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Canadian Council of Ministers of the Environment

Le Conseil canadien des ministres de l'Environnement

Environmental Code of Practice

for

On-Road Heavy-Duty Vehicle Emission Inspection and Maintenance Programs

CANADIAN COUNCIL OF
MINISTERS OF THE ENVIRONMENT

PN1328

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Foreword

This *Environmental Code of Practice for On-Road Heavy-Duty Vehicle Emission Inspection and Maintenance Programs* is intended as a guide for all parties involved in the development of new heavy-duty vehicle (HDV) emission inspection and maintenance (I/M) programs in Canada. The Code is also intended as a guidance document for those who may wish to align the parameters of an existing program in a uniform manner with those of other I/M programs in Canada and the United States.

None of the recommendations or suggestions presented in the Code is compulsory or legally binding in any way. Readers are therefore advised to view the content of the Code in that context.

The suggestions and recommendations outlined in the Code in no way prohibit jurisdictions from adopting more comprehensive or stringent requirements.

As a result of the changes foreseen in regard to I/M emissions test procedures and HDV emissions standards, it is recommended that the Code be revisited and revised within the next three years.

This Code was developed by the members of the National Working Group for On-Road Heavy-Duty Vehicle Emission Inspection and Maintenance Programs. The contributions of all participants and respondents who helped develop this Code are gratefully acknowledged (see list of Working Group and Corresponding Working Group Members in Appendix A).

Inquiries and comments on the Code are welcome and may be sent to:

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Air Pollution Prevention Directorate
Environment Canada
Ottawa, Ontario K1A 0H3
Fax: (819) 953-7815

Requests for copies of the Background Report and other material related to the development of this Code may also be sent to the above address.

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Background

This *Environmental Code of Practice for On-Road Heavy-Duty Vehicle Emission Inspection and Maintenance Programs* provides guidance to provincial, regional, and municipal transportation and environmental regulatory agencies regarding on-road heavy-duty vehicle (HDV) emission inspection and maintenance (I/M) programs as a means of reducing "excess" exhaust emissions. The Code is intended to provide a basis for implementing consistent and uniform control measures for the testing of on-road HDVs — trucks, buses, and other licensed road vehicles — across Canada. Agencies wishing to operate HDV emission I/M programs will realize a number of benefits by following the recommendations and suggestions in the Code. In addition to reduced emissions, benefits resulting from I/M program implementation include closer adherence to HDV engine maintenance schedules and hence better maintained, less troublesome HDVs with improved fuel economy.

Air Pollution Issues

Internal combustion engines used to power motor vehicles are responsible for significant levels of air contaminants in any urban area. From an environmental perspective, the emissions from on-road HDV engines that are of concern include nitrogen oxides (NOx), acid aerosols, visible smoke, particulate matter (PM), carbon monoxide (CO), and hydrocarbons (HC), including total HC, non-methane HC, and volatile organic compounds (VOCs). For gasoline-fuelled HDVs, toxics such as benzene are also a concern.

PM air pollution refers to a mixture of solid and liquid particles suspended in the air. Some particles are large or dark enough to be seen as soot or black smoke. The smaller particulates are sometimes described as an aerosol, which refers to a stable mixture of particles suspended in a gas. Airborne PM is a mixture of chemical species and size fractions. Particles usually range in diameter from 0.005 to 100 µm. The particles of greatest concern from a human health perspective are those with an aerodynamic diameter of less than 10 µm, since they can penetrate deeply into the lung.

In Canada, for ambient air assessment, fine PM is currently divided into two distinct fractions: PM that is less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) and the coarser fraction, PM that is less than 10 µm in aerodynamic diameter (PM_{10}).[1] These smaller, or fine, PM fractions, PM_{10} and $PM_{2.5}$, are of particular concern in relation to their adverse health effects. Minute particulates in the ambient air may occur naturally or be human-made. The operation of motor vehicles can result in PM emissions from the combustion of fossil fuels, brake wear, or tire wear or as dust from unpaved roads. At present, there is a Canada-wide Standard for $PM_{2.5}$. In addition, PM_{10} has been declared toxic under the new *Canadian Environmental Protection Act* (CEPA) (*Canada Gazette* Part II, 9 May 2001).

In addition to concerns regarding the health effects of PM, black smoke from diesel vehicles is a visible nuisance pollutant that is the subject of public complaint. Engines in a poor state of repair emit higher levels of smoke than do those that are well maintained. A portion of this visible black smoke may also be fine PM; therefore, a reduction of visible black smoke may reduce emissions of fine PM.

> "The high black carbon content of diesel exhaust makes it an efficient light absorber, contributing significantly to urban and regional haze, as well as to increases in the earth's radiation balance. Diesel particles soil bridges, tunnels, and other surfaces, with high associated clean-up costs" (Lloyd *et al*. 2001).

Ground-level ozone (O_3) episodes result from photochemical reactions between the O_3 precursors NOx and VOCs. O_3 and PM are also two constituents of "smog." Smog is a mixture of gaseous, solid, and liquid pollutants that are harmful to human health, plant life, and building materials. O_3 in the upper

[1] Note that PM_{10} includes $PM_{2.5}$.

atmosphere occurs naturally. In the upper atmosphere, O_3 serves to shield the Earth from ultraviolet radiation. At ground level, O_3 causes inflammation of the lungs and reduces lung function and resistance to infection. People with heart and lung problems are particularly vulnerable to the harmful health effects of O_3.

The term "smog" was coined over 40 years ago to describe the joint presence of smoke and fog in the environment. In recent years, it has become the term given to the chemical "soup" that is often visible as a brownish yellow haze over urban areas. It is largely formed from a combination of motor vehicle and industrial pollution and is usually most obvious in large cities. However, as a result of the action of prevailing winds, suburban and rural communities are not exempt from smog. Vehicle emissions reduction initiatives that in some way diminish PM and O_3 (or its precursors) may also result in smog reductions for the area affected.

NOx consists principally of nitric oxide (NO) and nitrogen dioxide (NO_2). In addition to being a ground-level O_3 precursor, NOx from HDVs is also a contributor to acid rain.

Climate change related to the greenhouse effect is another major environmental issue. Motor vehicle emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are also of concern because of their contribution to greenhouse gas (GHG) accumulations and their influence on climate change.

CO is a product of the incomplete combustion of fossil fuels in motor vehicles. CO interferes with the oxygen-carrying capacity of the blood.

Health Concerns

Adverse health symptoms have been observed even at low levels of atmospheric pollution. For O_3 and fine PM, some people will experience discomfort at low levels of pollution and are under some degree of stress, even if symptoms are not felt or observed. The various constituents of vehicle exhaust, and their photochemical products, are known to either cause or exacerbate a number of ailments.

Smog can be hazardous to human health; the main concern is its potential to affect the respiratory system. However, because smog is a mixture, possible health effects can vary. The mixture is complex and ever changing, and, in some cases, the health effects of one pollutant such as O_3 may provoke a stronger adverse reaction in regard to human health when it is coupled with fine PM and/or acidic air pollutants.

In regard to the impact of PM emissions, the *Canada Gazette* Part I, dated 27 May 2000, stated:

> There is ample evidence that these substances cause serious human health and environmental impacts. While there may be some uncertainties in the science and other impacts with respect to PM, and to a lesser extent ozone, governments are satisfied that there is sufficient evidence that requires action to be taken now.

Of particular concern to this Code are the health concerns related to air pollution that is associated with on-road HDV exhaust emissions. There is specific concern regarding PM emissions from HDV diesel engines:

> More than 90% of diesel exhaust-derived PM is smaller than 1 micron in diameter… These small particulates are respirable and penetrate deep into the lungs… Diesel PM has been associated with lung cancer and short-term respiratory ailments, such as asthma, in occupational and general population epidemiological studies. Small particles, which are both directly emitted from diesel engines and formed from gaseous emissions, can lead to premature death, and major respiratory problems. (Lloyd *et al*. 2001)

and

> There is great concern about the adverse health effects associated with exposure to diesel exhaust. Exposure is widespread, particularly in urban areas, and according to several national and international agencies, there is increasing evidence that diesel exhaust or diesel particulate matter (soot) may cause lung cancer in humans. Non-cancerous effects such as lung damage and

> respiratory problems are also associated with exposure to diesel exhaust. (EPA 2000a)

The U.S. Environmental Protection Agency (EPA) has labelled PM a likely human carcinogen (EPA 2000b).

Readers seeking more information on the health and air pollution issues related to vehicle emissions are referred to Environment Canada or the publications listed under References in this Code.

On-Road HDVs

At present, as defined in Canada's *Motor Vehicle Safety Act*, a "heavy-duty vehicle" is considered to be:

> Any motor vehicle rated at more than 3855.6 kg (approximately 8500 lb.) Gross Vehicle Weight Rating (GVWR) or that has a vehicle curb weight of more than 2721.6 kg (approximately 6000 lb.) or a basic vehicle frontal area in excess of 4.2 m^2 (approximately 45 sq. ft.).

On-road HDVs (trucks and buses) can be separated into three broad categories according to weight. Vehicles that are greater than 3855.6 kg and less than 6400 kg GVWR (approximately 8500 lb. and 14 000 lb.) are dominated by gasoline engines and tend to be used more by individuals and in urban settings. Vehicles greater than 6400 kg and less than 11 800 kg GVWR (approximately 14 000 lb. and 26 000 lb.) are more equally divided by fuel type and exhibit a broad array of usage patterns. Vehicles greater than 11 800 kg GVWR (approximately 26 000 lb.) are dominated by line-haul (or long-distance) diesel trucks. This latter category tends to comprise vehicles of similar technology and usage patterns. Vehicles in this category also tend to have a long useful life and to accumulate high mileage (NESCAUM 1997).

On-Road HDV Emissions

Internal combustion engines used to power motor vehicles are responsible for a major portion of the air pollution produced in Canada. Of all transportation sectors, motor vehicles operating on the roads and highways (on-road or in-use vehicles) in Canada are the most significant source of VOC, CO, and NOx emissions.

Diesel-fuelled engines are an entirely different technology from gasoline-fuelled engines and as such have very different exhaust emissions patterns. In a diesel engine, the fuel is introduced into the combustion chamber as an atomized liquid and is ignited by compression, not by a spark plug. Therefore, there is a greater likelihood of unburned or partially burned diesel fuel being emitted in diesel exhaust in the form of tiny droplets or very small carbon particles or PM (NESCAUM 1997).

When discussing diesel emissions, it is important for readers to be aware of the differences between the terms "diesel smoke," "fine PM," and "exhaust."

- **Diesel smoke** — All particles, including fine and coarse particulate, black carbon, and aerosols, suspended in the exhaust stream of a diesel engine that absorb, reflect, or refract light. Throughout the text of this Code, unless noted to the contrary, the term "smoke," in general, refers to "black diesel smoke."
- **Fine PM** — All PM less than 10 µm in diameter. This category includes both $PM_{2.5}$ and PM_{10} fractions.
- **Exhaust** — All gaseous, liquid, and PM that exits a vehicle tailpipe.

For HDV engines, the Canadian government limits the amount of CO, HC, NOx, and, for diesel-powered vehicle engines, PM that may be emitted by *new* vehicle engines offered for sale in Canada. Federal mass emissions standards for new engines were established by regulation under the *Motor Vehicle Safety Act*. These standards are now administered federally by Environment Canada. Heavy-duty engine compliance with the federal emissions standards is measured using the Federal Test Procedure (FTP). While the Canadian standards have not undergone a regulated change beyond the 1998 limits, it is the intent of Environment Canada to see that the standards remain harmonized with U.S. standards until they are replaced by new regulations under CEPA. Therefore, it is likely that the Canadian standards will soon change to incorporate the

	Percentage of Total Canadian Emissions, 1995*		
	LDVs	HDVs	HDDVs
PM_{10}	2	6	6
$PM_{2.5}$	2	7	7
NOx	18	18	17
VOCs	19	2	2
CO	50	4	2
CO_2	15	7	6
SOx	1	1	1

* The emissions from open sources were excluded from Canadian totals in the derivation of these percentages.

2004–2007 heavy-duty engine standards that were recently adopted in the United States (see Appendix F).

For light-duty vehicles (LDVs), the FTP involves compliance testing of vehicles on a chassis-dynamometer. The major difference between the FTPs for LDVs and HDVs is that for HDVs, the standards are set for engines that are removed from a vehicle chassis. The heavy-duty engine FTP measures mass emissions of contaminants over a complex cycle, with the engine mounted on an engine-dynamometer. A well-maintained engine should have emissions at or below the federal standards for its useful life.

The federal government sets emissions standards for *new* HDV engines; however, when installed in vehicles operating on the roads and highways, these engines can have emissions in "excess" of the new engine standards. Poorly functioning heavy-duty engines can produce unnecessary or excess quantities of PM and certain gases. These excess emissions from on-road HDVs can result from lack of maintenance, tampering, or poor driving practices. Tampering refers to the removal, modification, misadjustment, or disablement of emissions or engine control systems and to the use of inappropriate fuels. Tampering [2] is sometimes undertaken in an effort to obtain more power from the engine or to improve fuel economy. In addition to increased emissions, tampering, improper maintenance, and poor driving practices often result in reduced engine life, degraded performance, and higher life cycle operating costs.

For comparison, on-road LDVs, all on-road HDVs, and the heavy-duty diesel vehicle (HDDV) portion of the total HDV on-road fleet were estimated as having the impacts shown above on total emissions in Canada in 1995 (Jaques *et al.* 1997; Hutchinson 2000).

The data shown above illustrate that for the population of on-road HDVs, the diesel-fuelled portion of the fleet, HDDVs, is responsible for the majority of the emissions (with the exception of CO emissions) from this class of vehicle in Canada.

In the Vancouver area, despite representing only about 4% of the registered vehicle fleet, HDDVs are estimated to be significant sources of both NOx and PM, contributing 15% of total mobile source NOx and 16% of total mobile source-related PM. The contribution to overall PM would be greater except for a large amount of PM attributable to fugitive coal dust blown from trains, which accounts for 37% of the total mobile source PM inventory (Newhook and Gourley 2000).

This Code presents options for a control technique, the I/M program, that is designed to address the problem of "excess" emissions from the engines in all HDVs that operate on the roads and highways in Canada. However, particular emphasis is placed on reducing excess emissions from on-road HDDVs.

[2] In this context, tampering may not include modifications that involve the retrofit of emissions control systems.

HDDV emissions have been dramatically reduced in recent years because of improvements in fuel quality and engine technology. On average, it takes eight of today's cleaner diesel trucks to emit the same mass of pollutants as one vehicle powered by a 1990 or older diesel engine. However, new or old, diesel vehicles remain clean only as long as they are well maintained (AirCare 2000).

Also, to further improve new engine emissions performance, the U.S. EPA is issuing a final rule for the first phase of stricter standards for heavy-duty trucks and buses. In the first phase, the EPA is finalizing diesel engine standards beginning in 2004 for all diesel vehicles over 8500 lb. Additional diesel standards and test procedures in this final rule will begin in 2007. Heavy-duty gasoline engines will be required to meet more stringent standards starting no later than the 2005 model year. These new standards require the engines in gasoline trucks to be 78% cleaner and those in diesel trucks to be more than 40% cleaner than today's models. The second phase of the program will require cleaner diesel fuels and even cleaner engines and will reduce air pollution from trucks and buses by another 90% (EPA 2000a).

As a result of the stricter HDV engine standards proposed for Canada for the 2004 and 2007 engine model years, the complexion of HDV emission I/M is likely to change in the future. By 2004, the HC plus NOx emissions standards are required to be 50% lower than current standards. The EPA emissions standards for new HDVs for 2007 will require a 90% emissions reduction compared with the anticipated 2004 levels. Therefore, advances in emissions controls will likely result in levels of smoke emissions that will be so low by 2007 that the J1667 smoke test[3] may no longer be effective for HDVs that comply with the new standard. Future NOx standards will also have an impact on I/M testing, as will the introduction of low-sulphur diesel fuel.

However, at present, despite stricter new vehicle emissions standards, emissions from HDVs continue to be problematic. There is public concern about emissions from these vehicles. The U.S. EPA has noted that excessive emission of black smoke from highway HDDVs is one of the most common complaints received from the public (EPA 1999a). Similar public concern is voiced in Canada.

For HDDVs, whether it results from tampering, wear, or poor maintenance practices, excessive smoke can result in higher operating and maintenance costs, reduced fuel economy, and shorter engine life. Excessive smoke can also result from poor driving practices, such as excessive acceleration, lugging, and full throttle on inclines.

I/M Programs

One control program for the reduction of excess emissions from on-road diesel and non-diesel HDVs is the I/M program. In general, an I/M program comprises a requirement for selected HDVs to undergo an inspection or test. Those vehicles that fail to comply with the requirements of the inspection or test must subsequently undergo some level of repair to correct the problem(s) that caused their excess emissions.

The implementation of an HDV emission I/M program will have two effects on the local vehicle fleet. First, the inspection requirement will act as a deterrent to tampering and as a stimulus for the majority of HDV operators to improve the maintenance, or continue the proper maintenance, of their vehicles. Second, those vehicles that fail the inspection will be required to undergo some level of repair to reduce emissions. Depending upon program parameters, there may be a requirement that these repairs must be effected before the vehicle can be licensed or reregistered for road operation. The principal objective of HDV emission I/M programs is to screen vehicles with excess emissions and to reduce those excess emissions through repair or improved maintenance.

The adverse public opinion regarding excessive visible smoke from HDDVs is partly responsible for the implementation of HDV emission I/M programs in several states and provinces in North America. HDV emission I/M program implementation should address not only the public's concern about the possible health effects of visible smoke and other

[3] The J1667 is currently forwarded by the Society of Automotive Engineers (SAE) as a recognized, non-dynamometer method for measuring diesel smoke from HDV engines (SAE 1996).

emissions, but also the perceived inequity of subjecting LDV owners to an I/M program without also subjecting the owners of HDVs to similar requirements.

As noted above, visible black smoke is often an indicator that a diesel engine is in need of repair. Regular maintenance is one of the keys to reducing excess emissions. Proper or regular maintenance includes adherence to the manufacturer's maintenance schedule plus the repair of systems or faults that have led to excess emissions. The California Air Resources Board (CARB) feels that the best way to avoid penalties in its HDV emission I/M program is for owners to keep vehicles maintained according to the engine manufacturer's specifications (CARB 1998a).

To reiterate, the purpose of an HDV emission I/M program is to identify diesel and non-diesel HDVs that are excess emitters and cause them to be repaired so that their emissions are at levels consistent with what the engines were designed to achieve.

