

The New Zealand vehicle emissions screening programme

Resource document

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1. Introduction

Purpose of the resource document

The Ministry of Transport's preliminary proposals for the New Zealand vehicle emissions screening programme are set out in *The Proposed Vehicle Emissions Screening Programme—Discussion Document*, which can be downloaded from the ministry's website (www.transport.govt.nz).

This resource document must be read together with the discussion document. The resource document provides additional background information to complement and facilitate feedback on the proposals in the discussion document.

Information on making submissions, including the closing date for submissions, is on page 2 of the discussion document.

2. Air quality and health

The health impacts of vehicle exhaust emissions

Despite knowledge gaps, there is clear evidence that the contribution of vehicle exhaust emissions to sickness, hospitalisations, and premature deaths is significant in New Zealand.

In 2002, the National Institute of Water and Atmospheric Research Ltd (NIWA) released the results of research on the health effects of motor vehicle emissions. NIWA's report estimated that 400 premature deaths occur in New Zealand each year as a result of motor vehicle emissions.¹ In addition to premature deaths, acute and chronic health effects including asthma, heart disease and bronchitis, as well as increased hospitalisations and restricted activity days (sick days), are attributable to vehicle emissions.

A further 3-year research programme into the health effects of motor vehicle emissions is underway in New Zealand, with funding from the Ministry of Transport, the Ministry for the Environment, and the Health Research Council (HRC). This study is being managed by the HRC and is due for completion in 2005.

A 2003 literature review based on studies from New Zealand and overseas on the health impacts of particulate matter from all sources, including motor vehicle emissions, was carried out for the Ministry for the Environment. The review provided estimates of the health effects on a regional basis.² The review found that in Auckland and Christchurch there were an estimated 280 hospitalisations per year and 750,000 and 300,000 restricted activity days (sick days) respectively resulting from particulate air pollution. Significant proportions of these are believed to be attributable to vehicle emissions.

A number of overseas studies have also shown an association between respiratory disease and proximity to busy roads or roads used by a high number of heavy vehicles. Studies also suggest that children living near busy roads have an increased risk (approximately 50 percent) of developing respiratory disease.³ Children living within 50 metres of busy roads in Germany have been found to have nearly twice the risk of developing asthma symptoms.⁴

Estimates of the contribution of motor vehicle emissions to air pollution in Auckland and Christchurch are in the order of 70–90 percent for carbon monoxide and nitrogen oxides.⁵ Air monitoring has shown that both the New Zealand ambient air quality guidelines⁶ and international

¹ Fisher, G., et al., *Health Effects Due To Motor Vehicle Air Pollution In New Zealand*, Report to the Ministry of Transport, January 2002.

² *Health Effects of PM10 in New Zealand*, prepared by Environet Ltd for the Ministry for the Environment, Air Quality Technical Report No. 39, August 2003.

³ World Health Organisation (WHO) Regional Office for Europe. *Transport, Environment and Health*, WHO Regional Publications, European Series, No. 89, edited by Carlos Dora and Margaret Phillips, WHO, 2000.

⁴ Guo L., Nicolai T., and von Mutius E., Vehicle Fumes Increase Asthma Risk in Children, *European Respiratory Journal*, vol. 21, 2003, p. 956 and p. 964.

⁵ *Ambient Air Quality and Pollution Levels in New Zealand: Targets for Vehicle Emissions Control*, prepared by the Ministry for the Environment and the Ministry of Transport, Air Quality Report No. 9, December 1998.

⁶ Ministry for the Environment, *Ambient Air Quality Guidelines*, Ministry for the Environment 438, May 2002.

standards are regularly exceeded in urban areas such as Auckland, Christchurch, and Nelson and in some regional centres such as Timaru and Taupo.

Monitoring has found that concentrations of particulate matter, due mainly to emissions from home-heating fires used during winter and from motor vehicles, exceed ambient air quality standards in around 27 New Zealand towns and cities. Carbon monoxide and nitrogen dioxide concentrations also exceed the standards at certain sites located close to congested roads and intersections.

Ambient air pollutants

Ambient air pollutants can be divided into two categories.

(a) **Criteria pollutants**—these are the key pollutants from motor vehicles and their importance has long been recognised. They include carbon monoxide, nitrous oxides, photochemical oxidants (such as Ozone), sulphur dioxide, particles (such as PM₁₀), and lead. Since the introduction of unleaded premium-grade petrol in New Zealand in 1996, the detectable levels of lead have dropped to trace levels. Although lead may continue to be a concern for air quality in New Zealand in isolated locations, motor vehicles are no longer a significant contributor.

(b) **Air toxics**—These are pollutants present in the atmosphere in low concentrations that are known or suspected to cause serious health problems. Key air toxics produced by motor vehicles include polycyclic aromatic hydrocarbons and volatile organic compounds such as benzene and benzo[a]pyrene.

It should be noted that although vehicles are a significant contributor to air quality, they are not the only contributor (i.e. heating and industry are also significant sources).

Criteria pollutants

Carbon monoxide (CO)

Carbon monoxide enters the bloodstream via the lungs and attaches to blood haemoglobin. It can also aggravate cardiovascular disease. Extremely high concentrations of CO can cause death, but these concentrations do not occur in open air situations. Health effects from peak outdoor levels can include dizziness and headaches. The more susceptible subgroups include children, developing foetuses, and people with existing heart disease.

CO emission is caused by the incomplete combustion of fuels. Air emission inventories indicate that motor vehicle emissions and home heating are the main contributors to the build-up of CO emissions in most urban areas of New Zealand but that vehicle emissions dominate in Auckland (84 percent), Wellington (64 percent), Taranaki (71 percent), and Taupo (68 percent).

