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The State of Heavy-Duty Vehicle Emission Inspection and Maintenance in Canada and the United States

Final Report

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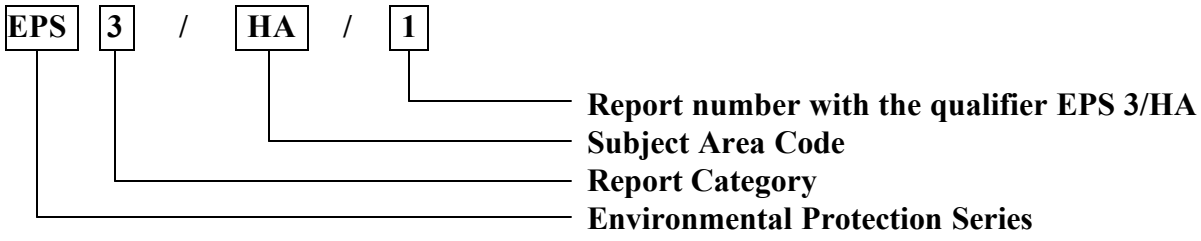

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The State of Heavy-Duty Vehicle Emission Inspection and Maintenance in Canada and the United States

Final Report

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GLOSSARY OF TERMS

AirCare®	British Columbia's vehicle inspection and maintenance program
CARB	California Air Resources Board
Cutpoint	The level of vehicle exhaust at which the vehicle fails an emission inspection. In the case of a diesel vehicle the cutpoint is expressed in terms of the opacity of the exhaust as it exits the tail pipe or exhaust stack. In a light-duty vehicle, it is expressed in terms of the amount of CO, HC, or NO_x in the exhaust stream. Cutpoints are determined by technical staff and vary according to vehicle age.
DriveClean®	Ontario's vehicle inspection and maintenance program
EPA	United States Environmental Protection Agency
CO_2	Carbon dioxide
CO	Carbon monoxide
HC	Hydrocarbons; often used interchangeably with VOC
HDD	Heavy-duty diesel
HDDV	Heavy-duty diesel vehicle
HDGV	Heavy-duty gasoline vehicle
I/M	Inspection and maintenance
LDDV	Light-duty diesel vehicle
LDV	Light-duty vehicle
MOU	Memorandum of understanding
NO_x	Nitrogen oxides
Opacity	The percentage of light emitted from a source that is prevented from reaching a light detector
Ozone	A gas formed as a result of chemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the lower atmosphere in the presence of sunlight and heat. Ozone also occurs naturally at high altitudes, where it shields the earth from excessive ultraviolet radiation.
PAH	Polynuclear aromatic hydrocarbons
PM	Particulate matter
PM_{10}	Particulate matter with particles less than or equal to 10 microns (µm) in diameter
$PM_{2.5}$	Particulate matter with particles less than or equal to 2.5 microns (µm) in diameter
SAE	Society of Automotive Engineers
Smoke	Particles, including aerosols, suspended in the exhaust stream of a diesel engine that absorb, reflect, or refract light
SO_x	Sulphur oxides
VOC	Volatile organic compound; often used interchangeably with HC

EXECUTIVE SUMMARY

Legislation governing the emissions from *new* diesel engines was first introduced in the United States in 1974. Allowable emissions from new engines have become increasingly restrictive since then. Canadian legislation governing new diesel engines mirrors that of the United States, in recognition of the highly integrated nature of the North American engine market.

In-use emissions from motor vehicles are a provincial and state responsibility. Some states and provinces have met this responsibility through the implementation of vehicle inspection and maintenance, or I/M, programs. These programs were introduced in recognition of, and to deal with, air quality problems and associated human health impacts that are a direct result of exhaust emissions from motor vehicles. Light-duty gasoline vehicles were the initial focus of these programs. More recently, heavy-duty diesel vehicles have become subject to emissions testing also. In Canada, British Columbia and Ontario have heavy-duty vehicle, as well as light-duty vehicle, I/M programs in force.

Although diesel engines are a major source of nitrogen oxide (NO_x) emissions, this report focuses on particulate matter (PM) from heavy-duty diesel vehicles (HDDVs). This is because:

- the technology to test HDDVs quickly and economically for NO_x, hydrocarbons (HC) and carbon monoxide (CO) does not yet exist; and
- the technology exists to quickly and economically measure the amount of smoke being emitted by HDDVs under controlled, repeatable conditions.

Particulate matter, and particularly matter with particles of 2.5 microns or smaller ($PM_{2.5}$), has been shown to be linked to such health effects as:

- asthma attacks;
- coughing and difficulty in breathing;
- chronic bronchitis;
- decreased lung capacity;
- lowered resistance to infection; and
- premature death.

PM has also been linked to the frequency of hospital visits and admissions and to absences from work and school.

Concerns over the health effects of PM have led the State of California to declare diesel exhaust to be a toxic air contaminant. Some components of diesel PM are known to be carcinogenic, though the relationship between diesel PM and human health is still poorly understood.

Most HDDV I/M programs in North America feature a roadside-administered test of the opacity of the visible emissions (i.e., of the smoke) from the exhaust stack. This test is usually administered only on those vehicles showing visible signs of excessive smoke. Some jurisdictions also, or instead, have programs requiring the periodic (often annual) inspection of all HDDVs registered there.

The test method of choice throughout North America is known as the *Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel Vehicles* (often referred to as SAE J1667 and discussed in more detail in this report), though other methods are used in some jurisdictions in the United States. Similarly, there is widespread agreement among jurisdictions on the choice of pass/fail criteria, or cutpoints. Cutpoints of 40% for HDDVs of model year 1991 or later, and of 55% for vehicles of model year 1990 or earlier, are the most common by far. Penalties for infractions vary widely in North America.

This report describes the HDDV I/M programs currently in force in North America and discusses issues related to quality control, costs, personnel training, and program implementation.

Although some jurisdictions are claiming that these programs are extremely cost-effective compared with other methods of controlling emissions of criteria pollutants, it is important to keep in mind that the objective of an HDDV I/M program is the reduction of visible smoke. Reductions of other criteria pollutants, such as NO_x, HC, and CO attributed to HDDV I/M are estimates only, based on computer modelling, not on observed measurement.

When implementing an I/M program, it is important to conduct a voluntary pilot phase prior to introducing the fully enforced program. It is also important to try to ensure that the program features are consistent with those of other jurisdictions and that there is reciprocity among programs. These are major considerations because of the nature of the heavy-duty vehicle business, which involves many vehicles travelling inter-jurisdictionally on a regular basis. Significant differences in I/M program features among jurisdictions can impose unnecessary burdens on the heavy vehicle industry.

1. VEHICLE INSPECTION AND MAINTENANCE: BACKGROUND AND NEED

1.1 Background

Vehicle emission inspection and maintenance (I/M) programs originated in the United States in response to the recognition there that vehicle emissions are a major source of the pollutants that cause smog, and that smog is a health hazard. The Clean Air Act Amendments of 1990 required the United States Environmental Protection Agency (EPA) to develop performance standards for I/M programs aimed at light-duty vehicles; that is, cars, pickup trucks, and vans. Program implementation and ongoing management are the responsibility of the states.

Most states that have areas within their borders that are not in compliance with the National Ambient Air Quality Standards (NAAQS) have light-duty vehicle I/M programs as part of comprehensive multi-sectoral plans. The purpose of these State Implementation Plans, or SIPs, is to reduce emissions of criteria pollutants with the objective of meeting the NAAQS. Failure of a state to meet the NAAQS can result in the federal government withholding transfer payments to the non-compliant state.

Although some heavy-duty vehicles, including both trucks and buses, are gasoline-powered, most are powered by diesel engines. The focus of this report is on heavy-duty diesel vehicle (HDDV) engines.

1.2 Need

Motor vehicles are a major source of the pollutants that contribute to the formation of smog and other environmental and health problems. These pollutants are:

NO_x	nitrogen oxides
VOCs	volatile organic compounds (also referred to as hydrocarbons, or HC)
PM_{10}	particulate matter of 10 microns in diameter and smaller
CO	carbon monoxide
SO_x	sulphur oxides
CO_2	carbon dioxide

1.2.1 Ozone Formation

NO_x and VOCs are important because they react, in the presence of light and heat, to form ozone, which is a primary constituent of smog. Smog is a mixture of gaseous, solid, and liquid pollutants that are harmful to human health, plant life, and building materials. Ozone, a gas that occurs naturally in the upper atmosphere and serves there to shield the earth from ultraviolet radiation, at ground level causes inflammation of the lungs and reduces lung function and resistance to infection. There is no safe level of ozone below which health effects do not occur. People with heart and lung problems are particularly vulnerable to the harmful health effects of ozone.

Light-duty vehicle I/M programs have as their objective the reduction of smog formation through the identification and repair of high emitters of ozone precursors. Other objectives are reductions in CO emissions and improvements in fuel economy.

1.2.2 Particulate Matter Formation

The term particulate matter, or PM, refers to a mixture in the air of solid particles and liquid droplets. Coarse particles (those larger than 2.5 microns in diameter) come from a wide variety of sources, such as windblown dust, construction activity, and grinding operations. Fine particles (those less than or equal to 2.5 microns in diameter) often come from the combustion of fuel, including from sources such as power plants, industry, and motor vehicles, particularly

diesel trucks and buses. See Table 1 for a comparison of the sources of particulate matter and other criteria pollutants in Canada. The data are for 1995, the latest year for which they are available.

PM_{10} refers to particulate matter that is 10 microns in diameter or smaller. (Thus it includes fine particles.) The origins of coarse PM_{10} (PM that is between 10 and 2.5 microns in diameter) include road dust and dust from agricultural activity. The origins of fine PM_{10}, or $PM_{2.5}$ (2.5 microns or smaller) include fuel combustion in entities such as motor vehicles, power plants, factories, wood-burning stoves and fireplaces. $PM_{2.5}$ can also be formed in the atmosphere, *after* the initial combustion of fuel, from SO_x, NO_x, and VOCs.