In Canada, by agreement, in-use emissions from on-road HDVs and their control are within the sphere of jurisdiction of the individual provinces. Therefore, HDV emission I/M program implementation is a provincial, regional, or municipal responsibility. HDV emission I/M programs are currently operating in Ontario and British Columbia. In November 2000, the Quebec government announced its intention to begin mandatory HDV emission I/M testing. Program implementation is expected to begin in 2003.

While two provinces have HDV emission I/M programs, these programs differ (see Appendix B). Compatibility between I/M programs in Canada is felt necessary, since on-road HDVs move across provincial boundaries and across the international border to the United States. Since uniformity in regard to I/M program design and operation is highly desirable, this Code will help to achieve this goal by providing uniform guidance for provinces seeking to implement or to redesign their I/M programs for HDVs.

HDV Emission I/M Program Options

In the parlance of HDV emission I/M programs, the "Administration" heads the government agency that supervises the I/M program and any related contract(s). The Administration also operates (or oversees via contract) the audit programs directed at both the inspection teams and the repair industry. In designing an HDV emission I/M program for its area, the I/M program Administration must choose from a variety of options for program parameters. Each of these options has its strengths and weaknesses.

The Code presents alternatives for the various HDV emission I/M program parameters. Where there appears to be a clear "best" in regard to a particular parameter, recommendations are made. Where the "best" is not as clear, options are presented.

A review of existing HDV emission I/M programs and related research revealed several distinct levels of operation, sophistication, and technology in regard to HDV emission I/M testing. In order to provide guidance for the provinces in choosing an I/M program format that best suits their needs or for aligning existing programs, the Code presents a discussion of each of the many parameters that must be considered when developing an HDV emission I/M program. The uniformity represented by a selection of the recommended parameters in the Code and the information contained in the background documents and references may ensure, to the extent possible, that vehicles are tested and repaired in a similar manner from province to province and from province to state. It is hoped that if a province adopts the parameters as recommended in the Code, it should achieve the best emissions reduction benefits from its I/M program with the least inconvenience to HDV owners and operators.

Periodic LDV emission I/M programs for the measurement of gaseous pollutants have been in operation in Canada and the United States for several decades. There can be significant variation in the performance of these LDV emission I/M programs with respect to fleet emissions reductions, and recent studies (NRC 2001) indicate that the emissions reductions achieved may not be as great as predicted at program onset. Therefore, HDV emission I/M program administrators are advised to be aware of

these performance variations. The Administration should select the parameters for its program that experience indicates are most likely to provide maximum benefits for its area. Regardless of the style of program and the parameters selected, for success, a periodic program should be well designed and tightly administered.

Of the various I/M program parameters, two of the most important are the *program type* and the *test procedures* or *inspection procedures* that each HDV must undergo. In regard to these two key parameters, a number of options for Canadian HDV emission I/M programs are listed below. For these two parameters, the on-road HDV emission I/M program options have been divided into two general categories:

- options for the reduction of visible smoke; and
- options for the reduction of visible smoke, PM, and gaseous pollutants.

A) Options for On-Road HDV Emission I/M Programs for Visible Smoke Reduction

1. Roadside Non-Dynamometer Smoke Test
2. Roadside Non-Dynamometer Smoke Test and Visual Inspection
3. Roadside Non-Dynamometer Smoke Test plus Periodic Non-Dynamometer HDDV Smoke Test and a Periodic Heavy-Duty Gasoline Vehicle (HDGV) Two-Speed Idle Emissions Test
4. Roadside Non-Dynamometer Smoke Test plus Periodic HDDV Smoke Test on a Chassis-Dynamometer and a Periodic HDGV Two-Speed Idle Emissions Test

Note: Options 3 and 4 allow an agency to include both diesel and non-diesel HDVs in its I/M program.

For agencies that wish to address the issue of visible smoke from HDDVs only, an I/M program that features a roadside non-dynamometer smoke test, Option 1, employing the SAE J1667 smoke or opacity test procedure is currently listed as the minimum requirement for HDV emission I/M by the nine states that comprise the Northeast States for Coordinated Air Use Management (NESCAUM 1999c).

The U.S. EPA has also issued guidance documents that recommend the J1667 test procedures as the standard for smoke or opacity testing along with cutpoints for the J1667 (EPA 1997 and EPA 1999a, respectively).

Option 2, employing the J1667 smoke test, is similar to the program now in operation in British Columbia (Newhook and Gourley 2000). Option 3, also employing the J1667 smoke test, is similar to Ontario's current HDV emission I/M program (Ontario 2000).

Option 4, a periodic smoke test using a chassis-dynamometer, is similar to the program that has been in operation in Colorado since 1987. This latter smoke test technique is also reported to be in use in Hong Kong, Singapore, and Taiwan.

Repairs to reduce a single pollutant such as smoke may, for certain HDV engines, increase the emissions of other pollutants. Therefore, the Administration may wish to consider the implementation of test procedures that will allow the measurement of more than one pollutant. Some of the test procedures that are capable of such measurements are listed in the B) Options section.

B) Options for On-Road HDV Emission I/M Programs for Visible Smoke, PM, and Gaseous Emissions Reduction

5. Roadside Remote On-Board Diagnostics (OBD) X-Level Interrogation
6. Roadside Emissions Test of All HDVs Using Remote Sensing Devices (RSDs) Combined with Other Emissions Tests
7. Roadside Mass Emissions Test for All HDVs Using a Chassis-Dynamometer
8. Periodic Mass Emissions Test for All HDVs Using a Chassis-Dynamometer
9. Periodic Mass Emissions Test for All HDVs Using a Chassis-Dynamometer and RSD Screening
10. Periodic OBD (Data Link) Interrogation for All Equipped HDVs
11. Periodic On-Board Mobile Emissions Test for All HDVs

Note: These options are not listed in any specific order of preference.One or more of the Options 5 to 11 could be combined to provide more comprehensive coverage of the in-use HDV fleet in a particular area.

If an agency wishes to introduce an HDV emission I/M program to reduce excess PM and gaseous pollutants in addition to visible smoke, then tests and procedures other than the J1667 are required. The options in Group B feature more advanced testing, such as mass emissions testing on a chassis-dynamometer, on-board mobile emissions tests, roadside remote emissions tests, remote OBD interrogations, and/or an OBD (data link) interrogation that could be performed by conventional link.

However, at present, the test procedures and options listed in Group B are experimental, are under development and are therefore of a non-commercial nature, or have undergone only limited application in I/M programs.

There are, at present in North America, no universally accepted standards for HDV I/M tests for measuring emissions of PM and gaseous pollutants from on-road HDVs. Therefore, it is assumed that before any of these test procedures are employed in mandatory on-road HDV emission I/M programs, they will have demonstrated their success in properly identifying engines that have excess emissions.

However, at this time, it is felt that a transient chassis-dynamometer mass emissions test for PM and gaseous pollutants is likely to have the potential for producing the greatest emissions reductions.

Authorities may wish to design their I/M programs so that they can be readily adapted to accept more advanced test procedures, once these procedures have been proven and accepted by recognized authorities and the industry in North America.

Where a regular I/M program is neither planned nor warranted, agencies with jurisdiction could consider enacting and enforcing anti-tampering legislation. They could also implement an industry outreach program aimed principally at the trucking industry, bus companies, and related service and repair industries. The industry outreach program should promote the positive benefits of regular and proper HDV maintenance and point out the adverse environmental effects of neglecting or tampering with engine and emissions control systems.

Recommendations

As a result of their deliberations in regard to the Code on HDV emission I/M programs, the National Working Group members recommend the following:

- That provinces, regions, and/or municipalities that wish to implement an on-road HDV emission I/M program, or to modify their existing program, select one of the options presented above and, to the extent possible, follow the suggestions and recommendations presented in this Code;
- That research into more advanced I/M test procedures for both diesel and non-diesel HDVs be funded;
- That an international task force be established to oversee progress towards conformity of HDV emission I/M programs, particularly for the provinces that border the NESCAUM states;
- That the federal and provincial governments work with engine manufacturers and the repair industry towards the development of engine and component retrofit programs for HDVs;
- That the potential for an Emissions I/M Code of Practice for off-road equipment and vehicles be studied;
- That the federal government be encouraged to consider the development and implementation of an aftermarket certification program for engine and emissions control system components for HDVs; and
- That the federal government monitor progress regarding OBD and the standardization of on-board emissions control system diagnostics and develop policies consistent with any HDV requirements that may be developed in the United States.

1. Legislative and Policy Considerations

1.0 General

1.0.1 To provide a basis for on-road HDV inspections, agencies having jurisdiction should enact legislative changes or make appropriate amendments to existing legislation as required. The changes should require all vehicles that are to be involved in the HDV emission I/M program to submit to all tests and procedures as required by the program.

1.0.2 The legislation should also contain provisions that legally enforce any penalties that may be included in the I/M program. It is suggested that the desirability and legality of a "buy down" option (the ability to apply or use repair costs to reduce total fines) should be investigated.

1.0.3 Special legislative provisions may be required to empower HDV emission I/M roadside inspectors to pull over and inspect vehicles. In some jurisdictions, roadside inspectors may be empowered to inspect vehicles only where evidence of "probable cause" indicates that a vehicle has excessive emissions. In order to show "probable cause," such officers may require specialized training and qualifications (see 6.2.2). It may be necessary to note these requirements in the appropriate legislation.

1.0.4 HDV emission I/M programs may involve the collection of inspection and test fees from the vehicle owners. Statutory authority for the collection of these fees must be in place before such programs can be implemented.

1.0.5 The Administration should develop HDV emission I/M legislation that clearly differentiates HDV *operators* from HDV *owners*.

1.1 Anti-Tampering Legislation and Aftermarket Components

1.1.1 Each province, if it has not already done so, should implement emissions-related anti-tampering legislation that encompasses all on-road HDVs. It may be necessary for certain provinces to amend their existing anti-tampering legislation to include HDVs. Such legislation would discourage emissions-related tampering within the province. This legislation would also assist other provinces and states. Subsequent to enactment of such legislation, HDVs moving between provinces and in and out of the United States would be less likely to have missing or tampered emissions-related systems and components.

1.1.2 The emissions-related anti-tampering legislation should make it illegal to remove, misadjust, replumb, or otherwise adversely affect the equipment or the performance specifications of emissions control systems or other engine systems and vehicle parameters that affect emissions, on vehicles and engines of all model years. Emissions control systems are considered to include the air/fuel mixture control systems. In the case of vehicles that have been converted to operate on alternative fuels, some exceptions may apply (see 1.2).

1.1.3 To complement anti-tampering legislation, it is recommended that the appropriate government authority or agency consider the implementation of an aftermarket component as well as an aftermarket (and used) catalytic converter and catalyzed particulate filter identification and/or accreditation process. The aftermarket component program is needed to provide consumer protection in regard to the increased demand for aftermarket components that may result from I/M program implementation. This program is meant to address only the replacement of equipment that was originally installed on the HDVs by the manufacturer. Assistance in the development of the aftermarket component program may be available from the California Air Resource Board (CARB).

1.1.4 The anti-tampering legislation may have to be modified to account for the retrofit of emissions control systems on HDV engines that were not originally equipped with such equipment.

1.2 Alternative Fuel Conversions

1.2.1 The Administration, in conjunction with the alternative fuels industry and the vehicle manufacturers, should develop an alternative fuel conversion policy for on-road HDV engines that have

been converted to operate on alternative fuels such as liquefied petroleum gas (propane), natural gas, and methanol. The alternative fuel conversion policy should cover certification or accreditation of conversions and allowed changes to the original equipment and specifications. The alternative fuel conversions referred to in this section are those conversions performed after sale or "aftermarket." Alternative fuel vehicles produced by the original equipment manufacturer (OEM) and conversions performed on new vehicles by OEMs or their representatives before first sale do not fall into this category.

1.2.2 With the few exceptions allowed by an alternative fuel conversion policy (1.2.1), on-road HDV engines that are converted to operate on liquefied petroleum gas (propane), natural gas, or methanol should be required to retain all the emissions control devices fitted by the original manufacturer, where relevant and practical. If converted from gasoline, the on-road HDV engine should also be required to meet the same tailpipe emission cutpoints as the HDGVs. "Tampered" vehicles and/or engines should be required to have the removed or disabled emissions control devices reinstalled.

1.2.3 If an on-road HDV engine has been converted, aftermarket, to operate on an alternative mono-fuel, or dual-fuel capability has been added to a gasoline fuel system, all OEM emissions control components and the OBD (data link) systems must be functional. Any exemptions should be specified in the alternative fuel conversion policy.

1.3 Retrofits and Engine Rebuilds

1.3.1 HDV retrofits and/or engine rebuilding may involve the installation of particulate traps and/or catalytic converters. The Administration may wish to consider developing a policy in regard to retrofits and rebuilds and how they should be applied in an HDV emission I/M program environment.

1.3.2 The Administration must develop a policy for identifying the model year of an engine in regard to the installation of a rebuilt engine.

1.4 Add-Ons, Fuel Mixing, New Fuels, and Additives

1.4.1 Experience gained with LDV emission I/M programs has shown that I/M program implementation generally coincides with an increase in the advertising and marketing of add-on devices or additives that make claims in regard to fuel savings, engine performance, and emissions reductions. Also, vehicles presented for reinspection after "repair" following a test failure may have devices installed or additives in the fuel. It is recommended that for consumer protection, the Administration be aware of the difficulties that may arise in regard to add-on devices. An add-on device is defined as any equipment or systems fitted to an engine or vehicle after manufacture and not as per original design or specification by the manufacturer. This includes equipment installed as part of an official retrofit program.

1.4.2 The Administration should also be aware of difficulties that may arise in regard to fuel mixing and new fuel blends.

1.5 Other Related Vehicle Legislation or Programs

1.5.1 It is suggested that the Administration should investigate legislative requirements in association with establishing reciprocal agreements with other provinces and states in regard to HDV I/M fines, registration denial, other penalties, and information exchange.

1.5.2 The Administration may wish to investigate links, for HDV emission I/M program data sharing, to programs such as the Commercial Vehicle Information Systems and Networks (CVISN).

1.5.3 The Administration should study systems and legislation regarding the right to affix a tamper-proof I/M program label to each vehicle, or the requirement to carry I/M-related documentation on each vehicle, subject to the I/M program. These techniques could solve potential vehicle, engine, and component identification problems.

1.5.4 A number of municipalities in Canada have implemented maximum idling legislation. The intent of such programs is to limit the idling time for all vehicles within their jurisdiction. Since, for roadside HDV emission I/M testing, it may be necessary for vehicles to remain at idle for a period that exceeds the legislated maximum idling time, it may be necessary for the Administration to have an exemption granted for its HDV emission I/M program.

2. HDV Emission I/M Program Parameters

2.0 General

2.0.1 Regardless of the I/M program type and the parameters selected, the following are recommended:

- Other than during a pilot phase, participation in the I/M program by HDV owners and operators must be mandatory.
- The repair or maintenance side of the I/M program is performed at a large number of private, independent local garages or service centres, which may be accredited by the Administration or a third party. The Administration, or a third-party agency, should establish the HDV emission I/M program requirements for inspectors, inspection and reinspection stations, repair facilities, and repair technicians (see Chapter 6).
- The Administration should make provisions for capturing heavy-duty trucks, buses, and other licensed HDVs that regularly transit through the designated I/M area, but are not registered in the area.
- To phase in any style of I/M program, a voluntary pilot program prior to commencement of mandatory inspections is recommended. This voluntary program is required to provide on-the-job training for all involved in the program, including the Administration, contractor(s), and repair industry personnel. The voluntary program is also needed to proof inspection procedures, refine cutpoints, and familiarize the truck and bus industry with the requirements of the program. A pilot program is recommended for at least a six-month period prior to the implementation of mandatory testing and the imposition of penalties.
- The Administration should set up and maintain a multistakeholder advisory committee to assist in the development and operation of the HDV emission I/M program.

2.0.2 It is recognized that certain program types and parameters may be more applicable than others in a specific region. Test procedures and alternatives are discussed in Chapter 3.

2.1 Program Type

2.1.1 Roadside Programs

2.1.1.1 At present, this style of I/M program generally features a roadside pullover of individual HDVs for an emissions test and/or a visual inspection. As recommended by NESCAUM, a roadside pullover program is currently the minimum requirement for on-road HDV emission I/M programs (NESCAUM 1999c).

2.1.1.2 The Administration could purchase the equipment and establish the roadside inspection teams, and/or it could contract for such roadside teams. The number of roadside teams will depend upon the size of the I/M program area and the impact that the government wishes to have on the excess emissions from the HDVs in that area. Appendix C provides an example of the implementation and annual operating costs for a two-unit HDV emission I/M roadside inspection team.

2.1.1.3 If the I/M program does not cover the entire province, for enforcement of anti-tampering legislation and public relations, where legislation permits, the roadside inspection teams could be dispatched to communities or areas throughout the province that are not in the I/M program area.

2.1.1.4 Due to the nature of the roadside test, it is recommended that all I/M program roadside personnel be in uniform.

2.1.1.5 At least one member of each roadside team should be an HDV emission I/M program accredited inspector (see 6.2).

2.1.1.6 Roadside teams should be equipped and trained to test at any secure roadside location.

2.1.1.7 At least one member of each roadside team should be empowered with the authority to stop an HDV and require the operator to submit the vehicle to the emissions test or inspection.

2.1.1.8 An adaptation of this style of program would be to use RSDs, remote OBD interrogation equipment, or visual assessments at the roadside to pre-screen HDVs. As a result of the remote test, only those vehicles suspected of having emissions well in excess of standards would be selected for further testing. Vehicles selected in this manner would subsequently be directed to either a roadside location or a fixed test centre for additional testing. The pre-screening tests are usually conducted remotely, with no physical contact with the vehicle.

2.1.2 Periodic Programs

2.1.2.1 A periodic I/M program features the testing of on-road HDVs at fixed or permanent facilities on a regular or periodic basis. Possible periodic program types[4] include:

- *Centralized Test-Only*: Generally, a single contractor operates a relatively small number of high-volume test facilities. This style of HDV emission I/M program separates the inspection and reinspection of vehicles from their repair or maintenance.
- *Decentralized Test-Only*: This style of I/M program is essentially the same as a centralized test-only program; however, instead of a single contractor, the Administration contracts with a number of private companies to operate test-only facilities. Inspections and reinspections are performed at a larger number of lower-volume test-only facilities dispersed throughout the I/M program area.
- *Decentralized Test-and-Repair*: This type of I/M program allows any private repair centre that is accredited by the Administration to conduct I/M inspections and reinspections. These repair centres are also allowed to perform any maintenance or repairs that may be required to enable HDVs to pass the test requirements.
- *Hybrid Combinations of Test-Only plus Test-and-Repair*: One example of a hybrid I/M program would combine high-volume, centralized test-only facilities (in densely populated urban areas) with smaller, decentralized test-and-repair centres (in less populated and remote satellite communities surrounding the large urban centre).