In most areas of New Zealand, concentrations of CO remain within the 'good' or 'excellent' air quality categories but there have been regular breaches of the CO national environmental standard close to busy roads and intersections during calm weather conditions, particularly in Auckland. In Christchurch, breaches often occur in winter at residential background and traffic sites, when there is a mix of CO from vehicles and home-heating fires.

Nitrogen oxides (NO_x)

Nitrogen oxides form nitric acid when they come into contact with the water in eyes, lungs, mucous membranes, and the skin. Laboratory studies indicate that susceptible humans (such as asthmatics) exposed to high concentrations of nitrogen dioxide (NO₂) can suffer lung irritation and potential lung damage. Epidemiological studies have found an association between NO₂ and daily mortality from respiratory and cardiovascular illnesses and an association with hospital admissions for respiratory conditions. Although concentrations of NO₂ in most parts of New Zealand meet the

national environmental standard, this standard has been exceeded at certain roadside sites in Auckland.

NO_x is produced by the combustion of fuels. In the presence of sunlight, nitrogen oxides in the air react with volatile organic compounds to form photochemical smog and ozone. Motor vehicle emissions are the dominant source of NO_x in most New Zealand urban areas and their recorded contribution in the four main population centres is 80 percent in Auckland, 68 percent in Wellington, 83 percent in Christchurch, and 93 percent in Hamilton.

Hydrocarbons (HC)

Hydrocarbons are a class of reactive organic gases that are formed solely of hydrogen and carbon. The primary health effect of hydrocarbons results from the formation of ozone and its related health effects. High levels of hydrocarbons in the atmosphere can interfere with oxygen intake by reducing the amount of available oxygen in the air through displacement.

Hydrocarbons also cause mucous membrane irritations, headaches, a loss of co-ordination, nausea, and liver damage. Some hydrocarbons are potentially carcinogenic.

Ozone (O₃)

Ozone is a respiratory irritant that at low concentrations can cause tissue injuries in the lungs and result in significant impairment of pulmonary function. The impact of O₃ on health depends on a number of factors, including concentration, duration of exposure, climate, individual sensitivity, and pre-existing conditions. Those most susceptible to concentrations of O₃ include children, people with pre-existing diseases, the elderly, and healthy adults exercising in the outdoors. The health implications of O₃ in New Zealand are difficult to determine because the amount of monitoring data is limited. However, based on the research released by the Committee on the Medical Effects of Air Pollution in the United Kingdom,⁷ O₃ concentrations experienced in Auckland may be linked to premature deaths.

Ground-level ozone is a secondary pollutant, formed when the primary pollutants NO_x and volatile organic compounds (VOC) combine in the presence of sunlight. The recorded contributions from motor vehicles for New Zealand four main population centres are 51 percent in Auckland, 41 percent in Wellington, 35 percent in Christchurch, and 53 percent in Hamilton. Figures as high as 81 percent have also been recorded in Taranaki.

Although monitoring of O₃ has not been carried out widely in other urban areas, the factors suitable for its formation (such as significant vehicle emissions, warm temperatures, sunlight, and still weather conditions) favour the existence of O₃ in Auckland, Christchurch, and Hamilton. O₃ is unlikely to be an issue in other urban areas.

Sulphur Dioxide (SO₂)

Sulphur dioxide (SO₂) is a potent respiratory irritant. When inhaled, SO₂ acts directly on the upper airways (nose, throat, trachea, and major bronchi), producing rapid responses, particularly in individuals with respiratory illnesses such as asthma. The symptoms of SO₂ inhalation may include wheezing, chest tightness, shortness of breath, or coughing.

Increases in hospital admissions and emergency-room visits for asthma and respiratory disease have been associated with ambient SO₂ levels. Long-term exposure to SO₂ and fine particle sulphates (SO₄²⁻) has been associated with an increase in mortality from lung cancer and development of asthma and with cardiopulmonary obstructive disease.

⁷ Department of Health, United Kingdom, 1998.

Motor vehicles are the dominant contributor to the build up of SO₂ in urban areas where industry emissions are minimal. Air quality monitoring for SO₂ in New Zealand, however, has largely been limited to Canterbury, Penrose (Auckland), and around some industrial sites. The Christchurch data showed that although there have been no recorded exceedances to the national environmental standard for the 1-hour average or 24-hour average from 1992–2001, there are some areas in the city where SO₂ concentrations have reached the 'acceptable' or 'alert' categories.

The recorded contributory values for motor vehicles in the four main population centres are 14 percent in Auckland, 12 percent in Wellington, 14 percent in Christchurch, and 65 percent in Hamilton. Figures as high as 77 percent have been recorded in Taupo.

SO₂ emissions from motor vehicles are dominated by diesel vehicles, an important issue given the increasing number of diesel-fuelled vehicles in the New Zealand fleet. This is expected to be offset by revised fuel specifications, including the progressive reduction of the maximum sulphur content in diesel fuels to 50 parts per million by 2006, making New Zealand fuels cleaner and bringing them into line with European standards.

Particulate matter (PM₁₀ & PM_{2.5})

Inhalation of fine particles, especially those smaller than 10 microns in diameter (PM₁₀), have been linked to premature death, respiratory diseases, and asthma attacks. A recent report estimated that 970 premature deaths occur each year in New Zealand from PM₁₀ inhalation⁸. This reinforces an earlier study published in *The Lancet*⁹ that linked premature deaths with air pollution and motor vehicle emissions in three European countries.