1.2.3 Health Effects

Although gasoline-powered vehicles are a source of PM_{10}, most PM_{10} from motor vehicles comes from diesel engines, and the vast majority of this is in the form of $PM_{2.5}$. (Diesel-powered vehicles are also a major source of NO_x but not of CO or VOCs.)

Particulate matter varies widely in its origins, size, and chemical and physical composition. Larger particles pose little health risk because they are heavy enough to fall quickly to earth, which reduces their chances of being inhaled. Coarse particles, ranging in size from 2.5 microns to 10 microns, are large enough that most are expelled from the body before they have an opportunity to penetrate deeply into the lungs.

However, fine particles, 2.5 microns and smaller ($PM_{2.5}$), do pose a threat to human health. $PM_{2.5}$ can make existing health problems worse among susceptible people, such as the elderly and those with cardiopulmonary disease. In addition, $PM_{2.5}$ can induce lung problems in people with no previous history of lung disease. Because of their small size, they can remain suspended in air for long periods of time, increasing their chances of being inhaled, and be transported by wind, potentially great distances. They can penetrate deeply into the lungs, where they can remain to cause breathing difficulties and sometimes permanent damage or disease.

Particulate matter originating from diesel fuel combustion presents particular health risks. PM2.5 from diesel engines is typically smaller than 0.1 micron. Particles this size are known as ultra-fine particles, or nano-particles, and are able to penetrate deep within the lung, right to the alveoli. Ultra-fine particles from diesel engines are composed of a number of substances, some of which are known to be a threat to human health and in some cases are suspected carcinogens.

Diesel PM consists of carbon particles that may adhere to one another and/or adsorb other contaminants onto their surfaces. Diesel PM is also composed of acidic particles formed from sulphuric acid in the exhaust stream.

Polynuclear aromatic hydrocarbons (PAHs) are one of the contaminants that adhere to the surface of the carbon particles. Some PAHs are known human carcinogens.

Particulate matter, and particularly fine particles (e.g., $PM_{2.5}$), has been shown to be linked to such health effects as:[1]

- asthma attacks;
- coughing and difficulty in breathing;
- chronic bronchitis;
- decreased lung capacity;
- lowered resistance to infection; and
- premature death.

[1] United States Environmental Protection Agency, Office of Air and Radiation, *Fact Sheet*, July 17, 1997.

Table 1 Criteria Air Contaminants Emissions for Canada (tonnes), 1995

Sector	PM_{10} [f]	$PM_{2,5}$	SO_x	NO_x	VOC (HC)	CO
Industrial Sources [a]	287,258	171,849	1,949,617	620,351	940,821	2,177,266
Non-industrial Fuel Combustion [b]	179,141	156,881	566,445	333,210	407,112	1,078,662
Transportation						
Air	1,115	787	2,263	34,026	11,636	61,758
HDDV	32,075	29,498	32,807	378,300	48,540	224,438
HDGV	528	414	588	15073	11,814	164,787
LDD Trucks	1,304	1,203	1,535	5,567	2,600	4,626
LDD Cars	379	347	632	1,978	747	1,667
LDG Trucks	2,509	1,986	4,399	112,437	142,425	1,461,808
LDG Cars	4,717	3,256	11,048	273,396	355,873	3,558,667
Marine	8,129	7,379	58,000	118,578	37,449	103,310
Motor Cycles	16	11	34	630	2,027	10,873
Off-road Diesel	17,087	15,714	16,149	209,231	22,581	66,365
Off-road Gasoline	3,867	3,393	1,005	25,395	93,111	1,027,393
Rail	19,492	17,933	7,226	115,604	5,608	22,022
Tire Wear & Break Lining	4 ,313	1,353				
Total Transportation	95,524	83,276	135,686	1,290,214	734,412	6,707,715
Incineration [c]	1,476	1,149	1,253	2,550	6,255	46,656
Miscellaneous [d]	14,368	9,232	2	1,068	549,731	14,239
Open Sources [e]	4,792,926	1,096,763	569	216,578	936,871	7,103,338

Source: Environment Canada.

[a] Includes cement, chemicals, petroleum refining, coal mining, pulp & paper, wood industry, mining, quarrying, iron & steel, petrochemicals

[b] Includes electric power generation, residential fuel combustion, including wood

[c] Includes municipal incineration and wood waste

[d] Includes cigarette smoking, meat cooking, pesticides and fertilizer application

[e] Include tilling and wind erosion, construction activities, dust from paved and unpaved roads, forest fires, mine tailings

[f] Includes $PM_{2.5}$

HDDV Heavy-duty diesel vehicle
HDGV Heavy-duty gasoline vehicle
LDD Light-duty diesel
LDG Light-duty gasoline

It has also been linked to the frequency of hospital visits and admissions and to absences from work and school.

Recent research on diesel exhaust and the role it plays in human health suggests that ultra-fine particles, considerably smaller than $PM_{2.5}$, pose a potentially significant health risk, though the magnitude of the risk is not well understood.

Concerns over the health effects of particulate matter have led the State of California to declare diesel exhaust to be a toxic air contaminant (an air pollutant that may cause or contribute to an

increase in mortality and serious illness, or which may pose a present or potential hazard to human health).[2]

Research is ongoing to determine more precisely the relationship between diesel PM and human health.

1.2.4 Diesel Smoke

Diesel smoke consists of "particles, including aerosols, suspended in the exhaust stream of a diesel engine which absorb, reflect, or refract light."[3] Although the particles are too small to be seen individually, collectively they can be visible as black smoke.

Diesel-powered vehicles that produce excessive visible smoke are perceived by most people to be major sources of air pollution. However, diesel particulate matter is only a relatively minor source of total PM, although it is the greatest source of PM within the transportation sector. See Table 1 for a condensed inventory of criteria pollutants, including PM, and their sources in Canada.

As a result of the threat posed by excessive visible smoke from heavy-duty diesels, public opinion in many jurisdictions has led to the implementation of HDDV emission inspection programs. The programs are intended to address not only the public's concern about the health effects of visible smoke, but also the perceived inequity of subjecting light-duty vehicle owners to I/M without also subjecting heavy-duty vehicle owners to similar requirements.

Black smoke is often an indicator that a diesel engine is in need of repair. Unlike the light-duty I/M programs, which test for NO_x, HC, and CO, HDDVs are tested to determine only whether they are emitting excessive amounts of visible smoke; i.e., the targets of the HDDV I/M programs are the gross emitters of visible smoke. These tests are conducted under controlled conditions and use standardized procedures, at the roadside or at an off-road facility, depending on the nature of the program and the test method being used. As with light-duty I/M programs, if an HDDV is found to be producing excessive emissions (in this case, smoke), the HDDV I/M program requires that the defect causing the emissions be repaired, or penalties imposed, or both. Test procedures and standards are discussed below in Section 5.

Excessive smoke can result from:

- restricted or clogged air filters;
- improper or maladjusted injection timing;
- clogged, worn, or mismatched injectors;
- a faulty fuel injection pump;
- a defective or maladjusted puff limiter;
- low air box pressure;
- air manifold leaks;
- a malfunctioning turbocharger;
- a malfunctioning aftercooler;
- a defective air/fuel controller;
- poor fuel quality; or
- a maladjusted governor.

Some of these defects result in too-rich air/fuel mixtures, which in turn result in excessive incomplete combustion.

Excessive smoke can also result from deliberate tampering. Common targets for tampering are:

- smoke puff limiters;
- fuel pump calibration;
- fuel injection timing; and
- excessive fuel flow rate.

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[2] California Environmental Protection Agency, Executive Summary for the "Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant," May 1997, quoted in Sierra Research, Inc., *Review of Air Quality and Motor Vehicle Technology Issues Pertaining to the Design of AirCare II*, July 1998.

[3] Society of Automotive Engineers, *Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel Vehicles*, February 1996.

Tampering is undertaken in an effort to obtain more power from the engine. Whether excessive smoke is a result of tampering or poor maintenance practices, excessive smoke can result in higher operating costs, reduced fuel economy, higher maintenance costs, and shorter engine life.

Excessive smoke can also be a result of poor driving practices. Excessive acceleration, lugging, and full throttle on inclines are common examples.

2. EMISSIONS FROM HEAVY-DUTY ON-ROAD VEHICLES

2.1 In-Use

Properly maintained heavy-duty diesel engines last a long time. Life spans of 15 to 20 years, with several engine rebuilds during that period, are typical, and are one of the features of diesels that make them desirable, along with economy of operation and superior power-to-weight ratio.

Data do not exist that provide the emission levels for HDDVs of a specific age or manufacture that are already in service. However, there are data that estimate the emissions of criteria pollutants by engines in certain broad age categories, by industrial sector and, within the transportation sector, by vehicle size and fuel, including heavy-duty diesel (HDD). Table 2 provides information on diesel engine emissions according to groupings by model year. The data are projected emissions that are expected in the years 2000, 2005, and 2010, from engines in model year groupings that are expected to comprise the fleet in those calendar years.

Diesel engines emit relatively large quantities of NO_x and PM_{10}, but relatively low quantities of HC and CO. They also offer superior fuel economy and, as a consequence, emit lower levels of CO_2, the principal greenhouse gas, per kilometre than other fuels *at the tailpipe*.[4]

Table 2 Relative Contribution of Different HDD Model Year Groupings to Total Year Emissions

Calendar Year	Model Year	PM (%)	NO_x (%)	HC (VOC) (%)	CO (%)
2000	1998–2003	7.6	12.8	19.6	18.0
	1994–1997	12.3	26.4	32.3	31.9
	1991–1993	11.8	10.3	12.7	13.4
	1985–1990	45.4	34.9	23.5	26.0
	pre-1985	22.9	15.7	11.9	10.7
2005	2004+	6.9	4.6	10.7	9.4
	1998–2003	31.1	42.0	48.2	46.1
	1994–1997	12.4	21.1	19.3	20.4
	1991–1993	19.4	12.9	11.9	13.0
	1985–1990	25.4	15.1	7.6	8.6
	pre-1985	4.9	4.3	2.3	2.4
2010	2004+	48.7	35.0	55.1	51.6
	1998–2003	24.6	35.9	28.3	29.7
	1994–1997	8.5	16.3	10.3	11.4
	1991–1993	8.8	6.2	3.9	4.5
	1985–1990	9.4	6.6	2.3	2.7

Source: Sierra Research, Inc., *Review of Air Quality and Motor Vehicle Technology Issues Pertaining to the Design of AirCare II*, July 1998.

