating I/M programs currently operating in Canada already test vehicles using a tailpipe emissions test, it is logical that they maintain those emissions tests for 1997 MY and older vehicles. However, it must be recognized that maintaining complex tailpipe emission tests is a simpler decision for a decentralized I/M program than for a centralized I/M program. The number of vehicles that require a tailpipe emissions I/M inspection would be drastically reduced if all 1998 MY and newer vehicles are exempt for the exhaust emissions test. However, will the volume of vehicles that remain be capable of sustaining a contractor-run centralized system such as they have in British Columbia?

Scanner Software

One suggestion for I/M program administrators is that their I/M program system, plus QA/QC requirements, should require that inspectors and repair technicians be equipped with the latest scanner software. As noted, OBD II systems continue to evolve and each new model year of vehicle over the next few years will have OBD II systems with innovations and capabilities not featured in current OBD II systems. In order to take advantage of these systems, and to not incorrectly diagnose 'new' vehicles, inspectors and repair technicians must be equipped with the latest scanner software.

The Future for I/M Programs

Based upon the current information available regarding OBD II, what should be the makeup of the next generation of LDV I/M programs?

- Dynamometer-based tailpipe emissions tests,
- OBD II interrogations,
- Roadside remote sensing,
- Remote sensing at an I/M station as a pre-screening tool,
- System function testing, and/or
- All or combinations of the above.

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Appendix A

OBD II Details

A.1 OBD II Hardware

It is important to note that the EPA's current OBD II requirements are slightly different from California's OBD II requirements. However, systems designed to meet California's requirements are also accepted by the EPA as meeting the federal requirements. (CARB 2003)

In the USA, to verify that your vehicle is equipped with OBD II, look for the words 'OBD II' on the emission control information label attached to the underside of the vehicle hood.

The OBD II Connector

In 1988, the Society of Automotive Engineers (SAE) set a standard connector plug and set of diagnostic test signals, the OBD standard, also known as *J1962*. This standard specifies the size, position and design of the OBD connector. The standard system allows anyone with a standard scan tool to plug into a vehicle's system to monitor the car's emission-related faults.

The OBD II connector must be located within three feet of the driver and must not require any tools to be revealed. All OBD-II cars have a connector located in the passenger compartment easily accessible from the driver's seat. Check under the dash or behind or near the ashtray. A cable is plugged into the OBD-II J1962 connector and connected to a scan tool. This scan tool can range from a simple hand-held meter that provides a coded read-out of the various diagnostic functions to a large console computer-based unit. (B&B 2003)

The J1962 is the SAE-established standard for the connector plug layout that is used for all OBD II scan tools. The OBD II connector has standard pin requirements: (B&B 2003)

Pin 2 - J1850 Bus+, Pin 4 - Chassis Ground, Pin 5 - Signal Ground, Pin 6 - CAN High (J-2284), Pin 7 - ISO 9141-2 K Line, Pin 10 - J1850 Bus, Pin 14 - CAN Low (J-2284), Pin 15 - ISO 9141-2 L Line, and Pin 16 - Battery Power.

OBDII equipped vehicles typically have: (Carley 2003)

- Twice the number of oxygen sensors as non-OBDII vehicles (most of which are heated O₂ sensors). The additional O₂ sensors are downstream of the catalytic converter.
- More powerful powertrain control modules, with either 16-bit (Chrysler) or 32-bit (Ford & GM) processors to handle up to 15,000 new calibration constants added by OBDII.
- Electronically Erasable Programmable Read Only Memory (EEPROM) chips that allow the PCM to be reprogrammed with revised or updated software changes using a terminal link or external computer.
- A modified evaporative emission control systems with a diagnostic switch for purge testing, or an enhanced EVAP system with a vent solenoid, fuel tank pressure sensor and diagnostic test fitting.
- More EGR systems with a linear EGR valve that is electronically operated and has a pintle position sensor.
- Sequential fuel injection rather than multi-port or throttle body injection.
- Both a MAP sensor and MAF sensor for monitoring engine load and airflow.

A.2 Communication Protocols - OBD II

While the parameters, or readings, required by OBD II regulations are uniform, the auto manufacturers had some latitude in the communications protocol they used to transmit those readings to scanners. There have been three different OBD II communications protocols in use, ISO 9141, J1850PWM, and J1850VPW. A fourth, the Controller Area Network (CAN) protocol is required on all new vehicles by 2008. (Carley 2003)

- **ISO 9141** - International Standards Organization OBDII communication mode, used by Chrysler, all European and most Asian imports.
- **J1850PWM** - (Pulse Width Modulated) SAE-established OBD II communication standard used by Ford domestic cars and light trucks.
- **J1850VPW** - (Variable Pulse Width Modulated) SAE-established OBD II communication standard used by GM cars and light trucks.
- **CAN** - Controller Area Network - vehicle communication protocol.

CAN will be allowed by EPA in 2004-2007 model year vehicles with the existing protocols. In the 2008 model year, CAN will be the only allowed protocol and the existing protocols (SAE J1850, ISO 9141 and 14230-4) will be eliminated. (Gardetto 2003)

On most 1996 and later vehicles, the protocol used can be identified by examining the OBD II connector:

- J1850 VPW - connector should have metallic contacts in pins 2, 4, 5, and 16, but not 10.
 - ISO 9141-2 -The connector should have metallic contacts in pins 4, 5, 7, 15, and 16.
 - J1850 PWM -The connector should have metallic contacts in pins 2, 4, 5, 10, and 16.
- If a vehicle has the OBD II style connector, but doesn't have the above pins populated, it is probably a pre-OBDII vehicle. To add some confusion, even having the connector with the contacts shown above is not a guarantee of OBD II compliance. This style connector has been seen on some pre-1996 vehicles that were not OBD II compliant.

Generally, the more expensive scanner consoles include decoding software and firmware for all three protocols in their units, making them universal. Less expensive units, for home or small shop use, are usually customized for a specific communications protocol.

A.3 OBD II Codes

The OBD II system can set emission related Diagnostic Trouble Codes (DTCs) and service codes that are not emission related.

A.3.1 Diagnostic Trouble Codes - DTCs (Carley 2003)

Type A - Diagnostic Trouble Codes are the most serious and will trigger the MIL lamp with only one occurrence. When a Type A code is set, the OBDII system also stores a history code, failure record and freeze frame data to help you diagnose the problem.

Type B - Diagnostic Trouble Codes are less serious emission problems and must occur at least once on two consecutive trips before the MIL lamp will come on. If a fault occurs on one trip but doesn't happen again on the next trip, the code won't 'mature' and the light will remain 'off'. When the conditions are met to turn 'on' the MIL lamp, a history code, failure record and freeze frame data are stored the same as with Type A codes.

Type C and D codes are non-emissions related. Type C codes can cause the MIL lamp to come 'on' (or illuminate another warning lamp), but Type D codes do not cause the MIL lamp to come 'on'.

A.3.2 Proprietary Sensor Readings

Though not part of the EPA's OBD II standard, the diagnostic read-outs used by dealership technicians are also read through the OBD II connector. These service codes can indicate, knock sensor operation, FI pulse width, ignition voltage, individual cylinder misfires, transmission shift points, and ABS brake condition. There can be over 300 readings available, depending on the vehicle manufacturer and model. Vehicles vary in the readings they will support. Scanners vary widely in the number of these signals that they can read. Some show just the basic OBD or OBD II signals, others show the full range of service codes. (B&B 2003)

A.4 Readiness Monitors (BAR 2003)

A *Readiness Monitor* determines whether a vehicle's on-board computer has completed its check of a specific emission control device. The tests are performed on many different components while the vehicle is being driven to determine if the components are operating within allowable limits. The on-board computer cannot run some of these tests until certain driving conditions are met. All of the self-diagnostic checks have not been completed if one or more readiness monitors read 'not complete'. A number of factors, including emission repair work or a disconnected battery, can result in Readiness Monitors being set to 'not complete'.

In most cases, the readiness monitors can reset to 'complete' very quickly. However, in some cases in order for the OBD system to clear the readiness monitors and complete its self-diagnostic checks, the vehicle must be driven under a variety of normal operating conditions or over a set OBD II Drive Cycle.

A.5 OBD II DRIVE CYCLE

Once a repair technician has performed an emissions related repair the success of the repair can be assessed by performing what is called an 'OBD II drive cycle'.