The key finding of the 2002 NIWA report stated that particulate pollution from motor vehicle emissions is responsible for an estimated 399 premature deaths per year of people aged over 30 years. The report also estimated that a total of 200 years of life lost due to motor vehicle emissions. These results are generally consistent with similar studies undertaken in Europe,¹⁰ North America,¹¹ and a recent study completed in Australia.¹²

Domestic heating is the principal source of PM₁₀ emissions in New Zealand, followed by motor vehicles (particularly diesel vehicles). The recorded contribution of motor vehicles varies from 0 percent (in Arrowtown, Wanaka, and Mosgiel) to 20 percent (in Taranaki). These data represent average wintertime emission sources. For PM_{2.5}, the data available on the contribution from motor vehicles is very limited and varies from 4 percent (in Timaru) to 32 percent (in Taranaki).

There are currently 27 urban areas in New Zealand where the maximum concentrations of PM₁₀ exceed 50 micrograms per cubic metre (µg/m³) (1-day average) more than 5 days a year. Four urban areas experienced maximum concentrations above 120 µg/m³ (1-day average). Due to the

⁸ Fisher, G., et al., *Health Effects Due to Motor Vehicle Air Pollution in New Zealand*, a report by NIWA to the Ministry of Transport, 2002.

⁹ Kunzli, N., et al., Public Health Impact of Outdoor and Traffic Related Air Pollution: A European Assessment. *The Lancet*, vol. 356, September 2000, pp. 795–801.

¹⁰ Kunzli, N., et al., Public Health Impact of Outdoor and Traffic Related Air Pollution: A European Assessment. *The Lancet*, vol. 356, September 2000, pp. 795–801.

¹¹ Dockery, D. W., et al., An Association between Air Pollution and Mortality in Six US Cities, *New England Journal of Medicine*, 329, 1993, pp. 1753–1759.

¹² Amoako, J., et al., *The Economic Consequences of the Health Effects of Transport Emissions in Australian Capital Cities*, Bureau of Transport and Regional Economics, presentation at the 26th Australasian Transport Research Forum, Wellington, New Zealand, 1–3 October 2003.

carcinogenic properties of particulate matter, health impacts are potentially serious even for the smaller urban centres.

Air toxics

Polycyclic aromatic hydrocarbons (PAHs)

PAHs are a group of over 100 organic compounds released into the atmosphere as a result of the incomplete combustion of organic matter. A number of them are known or suspected carcinogens. Long-term exposure to PAHs has been associated with lung cancer, depressed immune functions, and respiratory problems. In New Zealand, Benzo[a]pyrene (BaP), a five-ring PAH known for its carcinogenic potency, is used as an indicator for air toxics by the Ministry for the Environment. Only a small number of the emission inventories carried out in New Zealand have included an assessment of sources of BaP. Motor vehicles are recorded as contributing from between 2 percent (Timaru) and 17 percent (Taranaki) of emissions.

Monitoring of ambient air concentrations of BaP in New Zealand was unable to derive an annual average estimate of BaP concentrations because the detection limit for the method used—around 0.8 nanograms per cubic metre (ng/m^3) was higher than the guideline value ($0.3 \text{ ng}/\text{m}^3$). BaP concentrations were found in 8 percent of the samples (the highest concentration was found at Mount Eden).

Volatile organic compounds (VOCs)

VOCs, such as benzene, toluene, formaldehyde, and 1,3 butadiene are released from the combustion of fuels that contains carbon and from solvents such as glues and paints. Many VOCs can cause serious health problems such as eye, nose, and throat irritation and headaches. Chronic low-level exposure to some VOCs has also been associated with other adverse health effects. For example, benzene has been closely linked with leukaemia.

In New Zealand, benzene is used as an indicator for air toxics by the Ministry for the Environment. Only a small number of the emission inventories carried out have included an assessment of benzene sources. The recorded figures for relative contribution of benzene emissions from motor vehicles for the centres sampled are 32 percent in Timaru, 39 percent in Nelson, 42 percent in Christchurch, and 31 percent in Richmond. A 1993 Auckland air emissions inventory also indicates that motor vehicles are the most dominant source of benzene in Auckland.

Survey monitoring suggests that benzene concentrations in ambient air may have exceeded the current guideline at sites located near to major roads in central Auckland in 2002 and in Christchurch in 2003.

Benzene levels in exhaust emissions are due primarily to benzene levels in fuel. Fuel specification regulations will reduce benzene levels to 1 percent in 2006, consistent with other jurisdictions, such as Australia, Europe, and the United States of America (USA). This will result in a reduction in benzene exhaust levels.

New Zealand National Environmental Standards for ambient air quality

The Ministry for the Environment has developed the first suite of National Environmental Standards (NES), which are mandatory 'bottom-line' regulations that will apply nationally. These include five standards for ambient (outdoor) air quality. They apply for criteria pollutants only. There are currently no standards proposed for air toxics. The new regulations were gazetted on 6 September 2004 and will come into force on 1 September 2005.

The National Environmental Standards have the force of a regulation, and agencies responsible for managing emissions to air under the Resource Management Act 1991 (RMA) will be accountable

for ensuring that those standards are met. Compliance with the NES may also be used as a criterion for any resource consent applications for activities that discharge significant amounts of air pollutants. Setting formal national standards for ambient air quality provides a greater impetus for regional and national agencies to improve air quality. The New Zealand NES for air quality are outlined below and compared with other international standards.