2.1.2.2 A decentralized test-and-repair system is currently recommended for testing on-road HDVs in a periodic I/M program. For this type of program in particular, a real-time central computer monitoring system for tracking inspections, reinspections, and emissions test results is recommended in order to link accredited test-and-repair facilities (see 4.3). A real-time data link to transfer vehicle parameters and test data to a central computer system is recommended for all HDV emission I/M programs, regardless of type. Such a system is required to provide secure data transmission, provide registration validation, link the engine under test to the appropriate test cutpoints, facilitate data integration, and allow analyzer calibration verification.

2.1.2.3 The Administration may wish to investigate the use of a management contractor to oversee the general day-to-day administration in a decentralized I/M program. The management contractor would perform common functions, act as one level of referee for dispute resolution, and conduct the routine quality control (QC) functions required in a decentralized I/M network.

2.1.2.4 The Administration may wish to implement a fleet self-certification program as part of its periodic test requirement (see 2.13). As noted in 2.1.2.2, the Administration should also develop a real-time central computer monitoring system for tracking inspections, reinspections, and emissions tests at accredited fleet centres. The U.S. EPA (EPA 1999b) has provided guidance.

2.1.3 Program Combinations

2.1.3.1 In order to ensure coverage of a larger portion of the on-road HDV fleet, agencies operating roadside I/M programs may wish to add a periodic segment to their existing program, as outlined in 2.1.2. Conversely, a roadside component may be a desirable addition to a periodic program. A roadside program adds to a periodic program the ability to capture HDVs registered outside the I/M program jurisdiction as well as HDVs that may have slipped out of compliance in the period between periodic inspections.

[4] The *Environmental Code of Practice for Light-Duty Motor Vehicle Emission Inspection and Maintenance Programs* (CCME 1998) contains a detailed description of these various types of periodic programs.

2.1.3.2 Pre-screening using RSDs could also be used in conjunction, or in combination, with a periodic program. At fixed locations, HDVs could be assessed using RSDs or remote OBD X-level interrogation. Those vehicles that "fail" the pre-screening test would be required to undergo additional testing.

2.2 General Program Operation

2.2.1 The Administration is responsible for the overall operation of all aspects of the program. For roadside test programs, the Administration may wish to contract out both roadside inspection team startup and operation. For periodic decentralized test-and-repair programs, the Administration maintains overall control of the I/M program; however, the day-to-day aspects of the test-and-repair facility operation are the responsibility of the private repair facility owners and operators. For periodic programs, the Administration may wish to have inspections and reinspections performed by contractors at accredited private facilities.

2.2.2 With respect to inspections, reinspections, and repairs, the Administration should implement a dispute resolution process. The first level of resolution could be performed remotely by telephone or e-mail by either the Administration or a management contractor. At the next level, the Administration may wish to set up an independent referee (see 5.4) whose function is to resolve disputes over test results and repairs.

2.2.3 The Administration and/or the contractors should make provisions for liability in connection with all aspects and operations of the I/M program. It is recommended that the Administration develop a "damaged vehicle" policy to cover any vehicles that are damaged as a result of the inspection and testing process.

2.2.4 For periodic programs, the Administration may wish to consider phasing in inspections, especially during the first year of the program's operation (see 7.5).

2.3 Test Frequency and Vehicle Selection

2.3.1 Roadside Testing — Frequency

2.3.1.1 Roadside inspections should be conducted at a variety of locations on a year-round basis, weather permitting. It is recommended that the roadside test locations be selected to maximize the effectiveness of the program.

2.3.2 Roadside Testing — Vehicle Selection

2.3.2.1 Roadside units are unlikely to be capable of testing every HDV at a specific location. The following options are available for selecting HDVs for a roadside test:

- *Visible Emissions*: For both diesels and non-diesels, select HDVs with visible emissions. Currently, for the smoke emissions test, visible smoke is the principal method for selecting vehicles at a roadside location. The I/M program inspectors could be certified as visible smoke emissions observers using EPA Method 9 or EPA Method 22 (Appendix E).
- *Random*: Use a random system for selecting vehicles.
- *Vehicle or Engine Age*: Focus on the selection of HDVs of a particular vehicle or of a particular engine model year or older. For example, if older-technology engines were perceived to be the principal source of excess emissions, then only HDVs with pre-1991 engines would be selected.
- *Profile*: Selection could be based upon pattern failures or passes.
- *Hotspots:* Roadside units could be sent to areas where excess emissions from HDVs have been identified as a concern.
- *Remote Sensing Pre-Screen*: If available, remote sensing could be used to select vehicles for additional testing at a roadside location.
- *Combinations*: For example, selection could be based upon a combination of age and visible emissions.

2.3.2.2 These criteria are not meant to be restrictive. At any time, inspectors may select a vehicle for reasons other than those listed above. Also, the Administration must take into account any legal difficulties related to "probable cause" that may arise regarding vehicle selection in its jurisdiction.

2.3.3 Periodic Testing — Frequency

2.3.3.1 For periodic programs, the Administration must decide upon the gap between mandatory tests for the HDVs in its I/M program. Factors to be considered when setting the test frequency include:

- the overall impact on reducing emissions;
- the impact on the maintenance schedules of the subject fleet;
- the size of the HDV fleet within the jurisdiction;
- the number and throughput of testing facilities;
- the costs and cost effectiveness; and
- the convenience for the concerned parties.

2.3.3.2 At the time of writing, an annual periodic inspection was the requirement for all HDVs in Ontario, in the area covered by the I/M program. In the United States, the frequency of testing in HDV emission I/M programs is either annual or biennial. Test frequency is one of the parameters listed in the summary of I/M programs in Appendix B.

2.3.4 Periodic Testing — Vehicle Selection

2.3.4.1 The following options are available for selecting HDVs for a periodic test:

- *All HDVs*: All of the HDVs in a particular area could be subject to periodic testing.
- *Older-Technology Engines*: For older-technology heavy-duty diesel engines, the ease of adjustment of the parameters that can lead to excess smoke and other emissions must be taken into consideration. HDVs could be selected for periodic testing based upon engine and emissions control technology.
- *Profile*: Selection could be based upon pattern failures or passes.
- *Combinations*: For example, selection could be based upon a combination of age and a specific profile.

2.3.4.2 For registration and licensing purposes, the Administration may wish to set a validity period for I/M inspection pass certificates.

2.3.5 Resale

2.3.5.1 The Administration may wish to require HDVs to undergo an I/M inspection prior to reregistration after sale or other transfer of ownership. The Administration may wish to set a validity period for I/M inspection pass certificates in relation to vehicle resale.

2.4 Age Exemptions

2.4.1 For roadside I/M test programs, there should be no vehicle or engine age exemption.

2.4.2 In a periodic program, any HDV vehicle or engine age exemptions should be set at the discretion of the Administration.

2.5 Vehicle Lower Weight Limit

2.5.1 The definition of what constitutes an HDV can vary. The current provisions of the federal *Motor Vehicle Safety Act* define an HDV as any vehicle with a GVWR of more than 3855.6 kg (approximately 8500 lb.). However, in jurisdictions that operate LDV emission I/M programs, the HDV emission I/M program lower weight limit should be set to complement, and not interfere with, the LDV program. In areas where there is no LDV emission I/M program, it is recommended that the lower weight limit for the HDV emission I/M program be set at greater than 4500 kg (approximately 9900 lb.) to complement the benchmark set by the LDV emission I/M program Code of Practice (CCME 1998). Although not legislated for Canada at this time, the EPA has recently added a new class of medium-duty passenger vehicle in the 8500 to 10 000 lb. GVWR range for EPA Tier 2. This class of vehicle would then become an LDV.

2.5.2 All vehicles that exceed this lower weight limit, and that also meet the other qualifications in the Code, should be included in the HDV emission I/M program.

2.5.3 If it is not already a requirement of its provincial transport regulations, the Administration could develop some form of HDV weight identification system as part of the provincial reregistration process.

2.5.4 The Administration should be aware of difficulties that may arise in regard to HDV identification by weight. Weights may not be readily displayed, or the units may not be those required by the I/M program. Also, it may be difficult to classify

engines and vehicles with weight limits on the borderline between HDVs and LDVs. The Administration should be aware of, and make provisions for, vehicles with heavy-duty engines that are installed in vehicles that are under the selected weight limit and therefore are registered as LDVs. The Administration may wish to include a specific weight rating on an I/M program label or I/M documentation, such as suggested in 3.4.2.

2.6 Fuel Type

2.6.1 It is recommended that no vehicles be exempt from the HDV emission I/M program because of fuel type. The exception is vehicles that do not have tailpipe (exhaust) emissions — for example, vehicles that run solely on electric power. Special provisions may also have to be made for vehicles equipped with fuel cells. The use of special diesel fuel blends or mixtures may also require special treatment in regard to test procedures and cutpoints.

2.6.2 The current practice is to test dual-fuel vehicles using the fuel they are operating on when they arrive at the test site or facility. In general, this practice is followed for preconditioning considerations. Also, for vehicles equipped with computer adaptive learning features, non-typical emissions readings could result from testing if a sudden switch to the second fuel is required. For such vehicles, it may take up to one hour or longer for the on-board computer to relearn the optimal strategy for the second fuel. The Administration may wish to consider testing dual-fuel HDVs on both fuels; however, if the latter policy is adopted, customer convenience issues should be addressed. If the dual-fuel vehicle runs on electricity, however, the vehicle should be tested while using the non-electric fuel system.

2.6.3 Diesel-fuelled and non-diesel-fuelled HDVs will be subject to different test procedures. The fuel type for each HDV should be identified and tracked by software. On reinspection, the stated repairs should be matched to the systems that apply to that fuel.

2.6.4 Program design should accommodate both diesel-fuelled and non-diesel-fuelled vehicles.

2.6.5 It may be necessary to exempt certain hybrid vehicles, such as diesel-electrics, because of possible engine damage during testing. Also, it may be necessary to exempt vehicles that cannot be tested in their non-electric fuel mode. It is suggested that the Administration, in conjunction with the manufacturers, establish specific policies for the inspection of such vehicles.

2.7 Out-of-Province and Foreign Vehicles

2.7.1 Roadside test programs are recommended for HDV emission I/M as a practical means of capturing excess emitters that are registered out-of-province or out-of-country. For roadside test programs, all on-road HDVs operating in, or transiting through, an I/M program area should be included for possible capture in the testing program. This stipulation includes all trucks and buses.

2.7.2 The Administration must develop policies and procedures for the roadside interception and testing of out-of-province and foreign HDVs. A method for assessing and administering penalties for such vehicles must be developed. The Administration should investigate possible sanctions for out-of-province HDVs based on the current “pro-rate” or “reciprocity” plate system.

2.7.3 It is recommended that a province work with bordering provinces and states to develop reciprocal agreements regarding repair grace periods, pass certificate validity periods, and penalties levied against HDVs registered in each other’s locale.

2.8 Custom HDVs, Recreational Vehicles, and Unusual Vehicles

2.8.1 All multiple-axle-drive HDVs, anti-lock braking system (ABS) HDVs, traction control HDVs, recreational vehicles (RVs), and custom HDVs, if they are licensed for road operation, should be included in the I/M program, provided they meet other program criteria and are compatible with the testing systems.

2.8.2 Multiple-axle-drive, ABS, and traction control HDVs are likely to be an issue only if chassis-dynamometer testing is adopted. If chassis-dynamometer tests are to be employed, the Administration should be aware that many four-wheel-drive vehicles are all-wheel drive (AWD) and may not be capable of being operated on a conventional two-wheel-drive dynamometer without significant vehicle damage. An AWD, or multiple-axle-drive, dynamometer would be required to test these vehicles. These dynamometers could also be equipped for testing vehicles with ABS and traction control systems. Since AWD, multiple-axle-drive, ABS, and traction control vehicles cannot always be readily identified, it is recommended that all vehicles with the potential for being so equipped be routed to an AWD/multiple-axle-drive dynamometer lane. Since ABS and traction control systems can be disabled by the application of certain emissions test procedures, the Administration should ensure that test procedures contain provisions for restoring the operation of ABS and traction control systems before vehicles exit the test facilities.

2.8.3 For custom vehicles, the Administration will have to establish model year and/or emissions standards for each particular vehicle and/or engine.

2.8.4 The Administration should also establish procedures for warning its inspectors regarding "high revolution engines." Special procedures may be required for the testing of such engines (see 3.7).

2.9 Repair Cost Limits

2.9.1 The objective of the HDV emission I/M program is to reduce emissions by effecting repairs on vehicles with excess emissions. Consequently, a repair cost limit is not recommended for HDV emission I/M repairs. Vehicles that fail an I/M test must be repaired and reinspected to demonstrate that the condition causing the excess emissions has been corrected. All emissions-related repairs necessary to restore the engine and emissions control systems to the engine manufacturer's specifications should be performed.

2.9.2 However, the Administration may wish to investigate the legality of a "buy down" option, i.e., the ability to apply or use repair costs to reduce fines (see 2.10.2). Appendix D provides an example of some of the average repair costs reported for the HDV emission I/M program in British Columbia for 2000.

2.10 Compliance Enforcement

2.10.1 Registration denial is recommended as the compliance enforcement mechanism for HDV emission I/M programs. A system geared to the provincial vehicle licence or reregistration program is considered the most effective method of compliance enforcement and should be adopted for the HDV emission I/M program. For periodic programs, vehicles should be required to pass an I/M inspection before they can be licensed or reregistered. Similarly, for roadside programs, vehicles failing the roadside inspection should be required to pass a reinspection before they can be licensed or reregistered. For HDVs that "pass" an inspection or reinspection, it is recommended that the owner of the HDV be issued a "pass certificate." Pass certificates should have an expiry date or validity period; a 30-day minimum is recommended. The validity period allows a reasonable time for the owner/operator of an HDV to take the vehicle to a registry office for licensing or reregistration. The pass certificate should apply to a specific vehicle/engine combination and should become void if a different engine is added to the vehicle specified on the pass certificate or if the engine noted on the pass certificate is removed and installed in a different vehicle chassis.

2.10.2 To support a roadside HDV emission I/M program, the Administration should establish penalties or fines for HDVs that fail the inspection. In general, fines and penalties should be levied against the HDV owner. Also, as noted above, a "buy down" option, or the ability of owners to apply or use repair costs to reduce total fines, should be investigated.

Penalties assessed in regard to HDV emissions inspection "failures" should be set at a level sufficient to encourage owners/operators to properly maintain their vehicle. If possible, proceeds from penalties could be used to fund the program and/or to run outreach programs aimed at encouraging operators to maintain their vehicles.

2.10.3 The Administration of a roadside HDV emission I/M program may wish to establish a "grace period" for repairs. If repairs are performed within the grace period, the fines or penalties could be reduced or waived.

2.10.4 In a periodic program, any vehicle from outside an I/M program area that is relocating to the I/M program area should be required to undergo an emissions inspection before it can be licensed or registered for use within that I/M program area.

2.10.5 Provinces should consider recognizing and accepting repair grace periods, pass certificate validity periods, and fines and registration denial penalties from other provinces and jurisdictions. It is recommended that the Administration work with adjacent I/M programs. As noted in 2.7.3, the province should develop reciprocal agreements regarding fines and licence suspensions with neighbouring provinces and states (see also 1.5.1).

2.10.6 The Administration should develop a policy regarding multiple violations.

2.10.7 The Administration should incorporate provisions for vehicles that cannot be tested by scheduled dates due to extraordinary circumstances, such as natural disasters, that may impair access to inspection and/or repair facilities.

2.11 Customer Convenience

2.11.1 For roadside programs, easy and safe access to the test area should be provided.

2.11.2 For periodic programs, the number of accredited inspection, reinspection, and test-and-repair facilities should be capable of processing the expected monthly maximum vehicle volume plus an overcapacity figure to allow for fluctuations. For customer convenience, it is recommended that inspection and reinspection facilities offer appointments to minimize waiting time.

2.11.3 For customer convenience in roadside I/M programs, the Administration should aim to minimize test duration.

2.11.4 For periodic programs, HDV emission I/M tests should be coordinated, when practicable, with any periodic provincial safety inspection requirement. An attempt should be made to have a number of private facilities accredited for both safety and I/M inspections.

2.12 Inspection and Reinspection Fees

2.12.1 In general, inspection and reinspection fees apply only to periodic programs. For periodic programs, when setting inspection and reinspection fees, the Administration may wish to include a minimum fee level to cover government administrative costs. Inspection and reinspection fees cannot be set by the Code.

2.12.2 In general, the owner of the HDV pays inspection and reinspection fees.

2.13 Fleet Vehicles — Commercial, Utility, and Government

2.13.1 The HDV emission I/M program should apply to all commercial, utility, and government (or Crown corporation) fleet vehicles that meet the I/M program criteria.

2.13.2 The Administration should include all fleet commercial, utility, and government inspectors and repair technicians who are to be involved in I/M repairs in its accreditation programs. It should also include audits of the commercial, utility, and government repair facilities in its quality assurance (QA) program.

2.13.3 The Administration should allow self-certification of fleet vehicles (see 2.1.2.4).

2.14 Inspector and Repair Technician Safety and Health

2.14.1 The Administration should involve all federal, provincial, municipal, and regional health and safety authorities in the HDV emission I/M program design and implementation process. These health and safety agencies should be allowed to review preliminary plans and asked to make known their requirements for the safety of both inspection and repair facility personnel, before the I/M program design is finalized.

2.14.2 Safety and health devices or procedures required by the health and safety agencies should be installed in all inspection, reinspection, and test-and-repair facilities accredited by the I/M program. Where applicable, they should also be supplied to roadside crews. All personnel working in and around HDVs in accredited I/M inspection, reinspection, and test-and-repair facilities should receive training in the use of any of the required safety and health devices or procedures.

2.14.3 The Administration should contact the local fire marshall, and other appropriate or related authorities, with respect to system design and, in particular, any special provisions for hazardous materials used for analyzer operation or for the confined space operation of vehicles fuelled with gasoline, diesel, and alternative fuels. Similar provisions should be made for all hazardous materials carried as cargo by the vehicles under test.