The purpose of the OBDII drive cycle is to run all of the On-Board Diagnostics. The drive cycle should be performed after trouble codes have been erased from the PCM's memory, or after the battery has been disconnected. Running through the drive cycle sets all the system status 'flags' so that subsequent faults can be detected.

The OBDII Drive Cycle begins with a cold start (coolant temperature below 122 degrees F and the coolant and air temperature sensors within 11 degrees of one another).

A.5.1 Example OBD II Drive Cycle

The following is an example of a drive cycle for outlined in the Technical Service Bulletin of one particular manufacturer. The drive cycle described below is designed to set the following items, catalyst, evaporative system purge, O₂ sensor, and O₂ sensor heater. (Hyundai 2002)

IMPORTANT: In order to set the Readiness Monitors to READY, the vehicle must successfully complete the appropriate Drive Cycle two times. The definition of two consecutive drive cycles is the vehicle must:

1. Complete the Drive Cycle.
2. Ignition key must be turned to the OFF position and stay off for at least 30 seconds.
3. Complete the Drive Cycle a second time.

IMPORTANT: The two Drive Cycles MUST be completed on two consecutive drives. Consecutive means that the two successful OBD-II Readiness Drive Cycles cannot be interrupted by any other kind of driving between them.

ROAD CONDITIONS:

The type of road that the Drive Cycle is performed on is important. The BEST type of road for performing the Drive Cycle is one that is as Level (Flat) as possible. If the Drive Cycle is performed in an area with hilly terrain, it will be more difficult to successfully perform the Drive Cycle. In this case, it may require that the Drive Cycle be performed more than two times to ensure success.

STEP 1: (Starting Procedure)

- Check to make sure that there are no DTCs stored in the ECM (using the Hi-Scan Pro) and that the Check Engine Light is OFF. If there is a DTC, repair the vehicle first.
- Check the Readiness Status to note which monitors are NOT READY.
- Start the engine.
- Warm up the engine (coolant temperature at least 176 degrees F).
- Turn OFF the A/C.

STEP 2: (Transient to Steady State Driving)

- Connect the Hi-Scan Pro and go to the current data menu. The two items to look at during the drive cycle are Engine RPM and Engine Load (displayed in milliseconds).
- IMPORTANT: Two people should conduct the drive cycle, one person drives and the other person monitors the Hi-Scan Pro readings and keep track of the driving time.
- Drive the vehicle to a light traffic road where the required steady state driving condition can be duplicated.
- Any kind of driving is OK before the steady state driving is conducted.

STEP 3: (Steady State Driving - This is the MAIN part of the drive cycle)

- Drive the vehicle at a steady state where the engine speed is between 2,000 and 2,400 RPM in high gear (5th speed in a manual transmission equipped vehicle and "D" position in an automatic). The engine load should be between 2.0 and 3.0 ms.
- To drive the vehicle in this steady state mode, very little throttle is required.
- Drive in the Steady State Mode for a minimum of 10 minutes.
- Note: During this phase of the drive cycle, if the vehicle "falls out" of the steady state zone criteria (in terms of engine RPM and engine load), the accumulated time does not increase; however, there is no need to restart the steady state mode. 10 minutes is the required ACCUMULATED time. If vehicle "falls out" of the criteria, simply stop counting time and restart counting time when able to again meet the required criteria.

STEP 4: (Transient from Steady State Driving to an Idle State - Any kind of driving is OK during this step) After accumulating at least 10 minutes of Steady State driving, bring the vehicle to a stop at a location where the vehicle may idle.

STEP 5: (Idle State - This is the last phase of the drive cycle)

- After coming to a stop, allow vehicle to idle for one minute (transmission may be put into Neutral or Park).
- After one minute of idling, tip throttle in and out (to take engine out of idle briefly).
- Allow the vehicle to idle for one more minute.

STEP 6: (Engine Stop)

- The drive cycle is finished.
- Turn off the engine (key in the OFF position) and wait 30 seconds.
- After 30 seconds, restart the engine.
- If only one drive cycle has been completed, conduct one more drive cycle.
- After the conclusion of the second drive cycle, turn the key back on to the ON position. Check to see if the Readiness Monitors indicate READY (or COMPLETED).
- If not, then check if there are any DTC codes or if the Check Engine Light is ON. If yes, then repair the vehicle. After repair is completed, conduct drive cycle two times.
- If, after the conclusion of the second drive cycle, the Readiness Monitors still indicate NOT READY (or NOT COMPLETED), then conduct the drive cycle one more time and check the Readiness Codes again (previous attempts at the drive cycle may not have been successfully completed).

A.6 OBD II Manufacturer Design Checks

In the USA, the OBD Workgroup report listed measures that are used by the EPA and CARB to counter possible manufacturer fraud or OBD II design problems: (CAAAC 2002)

During Warranty Period

- CARB's certification process includes an extensive evaluation of OBD monitoring system design.
- CARB confirms manufacturer submitted *Durability Demonstration Vehicle* (DDV) testing results on 3 – 10 vehicles/year and these tests could be conducted on low (during warranty) or high mileage (100,000+ miles) vehicles.
- CARB staff conduct in-use testing for OBD performance on 20-30 random/targeted in-use vehicles/year that are generally less than two years old.
- EPA reviews CARB certification data. EPA/CARB enforcement action against manufacturers has been, and can be, severe. If a manufacturer is found to have an 'under-sensitive' OBD system, then EPA/CARB will take action.
- Newly adopted CARB requirements for the 2004 model year require each manufacturer to perform production vehicle evaluation (PVE) testing on 2-6 vehicles/year. Manufacturers must test every individual diagnostic (about 150 per car) on the vehicle by implanting malfunctions and verifying proper detection within the first 6 months of production.

After Warranty Period

- The CARB certification process also requires OBD DDV compliance testing at 100,000 miles on 1-3 vehicles/year per manufacturer (about 40 total per year) ensuring MIL illumination at 1.5 times the FTP standard for catalyst, misfire, EGR, fuel system, oxygen sensor, and secondary air.
- CARB confirms manufacturer submitted DDV testing results on 3-10 vehicles/year and these tests can be conducted on low (during warranty) or high mileage (100,000+ miles) vehicles. CARB conducts in-use emission and OBD testing of 40-120 vehicles/year (20 - 40 models per year with 2-5 vehicles per model tested) to assess the durability of emission control designs.
 - Tests vehicles at 40,000/100,000 miles.
 - High emissions or non-compliant OBD systems result in recalls.
 - Thus far, 73 manufacturer recalls based on in-use FTP testing since 1983.
- EPA is conducting on-going high mileage vehicle study to continue to monitor OBD performance at 100,000 miles and higher.
- An "over-sensitive" OBD system could be a "misbuild" and can result in EPA enforcement action. EPA's in-use compliance program is likely to find an "over-sensitive" OBD system. EPA tests about 50 different classes of vehicles and 150 vehicles annually.
- Starting with the 2004 model year, manufacturers are required to conduct in-use testing of approximately 2000 tests per year (see discussion on page 9).
- Defect reports are required by regulation to be provided by manufacturers. Technical Service Bulletins are also provided by manufacturers.
- EPA reviews independent service facilities letters, email, and calls concerning warranty, performance, fuel economy, and emission problems.
- J.D. Powers, Consumer Reports, and other sources track and rate "reliability" and "durability" of vehicles. Manufacturers producing over-sensitive OBD systems would risk substantial loss of market share due to decreased reliability/durability ratings.

Appendix B

An OBD-I/M Test

In June of 2001, the EPA issued guidance in regard to OBD in I/M programs to assist those states and local areas that were considering or planning early implementation of OBD checks as part of their I/M programs. The following was reproduced from the EPA guidance. (Sosnowski 2001, Sosnowski 2002)

B.1 Elements of an OBD II Test or Interrogation

An OBD-I/M check consists of two types of examination:

- A visual check of the dashboard display function and status (also known as the MIL and/or bulb check), and
- An electronic examination of the OBD computer itself.

These two examinations, taken together, comprise a seven-step procedure:

- 1] Initiate an official test by scanning or manually inputting required vehicle and owner information into the reporting medium (i.e., PC-based electronic reporting system or manual test report).
- 2] Visually examine the instrument panel to determine if the MIL illuminates briefly when the ignition key is turned to the "key on, engine off" (KOEO) position. A brief period of illumination of the MIL at start-up is normal and helps confirm the bulb is in proper, operating condition. This portion of the test procedure is also known as the "bulb check". Enter the results of the bulb check into the reporting medium.
- 3] Locate the vehicle's data link connector (DLC) and plug a scan tool into the connector. While it is recommended that this step be performed with the ignition in the "off" position, this step can also be performed with the ignition running. Given the variety of locations manufacturers have chosen in practice, locating the DLC may well be the most time-consuming element of the inspection.
- 4] Start the vehicle's engine so that the vehicle is in the "key on, engine running" (KOER) condition. The MIL may illuminate and then extinguish during this phase. Continued illumination while engine is running is cause for failure. Also, if the MIL illuminates during this phase but was not observed in step 2, the vehicle should not be failed for step 2.