Pollutant (averaging period)	New Zealand	Australia	United Kingdom	European Union	World Health Organisation
Particulate matter (PM ₁₀) (24-hour)	50 µg/m ³	50 µg/m ³	50 µg/m ³	50 µg/m ³	No safe level
Nitrogen dioxide (NO ₂) (1-hour)	200 µg/m ³	256 µg/m ³	200 µg/m ³	200 µg/m ³	200 µg/m ³
Ozone (1-hour)	150 µg/m ³	210 µg/m ³	-	170 µg/m ³	-
Sulphur dioxide (SO ₂) (1-hour)	350 µg/m ³	570 µg/m ³	350 µg/m ³	350 µg/m ³	-
Carbon monoxide (CO) (8-hour)	10 mg/m ³	-	-	-	10 mg/m ³

These standards are largely based on the *Ambient Air Quality Guidelines 2002* with the addition of two compliance criteria for most of the pollutants:

- a specified number of times that the standard limit can be exceeded per year
- an upper maximum limit that the ambient concentration cannot exceed even once.

The criteria aim to assist in determining non-compliance or when enforcement action should be taken.

National and regional air quality

Measurement of vehicle emissions in New Zealand is largely based on emission inventory studies carried out by regional councils for most of the larger urban areas of New Zealand. An emission inventory provides a quantitative assessment of the amount of a particular contaminant emitted from sources that include motor vehicles as well as domestic solid fuel burning and industrial emissions.

Methodological differences (including different test times, locations, and meteorological conditions) between these inventories and assumptions made relating to emission rates and fuel mean that the recorded figures have some degree of uncertainty.

Health-based ambient air quality guidelines

Pollutant	Ambient air quality value	Averaging time
Carbon monoxide	30mg/m ³	1 hour
	10mg/m ³	8 hour

Particulate matter (PM ₁₀)	50µg/m ³	24 hour
	20µg/m ³	annual
Particulate matter (PM _{2.5})	25µg/m ³	24 hour (assessment level)
Nitrogen dioxide	200µg/m ³	1 hour
	100µg/m ³	24 hour
Ozone	150µg/m ³	1hour
	100µg/m ³	8 hour
Benzene (year 2002)	10µg/m ³	annual
Benzene (year 2010)	3.6µg/m ³	annual
1,3-butadiene	2.4µg/m ³	annual
Formaldehyde	100µg/m ³	30 minutes
Acetaldehyde	30µg/m ³	annual
Benzo[a]pyrene	0.0003µg/m ³	annual

National environmental standards

Contaminant	Standard	Time average	Allowable exceedences per year	Start date
Particles (PM ₁₀)	50 µg/m ³	24 hours	1	1 September 2005
Sulphur dioxide (SO ₂)	350 µg/m ³	1 hour	9	1 September 2005
	570 µg/m ³	1 hour	0	1 September 2005
Carbon monoxide (CO)	10 mg/m ³	8 hours	1	1 September 2005
Nitrogen dioxide (NO ₂)	200 µg/m ³	1 hour	9	1 September 2005

Standard	Comment
Standards apply in ambient air wherever people may be exposed over the relevant time averaging period.	Does not apply indoors, in work places or inside vehicles. This may include roadsides (as exposure to hour NO ₂ concentrations are possible) but not tunnels (as exposure in tunnel is less than hour).

Monitoring for compliance to commence by 1 September 2005.	Councils to determine where to monitor. Ministry for the Environment to provide guidance on how and where.
Public reporting on any breaches of standards by 1 September 2005.	Ministry for the Environment to provide guidance and assist with training in standard methodologies for ambient monitoring.
In event of breach, council to prepare implementation plan to demonstrate compliance by 2013.	Original proposal was for compliance within 34 years.
Constraints on resource consents: Councils to take into account the net result of all activities and decisions taken towards improvement of air quality.	Provides more flexibility and recognises that industry is not significant contributor.

World Health Organisation guidelines for air pollutants

The World Health Organisation (WHO) is the main international body responsible for evaluating risks posed to human health by air pollution. Guideline values for air pollutants were first derived in 1958, and in 1987 the WHO Regional Office for Europe published the *Air Quality Guidelines for Europe (WHO 1999a)*. These guidelines have been revised and updated since 1993, and in December 1997 an Expert Task Force Meeting extended the guidelines for air quality and produced the *WHO Guidelines for Air Quality*. The values outlined in that document for vehicle emission pollutants provided estimated levels of air pollution below which lifetime exposure (or exposure for a given averaging time) was not believed to constitute a health risk. It is important to note that if the limits are exceeded in the short term, it does not automatically mean that adverse effects will occur but that the risk of such effects increases. The WHO guidelines for air pollutants are as follows.

Compound	Annual ambient air concentration ($\mu\text{g}/\text{m}^3$)	Observed effect level ($\mu\text{g}/\text{m}^3$)	Uncertainty factor	Guideline value ($\mu\text{g}/\text{m}^3$)	Averaging time
Carbon monoxide (CO)	500–7000	not applicable	not applicable	100,000 60,000 30,000 10,000	15 minutes 30 minutes 1 hour 8 hours
Nitrogen dioxide (NO ₂)	10–150	365–565	0.5	200	1 hour
Ozone (O ₃)	10–100	not applicable	not applicable	120	8 hours
Sulphur dioxide (SO ₂)	5–400	1000 250	2 2	500 125	10 minutes 24 hours

		100	2	50	1 year
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The figures for air quality provided in the *WHO Guidelines for Air Quality* are guidelines rather than standards. Standards for air quality are promulgated by individual governments and take additional factors such as the prevailing exposure levels, the natural background contamination, and environmental conditions such as humidity, temperature, and socioeconomic factors into account.

3. The New Zealand fleet and vehicle emissions

Make-up of the New Zealand vehicle fleet

New Zealand has one of the highest rates of car ownership in the world (perhaps as high as number two). One survey calculates a total of 526 vehicles per 1000 in comparison to 570 vehicles for the USA, 283 for Japan, and 446 for Australia.¹³

The New Zealand fleet is very diverse, with over 600,000 different vehicle makes and models recorded in New Zealand's motor vehicle register. Since 1996, there has been a significant increase in the number of cars and four-wheel drives (4WDs) imported and this shows no signs of decreasing, as ownership demand increases with population. Between 2000 and 2003, the New Zealand vehicle fleet grew by 9.15 percent (which included high motor vehicle sales in 2003).