2.14.4 The operation of all roadside inspection units must conform to all hazardous materials transportation requirements.

2.14.5 The Administration should investigate any additional insurance provisions that may be required for staff working with dynamometers, running roadside inspections, or operating vehicles over a test run.

2.15 HDV Operator Safety and Health

2.15.1 For roadside tests, operators must be informed as to the nature of the emissions test and their role in those tests. Tests should not proceed until the inspection staff is convinced that the operators are comfortable with their required tasks.

2.15.2 For periodic tests, the operator and all passengers should be required to exit vehicles for the duration of the tests. If required as part of an emissions test, an inspector should drive the vehicle onto (and operate the vehicle while on) the chassis-dynamometer or over a test course. While special inspector training may not be required, the Administration should develop a policy and technique for dealing with vehicles modified for operators with special ergonomic needs. A sign should be erected advising operators to remove all valuables from their vehicles during tests where they are required to exit the vehicle.

2.15.3 For periodic test facilities, operators should be required to wait in a separate area for their safety for the duration of the emissions tests.

2.15.4 For periodic test facilities, because of the potential danger involved in operating vehicles of different sizes in a confined area, inspection facilities that involve the operation and testing of HDVs and LDVs in the same test lanes should be carefully designed.

2.15.5 The Administration should investigate any additional liability or accident insurance that may be required for the owners/operators of HDVs participating in dynamometer tests or roadside inspections or operating vehicles over a test run.

2.16 Operating in Severe Weather Conditions

2.16.1 Roadside HDV emission I/M tests should not be conducted in severe weather conditions.

2.16.2 For roadside tests, all equipment and staff should be provided with protection from the elements.

2.16.3 *For government- or contractor-run periodic testing facilities*: Extreme weather conditions, such as hot, humid summers and cold winters combined with heavy rain or snow, can affect I/M station and equipment operation. The Administration should be aware of, and make provisions for in the station

design, the operating problems caused by extremes of local weather. Stations should be designed to use the latest and best methods for maintaining suitable conditions for HDV operators and inspection staff as well as for protecting delicate equipment.

2.16.4 *For privately run periodic testing facilities*: The Administration should inspect facilities that apply for certification or accreditation under the HDV emission I/M program to ensure that I/M tests will not be unduly compromised by extreme weather conditions.

2.17 Environmental Protection Provisions

2.17.1 All I/M inspection, reinspection, and test-and-repair facilities, whether contractor-run or privately owned, plus all roadside test sites, should comply with all federal, provincial, regional, and municipal regulations, codes, and guidelines for recycling, waste disposal, releases, and reuse of materials.

2.17.2 The following environmental protection-related issues are of particular concern in relation to HDV emission I/M programs:

- the venting of collected vehicle exhaust emissions during indoor testing;
- fuel and lubricant spills and leaks from the vehicle under test;
- cargo spills and leaks;
- noise pollution;
- the recycling of forms, brochures, and office waste paper;
- the recycling of any metal and glass used as part of the HDV inspection;
- the use of recycled paper;
- for new stations: aesthetics related to station design and location;
- the correct disposal or recycling of all wastes;
- the correct handling of all cleaning fluids and chemicals; and
- the disposal of any test-related fuels, lubricants, gases, and other chemicals.

Environmental protection considerations are not limited to the items listed here.

2.17.3 It is recommended that every roadside team and I/M station be supplied with (and be trained in the use of) the containment equipment to deal with an emergency spill of oil, fuel, or other fluids from the heavy-duty engines being tested or inspected. A minimum number of personnel at each station should be trained in emergency spill containment techniques. While containment of cargo spills is likely to be beyond the capability of the I/M inspection and repair personnel, all such personnel should be acquainted with, and have readily at hand, emergency spill hotline phone numbers and the procedures to follow should a cargo spill occur.

3. Test Procedures and Related Topics

3.0 General

3.0.1 HDV emission I/M programs could include one or more of the following test procedures:

1) *Tests that are currently available*
- Non-dynamometer smoke measurement test
- Non-dynamometer non-diesel engine idle emissions test
- Visual component inspections.

2) *Tests that are currently under development or that require standardization*
- On-board mobile emissions test
- OBD data link interrogation – first-generation OBD and OBD II
- Remote OBD X interrogation
- Remote emissions sensing combined with other test(s)
- Loaded chassis-dynamometer-based smoke emissions test
- Loaded chassis-dynamometer-based mass emissions test (either transient or non-transient).

3.0.2 Test equipment, test protocols, and appropriate cutpoints for the second group of testing options listed above have yet to be developed, standardized, and confirmed in North America. These tests and test procedures will need to demonstrate their success in properly identifying engines that have excess emissions before they can be considered for use in a mandatory HDV emission I/M program.

3.0.3 While the Code presents several HDV emission I/M program test procedure alternatives, the Administration should choose the most appropriate combination of test procedures and program parameters for its particular area and circumstances.

3.0.4 The management information system used to control the I/M program should be flexible in order to accommodate the testing of a varying number of vehicles using a variety of test procedures. Also, inspection and reinspection station layout plus the test hardware and software should be of flexible design so as to allow for the incorporation of one or more different test procedures into the I/M program.

3.0.5 In periodic programs, the Administration should make provisions in regard to its test procedures that are designed to discourage the practice of testing one vehicle while transmitting or recording the test results of another. This practice is commonly referred to as "clean-piping."

3.1 Non-Dynamometer Tests

3.1.1 Smoke Measurement Test

3.1.1.1 For the options that feature a non-dynamometer smoke test, the Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel-Powered Vehicles (SAE J1667) is recommended for Canadian HDV emission I/M programs. The SAE J1667 test is the accepted standard for testing smoke emissions from HDVs, including trucks and buses, powered by diesel engines. The J1667 test applies to vehicle exhaust smoke measurements made using the snap acceleration test procedure. Testing conducted in accordance with this procedure, in combination with reference smoke cutpoints, is intended to provide an indication of the state of maintenance and/or tampering of the engine and fuel system relative to the parameters that affect exhaust smoke (SAE 1996).

3.1.1.2 For a successful smoke test using the J1667 procedure, corrections must be made for ambient air conditions. The correction factors that must be applied are specified in SAE (1996). An accurate horsepower rating for the engine under test must be available in order to make the corrections that are required for the smoke readings (see 4.1.1).

3.1.1.3 Practitioners of the J1667 should be aware that certain vehicles and/or engines might be equipped with systems that may prevent the proper application of the method. Also, it has been reported that for a small number of vehicles, the engine speed during the test may become uncontrollable or "take off." Where problems with the testing of such vehicles or engines relate to a pattern failure, they

should be catalogued, and that information should be relayed to adjacent I/M regions. If problems with specific engines are known or are detected, it is suggested that they be referred to the engine manufacturer or supplier.

3.1.1.4 References for the SAE J1667 smoke test procedures are presented in Appendix E.

3.1.2 Non-Diesel Engine Two-Speed Idle Emissions Test

3.1.2.1 The two-speed non-dynamometer idle emissions test could be employed to test non-diesel HDVs for CO and HC emissions in a periodic program.

3.1.2.2 The I/M program hardware and software should be capable of performing a two-speed idle emissions test for VOCs and CO.

3.1.2.3 References for the two-speed idle emissions test procedures and cutpoints are presented in Appendix E.

3.1.3 On-Board Mobile Emissions Test

3.1.3.1 This type of emissions test requires the temporary installation of total PM and/or gaseous emissions sampling equipment on (or it can be towed by) each individual HDV that is to be tested. Emissions are then sampled as the vehicle is operated over a test strip or other appropriate test area. As currently designed, the test samples are subsequently transferred to an on-site measurement facility for analysis. The equipment for on-board mobile emissions testing is not commercially available at present; however, it is recommended that the Administration monitor developments in regard to on-board mobile emissions testing.

3.1.3.2 The Administration should implement a system that is capable of incorporating the on-board mobile emissions test or similar advanced test procedures at a future date.

3.1.4 OBD (Data Link) Interrogation

3.1.4.1 OBD (data link) interrogation could be included in an HDV emission I/M program for vehicles that are OBD (data link) equipped. An OBD (data link) interrogation capability should be built into the I/M system software. At present, very few Canadian vehicles over 8500 lb. GVWR have first-generation OBD (data link) capabilities or standardized OBD II-level systems installed. The EPA has issued draft guidance in regard to OBD interrogations for I/M programs (EPA 2000c).

3.1.4.2 An HDV emission I/M program should include a provision for malfunction indicator light (MIL) inspection on vehicles that are so fitted. An illuminated MIL may indicate an emissions problem. The manufacturer's vehicle and/or engine manual should be consulted regarding the implications of an illuminated MIL with respect to emissions.

3.1.4.3 Future OBD systems, OBD X, could feature the ability to conduct remote OBD interrogations. The Administration should monitor progress regarding OBD and OBD X for HDVs. When the remote interrogation systems are fitted on a substantial portion of the HDV fleet, remote interrogation has the potential to supplant emissions tests and other inspections.

3.1.5 Remote Sensing of Emissions Combined with Other Emissions Tests

3.1.5.1 This type of emissions test involves the measurement of emissions from moving HDVs from locations remote from the vehicles themselves. No equipment needs to be installed on the vehicle. Emissions may be monitored as the vehicle is operated on a normal road or highway or over a test strip. Remote monitoring could be used as a roadside test or as a pre-screening tool in a periodic inspection. The equipment, procedures, and standards for remote sensing of HDV emissions are still under development. However, it is recommended that the Administration monitor progress regarding the testing of HDV PM and gaseous emissions using RSDs.

3.1.5.2 The Administration should implement a system that is capable of incorporating the RSD emissions tests at a future date.

3.2 Chassis-Dynamometer Tests

3.2.1 Steady-State or Lug-Down Loaded-Mode Emissions Test

3.2.1.1 This style of emissions test requires the use of a chassis-dynamometer. In general, steady-state tests are conducted at multiple operational modes. Each mode is defined by a combination of speed and load that is held fixed or steady throughout the duration of the mode. For a lug-down test at full throttle, the load is gradually increased to pull back engine speed so that the engine is labouring, or "lugging."

3.2.1.2 The test equipment could be mobile or installed in a permanent test facility. If the equipment is installed in a permanent test facility, the test station layout plus the test hardware and software should be of flexible design so as to allow for the incorporation of one or more different steady-state, lug-down, or similar chassis-dynamometer test procedures during the life of the I/M program.

3.2.1.3 Since some of the heavy-duty engine manufacturers, vehicle assemblers, and HDV dealers operate facilities that are equipped with chassis-dynamometers, the Administration should investigate the development of a network that is connected to these test facilities. HDVs suspected as having excess emissions and detected either at roadside or as part of a non-dynamometer periodic testing program could be directed for a test at a network facility.

3.2.1.4 A smoke measurement is suggested as one possibility for a steady-state or lug-down dynamometer test. However, standardized testing protocol and cutpoints have yet to be developed for North America. Note that a lug-down test on an engine-dynamometer is part of the opacity test requirement in the FTP (see Appendix F).

3.2.1.5 A mass emission measurement of PM and/or gaseous pollutants employing a constant volume sampling (CVS) system is also an option for steady-state dynamometer emissions testing. However, standardized testing protocol and cutpoints have yet to be developed for North America.

3.2.1.6 References for the steady-state and lug-down loaded-mode test procedures are presented in Appendix E.

3.2.2 Transient Loaded-Mode Emissions Test

3.2.2.1 This style of emissions test requires the use of a chassis-dynamometer. The transient test exercises the engine over a schedule of varying speed and/or load conditions.

3.2.2.2 The test equipment could be mobile or installed in a permanent test facility. If the equipment is installed in a permanent test facility, the test station layout plus the test hardware and software should be of flexible design so as to allow for the incorporation of one or more chassis-dynamometer transient test procedures during the life of the I/M program.

3.2.2.3 References for transient loaded-mode test procedures are reserved until a standard transient emissions test for HDV emission I/M programs in North America is available.

3.2.2.4 A mass emissions measurement of PM and/or gaseous pollutants is suggested as the preferred option for transient dynamometer emissions testing.

3.2.2.5 Smoke measurement could be included as one element of a transient dynamometer test.

3.3 Cutpoints

3.3.0.1 All emissions tests will require a set of I/M test cutpoints or I/M standards. At present, the only HDV emission I/M test for which cutpoints have been established and generally accepted is the SAE J1667 smoke emissions test (see 3.3.1).

3.3.0.2 Cutpoints must be set so that properly maintained vehicles will not fail the test and that vehicles with emissions well in excess of standards will not pass. In other words, cutpoints should be set to minimize the occurrence of "false failures" and "false passes."

3.3.0.3 The cutpoints in the Code should be reviewed regularly and revised, as required, on a national basis and in collaboration with the OEMs.

The FTP standards for heavy-duty diesel engines are listed in Appendix F.

3.3.0.4 It is recommended that the Administration adopt any emissions test cutpoints set out in the Code, but these cutpoints should not be fixed so that an act of the provincial legislature is required to change them.

3.3.0.5 Cutpoints should be tested and any problems identified and corrected during the voluntary pilot program prior to the start date of the mandatory I/M program.

3.3.0.6 Since HDV engines are certified by engine model year, it is recommended that cutpoints be based upon engine model year. However, in order to align with local registration systems, certain jurisdictions may wish to set cutpoints based upon vehicle model year. The latter system should be problematic only when the difference between engine and vehicle model year spans a step change in FTP emissions standards.

3.3.0.7 One of the purposes of the Code is to attempt to ensure that HDV emission I/M programs in Canada and the rest of North America are compatible; therefore, the Administration should attempt to set cutpoints that are consistent with those of other jurisdictions.

3.3.1 Smoke Emissions Test Cutpoints

3.3.1.1 Smoke emissions test cutpoints are the HDDV I/M emissions standards set by the Administration that are used to assess excess smoke emissions. They are used to make emissions test pass/fail decisions. If the opacity for a particular engine is greater than the cutpoint, the vehicle fails the emissions inspection.

3.3.1.2 The recommended minimum smoke opacity cutpoints for a J1667 test are (CARB 1997c; EPA 1999a):

- for 1991 and newer model year engines — 40%; and
- for 1990 and older model year engines — 55%.

A listing of cutpoints used by various jurisdictions at the time of writing of this Code is provided in Appendix B.

3.3.1.3 While it is recognized that cutpoints may change, it is felt that for uniformity, the smoke opacity cutpoints noted above are the most acceptable for Canadian HDV emission I/M programs at this time. This is particularly true for the application of cutpoints to out-of-province or out-of-country vehicles. However, it is recognized that most heavy-duty engines, if properly maintained, should have significantly lower opacity than the cutpoints set above. Therefore, jurisdictions may wish to adopt stricter cutpoints for their I/M programs.

3.4 Visual Component Inspections

3.4.1 The visual inspection of emissions control and engine system components can yield evidence of tampering, malfunction, removal, and/or deterioration. Visual inspections are recommended for all HDVs in the I/M program where verifiable component information is readily available.

3.4.2 The certified engine family name can be used to identify the original engine manufacturer's part numbers for the critical emission components. The engine family name can be found on the Vehicle Emission Certification Information (VECI) label placed on the engine by the engine manufacturer. For vehicles equipped with the OEM engine and where the engine VECI label is missing, no longer legible, or not easily accessible, a replacement label (identical to the label installed during engine build) can be obtained by an authorized dealer. If this is not possible, to facilitate cases where the certification label may be missing, no longer legible, or not easily accessible, the Administration should consider provisions requiring the engine family to be included on its own I/M program label. This label should be conspicuously posted on the vehicle or contained in documentation readily available in the vehicle cab.

3.4.3 Provision for visual component inspections should be included in the test procedure software for the I/M program.

3.4.4 A visual inspection of HDVs should include verification that a "check engine," MIL, or other warning light is *off* while the engine is running on vehicles that are so equipped. The inspection procedures should include an on/off provision at some time during the inspection sequence to ensure

that the MIL is functioning and that the bulb has not burned out.

3.5 Preconditioning

3.5.1 Many emissions test procedures require engines and associated emissions control systems to be at their normal operating temperature prior to emissions testing. For engines, the normal operating temperature may be as indicated by a temperature gauge, temperature lamp, touch test on the radiator hose, or visual observation for overheating prior to an emissions test. During extreme ambient temperature conditions, inspectors should be trained to take special care to ensure that vehicles have received adequate preconditioning prior to emissions testing.

3.5.2 The test procedures should be designed to guarantee that preconditioning has taken place prior to pass/fail decisions being made. Because of particular operating temperature requirements for certain types of equipment, special provisions may be required for HDVs equipped with devices such as OEM or retrofit catalytic converters.

3.5.3 An exemption from maximum idling legislation may be required for certain jurisdictions.

3.6 Vehicle Chassis and Engine Model Year Identification

3.6.1 To identify and track the vehicle to be tested, the Administration should use the Vehicle Identification Number (VIN), or a portion of the VIN, to confirm the chassis or vehicle model year. The standardized VIN decoding can be used on 1981 and newer vehicles. It should be noted that at present, OBD (data link) interrogation may not yield the VIN number. The vehicle GVWR can be obtained from the Safety Certification Label (not to be confused with the engine VECI label) affixed to the driver door or door pillar. The GVWR and model year information can be used to ensure that the correct vehicle is under test.

3.6.2 For certain manufacturers, OEM alternative fuel vehicles can be identified via the VIN. Manufacturers should be consulted regarding their recommendations and suggestions for identifying such vehicles.

3.6.3 The Administration should make provisions to ensure that HDVs registered in their I/M program area have identification labels prominently displayed or carry documentation in the vehicle that lists the engine family name and the engine horsepower for the engine currently installed in the vehicle. Other information required for program administration, such as the GVWR and VIN, should also be displayed on labels or documentation. The Administration may wish to investigate the use of an I/M program label (or documentation) that lists the specific information that is needed for the operation of its I/M program (see 3.4.2).

3.6.4 To identify original components and the cutpoints for testing the engine emissions, it is important to check engine labels to verify both the engine and the engine model year. For emissions testing, the engine serial number and other emission-related details should be obtained from the manufacturer's engine plate. The Administration must develop a policy for dealing with and testing vehicles and engines that do not have appropriate labels.

3.6.5 The Administration should also develop a policy for dealing with HDVs where the engine and vehicle model years differ.

3.6.6 Disputes regarding the various identification parameters should be referred to the Administration, the engine manufacturers or rebuilders, and/or a referee (see 5.4). In regard to engine rebuild or replacement, at present, federal rules in the United States require that any replacement engine be the same or later (newer) model year relative to the engine being replaced.