[4] Full fuel cycle emissions of CO_2 are another matter. Other fuels may have better or worse greenhouse performance characteristics, depending on their origins, carbon content, and the nature of the vehicle drive train.

2.2 Legislation

Legislation governing emissions from *new* diesel engines was first introduced in the United States in 1974, and has become progressively more restrictive, in terms of the levels of pollutant emissions that are allowed from new HDDVs. The fact that Canadian legislation mirrors that in the United States is recognition that the vehicle and engine market in North America is so highly integrated that it would be undesirable to have different standards in Canada. One consequence of different standards would be higher vehicle and engine costs.

Table 3 traces the evolution of HDDV standards in the United States.

Legislation affecting the *in-use* emissions of motor vehicles is a state and provincial responsibility. Thus I/M programs in North America are designed and implemented by state and provincial governments.

In the United States, the role of the EPA has been to provide guidelines and "guidances" for the implementation of I/M programs. In the case of HDDV I/M programs, the EPA has issued two guidance documents, one recommending a diesel smoke testing method, the other recommending smoke opacity cutpoints. These guidance documents appear in Appendix 1.

Table 3 U.S. Federal Emissions Standards for 1974 to 2004 for HDDVs, by Model Year

Model Year	PM	NO_x	HC	$HC+NO_x$	CO
1974–1978	-	-	-	16	40
1979–1984	-	-	-	10	25
1985–1987	-	10.7	1.3	-	15.5
1988–1989	0.60	10.7	1.3	-	15.5
1990	0.60	6.0	1.3	-	15.5
1991–1993	0.25	5.0	1.3	-	15.5
1994–1997	0.10[a]	5.0	1.3	-	15.5
1998–2003	0.10[a]	4.0	1.3	-	15.5
2004+	0.10[a]	-	≤0.5	2.5	15.5

Note: Standards are expressed in grams per brake horsepower per hour (g/bhp-hr).
Sources: Sierra Research, Inc., *Review of Air Quality and Motor Vehicle Technology Issues Pertaining to the Design of AirCare II*, July 1998; United States Environmental Protection Agency, *Emissions Standards Reference Guide for Heavy-Duty and Nonroad Engines*, September 1997.
[a] Lower standards apply to urban buses

3. HEAVY-DUTY VS. LIGHT-DUTY I/M PROGRAMS

The purpose of both heavy-duty and light-duty I/M programs is to identify the gross, or excessive, emitters and cause them to be repaired sufficiently that their emissions are at levels consistent with what the vehicles were originally designed to achieve in their model year. Thus all I/M programs allow older vehicles to have higher levels of emissions than newer vehicles in recognition that they were designed to less stringent standards than are the newer vehicles and engines.

Heavy-duty I/M and light-duty I/M are quite different from each other in several respects. Although light-duty I/M programs in North America often vary according to test method and also to cutpoints, virtually all of them measure emissions of NO_x, CO, and HC.

Heavy-duty I/M addresses only visible smoke. This is because the vehicles' sizes, horsepower ratings, and axle configurations are so varied that it is not economically feasible to construct dynamometers capable of accommodating such a wide range of vehicles. Dynamometers are used to assess the non-PM component of vehicle emissions.

4. HEAVY-DUTY I/M PROGRAM FEATURES

Most HDDV I/M programs in North America feature a roadside-administered measurement of the amount of visible smoke being emitted from the vehicle's tailpipe or exhaust stack under specified test conditions, described in Section 5. Some jurisdictions also require periodic inspections of HDDVs, usually either annually or biannually, performed in fleet maintenance facilities or centralized inspection sites.

The roadside smoke test, or more accurately the smoke opacity test, may be carried out at weigh scales, customs inspection facilities, the roadside, or any other suitable site where conflicts with roadway operations do not exist. Tests may be conducted by police, or by highway or environment department staff. Inspections are usually random, in the sense that the location where they are being conducted on any given day is not publicized in advance. The actual selection of vehicles for opacity testing is usually not random in most programs; trucks and buses are selected for opacity testing because the inspection team suspects, on the basis of visual observation of the vehicles as they approach the test site, that they are excessive emitters of smoke. The inspectors' selections are based on experience, and their records of selecting vehicles that fail the opacity test are usually excellent.

The smoke test is often conducted as part of a vehicle safety inspection, in both the roadside programs and the periodic programs.

The roadside test usually applies to all HDD trucks and buses, regardless of their jurisdictional origin.[5] Failure of the roadside test may result in a fine, often waived or reduced if the owner furnishes proof, within a specified period of time, say 30 to 60 days, that the cause of the failure has been corrected. In some cases, vehicle registration may be withdrawn if the required repairs are not made within the specified time permitted, or if the vehicle is a repeat offender. There is no fee charged for the random roadside test.

In the case of periodic programs, it is common to require that a vehicle pass a smoke test in order for its registration to be renewed. Failure to demonstrate that the vehicle is not a gross emitter results in vehicle registration being denied. Frequently, the latest two, three, or four model years are exempt from the requirement to be tested periodically. This is because newer vehicles are very unlikely to be gross emitters. Such vehicles are, however, still subject to random roadside testing where these programs exist.

In jurisdictions with periodic testing, fleets are often certified to test their own vehicles, while certified private contractors conduct testing for those vehicles that are not part of fleets doing self-testing. In both cases, the regulatory agency maintains a program of monitoring to ensure minimum acceptable standards of quality assurance and control. Monitoring may involve site visits, audits, and real time electronic monitoring of vehicle testing.

Some jurisdictions limit the amount that must be spent by the owner to correct the cause of a test failure. In such cases, repairs to the vehicle may not completely correct the problem, and a waiver is issued that allows the owner to continue to operate the vehicle. The rationale behind the waiver is that it reduces the economic hardship to the owner of a potentially large and unexpected repair expense. Many jurisdictions that offer the repair cost waiver limit the number

[5] The state or province in which they are registered.

of times it can be applied to a specific vehicle. Proof that an effort was made to repair the vehicle must be provided.

Waivers usually apply only to non-warranted items, and are denied for vehicles showing signs of tampering. In some jurisdictions, the amount of the waiver depends on vehicle age and/or weight.

5. HEAVY-DUTY I/M TEST PROCEDURES

Because there is considerable inter-jurisdictional movement of heavy-duty road vehicles in the United States, there is a compelling need for consistency from state to state in certain aspects of heavy-duty vehicle emissions testing. Although administrative procedures, such as the amount of fines and waiver rules, may vary from state to state without undue hardship for vehicle owners or interruption of the free movement of vehicles, there is a need for consistency in smoke opacity testing procedures and in pass/fail criteria. The EPA has issued two guidance documents on these two key issues affecting interstate movement of vehicles.

Because of the very large volume of trade and therefore truck traffic between Canada and the United States, there is also a need to ensure HDD I/M program consistency between Canadian and U.S. jurisdictions, and also among I/M programs within Canada.

5.1 The Tests

There are several test methods in use, though the most common is the Society of Automotive Engineers (SAE) J1667.

5.1.1 SAE J1667

The EPA Office of Mobile Sources issued a *Guidance to States on In-Use Smoke Test Procedure for Highway Heavy-Duty Diesel Vehicles* in April 1997. The document provides guidance to the states on the use of the SAE Recommended Practice J1667, *Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel Vehicles*. J1667 was developed by a committee consisting of representatives from the trucking industry, engine manufacturers, smoke testing equipment manufacturers, and state and federal regulatory officials.

SAE J1667, which was issued in February 1996, enables the identification of emitters of excessive smoke. It recommends a smoke test method and instrument specifications and correction factors for ambient conditions, including altitude compensation.

The snap acceleration test, also known as the snap idle test, is performed on the vehicle while it is standing still and in neutral. The accelerator is depressed rapidly to the floor and held there until the engine reaches maximum governed speed. A smoke meter is positioned at the end of the tail pipe or exhaust stack, and the opacity of the smoke (i.e., the degree to which the smoke obscures a beam of light shining through it, expressed as a percent of light reduction, or percent opacity) is measured.

The test is quick, requires relatively inexpensive equipment, is easy to perform, and places no stress on the vehicle. Also, unlike other tests that require the vehicle to be in motion, the test does not require space for a straight, level, unobstructed path upon which the vehicle can move.

J1667 replaces an earlier SAE test, J1243, which does not provide for compensation, or correction, for ambient atmospheric conditions. These conditions can significantly affect the results of the test. Copies of J1667 can be obtained from the Society of Automotive Engineers.[6]

[6] Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania, 15096-0001, U.S.A. To inquire by phone about acquiring a copy, call SAE Publication Sales at (724) 776-4970.

5.1.2 Loaded Mode Test

Loaded mode tests attempt to simulate on-road vehicle operation by placing a load on the engine during the test. The load on the engine should result in emissions that are more representative of actual operating conditions.

(a) On-Road Lug-Down
In this test, while the vehicle is moving in a low gear at a specified speed at the governed or maximum rated RPM (wide-open throttle), the vehicle's brakes are applied to the point where engine speed is brought down to a specified percentage of the governed or maximum rated RPM. The opacity of the exhaust is measured during this lugged-down condition.

This test is hard on the engine, transmission, and brakes of the vehicle being tested and must be carried out on a secure pathway, which limits its use in areas where sufficient space is not available.