There are currently estimated to be around 3.7 million motor vehicles in New Zealand.¹⁴ The *Motor Vehicle Registration Statistics 2003* by the Land Transport Safety Authority (LTSA) break those motor vehicles into 'vehicle types' as follows.

Vehicle type	Total	Percentage of total motor vehicles
Light (< 3500kg)		
Cars (includes utes and small vans)	2,473,501	79.9%
Motorcycles and mopeds	84,170	2.7%
Heavy (> 3500kg)		
Trucks	452,628	14.6%
Tractors	32,045	1.04%
Motor caravans	16,937	0.55%
Buses and coaches	16,205	0.52%
Mobile machines	12,599	0.41%
Low volume		
All-terrain vehicles (ATVs)	2,462	<0.1%
Special purpose vehicles ¹⁵	2,182	<0.1%
Agricultural machines ¹⁶	1,384	<0.1%

¹³ Utrecht University in the Netherlands, worldwide statistics current to 2001.

¹⁴ Source: LTSA 30/09/04.

¹⁵ Vehicles designed for specialised purposes unrelated to transport (such as construction machinery, military equipment, and so on).

Source: LTSA publication, Motor Vehicle Registration Statistics 2003.

Age of the fleet and service life

The average age for all light passenger vehicles in the New Zealand fleet is 11.5 years and increasing. Since 1999, the average age of cars has risen by 3.5 percent, that of trucks by 4.9 percent, that of buses by 3.2 percent, that of motor caravans by 0.3 percent, and that of motorcycles by 8.5 percent.

Analysis of the age of motor vehicles suggests that although newer vehicles are being introduced into the New Zealand fleet, many of the older vehicles are being retained for longer periods.

An approximate breakdown of vehicle age is provided below

	Less than 2 years old	≥ 10 years old	≥ 30 years old*
Cars	7.8%	47.6%	3.23%
Motorbike	12.3%	35.8%	10.4%
Trucks	12.0%	41.3%	3.71%
Buses	8.5%	38.5%	3.72%
Motor caravans	8.77%	27.3%	17.95%

Source: LTSA publication, *Motor Vehicle Registration Statistics 2003*.

In comparison, the average age of passenger vehicles in the European Union's 15 states (as at 1998) is 7.3 years,¹⁷ and this varies from a high of 10.2 years in Portugal to a low of 4.2 in Luxembourg. The United Kingdom fleet has an average age of 6.3 years. The average age of passenger vehicles in Australia is 10.1 years. However, in the emissions context the year of manufacture carries greater significance than the average age—when the vehicle was built in terms of continually evolving automotive technologies for emissions control.

For example in New Zealand, the introduction of used Japanese imports since the late 1980s has had a significant, beneficial effect on the emissions capability of this country's vehicle fleet. Although the average age of the Japanese used imports is 7 years, due to strict manufacturing standards, market drivers, and a rigorous Japanese in-service test (the '*shaken*' test), many of the used imports are believed to have adequate emission-control systems.

It is anticipated that the average age of the New Zealand vehicle fleet will continue to remain in the region of 11–12 years for some time. There is a risk that the benefits of improvements in emission-control technologies from imported vehicles may be offset should the number of vehicles on New Zealand roads continue to grow. This would be exacerbated both by the increased number of kilometres travelled by the New Zealand fleet and the increasing urban traffic densities (as increasing congestion has a significant impact on emissions rates per kilometre). Other factors (such as rising fuel and vehicle prices) could significantly change that projection.

¹⁶ Combine harvesters and so on.

¹⁷ European Environment Agency (EEA)—The EU 15 states are; Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

Fuel types

The majority of motor vehicles in the New Zealand fleet (83 percent) are fuelled by petrol. Alternative fuelled vehicles, including those fuelled by compressed natural gas (CNG), liquid petroleum gas (LPG), and electricity, make up approximately 0.1 percent of the New Zealand fleet.

In recent years, the New Zealand fleet has experienced a steady but continuing increase in the proportion of diesel-fuelled vehicles (particularly heavy vehicles). In 2003, diesel-fuelled vehicles were estimated to make up 17.2 percent of the total fleet. The recorded increase in diesel vehicles is shown below.

Vehicle type	Percentage of total fleet fuelled by diesel			
	Year end 2000	Year end 2001	Year end 2002	Year end 2003
Cars (including 4WDs)	6.7%	6.9%	7.3%	7.9%
Motorcycles	-	-	-	-
Trucks	53.5%	55.6%	57%	60%
Buses and coaches	72.1%	73.7%	75.9%	78%
Motor caravans	66.7%	69.9%	72.9%	76%
Tractors	89.2%	89.8%	90.1%	91%

Source: LTSA publication, *Motor Vehicle Registration Statistics 2000–2003*.

The increase in diesel-fuelled vehicles in the light-vehicle fleet is largely due to the increased number of diesel-fuelled 4WDs introduced into New Zealand since 1996. Numbers rose from approximately 3000 in 1996 to approximately 15,000 in 2002.

A recent study by NIWA and the Auckland Regional Council (in 2003) for light-vehicle emissions in Auckland noted that 14 percent of the vehicles sampled were fuelled by diesel. It also noted that approximately 10 percent of the older vehicles sampled were fuelled by diesel, whereas 20 percent of the more recently manufactured vehicles were fuelled by diesel.