3.7 Pre-Test Safety Check

3.7.1 The HDV emission I/M program should include a check of all vehicles that are to be tested to ensure that the vehicles can safely undergo all aspects of the I/M program requirements. All test equipment should also be inspected prior to each vehicle test to ensure that it is operating in a safe manner. In particular, a pre-test check should focus on the chassis-dynamometers and on any on-board mobile emissions test equipment that is to be installed on vehicles.

3.7.2 For all diesel engine testing that requires the engine to be taken up to the governed speed, the governor should be checked to see that it is functioning prior to the test. If the governor is not limiting engine speed, for safety reasons, the vehicle should be rejected from testing. For periodic or roadside testing that involves the snap acceleration smoke test, precautions should be taken regarding engines that are likely to "run away" or otherwise react badly to the test procedures even when the governor is functioning. Such engines may be "pattern" problems. It is suggested that lists of pattern failures be maintained and checked prior to testing. Problem vehicles should be referred to the manufacturer.

3.7.3 For testing involving operation on a chassis-dynamometer or driving during an on-board mobile emissions road test, the Administration should reject from testing those vehicles exhibiting the following obvious problems:

- tire cords are visible;
- tires are flat or nearly flat;
- space-saver tires are installed on a drive axle;
- tires installed on a drive axle have studs (dynamometer tests only);
- there are severe exhaust leaks;
- there are significant fuel, oil, or other fluid leaks;
- the operator's door cannot be opened and shut easily;
- the brakes are not properly functioning; and/or
- the fuel cap is missing.

3.7.4 It is recommended that the Administration ensure that at least one member of each HDV emission I/M program inspection team has the training and is certified or accredited to conduct the I/M program safety inspections.

3.8 Test Reports

3.8.1 Each HDV operator should receive a test (inspection or reinspection) report that lists the test results and test cutpoints, identifies whether the vehicle passed or failed, and explains what the owner/operator must do to fulfil the remaining program requirements.

3.8.2 For all failed vehicles, the Administration may wish to prepare general diagnostic and repair information handouts for owners/operators. These handouts should provide information in a manner that is useful to repair technicians and does not distance the service and repair industry from the I/M testing process.

3.9 Failures and Reinspections

3.9.1 The Administration should take measures to ensure that the truck and bus industry fully understands the implications surrounding a vehicle I/M test failure.

3.9.2 The Administration should develop a policy regarding repeated failures and repeated reinspections of the same vehicle.

3.9.3 It is recommended that the Administration work with the manufacturers, industry associations, and repair technicians on the resolution of any detected pattern failures. The Administration should collate repair data and provide information on repeat or pattern failures to the repair industry, vehicle manufacturers, and other interested parties. The Administration should adopt test procedures that account for and accommodate known pattern failure vehicles.

4. Test Equipment

4.0 General

4.0.1 The Administration should establish a program either for accrediting or certifying test equipment or for ensuring that all equipment used for HDV emission I/M tests meets a set of standards.

4.0.2 The emissions testing equipment at periodic inspection, reinspection, and test-and-repair facilities should be connected so as to deliver real-time data to a central computer. That central computer system should relay the emissions standards and calibration requirements and store the measurement results of every test (see 4.3).

4.0.3 Facilities and test equipment will need to be designed to accommodate variations in regard to HDV exhaust system configuration — i.e., single, dual, vertical, horizontal, rain caps, swept outlets, etc. — and location on the vehicle.

4.1 Non-Dynamometer Test Equipment

4.1.1 SAE J1667 Smoke Test Equipment Requirements

4.1.1.1 The opacity monitor for the J1667 smoke emissions test should meet the technical performance requirements specified by SAE (1996) (Appendix E). The Administration is advised to ensure that the brand and model of opacity monitor that it selects has passed a check by Environment Canada's Emissions Research and Measurement Division or other recognized testing laboratory (Appendix E).[5]

4.1.1.2 As noted in 3.1.1.2, the SAE J1667 opacity measurements must be corrected for local ambient air conditions (SAE 1996):

> Ambient air conditions can affect the snap-acceleration smoke test results. To ensure reliable results, the correction factors in Appendix B of the SAE J1667 Recommended Practice should be applied to snap-acceleration testing results to account for normal changes in ambient conditions. However, these correction factors must be applied only when the ambient conditions are outside specific ranges for altitude, air temperature, wind speed, dry air density and humidity.

If data for these parameters are not readily available for each test location, the Administration should make provisions for their on-site measurement. The purchase of a weather station(s) for the measurement of ambient parameters could be a requirement for accreditation for each inspection or reinspection station.

4.1.1.3 A partial-flow or internal type of probe for the smoke opacity monitor can be employed if wind, rain, and fog interference is to be a problem for outdoor testing using a full-flow system.

4.1.1.4 For roadside tests using the J1667 smoke test procedures, a stable power supply for test equipment will be required for each roadside team.

4.1.1.5 For roadside tests using the J1667 smoke test procedures, a global positioning system (GPS) for each roadside team can provide information for analysis purposes.

4.1.1.6 It has been found that opacity readings for white smoke may vary with the sensors and the systems employed by individual makes of smoke meters. The Administration should determine the ability of its smoke opacity equipment to deal with smoke other than black smoke and develop a policy in regard to dealing with HDVs that display significant amounts of either white or blue smoke.

4.1.2 Non-Diesel Two-Speed Idle Emissions Test Equipment

4.1.2.1 There are no generally approved test equipment specifications specifically designed for the non-diesel HDV two-speed idle emissions test for CO and HC. However, the emissions sampling and measurement equipment should be similar to that employed for LDVs.

[5] At the time of writing of this Code, the SAE J1667 specifications for opacity meters and cutpoints were under review.

4.1.2.2 The Ontario HDV I/M specifications or the California BAR-97 two-speed idle emissions test equipment specifications could be used. References for the two-speed idle test equipment are presented in Appendix E.

4.1.3 On-Board Mobile Emissions Test Equipment

4.1.3.1 At the time of publication of this Code, standard specifications for the on-board mobile emissions test equipment and procedures were not available for application in North America.

4.1.4 OBD (Data Link) Interrogation Equipment

4.1.4.1 Three general levels of OBD (data link) are referenced:

- *First-Generation OBD*: There is no single standard for equipment (hardware/software) specifications for the "first generation" of OBD (data link) systems. In general, these systems are manufacturer specific.
- *EPA Enhanced OBD II*: Equipment meeting the EPA enhanced OBD II hardware/software specifications is recommended for the interrogation of vehicles so equipped (see Appendix E).
- *Future Remote Interrogation OBD X*: At the time of publication of this Code, standard specifications for the OBD X-level test equipment and procedures were not available for application in North America.

4.1.4.2 The hardware for an OBD (data link) interrogation could be supplied to roadside test teams, and the hardware could also be used in inspection and reinspection stations in a periodic testing program.

4.1.5 Remote Sensing Equipment

4.1.5.1 At the time of publication of this Code, standard specifications for HDV emissions remote sensing test equipment and procedures were not available for application in North America.

4.2 Chassis-Dynamometer and Associated Test Equipment

4.2.1 At the time of publication of this Code, standard specifications for HDV emissions chassis-dynamometer test equipment and procedures were not available for application in North America. However, for mass emissions measurements of gaseous pollutants, the sampling and monitoring equipment associated with HDV chassis-dynamometer emissions testing will likely be similar to those for the LDV steady-state and IM240 [6] transient measurement systems. For testing diesels, a PM measurement system, or tunnel, for sampling mass emissions would also be required. Regardless, the sampling and monitoring system must be able to accurately measure tailpipe emissions from all engines and vehicles in the program, including alternative fuel engines and vehicles (see Appendix E).

4.2.2 Analyzers and other equipment that have the least susceptibility to high humidity should be selected. Heated sample lines are recommended.

4.2.3 For mass emissions measurements where a CVS system is used, the system should be sized in a manner that prevents condensation in the dilute sample over the range of ambient conditions likely to be encountered. For most of Canada, a large system and large sample lines will be required to accommodate winter conditions. The CVS compressor unit should be designed to maintain choke flow in the main CVS venturi with an adequate margin, while minimizing downtime and maintenance.

4.2.4 The sampling and analysis equipment should be tolerant of gasoline and of all alternative fuels currently in use, as well as of the combustion emissions products of those fuels. In order to accommodate the PM associated with diesel emission measurements, it is recommended that diesel engines be tested using a separate system from that used for non-diesel-fuelled vehicles.

[6] A transient emissions test that approximates the first 240 seconds of the FTP.

4.2.5 Chassis-dynamometers should be capable of handling vehicles of up to the heaviest GVWR. Provisions should be made for the testing of variations in regard to combinations of non-powered and powered axles.

4.2.6 Dynamometers should be protected with adequate drainage systems and cleaned on a regular basis. During winter months, sand and salt should be washed from the rollers, and the pits should be cleaned and flushed daily.

4.2.7 For new programs, regardless of the test employed, it is recommended that all test lanes be constructed to allow for the future installation of transient chassis-dynamometers and their inertia weights and control systems.

4.2.8 The difficulties associated with vehicles that require augmented braking control should be investigated and the system designed to handle these and multiple-axle-drive vehicles.

4.3 System Computer Requirements

4.3.1 For both roadside and periodic I/M programs, computerized systems are required for controlling all test procedures and recording all measurements on subject vehicles. It is recommended that the Administration set computer software specifications related to all aspects of its HDV emission I/M program. Subsequently, all equipment software should be required to be compatible with the specifications set by the Administration.

4.3.2 To facilitate testing and real-time exchange of information, it would be advantageous for all roadside and station computers to have a real-time link to a host computer and a main database. Real-time links, possibly via the Internet, could be used for controlling individual test parameters and for confirming test vehicle identification.

4.3.3 All computer equipment should be designed to be flexible and expandable to allow for rapid system and component upgrade. The main system computers and database should be capable of being interlinked with similar systems in other I/M programs within Canada and North America.

4.4 Engine Parameter Measurement Equipment

4.4.1 Many of the emissions tests listed in the Code require a reading of the engine revolutions per minute (rpm) during the test. For rpm detection, it is recommended that each roadside inspection team and fixed inspection or reinspection station be equipped with rpm measurement devices that feature both direct pickup and non-contact pickup for rpm measurements. For roadside smoke test inspections, teams may attempt to use individual vehicle tachometers for rpm measurement; however, since such equipment may not be installed on all HDVs, rpm measurement devices are recommended. For vehicles equipped with OBD II technology, engine rpm must be monitored via the diagnostic data link connector.

4.4.2 Where possible, non-contact, remote sensing rpm measurements should be used, since they minimize contact between the inspector and engine components.

4.4.3 Certain tests may also require measurement of the engine temperature and other parameters. For these measurements, temperature and other measurement equipment could be supplied where required.

4.5 External Engine Cooling System

4.5.1 An external cooling system that directs air of adequate capacity at the radiator of each vehicle while it is being tested on a chassis-dynamometer is required (see Appendix E).

5. Quality Control and Quality Assurance

5.0 General

5.0.1 The terms "quality control" and "quality assurance" are sometimes confused or interchanged. For the purpose of this document, QC will refer to the system checks carried out during a routine daily program. QA will refer to the broader topic of the audit of overall I/M program performance to determine whether it is functioning to specification or potential.

5.0.2 QA and QC involve the careful monitoring of all aspects of the I/M program to ensure that all systems are performing at or near the standards set for successful program operation.

5.0.3 Strict QC schedules should be developed and maintained for all test equipment. Where possible, the QC procedures should be automatic and activated by the system software. QC is one of the most important issues in the development, implementation, and operation of an I/M program. QC involves frequent (per test, hourly, and/or daily) checks of all the equipment and systems in the program. QC procedures should ensure that emissions measurement equipment is calibrated and maintained properly and that inspection records, calibration records, and control charts are accurately created, recorded, and maintained.

5.0.4 QA programs include accurate data collection, inspector training, test procedure auditing, inter-unit precision and accuracy determinations, program data analysis, and repair effectiveness audit, analysis, and assessment. QA also involves the monitoring and reporting of overall program effectiveness (see 5.6).

5.1 Equipment QC

5.1.1 Approval or Accreditation of Equipment

5.1.1.1 All equipment employed for the inspection or reinspection of HDVs in the I/M program should be approved or accredited by the Administration. The Administration should require all equipment that is used in the program to be guaranteed by each manufacturer/supplier to conform to all equipment specifications that the Administration sets for the I/M program.

5.1.1.2 The Administration should establish procedures or protocol for the approval and accreditation of all inspection and reinspection equipment and peripherals. The Administration should conduct random equipment audits of all I/M program inspection and reinspection equipment.

5.1.2 Instrument Calibration

5.1.2.1 For each piece of I/M-related equipment in each inspection or reinspection station, a thorough calibration program should be developed and implemented. If available, the calibration procedures and schedule set by the instrument manufacturers should be used as the minimum requirement. However, the Administration may wish to establish stricter calibration protocols for its I/M program.

5.1.2.2 The calibration schedule should be part of the interlinked computer system that allows a central computer to monitor the calibration of test equipment located in all inspection and reinspection facilities.

5.1.2.3 For gas analyzers, the Administration should establish a consistent source of calibration span and zero gases. Reference calibration gas standards should be obtained from commercial gas suppliers whose operations meet the EPA gas certification requirements. Special provisions will be required for the calibration of smoke opacity monitors. References for opacity standards are listed in Appendix E. Special calibration standards will also be required for mass emissions measurement equipment.

5.1.2.4 Weather station equipment should be calibrated on a regular schedule.

5.1.3 Chassis-Dynamometer Calibration and Checks

5.1.3.1 Daily visual inspections of the chassis-dynamometer for physical damage to the rollers, bearings, and other equipment should be implemented.

5.1.3.2 The manufacturer's recommended dynamometer calibration procedures should be adopted and implemented.

5.1.3.3 Chassis-dynamometer calibration procedures and requirements will differ according to the type of test employed in the I/M program.

5.2 QA and Audits

5.2.1 The Administration should develop, conduct, and strictly adhere to a well-designed QA program backed by effective audit techniques.

5.2.2 The Administration should put the QA program into operation early in the I/M program implementation process, preferably during the pilot or voluntary phase. The Administration should ensure that all audit functions are tested and that all I/M roadside units, inspection stations, and repair and reinspection facilities are subject to a thorough acceptance procedure or initial audit before the I/M program begins regular operation. One possible option is the use of an Administration or contractor vehicle as part of a cross-comparison audit between roadside units and between I/M inspection and reinspection stations. The purpose of the cross-comparison audit is to ensure that all components of the system are capable of providing comparable test results for the same vehicle.

5.2.3 The Administration should employ both unannounced and announced audits. The Administration should recognize that fleet self-certification programs might require special audit provisions. If roadside inspections find discrepancies or failures for vehicles that have been self-certified and self-repaired as part of a fleet program, it is recommended that the Administration audit the fleet facilities (if not already included in its audit program).

5.2.4 It is recommended that the Administration include a random spot check and monitoring program of accredited or approved HDV repair facilities in the QA program.

5.2.5 In areas where I/M is not to be implemented, if legislation allows, the Administration should institute an HDV repair industry audit program. The purpose of this program would be to ensure repair quality and adherence to anti-tampering legislation.

5.3 Vehicle Test Data

5.3.1 The accurate recording and gathering of vehicle parameter information plus test and repair data are essential for effective program evaluation. The on-line, real-time collection of test data via a link to a central computer should be established. All I/M units and inspection and reinspection facilities should be electronically connected to allow real-time data transfer between stations and a central host computer.

5.3.2 The Administration should investigate the use of the latest computer/data processing techniques and a labelling system for the rapid electronic recording of the required data.

5.3.3 Generally, for periodic programs, data should be electronically recorded for each HDV that is tested and available for year-to-year comparison. The items suggested for data collection are listed in Appendix G. Certain items may be more applicable to specific types or styles of I/M program and tests, while the recording of some items may also be required for each phase of an emissions test. Special provisions will be required for roadside inspection programs. Not all of the information listed in Appendix G may be required as part of the roadside data-gathering exercise.

5.3.4 The Administration should establish an I/M program data analysis system. The system should allow for the assembly, collation, and analysis of all I/M program data. The system should also make provisions for integrating and comparing data with similar data from I/M programs in other jurisdictions.

5.4 Research, QC, and Referee Program

5.4.1 It is recommended that the Administration develop a separate program that would perform I/M program research, QC, and referee functions. For impartiality, it is recommended that the "separate" referee function be performed by a "third party" that is different from the Administration or the contractors who may be responsible for operating other parts of the I/M program. This separate referee program could

act as the final arbitrator for settling disputes involving test results and repairs and for testing aftermarket equipment, fuel mixtures, and add-on devices. This referee program should be in operation before the mandatory I/M program start date.

5.4.2 In order to provide technical assistance, to add expertise, and to arbitrate disputes for inspection and reinspection facilities, it is recommended that the Administration require, and arrange for, access to the services of an accredited HDV repair technician (either in person or via electronic link). Access to the HDV repair technician could be limited to the normal hours of operation of the I/M program inspection and reinspection facilities.

5.5 Periodic Information Reports

5.5.1 The Administration should prepare periodic information reports that contain the following information, where applicable and practicable:

- *Total Test Volume*: initial inspection and reinspection, separated and compared to provide a measure of compliance with any compliance rate target.
- *Test Duration Time and Customer Waiting Time*: in centralized test-only systems to monitor customer convenience and a possible need for more test lanes.
- *First Emissions Test Fail Rate by Chassis and Engine Model Year*.
- *Tampering Rates*: to monitor the first-year tampering rate and to chart any yearly changes resulting from implementation of the I/M program.
- *Emissions Reductions after Repair*: to monitor the success of the program in achieving its stated goals.
- *Failure by Test Category and Standards*: to provide a measure of where future changes or efforts could be directed to achieve even greater emissions reductions.
- *Failure by Type of Fuel*.
- *Failure by Age and Odometer Reading*.
- *Failure by Type of Engine Control Technology*.
- *Repair Industry Data from Returned or Failed Vehicle Reports*: to monitor the success of vehicle repairs and any possible requirement for improved repair technician training.
- *An Estimate of Overall Program Effectiveness*: in a format that can be easily compared with external evaluation reports and other I/M program effectiveness evaluations (see 5.6).