(b) Dynamometer
A chassis dynamometer can be used to simulate actual driving conditions, and would also enable the testing of NO_x emissions. Chassis dynamometers large enough to accommodate heavy, tandem axle vehicles are uncommon because of their expense. Their use would require HDDVs to travel to dedicated test facilities that would be few in number and therefore inconvenient for many trucks. Travel costs and opportunity costs associated with driver time, vehicle downtime, and forgone income could be significant.

5.1.3 Rolling Acceleration Test

This test, whether conducted from a standing start or a rolling start, also attempts to simulate loaded, on-road operating conditions. It, too, requires a dedicated pathway or stretch of test track. The vehicle is accelerated at wide-open throttle, using its own weight as the load, in low gear to the maximum governed engine speed, or to 85% of maximum engine speed or 12 miles per hour, whichever comes first.

5.1.4 Stall Test

This test is performed on HDD vehicles equipped with automatic transmissions. The vehicle's brakes are set and wheel chocks used to keep the vehicle stationary for the duration of the test. As in the snap acceleration test, the accelerator is rapidly depressed to the floor and held there until engine speed stabilizes, at which time peak smoke production is achieved, and its opacity measured.

5.1.5 Visual Assessment

Visual smoke assessment requires that inspectors be trained in determining smoke opacity levels through visual estimation of opacity percentages. This method is clearly subject to human error and is used in few jurisdictions.

5.2 The Pass/Fail Criteria

J1667 and the other test methods do not define pass/fail criteria, nor do smoke opacity measurement devices. Pass/fail criteria are the responsibility of the regulatory agencies, which in North America are at the state and provincial levels of government. In February 1999, the EPA Office of Mobile Sources issued a *Guidance to States on Smoke Opacity Cutpoints to be Used with the SAE J1667 In-Use Smoke Test Procedure*. The purpose of this second guidance

is to "encourage states to use similar smoke opacity cutpoints in their in-use testing programs,"[7] again, as with the test procedure, to establish uniformity and consistency among jurisdictions.

The cutpoints recommended in the guidance are based on the results of a study of state HDDV inspection programs conducted for the EPA by SAE. The cutpoints recommended in the guidance were already being used by 83% of the states that were using J1667 as their test method (86% of states that responded to the study were using or planning to use J1667). These cutpoints are 40% opacity for 1991 and newer HDDVs; 55% opacity for 1990 and older HDDVs.

In addition, some jurisdictions are using a cutpoint of 70% for HDDVs that are 1973 and older.

At the time of the SAE cutpoints study, some high-altitude states were using cutpoints lower than 40/55. It was found, however, that when corrected for altitude as recommended in J1667, the 40/55 cutpoints were consistent with the cutpoints being used by those states.

Copies of the two guidances appear in Appendix 1.

[7] United States Environmental Protection Agency, *Guidance to States on Smoke Opacity Cutpoints to be Used with the SAE J1667 In-Use Smoke Test Procedure*, February 1999.

6. IMPLEMENTATION TO DATE

The following jurisdictions, listed alphabetically, have implemented or are about to implement HDD inspection programs: Arizona, British Columbia, California, Colorado, Connecticut, Illinois, Indiana, Maine, Maryland, Massachusetts, Nevada, New Hampshire, New Jersey, New York, Ontario, Rhode Island, Utah, Vermont, and Washington. Detailed information on each of these programs appears in Table 4.

In addition, the Northeast States for Coordinated Air Use Management (NESCAUM) has succeeded in obtaining the commitment of nine northeastern states to participate in a memorandum of understanding (MOU) regarding smoke opacity testing in the northeastern United States. The MOU was signed on June 16, 1999, by Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

The intended purpose of the MOU is "to maximize the emissions reduction potential and minimize the compliance burden of roadside smoke inspection programs by establishing consistent and compatible smoke opacity programs in the Northeast."[8]

Although the agreement is flexible and accommodates some states' desire for either greater stringency or alternative test methods, the MOU encourages the use of J1667 as the minimum acceptable standard test method.

The MOU's suggested cutpoints are 40% opacity for 1991 and newer vehicles, 55% for 1990 and older vehicles, and 70% for 1973 and older vehicles. Also, some states may opt for even more stringent cutpoints for buses. Where this is the case, the MOU recommends 30% for 1994 and newer buses, and 40% for 1993 and older buses.

Recognizing the need to minimize the compliance burden associated with smoke testing programs, and the fact that in the northeast there is a very high level of interstate heavy-duty vehicle traffic, the MOU provides for a regional approach to penalty compliance. A regional approach reduces the potential of a truck receiving multiple citations before there has been a reasonable opportunity to repair the fault.

The MOU gives the signatories flexibility in dealing with tampering offences while encouraging a minimum level of enforcement of anti-tampering laws. It also provides for the collection and sharing of data for use in monitoring and evaluating smoke reduction programs on a regional basis.

A copy of the MOU appears in Appendix 2.

[8] Northeast States for Coordinated Air Use Management, *Regional Smoke Opacity Testing of Heavy-Duty Diesel Highway Vehicles, Memorandum of Understanding*, June 1999.

Table 4 North American HDD Smoke Testing Programs

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
Arizona Contact: Rick Day, Department of Environmental Quality (602) 207-7013	Program in place. Covers vehicles registered in Maricopa (Phoenix) and Pima (Tucson) counties.	Loaded mode using lug-down. Tests conducted at centralized sites or fleet yard. Centralized sites are contractor-operated. Maricopa may adopt J1667.	Annual. Test fee $10.00 to $12.50 (subsidized). Fee in Maricopa may increase to "market rate."	20% 0–2,000 ft 30% 2,000–4,000 ft 40% 4,000+ ft	26,000 lb. or greater, and any tandem axle truck. Out-of-jurisdiction vehicles not currently tested.	Enforced by registration denial. Amount of repair cost waiver depends on age and weight of vehicle. In Maricopa County, $200– $500.[a] In Pima County, $50–$300.
British Columbia Contact: Dave Gourley, Vehicle Emissions Inspection & Maintenance Department (604) 775-0097	Program in place as of summer 1999 in B.C. Lower Mainland (Greater Vancouver Regional District and Fraser Valley Regional District).	Roadside test using J1667.	Random. No test fee.	40/55%[b]	>5,000 kg	Registration denial possible for provincially registered trucks if not repaired within 30 days of notice. A fine for each occurrence is being contemplated. Notification is sent to host jurisdiction of out-of-province vehicles that fail. No repair cost waiver.

Sources: Manufacturers of Emission Controls Association, Diesel Testing Program Report, November 1998; Air & Radiation Management Administration, Maryland Department of the Environment, Other State Diesel Vehicle Smoke Testing Program Summary; direct communications with program contacts.

Note: Reference to ft refers to elevation above sea level.

[a] In U.S. jurisdictions, values are in U.S. dollars. In Canadian jurisdictions, values are in Canadian dollars.

[b] 40/55% and 40/55/70% refer to cutpoints of 40% for 1991 and newer vehicles; 55% for vehicles older than 1991; and 70% for vehicles older than 1973. Note that there are exceptions. Utah's cutpoint of 70% for all HDDVs is a reflection of that state's high altitude.

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
California Contact: Don Chernich, Mobile Source Division, CARB (916) 322-7061	Program in place.	Roadside test using J1667 and decentralized periodic self-testing using J1667. Mobile contractors for testing fleets.	Roadside: Random. No test fee. Periodic: Annual. No test fee. Mobile: Market rate fee.	40/55%	Roadside: All heavy-duty vehicles >6,000 lb. GVW. Periodic: All heavy-duty vehicles older than 4 model years registered in Calif. in fleets >1 vehicle and >6,000 lb. GVW.	Roadside: Fine of $800 for initial offence, reduced to $300 with proof of repair within 45 days. $1,800 for second offence in year. Possible removal from service for subsequent offences in year. Periodic: Failure to self-inspect or to keep proper records could result in CARB audit. Threat of failing on-road program encourages adherence to rules of periodic program. No repair cost waiver.
Colorado Contact: Macie LaMotte, Department of Public Health and Environment (303) 692-3133	Periodic program in place in 9 counties that include Denver, Boulder, and Colorado Springs (the Air Program area). Roadside program throughout the state.	Various loaded mode tests; self-tests by certified fleets of 9 or more vehicles. Non-fleet vehicles dyno tested at licensed sites. Roadside program uses visual test by cert'd inspector, with dispute resolution through dyno test & smoke meter. Considering adopting J1667.	Annual for loaded mode tests. Test fee up to $45 at state-licensed site. Retest fee $35 if done within 30 days at same test site. On-road program random.	35% for naturally aspirated engines; 40% above 7,000 ft; 20% for turbocharged engines.	>7,500 lb. empty weight	Periodic: Registration denial. Repair cost waiver $1,500. No repair cost waiver for self-inspected fleets that fail random testing. Vehicles registered elsewhere but which operate in or from the Air Program area must display a sticker indicating a pass. Roadside program: Fine of $300 within Air Program area; $100 in rest of state. Some municipalities have more stringent ordinances than the state statute.