Note: While it is possible to perform the electronic scan portion of the OBD-I/M check in the KOEO position for most vehicles, EPA discourages this practice because it can lead to false failures for some makes and models of vehicles (such as MY 1996 to 2001 Subaru).

- 5] With the scan tool in the "generic OBD" mode, follow the scan tool manufacturer's instructions to determine:

- Vehicle readiness status,
- MIL status (whether commanded on or off), and
- Diagnostic Trouble Codes (DTCs) for those vehicles with MILs commanded on.

Note: For I/M purposes, the inspectors and repair technicians should be advised to conduct the scan in "generic" mode as opposed to a vehicle manufacturer specific mode. EPA is aware of some instances in which using a scan

EPA's original OBD-I/M failure criteria were limited to power-train, emission-related DTCs (refer to SAE J1979 MODE 03). In its April 5, 2001 rulemaking, however, EPA simplified the failure-triggering DTC criteria to any DTC that leads to the MIL being commanded on.

- 6] Record the results of the OBD inspection in the appropriate medium. Depending upon the design and feature requirements of the program, this may be an automated process.
- 7] Without clearing DTCs or readiness codes, turn off the vehicle ignition, and then disconnect the scan tool. Clearing codes, if such is necessary, should be reserved for the repair portion of the program (even though in test-and-repair programs, the same personnel may be engaged in both

activities). These codes (and the associated "freeze-frame" data) are important for the performance of proper diagnostics prior to repair.

Note: For programs conducting both OBD and tailpipe testing on OBD-equipped vehicles, the tailpipe test may be conducted prior to this step, to avoid an extra, unnecessary key-off, key-on cycle.

Although the above inspection elements are listed sequentially, current regulations do not specify the sequence that must be followed in performing the OBD-I/M inspection, and EPA sees no reason for applying a rigid sequence at this time. In some cases it may make more sense to conduct the visual portion of the inspection after performing the onboard computer scan.

Reporting

If a vehicle fails, the test report given to the motorist should include the status of the MIL illumination command and the alphanumeric fault code(s) listed along with the DTC definition(s) as specified per SAE J2012 and J1930. Only the fault codes leading to the inspection failure should be listed on the report given to the motorist. EPA makes this recommendation because it is possible that an OBD system may set DTCs without commanding a MIL to be illuminated. These DTCs usually reflect an intermittent condition that may or may not be a problem at the time of testing. If the condition does not recur within a certain number of trips, the code will eventually be cleared; if the condition does recur, the system may then determine that a MIL should be illuminated. Therefore, no DTCs should be printed on test reports for vehicles that pass the inspection. An owner who receives notice of these codes on the same sheet of paper with notification of passing the state inspection may become confused or desensitized to the importance of DTCs and the MIL.

At a minimum, EPA believes that for an OBD-I/M test program to be most effective -- whether centralized or decentralized -- it should be designed in such a way as to allow for:

- \$ Real-time data link connection to a centralized testing database;
- \$ Quality-controlled input of vehicle and owner identification information (preferably automated, for example, through the use of bar code); and
- \$ Automated generation of test reports.

Basis for Failure or Rejection

Unless otherwise noted in this guidance, a vehicle should be failed for any of the following five reasons, with the exception of the last (for which the appropriate action is rejection):

States should be aware that some vehicles have atypical OBD configurations, and should take steps to avoid unfairly penalizing motorists. For example, states may incorrectly suspect motorist tampering for those vehicles that are manufactured with the DLC in a hard-to-find location. EPA is working with manufacturers, operating OBD-I/M programs, and Weber State University to develop an online clearinghouse of OBD-related information useful to state I/M programs and other stakeholders, including all OBD-related Technical Service Bulletins (TSBs) from manufacturers and all relevant updates.

1] It is a 1996 or newer vehicle and the data link connector (DLC) is missing, has been tampered with, or is otherwise inoperable. (Action: Failure)

Tampering is considered to be any modification of the vehicle that deviates from the certified configuration of the vehicle. Particularly if such modification has the practical effect of making the vehicle untestable (by, for example, making the DLC inaccessible) or otherwise constitutes an attempt to evade the program (by, for example, using illegal aftermarket devices designed to circumvent the OBD computer or provide false results during an OBD-I/M check). Under this definition, moving a DLC as part of collision repairs would not necessarily constitute tampering -- provided the DLC was not hidden or rendered otherwise inaccessible as a result of being moved.

2] The MIL does not illuminate *at all* when the ignition key is turned to the KOEO position. The MIL should illuminate (on some vehicles, only for a brief period of time) when the ignition key is turned to the KOEO position. (Action: Failure)

3] If the MIL illuminates continuously or flashes *after* the engine has been started, even if no fault codes are present, since this could indicate a serial data link failure. (Action: Failure)

States should be aware that some vehicles will illuminate a MIL when a scan tool is connected and the vehicle is still in the Key On, Engine Off (KOEO) condition. In some cases, the scan tool will indicate that the MIL is, in fact, commanded on -- even though no DTCs may be present. EPA has found that these vehicles will usually extinguish the MIL and remove the *MIL Commanded On* indicator when the engine is started. To avoid falsely failing vehicles, therefore, it is important that the electronic portion of the OBD-I/M check be conducted

4] Any DTCs are present *and* the MIL status, as indicated by the scan tool, is commanded *on*, regardless of whether or not the MIL is actually illuminated. Do not fail the vehicle if DTCs are present and the MIL status, as indicated by the scan tool, is *off*, because such non-MIL-triggering DTCs are considered 'pending' and frequently self clear without requiring repair of the vehicle. MIL command status must be determined with the engine running. (Action: Failure)

5] The number of OBD system monitors showing a *Not Ready* status exceeds the number allowed for the model year in question. (Action: Rejection)

Although earlier requirements stipulated that OBD-equipped vehicles be rejected from further testing if any monitor was Not Ready, EPA has revised these readiness criteria to allow states to *not* reject MY 1996-2000 vehicles with two or fewer unset Readiness Codes, or MY 2001 and newer vehicles with no more than one unset Readiness Code. The complete MIL check and scan should still be run in all cases, however, and the vehicle should still be failed if one or more DTCs are set and the MIL is Commanded On. The vehicle should also continue to be rejected if the OBD computer does not set readiness codes for 3 or more monitors on MY 1996-2000 vehicles, or two or more monitors on MY 2001 and newer vehicles.

B.2 Possible OBD II I/M Test Outcome

The EPA guidance document provides the following as the possible outcome of OBD II I/M tests: (Sosnowski 2001)

Table B.1 Possible OBD I/M Test Outcomes

Vehicle PASSES If	<ul style="list-style-type: none">• Bulb check OK, and• MIL not lit while engine running, and• MIL not commanded 'on' for any DTCs, and• All required Readiness Monitor Codes are set.
Vehicle FAILS if	<ul style="list-style-type: none">• Bulb check not OK, and/or• MIL lit while engine running, and/or• MIL commanded 'on' for any DTCs, and/or• DLC missing, tampered, or inoperable.
Vehicle REJECTED if	<ul style="list-style-type: none">• More unset Readiness Monitor Codes found as 'not ready' than allowed based upon MY and/or• DLC cannot be located or is inaccessible.

Appendix C

States with OBD I/M

The following information was extracted largely from information published on state Internet sites in 2003 and 2004. Information for the 33 states (and Washington, DC) cited by the EPA, plus I/M programs in two other states, Colorado and Michigan, are presented.

1] Alaska - <http://www.state.ak.us/dec/dawq/aqi/biennial.htm> and BeesonHK@ci.anchorage.ak.us
Full OBD II testing began in Anchorage and Fairbanks in June 2003: The Anchorage and Fairbanks programs started OBD testing in July 2001 but had a limited number of Readiness Monitors being considered. In June of 2003 they allowed three Readiness Monitors to be unset and still pass and two Readiness Monitors unset after repair. This is still not up to EPA standards but they would have an exceptionally high number of failures with EPA standards. Officials are currently working to upgrade the Readiness Monitor limit to EPA standards.
All OBD (1996 and newer) vehicles also receive a visual inspection of all ECS components and a functional inspection of some of the ECS components in addition to the OBD test. Each vehicle must pass every phase of the test to be certified. The only OBD vehicles that receive a tailpipe test are the ones that cannot be tested with OBD. All 1968 through 1995 vehicles are tested with a visual, functional and tailpipe test, which is a two-speed idle test.