5.5.2 Once these reports have received proper validation by the Administration, they should be made public.

5.6 HDV Emission I/M Program Performance Evaluation

5.6.1 The Administration should periodically evaluate and report on the I/M program's effectiveness. The performance evaluation could include some or all of the periodic information reports listed in 5.5.

5.6.2 In addition to internal QA checks and reports, the Administration should contract for an independent evaluation of the success of the I/M program in reducing excess HDV emissions in the area covered by the program. The external evaluation should also include an estimate of the effectiveness of the program and of the improvements in local repair industry effectiveness since program inception. If feasible, the external program evaluation should conform to an accepted format that would enable I/M program effectiveness to be compared with the performance of other HDV emission I/M programs in Canada and the United States. The results of the external program evaluation and of any cross-comparisons should be made public.

5.6.3 It is recommended that the Administration develop an integrated data system that is compatible with the provincial or regional emissions inventory management systems. Recorded data could then be used not only to judge program effectiveness, but also to compare data and effectiveness with those of other emissions reduction programs.

5.6.4 As noted in 5.3.4, the Administration should establish an I/M program data analysis system for integrating and comparing data with similar data from I/M programs in other jurisdictions.

5.6.5 Once these program effectiveness reports have received proper validation by the Administration, they should be made public.

6. Personnel Training and Accreditation plus Facility Accreditation

6.0 General

6.0.1 It is recommended that the Administration develop training and accreditation programs that cover all aspects of its HDV emission I/M program.

6.1 HDV Emission I/M Program Orientation Course

6.1.1 It is recommended that the Administration develop, to the extent possible, an HDV Emission I/M Program Orientation Course. The Administration should attempt to integrate this course into local HDV repair technician training programs. Efforts should be made to ensure that this integration does not compromise either the existing repair technician training program or the I/M training requirements. The HDV Emission I/M Program Orientation Course could be an "add-on" to an existing training program for technicians who wish to obtain I/M repair technician accreditation.

6.1.2 It is recommended that the HDV Emission I/M Program Orientation Course be a "stand-alone" training segment designed for local schools and for all principal members of the HDV parts, sales, and engine rebuild and repair industry. This orientation program initiative should include input from, and be developed in conjunction with, the truck and bus operators industry, engine manufacturers, the sales industry, the parts industry, and the repair industry.

6.1.3 To the extent possible, the HDV Emission I/M Program Orientation Course should be developed on a national basis. It is recommended that any existing national curriculum be amended to include local I/M program requirements so that repair technician certification will remain portable between provinces. The Administration may wish to work with local technical schools, colleges, related industry representatives, and private repair technician training institutes in developing the HDV Emission I/M Program Orientation Course component for local repair technician training programs. As part of its QA program, the Administration may wish to monitor the local training programs for their I/M program content and presentation.

6.1.4 It is recommended that if repair technicians wish to be accredited by a local HDV emission I/M program, they should be required, as a minimum, to take the HDV Emission I/M Program Orientation Course. Other members of the HDV repair industry — certified repair facility owners, managers, regional service representatives and service writers — as well as dealer parts department and separate parts company staff could also be encouraged to take the orientation course to become familiar with the I/M program and its requirements. It is also recommended that, following the orientation course, all repair technicians be tested regarding emissions control components and systems. Those who fail the examination may be requested to undergo additional I/M program training of sufficient duration to meet minimum standards (as adopted by the Administration) for practical and theoretical content and to pass a second examination. The Administration's HDV Emission I/M Program Orientation Course should allow for local factors and specific fuel requirement training when determining course duration.

6.1.5 It is suggested that, at a minimum, the HDV Emission I/M Program Orientation Course include the following topics:

- the purpose and objective of the HDV emission I/M program;
- HDV emission I/M program requirements in regard to repair facilities and reporting requirements;
- dealing with HDV operators and owners;
- frequent I/M program complaints and problems;
- anti-tampering legislation and what constitutes tampering;
- how to interpret the failed vehicle inspection reports;
- how to fill out I/M repair reports on repaired vehicles;
- past, present, and proposed federal engine emissions standards;

- HDV emissions control systems identification and operation;
- the differences between federal emissions standards and I/M program cutpoints;
- the basis of the smoke and mass emissions tests;
- the differences between the I/M tests and the FTP engine certification tests;
- vehicle classifications — inclusions and exclusions;
- potential new developments in HDV engines, engine standards, and fuels;
- I/M emissions test technology; and
- the I/M hotline, library, newsletter, and available Internet services.

6.1.6 All accredited HDV emission I/M program inspectors should also be required to take the course. Those repair technicians and inspectors-in-training who fail the HDV Emission I/M Program Orientation Course examination could be required to retake the course. Inspectors and repair technicians could be required to take a revised HDV Emission I/M Program Orientation Course if I/M program parameters are significantly changed.

6.1.7 It is recommended that the HDV Emission I/M Program Orientation Course be developed as soon as the I/M program is approved and be in place at least six months before the mandatory I/M program start date.

6.1.8 It is recommended that the Administration encourage the early participation of a large portion of the technicians from the local service industry in the HDV Emission I/M Program Orientation Course.

6.2 Inspector Training and Accreditation

6.2.1 The Administration should establish a training and accreditation program for all I/M program inspection and reinspection personnel for both roadside and periodic programs. The HDV Emission I/M Program Orientation Course should be an integral part of the training program for all accredited HDV emission I/M program inspectors. All inspectors should receive classroom and practical training on HDVs of all fuel types included in the program before the start of mandatory testing. These inspectors should receive field or on-the-job training with active roadside units, or at active inspection and reinspection facilities, before they become accredited inspectors. When initiating a program, accredited inspectors should receive on-the-job training as soon as possible, preferably during the pilot program. The inspectors should be required to pass a standard test that includes both written and practical sections, as set by the Administration. For training in regard to the J1667 smoke test, the following should be considered:

- training on the J1667 procedures along with any recognized difficulties in relation to its application;
- training regarding the operation of specific opacity meters;
- instruction on the calibration and maintenance of opacity meters; and
- instruction regarding any regulatory requirements of the program.

6.2.2 As noted above, to ensure that their authority to conduct I/M tests is recognized by participating HDV operators, all inspection personnel at roadside inspections should be in uniform. At least one member of each roadside team should be a roadside inspector that has been accredited by the Administration. Inspectors in roadside programs may also require special training to develop appropriate qualifications in regard to the determination of "probable cause." For roadside teams, an inspector could be certified as a qualified observer regarding visible smoke emissions (EPA Method 9). An alternative would be to adopt the "smoke or no smoke" observer qualification (EPA Method 22) (Appendix E).

6.2.3 Inspector training programs could be run under contract. The Administration should monitor all inspector training programs run by contractor(s).

6.2.4 It is important that I/M inspectors be trained to not provide owners or operators with any diagnostic information other than the general information provided on the test reports.

6.2.5 All personnel working in and around HDVs in accredited I/M inspection and reinspection facilities should receive training in the use of the required safety and health devices or procedures. All

inspection station staff should receive Workplace Hazardous Materials Information System (WHMIS) training. The labelling and signs appropriate to WHMIS should be adopted and installed.

6.2.6 Roadside inspection staff should receive training in the safe stopping, handling, and control of the largest HDVs in restricted test areas. The operation of all roadside inspection units must conform to all hazardous materials transportation requirements, and all roadside inspection staff should receive training related to these requirements.

6.2.7 If HDVs are to operate on chassis-dynamometers, the Administration must ensure that the appropriate inspection staff receives training in vehicle restraint and dynamometer operation.

6.2.8 If HDVs are to be operated over a test run, inspection staff will require specialized training and possibly special licensing.

6.3 Repair Technician Training and Accreditation

6.3.1 It is suggested that the Administration establish accreditation standards for repair technicians involved in its I/M program. A local HDV repair technician training program is essential for successful operation of an I/M program. The outline for the elements of a generic HDV Emissions Repair Technician Training Program is provided in Appendix H. This outline was developed as part of a national exercise involving engine manufacturers, assemblers, colleges, and fleets (Ramik 2001).

6.3.2 The present training and certification for repair technicians vary by province. Some provinces have compulsory certification, while others list such certification as a voluntary trade requirement. "Truck and Transport Mechanic" is a "Designated Red Seal Trade," which means that it is recognized nationally and provides technicians with the ability to work in any province. The Red Seal is provided to those scoring high marks on the certification exam. Therefore, one may think of the present situation regarding provincial repair technician certification as having three levels:

1. *None* — in provinces where it is a voluntary trade;
2. *Provincially Certified*; and
3. *Provincially Certified with Red Seal* or nationally recognized.

6.3.3 The Administration may wish to provide the HDV repair technicians and/or the accredited repair facilities with:

- a hotline and an interactive website staffed by experienced repair technicians;
- a regular newsletter;
- an on-line technical information system, complete with diagnostic information and manuals, available in hard cover and on CD-ROM; and
- an indication as to how they are performing with respect to I/M repairs before, or if, such a list is published.

6.3.4 The Administration may wish to prepare and distribute reports or updates on:

- the latest repair information and average repair costs;
- the most frequent repairs and whether they apply to emissions failures;
- the performance of the individual repair facilities with respect to I/M repairs. This report would be linked to a report card system highlighting the performance of the individual repair facility with respect to successful I/M repairs. Reports on repair facility performance should be made public, depending upon provincial access-to-information requirements and other legal restrictions. Reports on individual technicians may have to remain confidential to the agency, depending upon provincial legislation regarding privacy and libel; and
- vehicle recalls.

It is recommended that the Administration's data-handling system be capable of generating real-time information on the above topics, and that data be available for ready distribution.

6.4 Inspection and Reinspection Unit and Facility Accreditation

6.4.1 While inspections and reinspections in a periodic program will likely be conducted at private facilities, these facilities should still be approved or accredited by the Administration. Roadside inspection units should also be approved or accredited by the Administration.

6.4.2 It is recommended that the Administration exercise strict control over signage, register the program logo as a trademark, and control logo use by both roadside units and inspection and reinspection facilities.

6.4.3 For centralized test-only I/M programs, particularly where the inspection and reinspection facilities are of new construction, the following should be taken into consideration:

- Any new HDV emission I/M program test-only fixed facilities should be designed for maximum HDV operator convenience. Ease of access and egress without tight turns or congested manoeuvring areas is an essential requirement.
- Facilities should be designed with escape paths for vehicles that become trapped behind disabled vehicles, for vehicles that are refused a test for safety or documentation reasons, and for vehicles whose operators wish to leave the queue for personal reasons.
- Centralized I/M test-only inspection and reinspection stations should be located on property of sufficient size to allow for future expansion and in an area where HDV operation on adjoining streets is not restricted. The stations should provide entrance lanes that are long enough to prevent the spillover of waiting vehicles onto adjacent streets. In addition, lanes should be large enough to house the equipment for performing all the recommended tests and to accommodate possible future expansion or technology changes.
- Early in the I/M program planning phase, local governments and other appropriate provincial departments should be contacted regarding zoning. A plan that includes provisions for delays from any anticipated zoning problems should be prepared.
- I/M inspection and reinspection stations must conform to all local building, electrical, plumbing, fire, health, safety, environmental, and other appropriate codes.
- Regardless of program style, the Administration should include in the contract provisions for supplanting contractor(s) during the course of the contract(s) or at contract conclusion.

To the extent possible, the Administration should encourage the owners of private HDV emission I/M program inspection, reinspection, and test-and-repair stations to strive to achieve similar conditions in their facilities.

6.5 Repair Facility Accreditation

6.5.1 If the Administration should choose to implement a repair facility accreditation program, it is recommended that the program outline both the equipment required for accreditation and the accreditation requirements for staff members. Separate accreditation for diesel and non-diesel vehicle repair facilities may be required. It is also recommended that the Administration exercise strict control over signage and control logo use by repair facilities.

6.5.2 It is recommended that the Administration establish the system of records that it requires each accredited repair facility to maintain and transmit with regard to I/M repairs. The Administration's QA program should include routine monitoring of those records. The system for recording repairs and transmitting those records from the facility to the customer and the main HDV emission I/M program database should be automated where possible to reduce transcribing errors.

6.5.3 It is recommended that following an inspection by the Administration, repair facilities receive an accreditation that is subject to review.

6.5.4 As noted in 5.2.4, the Administration may wish to establish a repair facility monitoring program using both unannounced and announced audit methods as part of its QA program.

6.5.5 It is recommended that the Administration retain the power to revoke accreditation, with a right to appeal, on short notice.

6.5.6 The Administration may wish to maintain an up-to-date list of accredited repair facilities available on-line. Copies of the list could be made available to all those who participate in the I/M program.

6.5.7 It is recommended that the Administration encourage repair centres to seek accreditation prior to the program start date. As an option, the Administration could announce that all stations that

receive accreditation at some fixed date prior to the program start date would be listed on a published notice.

6.5.8 It is recommended that all I/M program accredited repair facilities be required to conform to all local building, electrical, plumbing, fire, health, safety, environmental, and other appropriate codes.

6.6 Potential Compatibility Problems

6.6.1 If an I/M program were to adopt emissions test procedures that feature equipment that is unlikely to be installed in many of the HDV repair facilities in the I/M program area, there is a potential for compatibility problems. In such cases, it is recommended that the Administration institute programs that reduce compatibility problems regarding the service industry's ability to determine repair effectiveness.

6.6.2 It is recommended that the I/M program main computer database and system software be capable of providing a vehicle test report to each HDV owner/operator whose vehicle fails an I/M program inspection. Where compatibility problems are anticipated, it is also recommended that the vehicle inspection and reinspection facilities provide limited, general diagnostic and repair information. The report should contain an indication of a "good" emissions test result for the particular make of vehicle, engine, and/or engine family being tested.

6.6.3 Few compatibility problems are anticipated for I/M programs that feature only the conventional snap acceleration smoke test plus visual component inspections.

7. Outreach Programs

7.0 General

7.0.1 In order to gain maximum acceptance of the HDV emission I/M program by all those who will be affected by it, the Administration should develop a number of outreach programs. These programs should be designed to reflect the interests and concerns of specific sectors.

7.1 Industry, Media, and Public Awareness Campaigns

7.1.1 Awareness campaigns are an integral part of an I/M program's industry, media, and public outreach program. These campaigns should advertise the requirements of the HDV emission I/M program to the industry and the benefits of the program and of effective vehicle maintenance to HDV owners and operators. The owners and operators of heavy-duty trucks and buses are the principal targets of these campaigns, but it is also recommended that the industry awareness campaigns be directed at the HDV sales, engine rebuild, parts, and repair industries. It is recommended that the persistent, well-structured industry, media, and public awareness campaigns be developed and implemented well in advance of the I/M program start date. It is also suggested that all levels of I/M program management and local politicians be involved in the awareness campaign from the early I/M program planning stages. As well as media broadcasts, these programs could include the focus testing and distribution of the most effective I/M program incentives, such as brochures, hats, buttons, and bumper stickers, plus static displays for HDV emission I/M program information in malls and public buildings.

7.1.2 The campaigns could include some or all of the following:

- the purpose of the I/M program and why it is necessary;
- the benefits of regular vehicle maintenance in regard to the environment, health, and fuel economy;
- what the I/M program requires from both HDV operators and owners;
- the content of the vehicle tests;
- reassurance that tests will not damage vehicles;
- the frequency of the I/M inspection requirement;
- the requirement that vehicles must be tested to be reregistered (if applicable);
- how to determine the chassis and engine model year;
- which vehicles require an inspection and the exemptions that are available;
- reassurance that well-maintained HDVs should not fail;
- why a vehicle may fail and what to do next;
- the emissions cutpoints and the significance of a "near" pass or a "near" failure;
- referring owners to the manufacturers' owner's manuals for maintenance schedules, recommended fuels and lubricants, what to do if the OBD MIL is illuminated, and recommended tire pressure;
- the problems caused by removed or damaged components and other forms of tampering;
- the policies regarding the replacement of components and aftermarket components;
- what is expected from and what to expect from the repair industry;
- alternative fuels and their place in the I/M program;
- information on add-on components and their history;
- information regarding related programs;
- the fact that certain heavy-duty engine families may require special consideration; and
- information on emissions-related recalls and how they work.

7.2 Hotline/Internet Link

7.2.1 It is recommended that the Administration operate and maintain an information hotline and an interactive website with links to related websites. It is suggested that these information tools commence operation during the pilot program and that the hotline operators and website attendants have sufficient training to answer requests for technical as well as general information.

7.2.2 The hotline and interactive website could be designed to provide answers, address complaints, and supply information on the topics listed in 7.1.2.

7.3 Industry Outreach Program

7.3.1 It is recommended that the Administration work with the various industry associations in the development of an industry outreach program and allocate a minimum amount of resources each year to the program. The amount allocated could be set at double the normal annual requirement during the pilot program and the first year of mandatory program operation. The Administration could consider having all industry outreach program activities performed under contract. The industry outreach program could include one or more of:

- an HDV Emission I/M Program Orientation Course (6.1);
- information videos for distribution to trucking associations, transit companies, and the local HDV sales and repair industry;
- a full-time public relations staff;
- the focus testing and distribution of the most effective I/M program incentives, such as brochures, hats, buttons, and bumper stickers;
- static displays of HDV emission I/M program information for repair facilities, dealer showrooms, and ancillary industries;
- implementation of industry-oriented awareness campaigns;
- the use of a roadside team to visit individual truck and bus companies and repair facilities to explain the HDV emission I/M program, to put on the HDV Emission I/M Program Orientation Course, and to demonstrate the I/M emissions test; and
- the use of an industry-specific Internet website with links to related websites to advertise the program.

7.3.2 The Administration may wish inspection, reinspection, and repair facilities to have visual displays and written descriptions of the inspection process available during operating hours.

7.3.3 It is recommended that the Administration retain the right to review and approve all public information material prepared by private inspection, reinspection, and/or repair facilities.

7.3.4 The Administration may wish to retain the right to distribute information of its choice at all I/M inspection and/or repair facilities.

7.3.5 The Administration may wish to consider including a roadside testing program for communities outside the I/M area as part of its outreach program.

7.4 Media Information and Coordination

7.4.1 The Administration may wish to designate a media coordinator. Contact could be made with the local media early in the development phase and their support solicited.

7.4.2 Complaints and problems should be anticipated. It is suggested that media information packages be prepared in advance of program operation.

7.5 Pilot Program and Program Phase-In

7.5.1 In order to introduce the heavy-duty truck and bus and HDV repair industries to the requirements of the HDV emission I/M program, a pilot program is recommended for at least a six-month period prior to the implementation of mandatory testing and the imposition of penalties.