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
Connecticut Contact: John Mrozowiski, Motor Vehicle Department (860) 528-7623	Program in place.	Roadside test using J1667. Also at weigh stations and rest areas.	Random. No test fee.	40/55/70%[b]	>26,000 lb. GVW. Includes out-of-state vehicles.	$200 fine for first offence; $500 for subsequent offences. Proof of repairs required within 45 days or possible registration suspension or denial of right to operate in Connecticut. Currently no repair cost waiver, but $1,000 waiver is under consideration.
Illinois Contact: Elizabeth R. Tracy, Illinois EPA (217) 782-0408	Legislation in place. Program to commence July 1, 2000. Details to be finalized.	Uses J1667. Testing at decentralized contractor sites; some fleets certified to self-test.	Annual. Test fee at market rate.	40/55/70%* *after 2002, 55% for 1973 and older.	Vehicles >16,000 lb. GVW registered in specific non-attain-ment “affected areas” (counties and townships, including metro Chicago). Vehicles less than 2 years old exempt.	Failed vehicles must be proven to have been repaired within 30 days of issuance of warning notice. If not in compliance within 30 days, vehicle is ordered out of service. Fine for continuing to operate when out of service is $1,000. Repair cost waiver is $3,000. Some vehicle categories exempt from program.
Indiana Contact: Mike Worrell, Department of Environmental Management (317) 232-8218	Pilot program to gain experience and understanding of the issue.	Voluntary testing using J1667 at specific weigh station.	Pre-arranged with interested truckers.	40/55%	Heavy-duty trucks; GVW not specified.	Next step: may conduct another pilot, focusing on non-interstate traffic.

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
Maine Contact: Scott Wilson, Department of Environmental Protection (207) 287-8442	Pilot program in place. Mandatory program to begin in January 2000. Standards and regulations to be finalized.	Roadside test using J1667.	Random. No test fee. Free fleet yard tests with no penalty, by appointment with DEP, as part of outreach.	40/55/70%	Originally vehicles >26,000 lb. GVW; starting January 2000, >10,000 lb.	Enforced by DEP staff in company of state police at police safety inspections. Fine waived if proof of repair within 30 days; if no proof, first fine $200, subsequent fines $500. No repair cost waiver.
Maryland Contact: Tim Sheppard, Department of the Environment (410) 631-3236	Second phase of voluntary program started in January 1999. Mandatory program expected July 1, 2000.	Phase 2: Voluntary test using J1667 in fleet yards. Mandatory test using J1667 at roadside.	Mandatory: Random. No test fee.	40/55%	Mandatory: All vehicles >10,000 lb. GVW.	Mandatory: Fine up to $1,000; possible registration denial for MD-registered vehicles if proof of repair not provided within 30 days. Repair cost waiver to be decided.
Massachusetts Contact: Frederick Civian, Department of Environmental Protection (617) 292-5821	Program to commence in October 1999.	Roadside test using J1667; decentralized periodic self-testing; and testing by certified shops, using J1667.	Roadside: Random. No test fee. Periodic: Biannual. Fees to be determined.	Trucks: 40/55% Buses: 30/40%[c] Model years pre-1984 will not be tested.	All vehicles >10,000 lb. GVW.	Roadside: considering requiring proof of repair within 60 days or registration withdrawn. Fine for roadside failure to be determined. Periodic: Proof of repair required within 60 days or registration withdrawn. Test exemption possible for vehicles tested in other jurisdictions. Test required for ownership transfer. No repair cost waiver.

[c] 40% for model years 1984 to 1990; 30% for 1991 to present

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
Nevada Contact: Adele Malone, Bureau of Air Quality (775) 687-4670	Program in place.	Roadside test using J1667.	Random. No test fee.	70%	All vehicles >8,500 lb. GVW.	Fine of $850 is waived upon proof of repair within 45 days. Repair cost waiver is $1,000 if repairs are performed in a commercial shop; $750 if self-repaired.
New Hampshire Contact: Jim Ponicello, Air Resources Division (603) 271-4131	Program in place since January 1999.	Roadside test using J1667.	Random. No test fee.	40/55/70%	All vehicles >10,000 lb. GVW.	Fine $100 for first offence; $300 for second within the year; $500 for third within the year. Provision for criminal violations and/or registration removal.
New Jersey Contact: Tony Iavarone, Department of Environmental Protection and Energy (609) 530-4064	Program in place.	Roadside test using J1667, rolling acceleration, and stall tests. Periodic program uses rolling acceleration and stall tests only, at centralized sites licensed by DOT.	Roadside: Random. No test fee. Periodic: Biannual. Fee equal to 1 hour labour (approximately $60). Fleets >20 vehicles can be certified to self-test.	Trucks: 40/55/70% Buses: 30/40%	All vehicles >8,500 lb. GVW.	Roadside: Fine of $700 is reduced to $300 with proof of repair within 45 days. Fine of $1,300 for second failure within year is reduced to $500 with proof of repair within 45 days. Fine for subsequent failures within same year: $1,300. Possibility of removal from service for multiple failures. No repair cost waiver. DOT staff conduct smoke test with assistance of state police, often as part of police safety inspection. Periodic: Registration denial.

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
New York Contact: Steve Flint, Division of Air Resources, Bureau of Mobile Sources (518) 485-8913	Program begins in fall 1999.	Roadside test using J1667 outside NYC. Periodic program administered as part of annual safety inspection using J1667 at accredited sites in NYC metro area. Fleets may also self-test.	Roadside: Random. No test fee. Periodic: Annual. $25 test fee.	40/55/70%	All vehicles >8,500 lb. GVW.	Roadside: Fine of $700 reduced to $150 if proof of repair provided within 30 days. Subsequent same-year violations: fine of $1,300, reducible to $500. Periodic: Fine of $700 reduced to $350 if proof of repair within 30 days. Subsequent same-year violations: fine of $1,300, reducible to $500. Failure to repair results in denial of annual safety sticker, effectively denying registration renewal. Repair cost waiver depends on vehicle size, varying from $1,000 to $4,000 annually.
Ohio Contact: Andrea Stevenson, Ohio EPA (614) 644-3590	Program in place for LDDs <10,000 lb. GVW. Possibility of testing urban buses beginning in late 2000.					Details of proposed urban bus testing program to be determined.

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
Ontario Contact: Jeff Taylor, Drive Clean Office, Ministry of the Environment (416) 314-1307	Program to begin in fall 1999. HDD program to be province-wide; HDG program to coincide with LDV program's geographic limits.	Roadside test using J1667. Periodic testing by contractors at decentralized sites and by certified fleets, using J1667. Mobile contractors for testing fleets, by appointment. HDG two-speed idle test at certified sites.	Roadside: Random. No test fee. Periodic: Annual. Market cost. Retest fee also market rate.	40/55%	Roadside: All heavy-duty vehicles >4,500 kg. Periodic: All HDVs >4,500 kg registered in Ontario. Latest 3 model years exempt.	Roadside: Fines vary from $305 to $450.[a] Fines can be additive (e.g., $305 for roadside test failure plus $450 for tampering, if applicable). No limit to number of fines per year. Periodic: Registration denial. Ownership transfer requires a pass. No repair cost waiver.
Rhode Island Contact: Tom Barry, Department of Environmental Management (401) 222-2808	Pilot completed 1997. Mandatory program under development.	Will use J1667. Likely to include random roadside, periodic fleet self-testing, and periodic testing at certified contractor sites.	To be determined.	Likely 40/55%	To be determined.	Program under development and to be consistent in standards and enforcement with NESCAUM MOU. Possible target start is 2001.
Utah Contact: Joe Thomas, Department of Environmental Quality (801) 536-4175	Program in place in Davis, Salt Lake, and Utah counties; administered by counties; monitored by state.	Periodic testing program using J1667. Buses are self-tested by certified fleets.	Annual. Fee $24 in Salt Lake and Utah counties.	70% in Salt Lake and Utah counties; 80% in Davis.	Vehicles >16,000 lb. GVW. 1967 and older vehicles, and vehicles registered out of state, exempt from program.	Enforcement through registration denial. Model year exemptions vary by county; newest 3 model years generally exempt. Repair cost waiver $1,500 in Salt Lake and Utah counties; no waiver in Davis.

Table 4 North American HDD Smoke Testing Programs (continued)

Jurisdiction	Program Status	Test Method & Site	Test Frequency & Cost	Cutpoints (% opacity)	Vehicles Tested	Enforcement & Waivers
Vermont Contact: Harold Garabadian, Agency of Natural Resources (802) 241-3849	Pilot completed; advisory letters being sent to violators. Final phase expected to be mandatory program with penalties for violators.	Will use J1667.	To be determined.	40/55%	To be determined.	In early planning stages. Not yet in legislation.
Washington Contact: John Poffenroth, Department of Ecology, Air Quality Program (509) 456-3283	Program in place.	Centralized, contractor-run program using J1667. Self-testing by fleets is permitted.	Biannual for private sector vehicles; annual for public sector. Test fee $12 when tested by contractor.	40/60/70%. Cutpoints under review; may adopt 40/55%.	All HDDVs >8,500 lb. GVW registered and operated in metropolitan areas.	Enforcement through registration denial. Repair cost waivers currently $100 for vehicles older than 1980; $150 for vehicles 1981 and newer. No waiver if tampering is found. Test required for ownership transfer. Prorated vehicles exempt.

7. QUALITY ASSURANCE AND CONTROL

Measures used to ensure quality assurance and control vary among jurisdictions and programs.

Most roadside testing programs are administered by a provincial or state agency whose inspectors have the authority to require vehicles to submit to an inspection (for safety or other reasons) and to issue citations. These personnel are trained in the visual identification of likely excessive smoke emitters, and are certified in the administration of the smoke opacity test. Quality is assured and controlled because these inspectors are law enforcement or quasi-law enforcement personnel employed by governments or agencies of governments, and are trained and certified in HDDV I/M.

Periodic testing programs also require the training and certification of personnel who conduct smoke opacity tests, as well as the certification of the facilities in which the tests are conducted, which can be private fleet facilities or contractor-operated testing facilities. In addition, many jurisdictions, as a condition of granting certification to a facility, require that the facility submit to inspections and audits by the regulatory authority. Quality is assured by the training and certification of personnel and the use of approved test methods (usually SAE J1667) and testing equipment.

Quality is controlled by the ongoing facility inspection and audit process, and by the possibility that certification may be withdrawn for poor-quality testing or for the more serious issue of fraud. Some jurisdictions put in place data management processes, some of which gather test data in real time from each testing site. These data management processes enable the regulatory agency or its program management contractor to monitor test facility performance in real time and to identify data anomalies that indicate either poor testing practices or fraudulent activity, or both.