A significant proportion of diesel-fuelled vehicles in New Zealand are heavy vehicles (buses, trucks, and so on). In general, heavy vehicles tend to travel significantly longer distances and contribute more emissions per kilometre than light vehicles. A breakdown of data from road user licences indicates that the number of diesel-fuelled vehicles is increasing. Annual road user charges also show that the overall distances travelled by passenger and freight diesel-fuelled vehicles (heavy and light combined) have increased significantly from 2.99 billion kilometres in 1997 to 3.58 billion kilometres in 2002.¹⁸

It is likely that the number of diesel-fuelled vehicles in the New Zealand fleet will continue to increase steadily over time, consistent with market trends in the USA and Australia.

¹⁸ LTSA, *Review of Heavy Vehicle Safety*, August 2003.

Contribution to air pollution by vehicle type

Light passenger vehicles

Light passenger cars and vans make up almost 69 percent of the total New Zealand motor vehicle fleet. The principal pollutants emitted by petrol-fuelled, light passenger vehicles are CO, HC, and NO_x. The increasing number of diesel-fuelled passenger vehicles also means increased volumes of sulphur dioxide, VOCs (including aromatic compounds such as benzene and PAHs), fine particulate matter, and reactive organic compounds.

Heavy goods vehicles

Almost all heavy goods vehicles in the New Zealand fleet are fuelled by diesel. A breakdown of data from road user charges (based on the number of kilometres travelled) indicates that the number of kilometres travelled by trucks has increased significantly over the years from 1.9 billion in 1997 to 2.2 billion in 2003—an increase of almost 15 percent over 6 years.¹⁹

A comparison of heavy and light diesel-fuelled vehicles indicates that despite the lower number of heavy vehicles, the distances they travel are significantly higher than the distances travelled by light vehicles.

Buses and coaches

As with heavy goods vehicles, there are significantly fewer buses and coaches on New Zealand roads than light passenger vehicles. Due to the large loads they carry and the fact that they are generally used more frequently than light passenger vehicles, buses are believed to contribute a greater volume of emissions per vehicle than light passenger vehicles. Analysis of road user licence data also indicates that the distances travelled by heavy diesel-fuelled buses has increased from 0.19 billion kilometre in 1997 to 0.23 billion kilometre in 2002—an increase of approximately 21 percent over 6 years²⁰.

Almost all buses in New Zealand are diesel fuelled. Therefore, the most significant emissions contributed by the bus fleet would include NO_x, VOCs, particulate matter, and reactive organic compounds.

Motorcycles, mopeds, and all-terrain vehicles

Motorcycles make up 2.4 percent of New Zealand's total motor vehicle fleet.²¹

Two-wheel vehicles using two-stroke engines emit substantial quantities of HC, CO, and particulate matter. They use high proportions of lubricating oil, usually up to 2 percent of the fuel. Unlike the four-stroke engine, which has an oil-sump, the lubricating oil in the two-stroke engine is introduced along with the air-fuel mixture and is emitted primarily as smoke.

Internationally, the tendency is that the relative contribution of vehicle emissions from motorcycles is rising due to the introduction of restrictive measures for other types of vehicle. In the USA and Europe, amendments to motorcycles emissions limits for manufacturers are being made for implementation in 2006 (Europe and the USA) and 2010 (USA). The new emissions controls in the USA will be for highway motorcycles. Due to the low percentages of motorcycles in the national fleets (and the small size of their motor engines), emissions screening programmes for

¹⁹ LTSA, *Review of Heavy Vehicle Safety*, August 2003.

²⁰ LTSA, *Review of Heavy Vehicle Safety*, August 2003.

²¹ Figure as of 30/09/04—source LTSA

motorcycles are not performed in many countries. The exceptions to this are for certain densely populated countries (such as India, Taiwan, and Thailand) that rely on the motorcycle as an essential means of transportation.

Motor caravans

Motor caravans make up 0.5 percent of the New Zealand motor vehicle fleet (0.17 percent less than 3500 kilograms and 0.33 percent greater than 3501 kilograms).²² The number of privately owned motor caravans is believed to be significantly smaller than the number of motor caravans used for self-guided touring in commercial rental fleets.

As with buses, the majority (76 percent) of motor caravans in New Zealand are diesel fuelled, thereby contributing emissions of SO₂, VOCs, particulate matter, and reactive organic compounds. Approximately 24 percent of the motor caravan fleet is fuelled by petrol contributing CO, HC, and NO_x emissions.

Tractors

Tractors make up 0.19 percent of the New Zealand vehicle fleet and the majority of these are fuelled by diesel (91 percent). In general, tractors are designed for off-road use and do not travel major distances. They are not believed to contribute significant emissions to the environment. Most of the distances travelled by tractors are in rural areas as opposed to the urban areas identified as being of concern for the impact of emissions on health.

Other vehicles

As with tractors, the majority of other vehicles used in New Zealand are designed for specific off-road purposes. These include mobile machines (such as graders), agricultural machines (such as combine harvesters), and special purpose vehicles (such as military vehicles). Although these vehicles have large engines, the distances travelled (and associated emissions) are minimal.

²² Figures as of 30/09/04. Source, LTSA

4. Entry and in-service certification regimes

Entry certification regime

When used vehicles enter New Zealand they undergo a basic check by Ministry of Agriculture and Forestry (MAF) Quarantine officials,²³ who record importer details, vehicle identity details (vehicle identification number and chassis number, make, and model), odometer readings, whether the vehicle is left-hand drive or right-hand drive, and any obvious structural damage or repair. MAF officials send this information to the LTSA Transport Registry Centre for inclusion on the LANDATA database.