7.5.2 In order to ease the impact of the program on the heavy-duty truck and bus and HDV repair industries, the Administration may wish to stagger or phase in the program, especially for fleet vehicles.

7.6 Complementary Programs

7.6.0.1 There are other programs that could be run in conjunction with, but remain separate from, an I/M program. These programs may assist in the reduction of excess on-road HDV emissions.

7.6.1 Component and Engine Retrofit/Rebuild Programs

7.6.1.1 The Administration may wish to investigate programs for the retrofit of emissions control systems on trucks and buses that were not originally equipped with such equipment and on engine rebuild and upgrade programs.

7.6.2 Off-Road Equipment Programs

7.6.2.1 The Code addresses excess emissions from on-road HDVs only, but programs for reducing excess emissions from off-road heavy-duty engines could complement an on-road HDV emission I/M program. The Administration may wish to investigate the possibilities for off-road HDV emissions reduction programs for its jurisdiction.

7.6.3 Vehicle Scrappage and Parts Recycling Programs

7.6.3.1 The Administration may wish to consider including HDVs and heavy-duty engines in any local vehicle scrappage or parts recycling programs.

7.6.4 Maximum Idling Legislation

7.6.4.1 A number of municipalities in different provinces have enacted maximum idling legislation that limits the idling time for most on-road vehicles operating in urban areas. In order to further reduce excess emissions, the Administration may wish to consider maximum idling legislation for the area covered by the on-road HDV emission I/M program (see 1.5.4 regarding exemptions to this provision).

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Glossary of Terms

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 a heavy-duty vehicle emission inspection and maintenance program
aftermarket	parts from companies other than the original equipment manufacturer
AirCare	the heavy-duty vehicle emission inspection and maintenance program in British Columbia
all-wheel drive (AWD)	vehicle designed to operate only in four-wheel-drive mode
alternative fuel	a fuel other than gasoline or diesel
centralized I/M program	a program in which a small number of high-volume inspection and maintenance stations are dispersed throughout an area
centralized test-only I/M program	a program in which the only function of the centralized inspection and maintenance stations is the vehicle inspection or test
chassis-dynamometer	a set of driven rollers that simulate road operation
clean-piping	the practice of using the emissions test readings from a "clean" vehicle in place of those of a "dirty" vehicle
Code of Federal Regulations (CFR)	a codification of the rules published in the U.S. Federal Register by executive departments and agencies of the U.S. federal government
Commercial Vehicle Information Systems and Networks (CVISN)	a program for existing and new systems to exchange information
compliance enforcement	method of enforcement to ensure that designated vehicles meet emissions standards
constant volume sampling (CVS)	a system for measuring exhaust emissions as mass of contaminants
contractor(s)	the contractor(s) who run centralized test-only inspection and maintenance programs, roadside inspections, or inspection facilities
contractor-run	run under contract to a government agency
curb weight	the designated unloaded weight of a vehicle

cutpoints	chosen emission level at which a vehicle passes or fails a test or inspection
decentralized I/M program	a program in which local garages act as inspection and maintenance stations
decentralized test-and-repair I/M program	a program in which inspection and maintenance stations perform both inspections and repairs at the same location
decentralized test-only I/M program	a program in which the only function of the inspection and maintenance stations is the vehicle inspection or test
Drive Clean	the inspection and maintenance program in Ontario
dual-fuel vehicle	a vehicle that can operate on either of two fuels and has two separate fuel systems
dynamometer	see chassis-dynamometer or engine-dynamometer
dynamometer — steady-state	the dynamometer simulates loaded operation at set speeds
dynamometer — transient	the dynamometer simulates both loaded speeds and accelerations
engine-dynamometer	a device that is capable of simulating engine loading on an engine that is removed from a vehicle
evaporative emissions	emissions resulting from the evaporation of fuel
excess emissions	emissions greater than a heavy-duty engine's federal certification (FTP) standards
Federal Test Procedure (FTP)	procedures for testing heavy-duty engines to the federal emissions standards
fine particulate matter	all particulate matter less than 10 µm in diameter; includes both $PM_{2.5}$ and PM_{10} fractions
fuel conversion	changing an engine to use a fuel other than that originally certified by the manufacturer
government-run	inspection and maintenance program inspections performed by government employees
grams/mile or grams/kilometre	a mass measurement of contaminants
greenhouse gases (GHGs)	gases in the atmosphere that contribute to the "greenhouse effect"; GHGs inventoried by Environment Canada that are not covered by the Montreal Protocol include CO_2, CH_4, N_2O, sulphur hexafluoride, perfluorocarbons, and hydrofluorocarbons

Gross Vehicle Weight Rating (GVWR)	the maximum loaded weight of a vehicle
heavy-duty diesel vehicle (HDDV)	a heavy-duty vehicle that uses diesel fuel
heavy-duty gasoline vehicle (HDGV)	a heavy-duty vehicle that uses gasoline fuel
heavy-duty vehicle (HDV)	for Canadian federal emissions standards: on-road vehicles, both trucks and buses, with a GVWR >2721.6 kg (6000 lb.) to 1987 model year inclusive and >3855.6 kg (8500 lb.) for the 1988 model year and newer
hybrid I/M program	an inspection and maintenance program that combines one or more inspection and maintenance program types
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 inspection and maintenance program
inspection and maintenance (I/M) program	a program for the inspection and repair of in-use vehicles
in-use vehicle	vehicle that is licensed and operating on the road
J1667	SAE J1667 Recommended Practice — Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel-Powered Vehicles
light-duty vehicle (LDV)	for Canadian federal emissions standards: on-road vehicles with a GVWR <2721.6 kg (6000 lb.) to 1987 model year inclusive and <3855.6 kg (8500 lb.) for the 1988 model year and newer
loaded or loaded-mode test	emissions test with the vehicle or engine operated under load
lug-down or lugging (of an 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 led to excess emissions
mono-fuel or single-fuel vehicle	vehicle that operates on only one fuel
multiple-axle drive	a vehicle where more than one axle is driven by the engine
new vehicle	vehicle as produced by the manufacturer and before first sale

Northeast States for Coordinated Air Use Management (NESCAUM) Memorandum of Understanding (MOU)	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
OBD X	an on-board diagnostics system that can perform remote interrogations and requires no physical connection to the vehicle
off-road (also non-road)	all vehicles or engines other than those licensed to operate on roads and highways; includes rail and marine vehicles/engines, plus agricultural, construction, forestry, and lawn and garden equipment
on-board diagnostics — OBD (data link)	a computer-controlled vehicle information system to monitor selected parameters
on-board emissions test	an emissions test where the sampling equipment is installed on-board or towed by a moving vehicle
on-road	for the purposes of this Code, vehicles licensed to operate on roads and highways; vehicles licensed for road operation may vary with province
opacity	the percentage of light transmitted from a source that is prevented from reaching a light detector
overt audit	an audit in which inspectors or mechanics know the vehicle is an audit 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 (O_3)	a gas formed as a result of chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the lower atmosphere in the presence of sunlight
particulate matter	any aerosol that is released to the atmosphere in either solid or liquid form
pre-screening	in general, vehicles undergo a test that requires no contact with the vehicle; if they pass, no additional testing is required
probable cause	certain provinces may require roadside inspectors to demonstrate a verifiable reason for pulling over a vehicle for a roadside test
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
recall	the recall of a vehicle by the original equipment manufacturer to correct faults
remote sensing device (RSD)	a system for measuring exhaust emissions that does not require physical contact with the vehicle being tested
roadside inspection or test	inspections or emissions tests conducted on the side of a road or highway; test site may be a weigh station or other similar facility
smoke (diesel)	all particles, including fine and coarse particulate, black carbon, and aerosols, suspended in the exhaust stream of a diesel engine that absorb, reflect, or refract light; throughout the text of this Code, unless noted to the contrary, smoke refers to "black diesel smoke"
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
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 emissions control systems)
test-and-repair stations	inspection and maintenance stations that perform both inspections and repairs at the same location
test-only stations	inspection and maintenance stations that are permitted only to test or inspect vehicles
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
two-speed idle test	a stationary vehicle test that combines the idle plus a 2500 rpm (or higher speed) emissions test
unannounced audit	an audit in which inspectors or mechanics do not know the vehicle to be tested is an audit vehicle or auditors arrive unannounced
volatile organic compounds (VOCs)	photochemically reactive HC; therefore, excludes CH_4, ethane, and several chlorinated organics

Abbreviations and Acronyms

ABS	anti-lock braking system
ACORP	AirCare On-Road Program
AFR/AFC	air fuel ratio/air fuel controller
AWD	all-wheel drive
BAR	California Bureau of Automotive Repair
bhp	brake horsepower
CAA	*Clean Air Act* (USA)
CARB	California Air Resources Board
CARS	Canadian Automotive Repair and Service Council
CCME	Canadian Council of Ministers of the Environment
CEPA	*Canadian Environmental Protection Act*
CO	carbon monoxide
CO_2	carbon dioxide
CVISN	Commercial Vehicle Information Systems and Networks
CVS	constant volume sampling
dyno	dynamometer; may be either a chassis- or an engine-dynamometer
EPA	U.S. Environmental Protection Agency
FTP	Federal Test Procedure
g	gram(s)
GHG	greenhouse gas
GPS	global positioning system
GVWR	Gross Vehicle Weight Rating
HC	hydrocarbons
HDDV	heavy-duty diesel vehicle
HDGV	heavy-duty gasoline vehicle
HDV	heavy-duty vehicle
I/M	inspection and maintenance
J1667	SAE J1667 Recommended Practice
kg	kilogram(s)
lb.	pound(s)
LDV	light-duty vehicle
mi.	mile(s)
MIL	malfunction indicator light
MOU	Memorandum of Understanding
mph	miles per hour
NESCAUM	Northeast States for Coordinated Air Use Management
NO	nitric oxide
NOx	nitrogen oxides
NO_2	nitrogen dioxide
O_3	ozone
OBD	on-board diagnostics (data link)

OBD X	future remote interrogation style OBD systems
OEM	original equipment manufacturer
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 µm in diameter
PM_{10}	particulate matter less than 10 µm in diameter
QA	quality assurance
QC	quality control
rpm	revolutions per minute
RSD	remote sensing device
RV	recreational vehicle
SAE	Society of Automotive Engineers
SOx	sulphur oxides
VECI	Vehicle Emission Certification Information
VIN	Vehicle Identification Number
VOC	volatile organic compound
WHMIS	Workplace Hazardous Materials Information System

Appendix A National Working Group for On-Road Heavy-Duty Vehicle Emission Inspection and Maintenance Programs

Working Group Members

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Gary Strachan	Coast Mountain Bus Company Ltd.
Hélène Tanguay	Canadian Urban Transit Association
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Gerry Ternan	Environment Canada, Atlantic Region
Christine Timchek	Robert H. Wager Co., Inc.
Hu Wallis	British Columbia Ministry of Environment, Lands and Parks

Appendix B Summary of HDV Emission I/M Programs

B.1 Canadian HDV Emission I/M Programs

The details of the two HDV emission I/M programs currently operating in Canada are shown in Table B.1 (Hutchinson 2000). Quebec recently announced that it intends to begin an HDV emission I/M program in March 2003.

The details of the HDV emission I/M programs currently operating in the United States are shown in Table B.2. Table B.3 lists similar information for a number of states not included in Table B.2.

B.2 International HDV Emission I/M Programs

B.2.1 Hong Kong

Of HDV emission I/M programs outside of North America, the one in Hong Kong is worthy of mention. In September 2000, Hong Kong began a more comprehensive smoke test program for all vehicles during their annual inspection. Hong Kong has also completed the installation of a dynamometer in its Kowloon Bay vehicle examination centre for the smoke testing of approximately 10% of vehicles called into the centre. For HDVs from 5500 to 40 000 kg, inspectors perform a lug-down smoke test at a series of steady-state speeds on a dynamometer.

Also pertinent to the present exercise, the Hong Kong Commissioner of Transportation issued a Code of Practice for Designated Vehicle Emission Testing Centres in June 2000 (Hong Kong 2000).

B.2.2 Europe

Smoke testing using the ISO 3171 snap idle test is used in different variations in at least 14 countries, including Austria, the Czech Republic, Denmark, England, Finland, France, Germany, Greece, Ireland, The Netherlands, Poland, Slovakia, Spain, and Switzerland.

In Germany, testing is required annually for all vehicles over 3500 kg.

B.2.3 Singapore

An HDV emission I/M program is reported to be running in Singapore.

B.2.4 Taiwan

An HDV emission I/M program is reported to be running in Taiwan.

Table B.1 Summary of HDV Emission I/M Programs in Canada

Province	Program Status	Type & Test	Vehicles Selected & Cost	Smoke Test Cutpoints	2-Speed Idle Test Cutpoints	Vehicles Tested	Enforcement & Waivers
British Columbia	Program began operation on 1 May 1999 in B.C. Lower Mainland for HDDVs only	*Roadside*: Smoke test	Visibly smoking HDDVs No test fee	40% for 1991 and newer 55% for 1990 and older by **engine** model year		>5000 kg GVWR	Registration denial Notification to host jurisdiction out-of-province vehicles No repair cost waiver
Ontario	HDDV program began in fall 1999 HDDV program province-wide HDGV program began in fall 1999 and coincides with LDV program's geographic limits	*Roadside*: HDDV smoke test *Periodic*: HDDV smoke test by contractors at decentralized sites HDGV two-speed idle test at certified sites	*Roadside*: Random selection No test fee *Periodic*: Annual Fee is market rate Reinspection fee also market rate	40% for 1991 and newer 55% for 1990 and older by **vehicle** model year	Visible emissions: 5 seconds in any 1-minute period; HC, CO: see table below*	>4500 kg GVWR Latest three model years exempt	*Roadside*: Fines issued; no limit to number of fines per year *Periodic*: Registration denial Ownership transfer requires a pass
Quebec	To begin in March 2003 Province-wide	*Periodic*	*Periodic*				No repair cost waiver

* Ontario's Maximum Emission Standards for the Two-Speed Idle Test: Gasoline-Fuelled Heavy Vehicles

Model Year	HC (ppm) by volume	CO (%) by volume
1998 and later	200	1
1988–1997	220	1.2
1980–1987	300	3
1975–1979	400	4
1970–1974	800	6.5
1969 and earlier	1000	8

Table B.2 Summary of HDV Emission I/M Programs in the United States in 2001

State	Status, Enforcement, and Type	Weight (lb.)	Frequency, Every…	Roadside	Periodic and/or Mobile	J1667 Smoke Test	Smoke Test Cutpoints*	Other Smoke Test	Loaded Dyno Test	Loaded Test Cutpoints	Rolling or Other Test	HDGV Tested	2-Speed Idle Test Cutpoints
Arizona	- operating - registration denial - centralized	>8500	year	Pilot program to start March 2002 for >10 000 lb.	yes selected counties	yes (Maricopa county)	40, 55		yes (Pima county)	0–2000 ft - 20% 2000–4000 ft – 30% 4000+ ft - 40%		yes loaded dyno + idle	
California	- operating - decentral-ized - periodic self-testing for fleets	>6000	year for HDDVs 2 years for HDGVs	yes	yes for fleets of two or more - mobile contractors for fleets	yes	40, 55					every 2 years 2-speed idle	
Colorado	- operating - registration denial - decentral-ized	>7500	year	yes statewide	yes periodic in nine counties - self-certify for fleets of nine or more	no	35% naturally aspirated engines 20% for turbocharged engines	yes	yes		Acceleration + Lug-Down + Stall	2-speed idle	
Connecticut	- operating - sticker enforcement	>26 000	HDGVs - annual 68 to 80 and every 2 years for 81 and newer	yes	yes for non-diesel >8500 lb. and <10 000 lb.	yes	40, 55, 70					idle test for >8500 lb. and <10 000 lb.	
Illinois	- operating - decentral-ized - at contractor sites	gasoline >8500 diesel >16 000	2 years	yes	yes for non-diesel in non-attainment areas	yes	40, 55, 70 until 12/31/02					idle test plus fuel cap	
Maine	- operating	>18 000		yes		yes	40, 55, 70 until 2003						
Maryland	- operating	>10 000 all HDVs		yes	no	yes	40, 55, 70					gasoline 1977 to 1983 plus visual inspection	idle test

State	Status, Enforcement, and Type	Weight (lb.)	Frequency, Every…	Roadside	Periodic and/or Mobile	J1667 Smoke Test	Smoke Test Cutpoints*	Other Smoke Test	Loaded Dyno Test	Loaded Test Cutpoints	Rolling or Other Test	HDGV Tested	2-Speed Idle Test Cutpoints
Massachusetts	- operating - decentral-ized	>10 000 pre-1984 not tested	2 years		yes & mobile	yes	- trucks 40, 55 - buses 30% 1991 and newer 40% 1984 to 1990					2-speed idle	
Nevada	- operating	>8500		yes	no	yes	70% all HDDVs						
New Hampshire	- operating	>10 000		yes	no	yes	40, 55, 70						
New Jersey	- operating - decentral-ized - registration denial	>18 000	year	yes	yes - also commercial bus program	yes - for roadside only	40, 55, 70 - for diesel buses use 30% 1988 and newer 40% 1987 and older	no visible blue smoke >3 consecutive seconds			Rolling Acceleration + Stall for all HDDVs - visible black smoke test (screen)		
New York	- operating - decentral-ized	>8500	year combined with annual safety inspection in NY City Metro area	yes	yes	yes	40, 55, 70					no	
Ohio	- operating	up to 10 000 also urban bus program to start in 2002	2 years		yes	yes		yes	yes				
Rhode Island	- program to begin spring 2002 - at certified contractor stations		year	yes	yes	yes	40, 55 35 for buses						
Texas	- operating		year		yes for all HDGVs							yes	

State	Status, Enforcement, and Type	Weight (lb.)	Frequency, Every…	Roadside	Periodic and/or Mobile	J1667 Smoke Test	Smoke Test Cutpoints*	Other Smoke Test	Loaded Dyno Test	Loaded Test Cutpoints	Rolling or Other Test	HDGV Tested	2-Speed Idle Test Cutpoints
Utah	- operating - registration denial	>16 000	year - 1967 and older are exempt - newest three model years exempt		yes in three counties buses are fleet self-tested	yes	70% in two counties 80% in the third						
Vermont	- operating					yes	40, 55						
Virginia	- operating	<10 000	2 years		yes for HDGVs	yes						yes	
Washington	- operating - registration denial - centralized contractor run	>8500	2 years - year for government vehicles		yes in metro areas	yes	40, 60					idle test	
Wisconsin	- operating	<10 000	2 years		yes HDGVs only	no						IM240	

* 40 = 40% opacity for 1991 and newer; 55 = 55% opacity for 1990 and older; 70 = 70% opacity for 1973 and older.