Other jurisdictions rely on the possibility of a vehicle, mistakenly or fraudulently passed at a fleet- or contractor-operated site, failing a roadside test to keep the fleet and contractor sites vigilant and honest. This approach works only in jurisdictions where both random roadside and periodic testing are taking place.

J1667 specifies the technical performance requirements of opacity test instruments, which are produced by several manufacturers. Not all manufacturers' equipment meets the J1667 requirements. The Ontario Ministry of Environment recently invited manufacturers to submit their equipment for testing by Environment Canada. Only three manufacturers responded. The equipment of two received full approval and was certified for use in Ontario. The equipment of the third received conditional approval and will be certified for use in Ontario once it has been shown to comply with J1667.

The California Air Resources Board (CARB) is sufficiently concerned about the accuracy of manufacturers' smoke meters that it is advocating that an independent entity, such as the Society of Automotive Engineers, undertake a smoke meter certification program. The program would entail the testing of all smoke meters for sale in California to ensure they meet the requirements of SAE J1667. Currently, California provides a list of smoke meter manufacturers to users but does not endorse the meters for accuracy. Rather, CARB reminds users that the smoke meters they acquire and use must meet the requirements of J1667.

8. COSTS AND COST-EFFECTIVENESS

8.1 Costs

Estimating the costs associated with a proposed program requires making assumptions about expected failure rates and administrative and repair costs.

Prior to the implementation of California's HDDV I/M program (composed of the Heavy Duty Vehicle Inspection Program (roadside) and the Periodic Smoke Inspection Program), CARB conducted a comprehensive analysis of the proposed program. Included in its analysis was a random truck opacity survey carried out to establish a reasonable assumption about what failure rates could be expected from the program. CARB then estimated program costs using its assumptions of failure rates and its knowledge of repair costs and other expenses related to the trucking industry.

CARB categorized its HDDV program costs as follows:[9]

Program administration costs

Administrative costs to fleets
- annual labour cost (the cost of fleet self-inspection)
- annual capital cost for smoke meters
- annual cost of inspections done by contractors

Costs to vehicle owners
- annual failed vehicle repair cost
- annual increased maintenance cost (resulting from voluntary repairs performed due to the threat of inspection and issuance of citation)
- annual lost opportunity cost of time (unscheduled downtime spent at roadside inspection)
- annual cost of fuel (this has a negative value, representing a benefit)

It is debatable whether all of the above-noted costs should be attributed to the I/M program. (This issue has also arisen in the case of light-duty programs.) The debate centres on the contention that a vehicle should be maintained throughout its service life to operate as it was designed to do. Failure to adequately maintain a vehicle, which as a result becomes an excessive emitter, imposes a cost burden on the rest of society that should rightly be borne by the vehicle owner as a normal cost of operating a vehicle responsibly. Thus, it is contended that increased annual maintenance costs associated with I/M are the result of nothing more than a fleet upgrading its maintenance procedures to what they should have been in the first place.

Similarly, the lost opportunity cost of downtime and failed vehicle repair cost, though real costs, perhaps should not be attributed to the inspection program, and certainly should not be used as an argument for not implementing a program.

8.2 Cost-Effectiveness

Light-duty programs are designed to effect improvements in NO_x, HC, and CO emissions. As a result, they can *measure* the reductions in these emissions from failing vehicles that are repaired and retested. The costs of achieving these reductions can be calculated and compared with the costs of achieving similar reductions in the same pollutants by other means.

HDDV I/M programs, however, are not designed to effect improvements in HDDV

[9] California Environmental Protection Agency, Air Resources Board, *Technical Support Document for the Proposed Amendments to the California Regulations Governing the: Heavy Duty Vehicle Inspection Program and the Periodic Smoke Inspection Program*, October 1997.

performance in terms of emissions mass. Rather, their goal is to reduce the opacity of exhaust smoke, a reduction that "cannot be meaningfully addressed in terms of mass."[10] (A reduction in the opacity of the particulate matter does not necessarily result in a reduction in its total mass. This is the subject of ongoing research to determine the relationship between smoke opacity reduction and the reduction of particulate mass.)

Further, HDDV I/M programs are not designed to effect reductions in other pollutants, such as NO_x, HC, and CO. Reductions in the mass of these pollutants and PM, as well as improvements in fuel economy and vehicle reliability, are, at least in the California program, considered secondary benefits of an HDDV I/M program. The primary benefit is the reduction in the number of HDDVs that emit excessive smoke.[11]

This said, however, California, New Jersey, and possibly some other states, as well as British Columbia,[12] have undertaken comprehensive analyses, based on computer modelling, to *estimate* these secondary benefits, and to compare the cost per tonne of achieving them to the cost per tonne of achieving them by other means. (Such means might include, for example, improved scrubber technology at thermal electricity generating stations.)

Other states have undertaken less comprehensive analyses and prepared social and environmental impact statements of a more qualitative nature to support their programs. Still other states have relied on the pioneering work of others, notably California, and performed minimal analysis of their own.

CARB's analysis included sophisticated computer modelling to predict the theoretical secondary benefits of the state's smoke inspection program, including the expected effect on NO_x, HC, and CO emissions and improvements in fuel consumption. The analysis was based on the assumption that the California program would consist of two elements: the random roadside program using a snap acceleration smoke test (Heavy Duty Vehicle Inspection Program, or HDVIP) and the periodic program (Periodic Smoke Inspection Program, or PSIP), also using a snap acceleration smoke test.

British Columbia's approach was different from California's in that the analysis was not undertaken on the assumption that a particular program type or test would be the subject of the analysis. Rather, British Columbia conducted a feasibility analysis, which also made use of computer modelling, that considered a range of alternative HDDV I/M program types and test methods. These included random roadside and periodic types using a snap acceleration test and dynamometer testing, but also included variants of what could be considered basic roadside and periodic programs (the California model). The analysis led British Columbia to select random roadside testing using a snap acceleration test as its program type.

California, New Jersey, and British Columbia estimated the costs per unit mass of reducing NO_x, HC, CO, and PM_{10}. It would be meaningless, however, to compare their cost estimates without knowing in detail the underlying assumptions and the analytical methods used, which are beyond the scope of this status report.

10 Ibid., page 8-1.

11 Ibid., page 7-1.

12 See, for example, Greater Vancouver Regional District, Province of British Columbia, and Environment Canada, *Heavy Duty Vehicle Emission Inspection and Maintenance Program Implementation in the Lower Fraser Valley*, October 3, 1994.

It should be noted, however, that the cost-effectiveness of California's HDDV program in reducing criteria pollutants (a secondary benefit behind reducing the number of excessively smoking vehicles) was estimated to be superior to that of other emission control programs whose primary objective was the reduction of criteria pollutants. In fact, California's HDDV program was estimated to be between 2.4 and 4.7 times more cost-effective than other methods.[13] New Jersey also found that the cost-effectiveness of its program in reducing criteria pollutants was superior to the effectiveness of non-road programs.

[13] California Environmental Protection Agency, Air Resources Board, *Technical Support Document for the Proposed Amendments to the California Regulations Governing the: Heavy Duty Vehicle Inspection Program and the Periodic Smoke Inspection Program*, October 1997, page 8-1.

9. PERSONNEL TRAINING

9.1 Inspection Personnel

In Canada, inspection personnel tend to be trained and certified by the program contractor. The test equipment manufacturer may have a role in training in the use of its equipment. However, it is the contractor's responsibility to ensure that ongoing training is undertaken as required, to ensure consistency in performance and to retrain personnel when testing equipment technology changes.

In California, the Air Resources Board provides training for its inspectors in the fundamentals of enforcement, including data collection and documentation, to ensure their ability to defend a citation in court. Inspectors are also trained in visual smoke inspection and are encouraged to undertake continuing education, including an SAE certification in diesel engine technology.

9.2 Repair Technicians

In Canada, there is no repair facility or repair technician certification for the heavy-duty programs.

The Canadian Automotive Repair and Service (CARS) Council is promoting the establishment of an international industry standard for the training and certification of engine repair technicians and technician trainers that is consistent with light-duty vehicle and heavy-duty vehicle emissions programs throughout Canada.

In California, there is no repair technician certification, though persons involved in diesel engine service and repair are encouraged to take a voluntary one-day course in diesel smoke measurement.

10. PUBLIC INFORMATION AND AWARENESS

When designing their smoke testing programs, most jurisdictions focused their outreach efforts on the group to be immediately affected by their testing programs: the fleet and vehicle owners and operators. Outreach activities included mailing brochures, issuing media releases, including industry groups on I/M program planning committees, and informal communications between regulatory agency staff and industry representatives. Typically, the groups consulted included truck operators, engine manufacturers, the vehicle I/M industry, and enforcement agencies if enforcement was to be undertaken by an agency other than the regulatory agency.

The general public was generally not a target audience of the outreach programs.

An important element of the information and awareness efforts of smoke inspection programs has been the pilot program. Often lasting 6 to 12 months, the pilot program allows the regulatory agency to attract the attention of the heavy-duty vehicle operators and alert them to the impending mandatory program, its features, and its start date. This gives operators an opportunity to bring problem trucks into compliance during the pilot grace period, and more importantly to establish maintenance procedures to deal with potential smoke-related problems before they occur.

Another important advantage of a pilot phase is that it gives the regulatory agency an opportunity to gather data and experience that are useful in designing the mandatory program. It also enables the agency to iron out enforcement and administration issues before mandatory testing begins, thereby avoiding potential problems that could impair the smooth functioning of the program and erode the industry's confidence in it.

Organized trucking associations in Canada and the United States virtually all agree that *random roadside* smoke testing programs are desirable. Trucking associations pride themselves in having members that take good care of their fleets and understand the advantages of maintaining a positive public image. These truckers insist that their vehicles are already running clean. But, if a member's truck does fail a roadside test, they agree that it deserves to incur the established penalty.