Beginning January 1, 1997 the vehicle I/M programs in Alaska phased to once every two years. DMV registrations are issued for one or two years based on the model year of the vehicle. This applies to Municipality of Anchorage (MOA), MOA commuters, and Fairbanks North Star Borough (FNSB) vehicle owners. Model year 1967 and older vehicles are exempt, as are the latest two model years.

2] Arizona - <http://www.adeq.state.az.us/envIRON/air/vei/index.html>
<http://www.adeq.state.az.us/comm/pr/2001/mar01.html>, MECA 2002

- *IM 147*: This is the enhanced test (a variation of the IM240) used for most 1981 through 1995 gasoline-powered vehicles in the metro Phoenix inspection program. In this test, the vehicle is driven on a dynamometer at varying speeds to simulate urban driving.
- *Steady-State Loaded and Idle*: This test is used for most 1967 through 1997 vehicles in Tucson and 1967 through 1980 models in Phoenix. The vehicle is tested at idle and at approximately 25 to 30 miles per hour. The results are shown in percent or parts per million.
- *On-Board Diagnostics*: The newest test to be used in Arizona is the On-Board Diagnostic test used on 1996 and newer light duty vehicles only.
- *Tampering*: In addition to one of the above tests, a vehicle may undergo a visual inspection to determine the presence of certain emission control components as installed by the manufacturer. Inspection includes catalytic converter, operational air pump, positive crankcase ventilation system and evaporative control system. These inspections coupled with the evaporative system integrity (pressure) test constitute the tampering inspection.

3] California - <http://www.smogcheck.ca.gov/stdhome.asp>

On November 12, 2002, the Bureau of Automotive Repair began phasing-in the OBD-II functional inspection readiness requirements by setting the Smog Check system's overall OBD-II readiness threshold to '5'. In September 2003 the threshold was set to 3.

- An enhanced I/M program (using ASM15/25 test [25/25 and 50/15] and BAR97 analyzers) with biennial inspections is operating in 'enhanced' areas of the State.
- In Basic and Change of Ownership program areas, vehicles may be tested using a BAR-90 or a BAR-97 system (with or without a dynamometer) employing a two-speed idle test. Regulation actions are pending to replace the BAR-90 Test Analyzer Systems (TAS) in the Basic and Change of Ownership program areas with the BAR-97 analyzer platform without a dynamometer.
- All vehicles equipped with OBD II (96 MY and newer) are tested. The same vehicles are tested with an ASM test (both at 15 mph and 25 mph) as well as visual, functional, and gas cap pressure checks. All tests are equally weighted and a car can fail for any of the tests.

In enhanced areas, 36% of the highest polluting vehicles are directed to Test-Only stations at the time of their biennial Smog Check inspection. Test-Only stations are licensed by the Bureau of Automotive Repair (BAR) to perform tests on vehicles, but are prohibited from performing any repair services. Potentially high-polluting vehicles in the State's Enhanced Smog Check regions are directed to Test-Only stations for their initial Smog Check inspection as required by State law. In addition, two percent of the vehicles in enhanced areas due for Smog Check inspections are randomly selected, and then directed each month to Test-Only stations, to aid in program evaluation. Most of the vehicles in the 'enhanced' areas have Smog Check inspections performed at Test-and-Repair facilities. In all areas of the State, vehicles that fail as "gross polluters" must have repairs certified at state-contracted Test-Only Referee Centers or Gold Shield Gross Polluter Certification Stations.

4] Connecticut - <http://www.ct.gov/dmv/site/default.asp>

As a result of the implementation of changes to the emissions testing program, emissions testing was suspended and resumed 19 September 2003.

- Testing will move from 25 centralized stations to at least 300 licensed dealers and repairers spread out across the state, and
- For 1996 model year vehicles and newer ones, a testing process called On-Board Diagnostics (OBD) will be used. For vehicles of other model years, the current ASM 2525 or the two-speed idle test will be done.

5] Delaware - http://www.dmv.de.gov/Vehicle_Services/Other/ve_oth_inspections.html

The Division of Motor Vehicles performs vehicle inspection's at all four DMV facilities. Inspections are performed for no fee. Usually, all vehicles being titled for the first time in Delaware must be inspected...The newest five model years of vehicles, weighing 10,000 pounds or less and being titled for the first time in Delaware are only required to have a Vehicle Identification Number (VIN) verification. Inspections include, a safety inspection covering such items as tires, brakes, windows and an exhaust emissions inspection that analyzes the vehicle's exhaust and a test of the fuel system for leaks. Beginning in the 2002, the Division implemented the new On-Board Diagnostic system (OBD II) inspection for 1996 or newer vehicles. A gas cap pressure test and an evaporative system function test are also included.

6] DC, Washington - http://dmv.dc.gov/serv/inspection/inspection_main.shtm (DC 2003)

OBD II testing on an 'information only' basis began January 2002. OBD II testing on a pass/fail basis for 1996 and newer is to begin by the end of January 2004.

The inspection performed in the District of Columbia includes and extensive safety inspection and brake test. Almost 10% of all cars tested in DC fail. However, a large percentage of these failures are in older vehicles. The inspections are biennial and apply to any vehicle that is registered in the District of Columbia. There are 8 centralized test lanes.

The IM240 test replaced the traditional emission detection. Model year 1968 to 1980 receive an idle emissions test. All vehicles receive a gas cap pressure test. When the OBD II testing begins on a pass/fail basis, the IM240 test will only apply to 1981 to 1995 MY vehicles.

7] Georgia - <http://www.cleanairforce.com/>

In the Atlanta area, starting in May 2002, all 1996 and newer vehicles subject to emission inspections have received a two-part inspection:

- An OBD test to check a vehicle's emission control performance history, and
- A fuel cap inspection to check for adequate seal.

If an OBD test is unable to be performed on a vehicle, it may be necessary to perform a Two-Speed Idle test (TSI).

All 1979 to 1995 MY vehicles will receive a four-part inspection:

- A visual inspection of the catalytic converter to check for tampering or removal,
- ASM2 or Accelerated Simulation Mode Test - A dual-mode test including a 25/25 test = 25 lbs. of load at 25 MPH and a 50/15 test = 50 lbs. of load at 15 MPH.
- A tailpipe exhaust emission test.
- A fuel cap inspection to check for adequate seal.

Older vehicles (1979-1995 model years) must be tested at stations marked "All Vehicles Welcome," where they will undergo an inspection using different testing equipment.

8] Idaho - <http://www.emissiontest.org/>

An annual emissions test is required in Ada County for LDVs of 1965 MY and newer.

While the EPA lists Idaho as having started OBD II checks at the end of 2002, no information regarding those tests is currently posted on their Internet site.

An Exhaust Emissions Inspection shall include all of the following:

- A measurement of Exhaust Emissions using an approved Exhaust Analyzer or other procedure or device approved by the Board to sample the Motor Vehicle's Exhaust Emissions, specifically including Carbon Monoxide and Hydrocarbon content of exhaust, and
- A determination as to whether Exhaust Emissions meet the Pass-Adjust Criteria; and
- A visual inspection, for model years 1984 and newer, to verify presence of the catalytic converter, air injection system, size of the fuel restrictor and any other visual inspection component(s) specified by the Board in the Rules and Regulations

Currently, only vehicles registered in Northern Ada County are required to undergo emissions testing. Vehicles must be tested annually.

9] Illinois - <http://www.epa.state.il.us/air/vim/>

Three types of tests are used. In July 2002, an On-Board Diagnostic test (OBD) replaced the traditional exhaust emissions test for most 1996 and newer passenger cars and light duty trucks (including vans and sports Utility vehicles.) An IM240 test is used for most 1981-1995 vehicles and a basic Idle test for 1968-1980 vehicles. As of June 1999, the program operates 35 stations and 139 lanes, making it the largest centralized vehicle emissions inspection program in the United States. Testing is on a biennial basis. Phase-in for new OBD Test Program -

- *Phase 1 from July to October 2002:* 1996 and newer vehicles that pass a gas cap pressure test and an OBD test will pass the emissions test. An exhaust test will not be performed when the vehicle passes the OBD test. If the vehicle fails the OBD test, it will be given a second chance to pass by receiving an exhaust test. In this phase, vehicles that fail the emissions test can be repaired to pass either the OBD test or the exhaust test.
- *Phase 2 from October 2002 to January 2004:* Owners of 1996 and newer vehicles will be able to decide whether to repair their vehicle if it fails an OBD test, or to be given a second-chance exhaust test. In this phase, vehicles that fail the emissions test can be repaired to pass either the OBD test or the exhaust test.
- *Phase 3 beginning January 1, 2004:* The emissions test for most 1996 and newer vehicles will consist of a gas cap pressure test and an OBD test. In this phase, vehicles that fail the OBD test must be repaired to pass the OBD test.