Once MAF and Customs procedures have been completed, vehicles are released to their importers. Before they can be registered for use on the road, they must be certified as complying with all applicable entry requirements. There are four organisations currently authorised by the LTSA to carry out entry certification—Vehicle Testing New Zealand (VTNZ), Vehicle Inspection New Zealand (VINZ), OnRoad New Zealand, and the New Zealand Automobile Association (NZAA). In total, these organisations use approximately 290 entry compliance centres throughout New Zealand to carry out entry certification inspections.

A vehicle inspector checks each vehicle's documentation to prove that the vehicle met all applicable legal, safety, and emissions standards at the time it was manufactured. The vehicle inspector is also responsible for a thorough inspection to ensure that imported vehicles meet safety requirements related to the performance and condition of their systems, parts, and components. There are additional procedures for used heavy vehicles and specialist vehicles (such as buses), which need to be inspected by specialist inspectors.

The vehicle inspector adds additional vehicle information to the LANDATA database. When a vehicle is certified as complying with all requirements (including the Vehicle Emissions Rule), the vehicle inspector will issue a MR2A form (which allows the vehicle to be registered). A Warrant of Fitness (WoF) or Certificate of Fitness (CoF) label is attached as evidence that the vehicle has passed its first inspection.²⁴ Importers can have repairs carried out to bring vehicles into compliance.

The entry certification regime for New Zealand new vehicles is not discussed in this discussion document, as it will not be affected by the proposed vehicle emissions screening programme.

In-service inspection regime

All vehicles in the New Zealand fleet are inspected periodically to make sure that they meet minimum safety requirements. Vehicles need a current WoF or CoF in order to be driven legally on New Zealand roads. The in-service regime differs from entry certification in that proof of standards compliance at the time of manufacture is not required as part of the in-service inspection.

²³ Some vehicles undergo the border check by MAF quarantine officers at facilities in Japan (approximately 60 percent of Japanese imports).

²⁴ There may be cases where the vehicle won't be driven and registration, licensing, and WoF labelling might be delayed (for example, if the owner is a dealer and the vehicle has not been sold).

Warrant of fitness inspections

Light vehicles (vehicles with a gross vehicle mass of 3500 kilograms or less) and others identified in the *Land Transport Rule: Vehicle Standards Compliance 2002* are required to have a WoF. Light vehicles include most cars, vans, utes, and many 4WDs.

Testing stations and LTSA authorised agents can inspect vehicles and issue WoFs to vehicles that meet the requirements set out in the *Vehicle Inspection Requirements Manual*. If a vehicle fails a WoF inspection and the previous WoF has expired, that vehicle cannot legally be driven unless it is being operated solely for the purpose of bringing it into compliance and obtaining a new WoF. A re-inspection is free of charge if the vehicle is returned to the same WoF inspection organisation within 28 days of the first inspection.

WoF inspections are required:

- every 12 months from the date of inspection for a vehicle that is less than 6 years from its year of manufacture

or

- every 6 months from the date of inspection for any other vehicle.

Certificate of fitness inspections

Heavy motor vehicles (with a gross vehicle mass of greater than 3500 kilograms)—those operating under a transport service licence (such as taxis, courier vehicles, and so on) and others as identified in the *Land Transport Rule: Vehicle Standards Compliance 2002*—are required to have a CoF.

Testing stations inspect vehicles and issue CoFs to vehicles that meet the requirements set out in the *Vehicle Inspection Requirements Manual*.

As with the WoF process, if a vehicle fails a CoF inspection and the previous CoF has expired, that vehicle cannot be legally be driven unless it is being operated solely for the purpose of bringing it into compliance and obtaining a new CoF. A re-inspection is free of charge if the vehicle is returned to the same testing station within 28 days of the first inspection.

CoF inspections are required:

- every 6 months from the date of inspection

or

- for a class MA rental vehicle that was new when first registered in New Zealand
 - (a) 12 months from the date of inspection

or

 - (b) 6 months from any subsequent inspection.

Alternative fuel inspections

Vehicles with alternative fuels such as CNG or LPG are required to have an additional safety inspection in addition to the WoF or CoF inspection. Approved agents specialising in alternative fuel systems inspect for faults such as leaks, corrosion to lines and tanks, fractures in the tank structure, and insecure lines.

The owner is provided with an Alternative Fuel Inspection Certificate as proof of inspection. If faults are detected during the alternative fuel inspection that result in an inspection failure, no certificate is issued until the necessary repairs are carried out.

The alternative fuel system is usually inspected before the vehicle is taken for a WoF or CoF inspection. Alternatively, vehicles can be submitted to an agent approved by the LTSA to carry out both the alternative fuel inspection and the WoF or CoF inspection.

The WoF or CoF will be withheld if a current Alternative Fuel Inspection Certificate is not supplied. Alternatively, the fuel system can be fully discharged.

Compliance and enforcement

Entry certification

Vehicles that do not meet the entry certification requirements set out in the *Vehicle Inspection Requirements Manual* cannot be issued with an MR2A form and cannot, therefore, be registered for use on New Zealand roads. If emission performance requirements were introduced, this would prevent the certification of vehicles with emission-control equipment that did not meet the requirements. If a vehicle that has failed the entry certification inspection has appropriate repairs carried out to fix the fault, the vehicle can be re-tested and, if it complies with the appropriate performance requirement, will be issued with a MR2A form.

Enforcement of the WoF and CoF regimes

A WoF or CoF label provides the evidence that a vehicle complied with the inspection requirements on the day of the inspection. The label states the date that the next WoF or CoF is due. It is illegal to drive a motor vehicle on the road if it does not:

- meet the WoF or CoF requirements
- or
- display a current WoF or CoF label.

This label is the principal mechanism for enforcement of the WoF and CoF regimes. The New Zealand Police and local-authority parking wardens enforce the requirement to display a current WoF or CoF label and issue infringement notices for non-compliance.