Trucking associations generally view *periodic* programs as both an unnecessary expense and inequitable, because they target only vehicles registered within the testing jurisdiction. They feel that this places in-jurisdiction vehicles at a competitive disadvantage compared with "foreign" operators, who may not be required to bear similar costs in their home jurisdiction.

Truckers not affiliated with trucking associations may lack enthusiasm for any kind of smoke testing program. Comments from staff in several states suggest that unaffiliated truckers are more likely to be excessive smoke emitters, possibly because they are less likely to spend as much on regular maintenance as their affiliated counterparts. They may also be less sensitive to the negative public image conveyed by excessive smoke. Naturally, there are exceptions, and this comment is not meant to suggest that all unaffiliated truckers are smoke opacity violators.

11. IMPLEMENTATION PROCESS — SOME SUGGESTIONS

11.1 Pilot Phase

For reasons noted above, a pilot phase should be considered an essential component of a smoke testing program.

11.2 Industry Outreach — Program Design

Industry involvement in the design of a smoke testing program should also be considered essential for two reasons. First, industry may be able to offer advice on program design, economic impact, enforcement, administration, and other issues that could enhance the program's effectiveness, efficiency, and equity. Second, failure to involve industry could lead to ill feelings, particularly if some program features are chosen that may unnecessarily disadvantage the industry, which in turn could lead to political activity and/or publicity that could impair the smooth implementation of the program and/or erode its credibility.

11.3 Industry Outreach — Ongoing Operations

Ongoing outreach activities such as distributing brochures to truckers and trucking companies, media releases, and articles in industry publications serve to reinforce the need for smoke control and good maintenance practices, recognize the industry for the progress it makes, and provide a forum for informing the industry of intra- and inter-jurisdictional changes to I/M programs that may affect it.

11.4 Inter-Jurisdictional Consistency and Reciprocity

Inconsistency between jurisdictions regarding the opacity test method and the establishment of cutpoints is less of an issue than it once was. SAE J1667 is widely used and appears to be gaining favour even among jurisdictions already using other test methods. Similarly, programs show a high degree of consistency on opacity cutpoints, with most jurisdictions favouring 40% opacity for 1991 and newer vehicles, and 55% opacity for pre-1991 vehicles.

Inter-jurisdictional reciprocity remains an issue. The trucking industry and the regulatory agencies both recognize that out-of-jurisdiction vehicles are often treated differently than locally registered vehicles in HDDV smoke opacity testing programs. This leads to the perception of inequity, which in some cases is justified from a cost/competitiveness viewpoint. Some jurisdictions do not test "foreign" vehicles at all. Others test them but do not issue citations.

Still others may test and fail a vehicle that was just tested and failed in an adjacent jurisdiction, before the operator had an opportunity to correct the cause of the failure.

The need for consistency and fairness in test method, pass/fail standards, and enforcement was recognized by the members of NESCAUM to be sufficiently important that they developed an MOU regarding smoke testing. This approach could become a model for a standard for the rest of North America.

The recommendation is that inter-jurisdictional consistency be considered a key factor in the design of HDDV emissions testing programs, whether they focus on smoke opacity, as is now the case, or on smoke opacity plus other pollutants should the technology to test for them at reasonable cost become available. In addition, current and proposed HDDV programs should assess the desirability of establishing reciprocal enforcement agreements with other jurisdictions.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR - 3 1997

OFFICE OF
AIR AND RADIATION

GUIDANCE TO STATES ON IN-USE SMOKE TEST PROCEDURE FOR HIGHWAY HEAVY-DUTY DIESEL VEHICLES

As part of its ongoing efforts to provide assistance to States regarding in-use testing programs and to promote uniformity with respect to smoke test procedures, the Environmental Protection Agency (EPA) is recommending the use of the SAE J1667 procedure for state-operated in-use testing programs for highway heavy-duty diesel vehicles (HDDV). This guidance document provides a technical recommendation that States can follow in the implementation of their in-use emission testing programs. Because highway HDDV travel across the country, EPA believes that the adoption of a common smoke test procedure by States would help address the concerns brought up by the trucking industry and heavy-duty engine manufacturers by promoting consistency between smoke measurements in state-operated in-use testing programs for HDDV.

The procedure SAE J1667, entitled *Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel Vehicles,* was developed between 1992 and 1996 by a committee of members representing the trucking industry, heavy-duty engine manufacturers, test equipment manufacturers, and state and federal regulators. SAE J1667, issued in February, 1996, recommends a smoke test method, instrument specifications and correction factors for ambient conditions, including altitude compensation. The SAE J1667 is a snap acceleration test under idle conditions, using engine inertia for loading, and is specifically designed for identifying excessive smoke emitters. Since it is a non-moving vehicle test, the SAE J1667 can be conducted along the roadside or in a test facility.

The Clean Air Act Amendments of 1990 do not require states to implement in-use testing programs for highway HDDV. However, as a means to address concerns about in-use emissions from HDDV, many states today are implementing in-use smoke testing programs. Excessive emission of black smoke from HDDV is one of the most common complaints received from the public by state and local air

quality agencies. Since the excessive emission of black smoke is often an indicator that an engine is in need of maintenance and/or repair and gaseous/particulate emission levels may also be high, states are focusing on black smoke opacity measurements for their in-use testing programs.

EPA is aware of several states which are in various phases of considering, or have already adopted, some form of an in-use smoke emission test for HDDV. These states include: Arizona, California, Colorado, Connecticut, Illinois, Maryland, Massachusetts, Nevada, New Jersey, New York, Ohio, Utah and Washington. Even though most of the state-operated in-use programs include smoke measurements, not all programs use the same test procedure for in-use smoke evaluations. These inconsistencies have created major concerns for the trucking industry, since trucks that travel across the country may be subject to inspections in different states with different test procedures. By using similar test procedures, states would have the advantage of being able to compare test results. Therefore, testing and administrative costs could be minimized. Furthermore, any environmental benefits that could be derived from the implementation of these programs would be much easier to quantify in regions that use the same test methods.

For the reasons cited above, EPA believes that uniformity in smoke test procedures is appropriate and is recommending the use of the SAE J1667 procedure for smoke evaluations in state-operated in-use testing programs. The SAE J1667 test is a peer-reviewed procedure that has been developed by a joint government-industry committee to provide a reliable method for in-use smoke measurement. The procedure is currently being used by several states and is viewed favorably by the trucking industry and highway heavy-duty engine manufacturers.

Margo T. Oge, Director
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4-03-'97
Date

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OFFICE OF
AIR AND RADIATION

GUIDANCE TO STATES ON SMOKE OPACITY CUTPOINTS TO BE USED WITH THE SAE J1667 IN-USE SMOKE TEST PROCEDURE[1]

On April 3, 1997, the Office of Mobile Sources of the Environmental Protection Agency (EPA) provided guidance to the States recommending the SAE J1667 smoke test procedure[2] for the in-use smoke testing of highway heavy-duty diesel vehicles (HDDVs). The purpose of that guidance was to promote consistency among state-operated in-use smoke testing programs. As a result of that guidance, several States are now using or considering the recommended SAE J1667 test procedure. EPA is pleased to know that the guidance provided in April 1997 served its purpose. However, EPA realized that in order to bring full uniformity among state-operated smoke testing programs, additional guidance was needed for States to adopt similar opacity cutpoints when using the SAE J1667 test procedure. As part of its efforts to continue promoting consistency by providing assistance to States regarding in-use testing programs, EPA is now recommending specific opacity cutpoints to be used with the previously recommended SAE J1667 test procedure. The opacity cutpoints recommended through this guidance are: 40% for vehicles 1991 and newer and 55% for vehicles 1990 and older.[3] These cutpoints are recommended to be used in determining smoke test failures when using the previously recommended SAE J1667 test procedure during state-operated in-use testing programs.

This guidance is based on the results of a study[4] conducted by SAE as part of a cooperative agreement with EPA to evaluate state-operated smoke testing programs. Under the cooperative agreement, SAE conducted a comprehensive survey of existing and planned programs. The survey was distributed to States and other stakeholders. Of the States that

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[1] This guidance document is not a mandated regulation, but a recommendation that States can follow in their implementation of in-use smoke testing programs.

[2] The procedure SAE J1667, entitled Snap Acceleration Smoke Test Procedure for Heavy-Duty Diesel Vehicles, was developed between 1992 and 1996 by a committee of members representing the trucking industry, heavy-duty engine manufacturers, test equipment manufacturers, and state and federal regulators. The SAE procedure includes the test method to be used, instrument specifications, and correction factors for ambient conditions. SAE J1667, issued in February 1996, is a snap acceleration test under idle conditions, using engine inertia for loading, and is specifically designed for identifying excessive smoke emitters. Since it is a non-moving vehicle test, the SAE J1667 can be conducted along the roadside or in a test facility.

[3] The recommended cutpoints are intended to be net values after correction for ambient test conditions, as specified in the SAE J1667 test procedure Appendix B "Corrections for Ambient Test Conditions" model.

[4] SAE International Cooperative Research Program, Report to U.S. EPA Under Assistance Agreement CX825906-01-0, "Establishment of Smoke Opacity Cutpoints for SAE J1667 Test Procedure," November 1998.

responded approximately 86% are using or planning to use SAE J1667. Of those States using SAE J1667, 83% were found to utilize cutpoints of 40% for vehicles 1991 or newer and 55% for vehicles 1990 or older. Those States that were using higher cutpoints were found to be high altitude States. It was determined that when the higher cutpoints were corrected for altitude, they were in line with the 40/55% limits. During various discussions with stakeholders, it was clear that States support the 40/55% limits, once corrected for altitude. Also, there was agreement among the participating States and stakeholders that cutpoints at the 40/55% levels yielded good results at screening gross polluters.