10] Indiana - http://www.state.in.us/idem/air/programs/imsite_new/index.html

Air Programs Branch of the Office of Air Quality - Testing is biennial. For model year vehicles 1981 through 1995, the emissions check has three steps. During the first step, an inspector will complete a basic visual inspection for leaking fluids and conditions that may present a safety problem. The lane inspector will then inspect for the presence of the catalytic converter and conduct a gas cap pressure test. During the second step, the vehicle is placed on the dynamometer. The dynamometer operates at various speeds (maximum 33 miles per hour) for up to 93 seconds. The test titled the IM93 is an IM240-type test and uses the first 93 seconds of the IM240 test. For model year vehicles 1976-1980, the three testing steps are similar except that these vehicles will not be tested on the dynamometer. The vehicle emissions are checked while the vehicle is idling. MY 1996 and newer vehicles are administered an OBD II system test. A scan tool will be hooked up to the vehicle's OBD connector to check the OBDII system status.

11] Kentucky <http://www.air.ky.gov/pubinfo/NKyemissions.htm>

In Louisville the I/M testing program is to cease in January 2004. However, Louisville began OBDII testing 1996 and newer autos and light duty trucks in July 2002. The procedure is to perform an OBD test on a vehicle, and if it passes, that vehicle undergoes no more testing. If the vehicle fails the OBD test, a loaded mode tailpipe test is performed. If it passes the loaded mode test then that vehicle undergoes no more testing. However, if the vehicle fails the tailpipe also, it is considered an OBD failure, and repair is required under the OBD rules. (VET 2003) Northern Kentucky chose not to institute the OBD testing as an initial test, but 'failed' vehicles receive an OBD test. (Weber 2003) There are drive-thru testing stations in Boone, Campbell and Kenton counties (across from Cincinnati, Ohio). Vehicles with 1968-and-newer model years must be tested if they are fueled by gasoline or Diesel and have a gross vehicle weight rating of 18,000 pounds or less. The test is composed of three steps:

1. All 1975 and newer gasoline-fueled vehicles receive a visual inspection for required emissions control equipment (unvented gas cap, fuel inlet restrictor, and catalytic converter – if part of original equipment).
2. Next, the engine idles while emissions levels are sampled.
3. Lastly, the evaporative system pressure test is performed on all gasoline-fueled vehicles model year 1981 or newer. The inspector lifts the hood, clamps off the charcoal canister, and attaches a pressure line to both the gas cap and fuel tank.

12] Louisiana - <http://www.deq.state.la.us/planning/mvimp/> and Louisiana 2003

Vehicles subject to annual emission testing are model year 1980 or newer gasoline fueled passenger cars and gasoline-fueled light and heavy-duty trucks with a GVWR of 10,000 pounds or less. Vehicles registered in the 5-parish Baton Rouge ozone non-attainment area (Ascension, East Baton Rouge, Iberville, Livingston, and West Baton Rouge parishes) are included.

- These new emissions tests are performed as part of an annual safety inspection at any certified Motor Vehicle Inspection (MVI) Station in the Baton Rouge ozone non-attainment area during normal inspection hours.
- In addition to inspection of your vehicle's safety equipment, all 1980 and newer vehicles receive a visual anti-tampering check of emissions system and a gas cap integrity test.
- OBD II testing of 1996 and newer vehicles, on a pass/fail basis, began in October 2003.
- The visual inspection includes the following emission control system components:
 - Catalytic converter system (catalyst), air injection system (AIS including belts, hoses, and valves), positive crankcase ventilation system (PCV system including hoses and valves), evaporative emission control system (charcoal canister, hoses, wires, and control valves), and exhaust gas recirculation system (EGR valve and hoses).
- The pressure test detects leaks in the vehicle's gas cap, to ensure a proper seal with the fuel system, thereby reducing harmful vapors.

13] Maine - <http://www.maine.gov/dep/air/mobile/enhancedautoinsp.htm> & Maine 2003

The enhanced motor vehicles inspection program went into effect January 1, 1999. The program requires that all gasoline-powered motor vehicles registered in Cumberland County be subjected to an enhanced inspection. The State has a gas cap pressure test and a visual inspection for the catalytic converter as part of its annual vehicle safety inspection program. Visual inspection for catalytic converters for all 1983 and newer MY vehicles. Gas cap pressure tests for all 1974 and newer MY vehicles.

OBD II testing began in January 2000. Enforcement started January 2001 for vehicles that are 1996 model year and newer. There is no tailpipe testing in Maine, but all vehicles undergo a visual tampering check of the catalytic converter and a gas cap pressure test. Vehicles failing the OBD portion of the inspection were required to make necessary repairs prior to receiving a safety inspection sticker.

14] Maryland - <http://www.marylandmva.com/mvaprog/veip/VEIPInfo>

Vehicle Emissions Inspection Program

The On-Board Diagnostic (OBD) test is required for vehicle model year 1996 and newer powered by gasoline, propane or natural gas with a gross vehicle weight rating (GVWR) of 8,500 pounds or less. The treadmill test IM240 dynamometer emissions test is required for vehicles model year 1984 through 1995 weighing up to 10,000 pounds and vehicles model year 1996 and newer weighing from 8,501 to 10,000 pounds powered by gasoline, propane, or natural gas.

A simple idle emissions tailpipe test is required for vehicles model year 1977 through 1983 powered by gasoline, propane, or natural gas weighing up to 26,000 pounds.

All vehicles that are required to have an emissions test are required to have a gas cap leak check. The newest two model years of a vehicle are exempted from the emissions test.

Vehicles that fail the emissions test must be repaired and pass a re-inspection at one of the centralized inspection stations. The VEIP testing network consists of 87 testing lanes at 19 centralized inspection stations located in 13 counties and Baltimore City. Approximately 2.4 million motor vehicles are tested every two years.

15] Massachusetts - <http://www.vehicletest.state.ma.us/> & paul.davis@state.ma.us

The Enhanced Emissions Safety Test has been in effect since October 1999 for all motor vehicles registered in the Commonwealth, including buses and trucks. Massachusetts uses a transient emission test for biennially testing pre-OBD [pre-96] vehicles with a GVWR of 10,000 lbs. or less, except those with non-disengageable traction control, non-disengageable 4wd/Awd, hand controls for handicapped operation, or unusual configurations that preclude dyno testing. These exceptions receive a two-speed idle test. The equipment used is MASS99, in a decentralized network of approximately 1,500 stations throughout the Commonwealth. The drive trace is the BAR31, a 31-second trace with a top speed of ~31 mph. The program currently uses OBD as a fast-pass - if the vehicle passes an OBD check, it bypasses the tailpipe test. If the OBD has too many unset monitors or the MIL is commanded on, it fails the OBD fast-pass check and is sent to a tailpipe test. They plan to move to full OBD pass/fail around January 2004. After full rollout, the only vehicles receiving tailpipe tests will be those with known communication problems identified by EPA or others.

16] Missouri - <http://www.dnr.state.mo.us/alpd/index.html> - MECA 2002

The Gateway Clean Air Program switched to biennial testing in 2003. The Gateway Clean Air Program began the phase-in of OBDII testing for 1996 and newer vehicles on January 2, 2003. Every two years, vehicles registered in the city of St. Louis and St. Louis, St. Charles and Jefferson counties are required to have an enhanced emissions test. Vehicles registered in Franklin County are required to have an improved idle test annually. All vehicles are also eligible for RapidScreen, which measures emissions as vehicles drive by the RapidScreen van. RapidScreen is an option under the Gateway Clean Air Program that allows vehicles to pass the new emissions test without visiting an emissions test station. Special technology is used to unobtrusively measure exhaust emissions while vehicles are driven on streets and highways. This technology has proven to be particularly effective for on-road identification of very clean vehicles. Phase-In Test Period: Starting Jan. 1, 2003, and lasting through Dec. 31, 2004, all 1996 and newer vehicles will be given a gas cap pressurization check at testing position one. The vehicle will then be moved to testing position two and given an OBD II test. If the vehicle passes both the gas cap and OBD II tests, the program provides the motorist with the appropriate passing certificate and sticker. If the vehicle fails the OBD II test, the vehicle will be given a second chance to pass by receiving an IM240 tailpipe test. If the vehicle fails the gas cap test, the entire process must be repeated whether or not the vehicle passed the OBD or tailpipe tests. Currently there is a basic program in Franklin County that features an annual BAR90 idle test for 1971 and newer model year vehicles under 8500 lbs. GVWR.