Table B.3 Information on HDV Emission I/M Programs in Other States in the United States in 2001

State	Comments on HDV Emission I/M Programs
Delaware	diesels not tested
District of Columbia	1974 to 1993 gasoline up to 26 000 GVWR receive a BAR-90 idle test
Georgia	diesels not tested
Indiana	pilot program was run for HDVs, current I/M is to 9000 lb. only
Kentucky	has I/M but weight limits listed
Louisiana	gasoline vehicles only up to 10 000 lb.
Michigan	no I/M program
Missouri	HDVs not referenced

Appendix C Example Costs for Roadside HDV Test Teams

C.1 System Costs — Government-Operated Roadside Inspections

In general, since no fee is charged for a roadside test by a mobile team, the cost of inspections must be borne solely by the government administration. In a recently published report, the Government of British Columbia estimated the startup and annual administrative costs for its roadside inspections, the AirCare On-Road Program (ACORP), which comprises two roadside inspection teams. The estimated costs are shown in Tables C.1 and C.2 (Newhook and Gourley 2000).

C.2 Costs — Smoke Test Equipment for Reinspection Facilities in Roadside Program

In British Columbia, participation as a reinspection facility in the ACORP program is voluntary. The potential reinspection facility owners were told, prior to program implementation, that an investment of between $10,000 and $20,000 would be required for the opacity meter and associated equipment required to perform the SAE J1667 smoke emissions test (Newhook and Gourley 2000).

Table C.1 AirCare Roadside Test Program Startup Costs

	Startup Costs ($Canadian 2000)
Systems development	$30,000
Vehicles (two used vans)	$27,000
Opacity meters and accessories	$35,000
Vehicle modifications	
Racks, shelves, lighting, markings, etc.	$8,000
Inspection tools and equipment	$9,000
Safety inspection equipment	$1,500
PCs and telecommunications	$16,000
Project development staff costs	$183,000
Qualified inspection facilities consultation, certification	$2,500
Miscellaneous	$7,000
Total Startup Costs	**$319,000**

Table C.2 AirCare Roadside Test Program Annual Program Administrative Costs

	Administrative Costs ($Canadian 2000)
Salaries and benefits (five full-time staff)	$245,000
Vehicle fuel, maintenance, insurance, etc.	$13,000
General office supplies	$3,000
Communications	$24,000
Qualified inspection facilities maintenance	$7,500
Outreach to industry and public	$45,000
Program evaluation and reporting	$60,000
Miscellaneous	$4,500
Startup cost repayment (amortized over five years)	$64,000
Total Annual Costs	**$466,000**

Appendix D Repair Cost Estimates

While HDV repair costs will vary for each type of repair and by region across Canada, Table D.1 provides an example of some of the average repair costs recently reported for ACORP, the HDV emission I/M program in British Columbia, for 2000.

The data suggest quite clearly that adjustment of the air fuel ratio/air fuel controller (AFR/AFC) control on the injector pump is the most common type of repair, appearing in 35 of 58 cases. While the average cost of repairs is reported at $345, almost half of the repairs, 27 cases in all, were performed for less than $100. In a few other cases, crankcase flushes were performed as well as the AFC adjustment. This immediately increased the cost to more than $300.

Table D.1 AirCare HDV I/M Repair Cost Data (Newhook and Gourley 2000)

Type of Repair	Number of Instances Indicated	Typical Cost ($ Canadian 2000)
Adjust AFR/AFC	35	$31–$61
Adjust injector pump	6	$265–$500
Injector pump parts	6	$1,000
Adjust fuel delay	8	$150
Fuel delay parts	7	$650
Repair injectors	3	$62–$100
Injector parts	2	$75–$300
Adjust valves	3	$62–$124
Adjust rack	1	$124
Turbo/blower	1	$1,000
Cooling system	1	$50
Crankcase flush	9	$250
Cylinder head overhaul	1	$4,500
Engine overhaul	2	$11,000
Air filter	1	$97
Other	3	$50
Average Cost		**$821**
Average Cost (Excluding Major Overhauls)		**$345**

Appendix E References for Emissions Test Procedures and Equipment Specifications

In the event of a discrepancy between the documents referenced below and this Code, the recommendations in the Code take precedence over those documents.

E.1 Opacity Test Procedures

The smoke emissions opacity test procedures for use in Canadian I/M programs should follow those outlined in the SAE J1667 recommended practice:

SAE (1996), *J1667 Recommended Practice, Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel-Powered Vehicles*, Society of Automotive Engineers

Note: At the time of writing of this Code, the SAE J1667 specifications for the opacity meters and the correction factors were under review.

E.1.1 Opacity Calibration Standards

For the calibration of opacity monitors, calibration standards may be obtained from commercial suppliers. For information on these vendors, the Administration could contact Environment Canada's Emissions Research and Measurement Division.

The Emissions Research and Measurement Division is also a source of information in regard to the accreditation of opacity monitors and for information regarding the calibration of those monitors.

E.1.2 Opacity Meter Test Specifications

Environment Canada's Emissions Research and Measurement Division has provided a testing service for the verification of opacity meters versus the SAE J1667 specifications. For information on this service, contact the Emissions Research and Measurement Division, Environment Canada, Ottawa, Ontario.

E.2 Two-Speed Idle Emissions Test Procedures

Where a two-speed idle emissions test is to be used, the procedures and cutpoints employed in the Ontario HDV emission I/M program are recommended. The two-speed idle test procedures are available from the Ontario Ministry of the Environment in the Drive Clean Guide and Regulation 361/98 from the U.S. EPA. Both are available as downloads at www.driveclean.com.

An alternative reference would be the California Bureau of Automotive Repair (BAR) test procedures. These procedures are presented in:

California Bureau of Automotive Repair (1996), *BAR-97 Emissions Inspection System Specifications*, May 1996, revised November 1996.

E.3 Steady-State and Lug-Down Loaded-Mode Chassis-Dynamometer Emissions Test

Where a steady-state, lug-down, or other non-transient loaded-mode chassis-dynamometer emissions test is included in the HDV emission I/M program, the procedures developed by the state of Colorado could be adopted. Colorado is continuing a research study on heavy-duty diesel emissions and inspection protocol options with the intent of improving the performance of the state's existing strategies.

Contact: Colorado Department of Public Health and Environment

Calibration requirements are likely to be similar to those listed for the LDV Code of Practice (CCME 1998).

For a smoke opacity lug-down test on a chassis-dynamometer, the procedures for testing in the lug-down mode on an engine-dynamometer are outlined in the *Motor Vehicle Safety Act*, Section 12, Test Procedures for Opacity of Smoke in Exhaust Emissions.

For mass emissions measurements, the sampling and measurement equipment is likely to be similar to that required by LDVs (CCME 1998):

- a constant volume sampler (CVS) complete with sample lines and probes;
- a flame ionization detector analyzer for HC;
- two non-dispersive infrared analyzers for CO and CO_2; and
- a chemiluminescence analyzer for NOx.

A particulate tunnel will be required for the mass emission measurement of PM. Calibration requirements are similar to those listed for the LDV Code of Practice (CCME 1998).

Environment Canada's Emissions Research and Measurement Division is a source of information in regard to the mass emissions measurement requirements for HDVs.

E.4 Transient Loaded-Mode Emissions Tests

At the time of preparation of this version of the Code, no HDV emission I/M program in North America was testing vehicles using a transient loaded-mode chassis-dynamometer emissions test. Therefore, there were no standard test procedures available for transient loaded-mode chassis-dynamometer emissions tests.

For mass emissions measurements, the sampling and measurement equipment is likely to be similar to that required for LDVs (CCME 1998):

- a CVS complete with sample lines and probes;
- a flame ionization detector analyzer for HC;
- two non-dispersive infrared analyzers for CO and CO_2; and
- a chemiluminescence analyzer for NOx.

A particulate tunnel will be required for the mass emissions measurement of PM. Calibration requirements are likely to be similar to those listed in the LDV Code of Practice (CCME 1998).

Environment Canada's Emissions Research and Measurement Division is a source of information in regard to the mass emissions measurement requirements for HDVs.

E.5 OBD (Data Link) Interrogation Equipment and Procedures

The on-board diagnostics (OBD) interrogation equipment for an LDV I/M lane and the procedures for performing an interrogation on vehicles equipped with EPA-specified OBD II, or more advanced systems, are outlined in:

> EPA (1996), *I/M Program Requirement — On-Board Diagnostic Checks, Final Rule*, 40 CFR Parts 51 & 85, 6 August.

The EPA has recently released a draft guidance document for OBD interrogations for I/M programs:

> EPA (2000c), *Performing Onboard Diagnostic System Checks as Part of a Vehicle Inspection and Maintenance Program: Draft Guidance*, Office of Air and Radiation, U.S. Environmental Protection Agency, EPA 420-P-00-006, December.

The California OBD II interrogation equipment for an I/M lane and the procedures for performing an interrogation on vehicles are outlined in:

> California Bureau of Automotive Repair, *BAR-97 Emissions Inspection System Specifications*, May 1996, revised November 1996, plus Specifications, Addendum 3, 24 April 1997.

Specifications for remote OBD interrogation, OBD X, hardware and software have yet to be developed and standardized in North America.

E.6 EPA Method 9 and Method 22

The information on qualifications for observers in regard to visible smoke emissions following EPA Method 9 and the "smoke or no smoke" observer qualification, EPA Method 22, can be obtained from the B.C. AirCare offices. Information in regard to Method 9 and Method 22 can also be obtained from the EPA website: www.epa.gov/ttn/emc/promgate.html

E.6.1 EPA Method 9 (Parkinson 2001)

Features of Method 9 for visual smoke opacity assessment:

- Used to visually assess smoke plumes
- Accurate to within ±7.5% on average
- Legally defensible method of smoke plume opacity estimation
- Could be used for enforcement or as basis for reasonable and probable grounds to pull over vehicles

Training:

- Certified smoke machine used
- 25 samples of black smoke and 25 samples of white smoke
- Estimations made to the nearest 5%
- Cannot exceed 15% error on any one sample
- Cannot average more than 7.5% error
- Sun must be in 140° arc behind observer
- Must record wind speed and direction
- Must observe smoke perpendicular to smoke plume
- Must record background colour behind plume and sky conditions

Observations:

- Observers should not look continuously at the plume but should observe the plume briefly at 15-second intervals
- Observers should rest eyes between observations to avoid eye strain and fatigue
- Contrasting background colour aids in accurate opacity estimation

E.6.2 EPA Method 22 (Parkinson 2001)

This is an alternative to EPA Method 9. It is used for determining the presence of visible smoke or no smoke and not opacity. At present, it is being used in New York State to provide a reasonable and probable cause to pull vehicle over.

No certification is needed, only training on effects of ambient conditions. Observers must be trained and knowledgeable in the effects on visibility of emissions caused by:

- background contrast;
- ambient light;
- observer position relative to the ambient light;
- wind; and
- the presence of water vapour.

Appendix F Canadian Federal Heavy-Duty Engine Exhaust Emissions Standards

Table F.1 lists the current Canadian standards for new heavy-duty engines at the time of publication of the Code. The standards for 2004 to 2007 that were enacted in the United States for heavy-duty diesel engines have also been included. It is the intent for Canada to align with those standards.

Table F.1 Canadian Federal Heavy-Duty Engine Exhaust Emissions Standards

Notes	Model Year	Fuel	GVWR (lb.)	(g/bhp-hr)*			
				HC	CO	NOx	PM
1	71 to 74	gasoline	>6000	N/A	N/A		N/A
2, 3	75 to 88	gasoline, diesel	>6000	CO = 40.0; HC + NOx = 16.0			N/A
4, 5	89 to 90	gasoline	>8500, <14 000	1.1	14.4	6.0	
4, 5	89 to 90	gasoline	>14 000	1.9	37.1	6.0	
4, 5	89 to 90	diesel	>8500	1.3	15.5	6.0	0.60
6	91 to 93	diesel	>8500	1.3	15.5	5.0	0.25
6	91 to 92	diesel urban bus	>33 000	1.3	15.5	5.0	0.25
6	93	diesel urban bus	>33 000	1.3	15.5	5.0	0.10
7	94 to 97	diesel	>8500	1.3	15.5	5.0	0.10
7	94 to 95	diesel urban bus	>33 000	1.3	15.5	5.0	0.07
	96 to 98	diesel urban bus	>33 000	1.3	15.5	5.0	0.05
8, 9	98 to 03	diesel	>8500	1.3	15.5	4.0	0.10
8, 9	98 to 03	diesel urban bus	>33 000	1.3	15.5	4.0	0.05
6, 7	91 to 97	gasoline	>8500, <14 000	1.1	14.4	5.0	N/A
6, 7	91 to 97	gasoline	>14 000	1.9	37.1	5.0	N/A
8, 9	98 to 04	gasoline	>8500, <14 000	1.1	14.4	4.0	N/A
8, 9	98 to 04	gasoline	>14 000	1.9	37.1	4.0	N/A
10, 11, 3	04 to 06	diesel	>8500	N/A	15.5	NMHC+NOx 2.4	0.10
9,3	05 to 08	gasoline	>8500, <14 000	N/A	14.4	NMHC+NOx 1.0	N/A
9,3	05 to 08	gasoline	>14 000	N/A	37.1	NMHC+NOx 1.0	N/A
	08	gasoline	>8500	NMHC 0.14	14.4	0.20	0.01
12	07	diesel	>8500	NMHC 0.14	15.5	0.20	0.01
			GVWR (lb.)	Evaporative Emissions			
	89>	gasoline	<14 000	3.0 g/test			
	89>	gasoline	>14 000	4.0 g/test			
			GVWR (lb.)	Smoke Opacity			
	75>	diesel	>8500	Shall not exceed	a) 20% during the engine acceleration mode b) 15% during the engine lugging mode c) 50% during the peak of the engine acceleration and the engine lugging mode		

A blank indicates there is, or was, no standard set for that category.
N/A = Not applicable
* Emission standards apply to the engines used in heavy-duty vehicles.

Notes:
1 9-mode test procedure.
2 13-mode test procedure for diesel, 9-mode for gasoline.
3 Combined HC + NOx standard.
4 Standards effective on engines built from December 1, 1988.
5 Transient engine test procedure.
6 Voluntary industry initiatives.
7 1995 to 1997 standards under memorandum of understanding (equivalent to 1994 U.S. federal standards).
8 Transport Canada regulations, *Canada Gazette* Part II, 20 August 1997.
9 Note that new Canadian standards have not been promulgated beyond the 1998 limits, but are designed to remain harmonized with U.S. standards until replaced by new regulations under CEPA.
10 Manufacturers have the option of increasing the combined NOx + NMHC standard to 2.5 g/bhp-hr if the NMHC ≤0.5 g/bhp-h. Canada has indicated that it intends to develop new regulations under CEPA to align with these requirements.
11 The EPA has recently added a new class of medium-duty passenger vehicle in the 8500 to 10 000 lb. GVWR range for EPA Tier 2 and therefore will fall under LDV standards.
12 EPA, Office of Air and Radiation, EPA 420-F-00-057, December 2000.

Appendix G Detailed Vehicle Test Data

Items for the vehicle test data record could include:

- test record number;
- inspector/repair technician name and I/M identification number;
- date of inspection and/or reinspection;
- ambient temperature, pressure, and humidity;
- test location (GPS information);
- inspection unit or facility I/M identification number;
- test certificate number (on form presented to the operator following a test);
- licence plate and/or registration number;
- Vehicle Identification Number (VIN);
- registration information;
- type of HDV and wheel arrangement;
- engine serial number, engine family, engine model year, and manufacturer;
- vehicle or chassis model year and make;
- the engine or chassis model year used to establish test cutpoints;
- engine rebuild and date;
- transmission type;
- bar code reading (if available);
- GVWR;
- emissions recalls outstanding;
- number of cylinders, horsepower, or displacement;
- odometer reading;
- fuel type;
- test sequence;
- emission scores and cutpoints;
- visual inspection results;
- post-repair emissions test data;
- repair data for failed vehicles;
- province(s) or country where HDV is registered;
- OBD (data link) interrogation results;
- initial or repeat test;
- vehicle preconditioning employed;
- fuel used for test (if applicable);
- multiple-axle, all-wheel drive, traction control, or other system;
- alternative fuel conversion manufacturer;
- any alternative fuel conversion exemptions;
- type of retrofit equipment;
- revolutions per minute (rpm); and
- engine temperature readings.

Special provisions will be required for roadside inspection programs. Not all of the information listed above may be required as part of the roadside data-gathering exercise.

Appendix H Elements of a Generic HDV Emissions Repair Technician Training Program

The possible elements for inclusion in an HDV Emissions Repair Technician Training Program are presented below (Ramik 2001).

H.1 Instructor Qualifications

One program feature should be a mandatory instructor certification program that:

- requires the mandatory pre-testing, training, post-testing, and certification of trainers;
- is offered to qualified public and private sector trainers; and
- must demonstrate the practical application of the material — not just the theoretical.

H.2 General HDV Repair Technician Training Requirements

A – Diagnose Diesel Emission Problems

- Perform visual inspection
- Determine nature of problem
- Troubleshoot mechanical system
- Troubleshoot fuel control system
- Troubleshoot electrical systems
- Troubleshoot electronic systems
- Comply with standards
- Determine course of action

B – Perform Repairs and Maintenance on Emission-Related Systems

- Comply with standards, specifications, and regulations
- Service mechanical systems
- Service electrical systems
- Service electronic systems
- Service fuel control systems
- Verify repair

C – Use Diagnostic Equipment and Tools

- Use up-to-date technical information
- Use a smoke opacity meter
- Use a gas analyzer
- Use electronic engine analyzer
- Use measurement tools
- Use dynamometer

D – Interact with Customers

- Obtain information from customers
- Explain nature of problem
- Explain operator/owner's obligation
- Explain cause of failure
- Explain diagnostic procedures
- Recommend course of action
- Provide details of repair
- Review repair with customer

E – Perform Administrative Duties

- Provide service reports
- Maintain accurate records
- Provide feedback to regulatory body

F – Demonstrate Personal Competencies

- Practise safety procedures
- Demonstrate professionalism
- Demonstrate communication skills
- Be a team player
- Demonstrate problem-solving skills
- Stay abreast of technology
- Demonstrate basic computer skills
- Demonstrate computer literacy