The purpose of this guidance is to encourage States to use similar smoke opacity cutpoints in their in-use testing programs. Although the Clean Air Act Amendments of 1990 do not require States to implement in-use testing programs for highway HDDVs, many States today are doing so to address public concerns about in-use emissions from these vehicles. Excessive emission of black smoke from highway HDDVs is one of the most common complaints received from the public by state and local air quality agencies. Since the excessive emission of black smoke is often an indicator that an engine is in need of maintenance and/or repair, States are focusing on smoke opacity measurements as part of their in-use testing programs. EPA is aware of several States that have adopted or are considering adopting some form of in-use smoke emission test for highway HDDVs.

Because many highway HDDVs move across State boundaries, EPA believes that uniformity among state-operated smoke testing programs is desirable and appropriate. Thus, EPA is hereby recommending that the States adopt the opacity cutpoints described in this guidance (i.e., 40% for vehicles 1991 or newer and 55% for vehicles 1990 and older) when using the SAE J1667 test procedure. These cutpoints are being used by the majority of the States and are viewed favorably by stakeholders, as reported in the SAE study referenced in this guidance.

Margo T. Oge, Director
Office of Mobile Sources

Date 2-25-99

APPENDIX 2 NORTHEAST STATES FOR COORDINATED AIR USE MANAGEMENT (NESCAUM) MEMORANDUM OF UNDERSTANDING

Regional Smoke Opacity Testing
of
Heavy-Duty Diesel Highway Vehicles

MEMORANDUM OF UNDERSTANDING
Among the States of
Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont

I. PURPOSE

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 hereby propose to adopt and coordinate smoke opacity testing programs in the Northeast.

II. BACKGROUND

Heavy-duty diesel engines used in trucks and buses are a significant source of nitrogen oxides and particulate matter which contribute to such critical air pollution problems in the Northeast Corridor as ozone, fine particulates, regional haze and acid deposition. In addition to emissions of nitrogen oxides and particulates, heavy-duty diesel engines emit smoke which has been regulated by the federal government since 1970.[1] Engines in a poor state of repair emit higher levels of smoke than do those that are well maintained. A pilot smoke testing program conducted in the Northeast States showed that as many as 20% of vehicles on the road emit levels of smoke above the federal standards for this pollutant. Concerns about heavily smoking diesel vehicles are commonly made known to state air pollution control programs. In addition, the public perceives an inequity between the emission inspection requirements for their passenger cars and light-duty trucks and those for heavy-duty vehicles.

To address the public's concern over heavily smoking diesel engines and to reduce particulate emissions from these vehicles, several Northeast States already have, or soon will begin to implement smoke opacity testing programs. The enforcement of smoke opacity standards will result in the repair of poorly maintained or tampered vehicles and encourage the long-term maintenance of these vehicles. In addition, the repairs and improved maintenance expected to result from the implementation of these programs will reduce heavy-duty diesel smoke emissions. Research currently being conducted on the relationship between smoke reducing repairs and criteria pollutant emissions will assist the states in assessing the impact of smoke inspection programs on criteria pollutants.

[1] Peak smoke emissions were not regulated until 1973.

This MOU is intended to maximize the emission reduction potential and minimize the compliance burden of roadside smoke inspection programs by establishing consistent and compatible smoke opacity programs in the Northeast. In order to promote consistency among state programs and to avoid a patchwork of regulations, the undersigned states propose to coordinate their respective smoke opacity testing programs as follows:

III. AGREEMENT

A. Model Cutpoints/Smoke Standards

Heavy-duty Vehicles Model Year	Smoke Opacity Cutpoint
1991 and newer	40% opacity
1990 and older	55% opacity
1973 and older[2]	70% opacity

While most states will adopt the 40/55 standards for buses, some states may adopt a more stringent smoke opacity standard for buses. If so, cutpoints at least as stringent as the following are recommended:

1994 and newer	30%
1993 and older	40%

B. Testing Methods

The states participating in this MOU agree to use at minimum the Society of Automotive Engineers (SAE) J1667 ("snap idle") test for random roadside inspection programs.[3] For the purpose of future program development, states will not be constrained from developing alternative methods to testing heavy-duty vehicles for inspection and maintenance and roadside enforcement programs.

C. Regional Roadside Penalty Compliance Period

States issuing citations for violation of the opacity standards at roadside are providing owners 30 to 60 days[4] to bring those vehicles into compliance before the vehicle is subject to a second violation. Given the level of interstate travel in the Northeast Corridor, trucks and buses traveling through the region could conceivably incur smoke opacity violations at roadside in different states prior to effecting needed repairs. One of the goals of this agreement is to ensure that drivers of commercial vehicles may finish their routes without incurring multiple penalties in the region. To this end, MOU signing states will make best efforts to waive a smoke penalty if a vehicle has received a smoke violation at roadside within the last 30 days from participating states. States will not waive a penalty for a smoke violation if the vehicle is found to be tampered in accordance with section E of this MOU.

All states will reserve the right to test and fine a heavily smoking vehicle for opacity even if the driver has documents showing it has recently passed a smoke inspection in another state. Documents showing

[2] Some states are adopting a 70% standard for 1973 and older vehicles.
[3] States reserve the right to test vehicles with other methods.
[4] The compliance period varies from state to state.

that a vehicle has recently been smoke tested and passed may, in certain states, help the vehicle pass through the inspection station more quickly than if it had not been tested.

D. Data Sharing Among States

The states agree to retain records on the number of heavy-duty vehicles tested in smoke inspection programs, the levels of smoke opacity by model year, and other emissions-related information about the vehicle. This information may be used by states to compile regional data on smoke opacity levels as a means of monitoring the long-term effectiveness of these programs.

E. Tampering

States will make best efforts to design anti-tampering programs within the confines of applicable enabling statutes, with the intent that enforcement and penalties should be at least as stringent as the penalties assessed for violation of emission standards.

Some examples of emission control apparatus tampering are disabling a smoke puff limiter, installing of fuel injectors which do not conform to the engine manufacturers specifications, and manipulation of engine control software. Some states may choose to respond to this issue by establishing a mechanism to enforce either federal statutes [Clean Air Act sec. 203(a)(3)] or codes [42 USC 7522(a)(3)], or individual state statutes and codes. In establishing such programs, states will make best efforts to ensure that enforcement of anti-tampering laws embody at minimum the concepts contained in *Mobile Source Enforcement Memorandum 1A* (which establishes federal guidelines for tampering enforcement) and all subsequent revisions.

F. Acceptance of Agreement

The states of Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont's proposal to implement this collaboration is hereby established by the signing of this MOU. States with current smoke inspection programs or laws requiring the establishment of smoke inspection programs (Connecticut, Massachusetts, New Hampshire, New York, New Jersey) will use best efforts to modify said testing programs to be consistent with the elements outlined in this MOU on or before July 1, 2001. States currently without programs (Maine, Maryland, Rhode Island, Vermont) will use best efforts to adopt and implement smoke testing programs consistent with the elements described in this MOU by July 1, 2001. The MOU may be amended in writing upon agreement of the signing states.

G. Inclusion of Other States in the Smoke Opacity Testing Agreement

Any other state that wishes to join in this MOU may do so by accepting the agreement as described in the previous sections.

Northeast Smoke Testing Memorandum of Understanding Fact Sheet

Background

- Diesel engines powering trucks and buses emit high levels of particulate and NO_x pollution. In addition, many older and poorly maintained diesel trucks and buses emit smoke.

- A poorly maintained diesel engine can emit over 10 times more pollution than a properly tuned engine. One of the lowest cost and most effective methods of reducing pollution from existing diesel vehicles is to ensure that the engines are properly maintained. Not only do properly maintained engines emit substantially lower levels of pollution than do those in a poor state of repair, they also have significantly increased fuel efficiency.

- California's diesel inspection and maintenance program reduced the number of vehicles emitting excess smoke by one third in the first two years of program implementation. When fully implemented the program is projected to cut diesel particulate and hydrocarbon emissions in half.

- Smoke is comprised of soot or particulates. Over 90 percent of diesel engine particulate emissions are highly respirable and carry toxins deep into the lung. The National Institute for Occupational Safety and Health and the International Agency for Research on Cancer have classified diesel particulate a probable human carcinogen. The U.S. EPA is in the final stages of a study which makes a similar recommendation. The California Air Resources Board has labeled diesel particulate a toxic air contaminant.

The Memorandum of Understanding

- The smoke testing agreement signed by nine states on June 16th establishes state smoke opacity standards and an agreement to ticket trucks and buses that violate those standards. In signing the memorandum of understanding (MOU) the states agreed to adopt and coordinate roadside smoke inspection and maintenance programs. The coordination of the programs will ensure that consistent smoke standards are enforced throughout the region. In addition, the memorandum of understanding would permit truck drivers to finish their routes without incurring multiple penalties in the region.

- Trucks and buses will be tested at roadside weigh stations and/or at pullover locations by Department of Motor Vehicle, Transportation, State Police, and/or Environmental staff. The trucks will be tested using opacity meters which measure the extinction of light as it passes through a plume of smoke. Trucks with excess smoke and/or trucks that have tampered engines will be assessed a penalty. The programs will require that trucks and buses emitting high levels of smoke be repaired within 60 days.

- The majority of trucks tested as part of the state programs will pass the smoke inspections. The roadside programs are aimed at ticketing and repairing the dirtiest trucks and buses. In pilot programs conducted in the nine states, approximately 20 percent of vehicles failed smoke inspections. Over 200,000 trucks were tested as part of those pilot programs with a majority of trucks being tested in New Jersey. New Jersey's comprehensive pilot and enforcement programs have provided states in the region with valuable information as they have developed their programs.

- Two states in the region are currently ticketing trucks and buses that emit heavy smoke. Five others have adopted legislation and will begin their programs within the next year.

- The MOU coordinates five elements of the state roadside programs: consistent smoke standards, a smoke testing method, penalties for tampering with heavy-duty engines, sharing of data among the states, and a regional compliance period. The MOU also establishes a date for implementation of all of the programs.