In St. Louis City and St. Louis, St. Charles, and Jefferson Counties tests feature:

- a. OBD II test 1996 and newer.
- b. IM240 for 1981 and newer vehicles 8500 lbs. GVWR and under.
- b. BAR90 idle test for 1971 to 1980 model year vehicles 8500 lbs. GVWR and under.
- c. Biennial testing for all model year vehicles.
- d. Testing exemption for first two model years when purchased new.
- e. Use a remote sensing component for clean screen exemptions.
- f. A gas cap integrity test.

17] Nevada - <http://www.dmvnv.com/emission.htm>

Emissions inspection stations in Nevada are privately owned and decentralized. Nevada uses On-Board Diagnostics (OBDII) Testing for 1996 and newer vehicles. Older vehicles are tested with a Nevada94, two-speed idle test. Passenger cars and trucks need an emissions test if they are based in the urban areas of Clark or Washoe county and are gasoline-powered, diesel-powered with a gross vehicle weight under 8,500 pounds; and 1968 model year or newer - new vehicles on their first and second registration are exempted.

18] New Hampshire - <http://nh.gov/safety/dmv/emissions/index.html>

New Hampshire's statewide, decentralized I/M program is conducted in conjunction with the annual safety inspection. On January 1, 1999, New Hampshire began an enhanced safety inspection program for all 1980 and newer vehicles. For all vehicles subject to the enhanced safety inspection, the State is conducting a visual anti-tampering inspection for the presence and proper connection of the gas cap, catalytic converter, fuel inlet restrictor, PCV valve, and air injection pump/pulse system. In regard to OBD II testing New Hampshire is currently in the process of evaluating and choosing a vendor to implement an OBD inspection program for the state. With the implementation of an OBD inspection (estimated to be in mid to late 2004) all 1996 and newer light duty gasoline vehicles and 1997 and newer light duty diesel vehicles will be subject to the OBD inspection. New Hampshire does not conduct tailpipe testing on any model year vehicles and has no plans to begin such a program. (New Hampshire 2003)

19] New Jersey - <http://www.state.nj.us/mvc/cleanair/> - <http://www.njinspection.com>.

New Jersey has these types of inspection stations: appointment only, central vehicle inspection (VIS) stations, and specialty inspection sites for inspection of salvage, reconstructed raised vehicles, farm labor transports, handicapped, summer camp buses and other specially constructed cars, trucks and motorcycles.

Beginning on August 4, 2003, most vehicles from model year 1998 to the present will have to pass the OBD test as part of the general inspection process. Beginning on January of 2004, the state will add the OBD testing requirement for most vehicles from model years 1996 and 1997.

- All gasoline-fueled vehicles are subject to inspection (with limited exemptions for historic and collector vehicles).
- The ASM5015 exhaust emission test is performed for 1981 and newer LDGVs and LDGTs under 8,500 lbs. GVWR. In addition, these vehicles, when applicable, receive the following tests: a. Gas cap evaporative test, and b. Visual inspection for catalytic converter on all 1975 and newer MY vehicles.
- 1981 and newer vehicles not amenable to dynamometer-based testing receive the following tests: a. 2500 RPM exhaust emission test, b. Gas cap evaporative test, and c. Visual inspection of catalytic converter on all 1975 and newer MY vehicles.
- Pre-1981 LDGVs and LDGTs and all HDGVs receive the following tests.
a. Idle exhaust emission test, b. Gas cap evaporative test, and c. Visual inspection of catalytic converter on all 1975 and newer MY vehicles.

20] New Mexico - <http://www.cabq.gov/aircare/> and GDennis@cabq.gov

The vehicle I/M program for the City of Albuquerque program:

OBDII testing will be phased in over the first 6 months of 2004 with all Air Care stations required to have new BAR97 OBDII analyzers by June 30, 2004. All 1996 MY and newer vehicles will be tested with OBDII while 1975-1995 vehicles will continue to receive a TSI test with visible inspection of the converter(s) and for visible smoke. We will discontinue the visible tamper check for O2 sensors and air injection systems but will add a pressurized gas cap test.

In the current I/M program an emissions test is required every two years for Bernalillo County-registered vehicles (includes Albuquerque) that are 1975-newer, have a gross vehicle weight between 1,000-25,999 pounds, and are spark ignited (gasoline, propane, and natural gas). The vehicle must pass three test components: pollution control equipment (catalytic converter, air injection, and oxygen sensor), exhaust analysis, and visible emissions/smoke.

New Mexico - Continued

The exhaust analysis measures carbon monoxide (CO) and hydrocarbons (HC) at both idle and high speed (2,500 RPM). The New Mexico analyzer specifications and test, patterned after the BAR 90, are referred to as the New Mexico 95 program. The NM 95 analyzers were phased in beginning July 1995.

An Air Care Inspector checks that the catalytic converter, air injection system and oxygen sensor are properly installed and are original or approved replacements.

Remote sensing - An RSD has many applications and can be configured in many different ways. Since the unit is permanently installed in a van, it can be set up quickly without effecting traffic flow. The unit can be easily moved from one site to another.

A centralized vehicle emissions testing program was started in 1982. This program was based on an annual dynamometer test operated by a contractor with oversight by the City of Albuquerque. In 1984, the New Mexico Supreme Court declared the vehicle testing program unconstitutional due to the manner in which the test fee was collected and the program was shut down. The Federal Highway Administration imposed funding sanctions from 1985-88 due to the lack of a vehicle emissions testing program. In 1989, the biennial, decentralized Air Care program was started.

21] New York - <http://www.nydmv.state.ny.us/vehsafe.htm#inspect>

The state is currently operating two separate I/M programs, a high enhanced I/M program for the downstate New York (City) Metropolitan Area (the five boroughs of New York City, Nassau, Suffolk, Rockland, and Westchester Counties) and a low enhanced I/M program for the remainder of the state (53 counties). The model year, weight and vehicle type determine the test methods and standards used, as follows:

- 1981 and newer models that weigh 8,500 lbs. and under go through a dynamometer test for exhaust emissions that exceed the acceptable limit. NYTEST (New York Transient Emissions Short Test) for 1981 and newer:
 - Vehicles weighing 8500 lbs. GVWR and less.
 - 1996 and newer models also go through an OBD check.
 - Vehicles before model year 1981 that weigh more than 8,500 pounds or have full-time traction control or all-wheel drive equipment receive the idle speed tailpipe test only.

All vehicles receive a gas cap check and a visual inspection to find evidence of tampering and to prevent malfunctions in the air pollution control devices. Vehicles exempt from the test include vehicles less than two model years old, or more than 25 model years (for example, a 1975 model in 2001),

22] North Carolina - <http://www.dmv.dot.state.nc.us/enforcement/emissionsinspections/>

Vehicles that are 25 years old and newer require an annual test. The State of North Carolina has a "decentralized" inspection network consisting of inspection and retest at privately owned facilities licensed by the state - i.e., gas stations, repair shops. Effective July 1, 2002, all 1996 and newer gasoline-powered vehicles registered in an emissions county are required to receive the On-Board Diagnostics (OBD II) emissions test.

Additionally, through December 31, 2005, all gasoline-powered vehicles less than 25 years old, up to and including model year 1995, registered in one of the original nine emissions counties, (Wake, Forsyth, Guilford, Durham, Gaston, Cabarrus, Mecklenburg, Orange, or Union), will require an exhaust (tailpipe) emissions test. The analyzer will test and disapprove a vehicle when the CO or HC reading is higher than the standards. The 1996 and newer vehicles that fall into this category are excluded from OBD testing because they are not equipped with the components necessary to perform an OBD inspection.

23] Ohio - <http://www.epa.state.oh.us/dapc/mobile.html> and Weber 2003

E Check Program. A centralized, contractor-run, test-only, enhanced (opt-in) I/M program (vehicles tested biennially) is operating in the Cleveland-Akron, Dayton-Springfield, and Cincinnati areas. When the program started, IM 240 was the primary vehicle emission test used by Ohio EPA. Vehicles were tested with a two-speed idle test, a steady-state loaded mode test, or a transient dynamometer test (IM 240). On May 18, 1998, the State Controlling Board approved a contract change to modify the emissions testing program. The modifications allowed for the application of a new enhanced vehicle emissions test that runs vehicles at a lower, steady speed and on average, is less time consuming than the old test. This new test, ASM 2525, has been in use since the summer of 2000. Envirotest operates the program in Cleveland-Akron and Dayton-Springfield areas and on March 1, 1999, in the Cincinnati area. ASM testing began on August 7, 2000, in the Cleveland-Akron and Dayton-Springfield area. ASM testing began in the Cincinnati area on October 3, 2000.

24] Oregon - <http://www.deq.state.or.us/aq/vip/>

Currently using the BAR31 test (a 31-second transient test using IM240 equipment) and a two-speed idle test. Mandatory OBD testing started December 2002. DEQ manages two vehicle inspection programs (VIP) in Oregon. The Portland area VIP started in 1975. The Rogue Valley VIP for Medford and surrounding areas began in 1986. DEQ operates eight Clean Air Stations in the Portland area and Rogue Valley.

In the Medford area: 1996 or newer - On-Board Diagnostics Test. 19 years or newer and pre-1996 - Basic Emissions Test, and 20 years or older - Do not need to take the test

In the Portland area: 1996 or newer - On-Board Diagnostics Test, 1981 - 1995 - Enhanced Emissions Test - Enhanced BAR 31 Transient Test, 1975 - 1980 - Basic Emissions Test - 2-speed idle test, and 1974 or older - Do not need to take the test

25] Pennsylvania - <http://www.drivecleanpa.state.pa.us/> and drivecleanpa@state.pa.us

OBD II testing will begin December 2003 and be phased in throughout early 2004 in 17 counties, including the Pittsburgh and Philadelphia areas as well as 8 central PA counties.

In general, 1996 and newer will get an OBD and gas cap test. In Philly and Pittsburgh areas with existing tailpipe tests, older vehicles will continue to get a tailpipe test, visual and gas cap. In the expansion counties, older vehicles will get a visual and gas cap test. Philly uses ASM and Pittsburgh a two-speed idle (Philly defaults to idle with certain vehicles -- full time AWD, etc.)

26] Rhode Island - <http://www.riinspection.com/> & Weber 2003

Testing is biennial. Every car and light truck weighing 8,500 pounds or less (GVWR) requires an inspection consisting of both a test for safety and for emissions. In January 2002, emissions standards became more stringent and vehicles now have to meet those new standards in order to pass. Motor vehicles 25 years old or older must undergo inspection for safety and emissions but will not be failed if they do not pass emissions standards. The *vehicle owner* may choose either a two-speed idle emissions test or the dynamometer test. During the phase-in period, which begins January 2003 only light duty vehicles built in model year 2000 or newer will be OBD II tested. Throughout the course of year the model year coverage will be adjusted until model year 1996 is reached. If a vehicle is eligible for the OBD-II test, no tailpipe emissions test will be performed. The low-enhanced program consists of a biennial, decentralized, test-and-repair program using the RI2000 test (three successive 31-second BAR31 tests) on NYTEST equipment with VMAS for gasoline vehicles up to 8500 lbs. GVWR along with a gas cap test. An opacity test will be implemented for light-duty diesel vehicles.

27] Tennessee - <http://www.tennessee.gov/safety/titlingandregistering.html#emissions>

<http://www.state.tn.us/environment/apc/emissions.php>

<http://www.state.tn.us/sos/rules/1200/1200-03/1200-03-29.pdf>

Davidson, Rutherford, Sumner, Williamson and Wilson counties in Middle Tennessee and residents of Memphis in West Tennessee must have their vehicles pass an emissions inspection prior to registration or registration renewal. Inspection is not required for vehicles of model year 1974 and older in Middle Tennessee. However, an inspection is required for vehicles of all model years in Memphis. Effective July 1, 2002, 1996 and newer model vehicles will undergo an On-Board Diagnostics test, and a gas cap leak check instead of the traditional tailpipe and tampering test. For 1996 and newer, the OBD II System checks the emissions system, so the only additional check that will be performed is a gas cap leak check.

For 1995 and older, your vehicle will undergo a 3 point tampering check prior to the 2- speed idle emissions test. The emission control devices subject to inspection are:

- A catalytic converter (Only if your vehicle was manufactured with a catalytic converter)
- A gasoline fuel inlet restrictor, and
- A fuel gas cap.

28] Texas - <http://www.txdps.state.tx.us/vi/act.htm>

AirCheck Texas is performed in counties in Dallas and surrounding counties plus in Galveston and surrounding counties. Vehicles in this area receive an ASM2 test. The 2-speed idle test is used in the El Paso area.

- If vehicle is 1995 & older (ASM testing) - Inspection Stations displaying the "Yellow Check Mark" 1995 & older vehicles should be inspected at a station with a yellow check mark can perform your inspection.
- If your vehicle is 1996 & newer (OBDII testing) - ALL inspection stations can perform your inspection.

29] Utah - <http://www.slvhealth.org/html/eh/html/imhist.html> or

<http://www.utahcountyonline.org/Dept/HealthEnvirAir/index.asp>

In Utah, the legislature has delegated I/M program administration responsibility to the respective county health departments.

Salt Lake County - The Valley Health Department decided to:

- Utilize and upgrade the current network of test stations.
- Implement new UTAH98 test specifications and systems.

The new I/M program includes:

- New, computerized ASM test system that detects additional pollutants such as oxides of nitrogen (NOx).
- New emissions test using a dynamometer or "treadmill" for vehicles. The new test is better, fairer, and more accurate but no more intrusive than the old test.

Utah County - OBD II combined with a 2-speed idle test.

An advisory OBDII test started in March 2000. OBDII became Pass/Fail in March 2001. An OBDII test is the only test for 1996 and newer model year vehicles. A 2-speed idle test is performed on 1995 and older MY vehicles.

Davis County - OBD II combined with a 2-speed idle test and a loaded DC98 test.

- OBD II testing began in January 1997. Only 1996 and newer vehicles receive the OBD II test.
- The DC98 test is a loaded mode test using I/M 240 equipment and load specs with a 30 mph loaded test then a single speed idle test for the 1995 and older vehicles.

Weber County - OBD II combined with a 2-speed idle test.

30] Vermont - <http://www.dmv.state.vt.us/inspection/inspection.htm>

In Vermont 1996 and new gasoline powered vehicles, and 1997 and newer diesel powered vehicles having a gross vehicle rating of 8,500 pounds or less, must have an annual On-Board Diagnostics (OBDII) examination as part of their annual safety equipment inspection. The OBDII examination tests the emission control system of the vehicle.

31] Virginia - <http://www.deq.state.va.us/mobile/homepage.html>

The program includes gasoline-powered vehicles, with a model year of less than 25 years prior to January 1 of the current calendar year, with a manufacturer's gross vehicle weight rating of 10,000 pounds and less. Testing is on a biennial basis.

- Most vehicles will also receive a gas cap pressure test to detect excessive fuel vapor leakage. For all vehicles, a visual inspection will be conducted of certain emissions control equipment that was originally installed by the manufacturer.
- Dynamometer - Exhaust emissions are tested while a vehicle operates on a treadmill-like device, called a dynamometer, at 15 mph and 25 mph only. No high-speed testing is performed. This test will be given to most 1981 and newer vehicles with a gross vehicle weight rating up to 8,500 pounds. Test is conducted by the inspector at local testing facility.
- Two Speed Idle Test - Some vehicles' exhaust emissions are tested while operating at idle and at an engine speed of 2,500 rpm. This test is only for vehicles with a gross vehicle weight rating of 8,501 to 10,000 pounds; and for 1980 and older model year vehicles or other vehicles that, because of size or other mechanical configuration, cannot be accommodated on the dynamometer.
- On-Board Diagnosis II (OBD II) Inspection - Most 1996 and newer model year vehicles will be subject to a new computerized analyzer check that will look for fault codes that may be present in the vehicle's on board computer. This inspection may be performed instead of the dynamometer or two speed idle test on eligible vehicles.

32] Washington - http://www.ecy.wa.gov/programs/air/cars/automotive_pages.htm

Gasoline and diesel vehicles at least five years old and up to 25 years old need an Emission Check every other year. Annual testing is required for all state and local government fleets. Federal government vehicles and private vehicles need to be tested every other year before renewing their licenses.

ASM2525 exhaust emission tests of gasoline cars and light trucks. Heavy-duty gasoline vehicles and other gasoline vehicles that cannot be tested on the dynamometer receive a two-speed-idle (Idle and 2500 rpm) test. A download of the problems detected by the On-Board-Diagnostic system OBD II of 1996 and newer gasoline cars and light trucks. Gas cap check of all gasoline vehicles. In Washington 1996 and newer cars and light trucks (<8501 pounds GVWR) receive an OBD II test and are not subjected to a tailpipe test. However, some makes/model that have readiness problems that would prevent OBD testing are automatically defaulted to a tailpipe test. All other vehicles receive a tailpipe test.

33] Wisconsin - <http://www.dot.wisconsin.gov/drivers/vehicles/im.htm>

Every other year, 1968 and newer vehicles with a gross vehicle weight up to 10,000 lbs. must be inspected for pollution before their license plates can be renewed. Most model year 1996 and newer vehicles equipped with OBDII computer systems are tested by means of a computer. On other vehicles the tailpipe emissions are measured while the vehicle is driven on a dynamometer. After the OBD check or emission test, the vehicle's gas cap is tested to ensure that it seals properly. The IM 240 test is much more effective than older technologies for identifying polluting vehicles. The Idle Test is performed as an alternate inspection when the IM 240 test can not be used. The test analyzes the CO and HC emissions while the vehicle is idling. There is no driving simulation. Vehicle also receives a 9-Point emission equipment inspection.

I/M Programs in Other States

The State of Colorado has suspended OBD testing as a pass/fail criterion for their I/M program. The state continues investigate apparent anomalies between OBD and IM240 test results.

The state of Michigan would likely have OBD testing if the state had not suspended I/M program development because of differences with the EPA over enhanced I/M requirements

a] Colorado - <http://aircarecolorado.com/>

- 1982 and Newer Vehicles - An enhanced emissions test (I/M 240) is required for gasoline-powered passenger vehicles and light trucks at an Air Care Colorado center every two years. Your vehicle registration renewal postcard will state whether or not a test is required.
- 1981 and Older Vehicles - A two-speed idle test is required every year for gasoline-powered passenger vehicles and light trucks at an Air Care Colorado facility or at an independent, licensed test station.
- Beginning with 1994 models, some vehicles have been equipped with standardized computer-controlled OBD. 1994 and newer vehicles are checked for OBD computer codes. The result of the OBD test is advisory only and illuminated MIL is no longer a reason for pass/fail.

b] Michigan - <http://www.michigan.gov/deq> - MECA 2002

An "enriched" I/M program, which is similar to an enhanced I/M program, had been planned in West Michigan (the Counties of Kent, Muskegon, and Ottawa) and possibly in the Detroit area. However, the U.S. EPA has since redesignated the Detroit metropolitan area and West Michigan to being in attainment of the federal air quality standards. For West Michigan, the State had already selected Systems Control in May 1994 to be the centralized testing contractor, and by February 1995, most enhanced inspection stations had been built and IM240 test equipment had been installed. But then, in a letter from the Governor dated January 12, 1995, the State's plan to begin IM240 testing on February 1, 1995 was ordered to be suspended until changes to the enhanced I/M requirements made by the U.S. EPA or the U.S. Congress became clear. In the meantime, in light of Detroit's re-designation, the State applied to the U.S. EPA for permission to terminate its I/M program altogether. The State has applied for and has been granted attainment status by EPA pending final direct rule. The I/M program was canceled as of January 1, 1996. There are currently no plans to implement a new I/M program. The State included an I/M program for Detroit in the state SIP as a contingency measure. Similarly, the State included an I/M program as a contingency measure for the West Michigan area. The State, however, is looking at other possible contingency measures such as a reformulated fuels program.

Appendix D

Canadian Vehicles

In the USA, OBD II testing is performed on 1996 MY and newer vehicles. However, when the AirCare program in the Vancouver area included OBD II as part of their program the lack of a legal requirement for OBD II on Canadian vehicles led them to restrict data gathering to 1998 and newer MY vehicles. However, it seems that only certain manufacturers sold vehicles in Canada that were not fully OBD II compliant: (AirCare 2003)

The stated reason (for non-OBD II compliance) was that MMT in gasoline could cause false MIL illumination and undue customer concern. In some vehicles, the manufacturer deleted the downstream O₂ sensor (catalyst efficiency monitor). However, all have been required to provide fully compliant OBD II systems since the 1998 model year.

As noted, the 1996 and 1997 MY vehicles built for sale in Canada did not have to meet U.S. OBD specifications. However, most makes/models will pass through OBD I/M without a problem and thus should not be bypassed from testing. (Sosnowski 2002)

In 1996 and 1997 vehicles built for sale in Canada did not have to meet U.S. OBD specifications. Most makes/models will pass through OBD I/M without a problem and thus should not be bypassed from testing. Certain Canadian vehicles were built identical to the U.S. versions, and therefore, if imported into the U.S., they will pass OBD I/M.

The following information regarding OBD II and Canadian Vehicles was taken from the appendix to the EPA OBD II guidance document. (Sosnowski 2002)

a] The following Canadian 1996 and 1997 MY vehicles were built identical to the U.S. versions, and therefore, if imported into the U.S., they will pass OBD I/M.

- BMW
- Ford
- Honda
- Hyundai
- Landrover
- Mazda
- Mercedes-Benz
- Nissan
- Porsche
- Subaru
- Toyota
- '97 Jaguar

b] This next set of 1996 and 1997 makes and models were not sold in Canada, and thus they will already be in attainment with U.S. OBD specifications:

- Chevrolet/Geo Prism
- Daewoo
- Kia
- Mitsubishi (other than Chrysler badged)
- '96 Cadillac Catera

c] 1996 and 1997 Canadian Vehicles that *Do Not Meet* U.S. OBD Specifications

Vehicles built for sale in Canada and then imported to the U.S. were supposed to have their OBD systems converted in order to meet U.S. specifications. However, the following list identifies and describes makes/models of Canadian vehicles that were not converted to meet the U.S. specifications due to confusion surrounding OBD compliance.

- Isuzu: Require new Powertrain Control Module (PCM).
- VW/Audi: Conversion not supported by manufacturer at this time.
- Suzuki: Require new PCM.
- 1996 Jaguar: Lack enhanced evap monitor, otherwise identical to U.S. built Jaguars.
- Lamborghini: Engine completely different.
- 1996 Volvo 800 Series non-turbo: Require complete replacement of "Fenix 5.2" ECM and hardware to "Bosch 4.3".
- 1996 Volvo 800 Series turbo and 1997 Volvo 800 Series: Must be an automatic and have ECM replaced.
- All 1996 and 1997 GM vehicles, including Saturn: Require US Federal OBD II engine calibration, except the following which require additional hardware:
 - Chevrolet Cavalier, Pontiac Sunfire (J), Pontiac Grand Am, Oldsmobile Achieva, Buick Skylark, Chevrolet Malibu (N), Chevrolet Corsica, and Chevrolet Beretta (L) equipped with 2.2 L or 2.4 L - Require US Federal OBD II engine calibration and Require installation of a rear oxygen sensor and installation of a catalytic converter and/or exhaust components manufactured with a rear oxygen sensor boss to facilitate sensor installation
 - Chevrolet/Geo Tracker, Chevrolet/Geo Metro, and Cadillac Catera - Require a US Federal engine controller

These vehicles are believed to represent a very small fraction of the overall fleet and as long as this fraction remains small a state has several options. For vehicles which do not meet the U.S. specifications a state may deal with them in different manners for purposes of inspection and maintenance:

- A state may choose to deny registration of this non-compliant vehicle and require that it be made to meet all OBD requirements for the applicable model year (see specific vehicle listed in this guidance),
- A state may choose to test the vehicle using only the MIL command if available to determine pass/fail status, or
- A state may choose to use an alternative test such as a tailpipe test to determine pass/fail status.

Regardless as to how a state chooses to deal with these vehicles, a state cannot require a change to the Vehicle Emissions Certification Information (VECI) label under the hood of the vehicle to anything other than the label that was originally installed on the vehicle at the time of manufacturer. Vehicles, which have been modified for importation into the U.S. from Canada, have an alternative label or paperwork to document this modification.