The police can require any vehicle to stop for a roadside vehicle check and routinely set up checkpoints to carry out random roadside inspections. These include (amongst others) inspecting current licences, checking that seatbelts are worn, and ensuring the vehicle has a current WoF or CoF.

In addition, LTSA Vehicle Compliance Officers carry out audits of transport operators to ensure that their vehicles meet all legal requirements and are safe to be operated on the roads.

The Commercial Vehicle Investigation Unit (CVIU) is a nationally managed police unit responsible for monitoring all areas of the commercial vehicle industry, including trucks, buses, taxis, couriers, mobile cranes, and mobile homes. CVIU enforcement officers operate both mobile and fixed weigh-bridge stations where commercial vehicles are inspected to ensure they comply with the legal requirements. The CVIU also has a number of Vehicle Safety Officers who carry out in-depth vehicle inspections. Approximately 140,000 commercial vehicles are inspected by the CVIU every year.

On-road enforcement by the New Zealand Police

In addition to an infringement notice, the police can issue the following to the owner of a vehicle that does not comply with all of the legal requirements:

- Pink sticker—where there is reason to believe that a vehicle is not in a safe condition to be driven on the road, the police can issue a pink sticker under Section 115(3) of the Land Transport Act 1998. A vehicle issued with a pink sticker must be inspected by a vehicle inspector employed by a testing station and be issued with a new WoF or CoF in order to be used on the road. When a new WoF or CoF is issued, the vehicle inspector removes the sticker and the owner takes the completed section to the police, who will remove the flag from their system.
- Green sticker—if there are reasonable grounds to believe that the vehicle does not comply with the legal requirements, the police can issue a green sticker under Section 115(1) of the Land Transport Act 1998. A vehicle that has been issued with a green sticker must be inspected by a vehicle inspector be issued with a new WoF before it can be used on the road. When a new WoF is issued, the vehicle inspector removes the sticker and the owner takes the completed section to the police, who will remove the flag from their system.
- Verbal or written direction—if a vehicle does not comply with the legal requirements, a verbal direction can be issued or a written direction on a Traffic Offence Notice provided to direct the vehicle to a place for repairs.

Smoky vehicle rule

Section 28 of the Traffic Regulations 1976 provides the only statutory control for in-service vehicle exhaust emissions. This regulation provides the police with the power to issue an instant fine to the owner of a vehicle that emits excessive amounts of smoke. Visible smoke or vapour emitted from a vehicle for a continuous period of more than 10 seconds is considered to be excessive. In addition to a fine the police can issue an instruction for the vehicle to be repaired and for the owner to present evidence of the repair within a certain time.

Performance review system

The LTSA Vehicle Certification Unit (VCU) makes sure that vehicle inspection activities carried out by garages, testing centres, and specialist vehicle inspectors are accurate, consistent, and in compliance with the requirements in the Vehicle Standards Compliance Rule 2002.

The VCU is based in Wellington and maintains a nationwide network of certification reviewers. Reviewers implement the Performance Review System (PRS) to assess the performance of certifiers and support them and the vehicle certification industry. The unit also produces technical guides for inspectors including the *Vehicle Inspection Requirements Manual*, to help inspectors achieve consistency in vehicle inspections. In addition, the VCU assesses those inspectors' training needs required to carry out certification activities and approves training programmes for vehicle inspectors.

6. Measuring exhaust emissions

The two principal test methods for measuring exhaust emissions are mass emission tests and concentration tests.

(1) Mass emission tests

These tests directly measure the mass of emitted pollutants. Results are expressed in grams of pollutant emitted over distance travelled. In general, mass emission tests require a dynamometer—a treadmill-like machine (that is, a rolling road) to allow cars to be tested under conditions that simulate on-road driving.

(2) Concentration tests

These tests measure the relative pollutant concentrations in a vehicle's exhaust as an indicator of the quality of combustion and the engine's maintenance condition. As the measurement is a concentration measurement, it does not give a measure of the absolute amount of emissions generated.

These tests normally measure:

- concentrations of exhaust carbon monoxide (CO)
- concentrations of exhaust hydrocarbons (HC)
- exhaust air-fuel ratio (lambda value).

Emissions tests for petrol-fuelled vehicles

A range of tests, varying in sophistication, are available to measure vehicle emissions for petrol-fuelled vehicles. The more sophisticated tests are predominantly 'loaded' tests (tests carried out with the engine of the vehicle in gear), such as the transient test (IM 240) or the static test (ASM). Loaded tests allow for the mass measurement of emissions rates under controlled test conditions. Loaded tests are considered to give a better representation of on-road conditions for CO and HC and can also be used to measure NO_x emissions.

'Simple' tests such as the two-speed-Idle/High Idle test tend to be cheaper and require less investment in testing equipment but are less accurate than the loaded tests. In addition, if the control function is working well and the catalyst operation can be verified through the CO and HC levels measured, NO_x concentrations are not normally far outside the type certification levels for that vehicle.

The following are the principal vehicle emissions tests used internationally for petrol-fuelled vehicles. The less sophisticated (and therefore, the less costly) the procedure, the less representative of actual engine performance condition it is likely to be.

IM 240 (or loaded transient) test

The Federal Test Procedure (FTP) 75-test cycle is a certification test used by vehicle manufacturers in the USA for measuring the tailpipe and exhaustive emissions before the vehicle can be sold. The IM 240 test replicates certain parts of the FTP-75 test.

The IM 240 test is one of the most complex tests for screening emissions and is in limited use for regular in-service screening. It is considered to provide the nearest test results to normal transient driving. During the test, it reproduces the vehicle inertia while undergoing varying speeds and conditions for 240 seconds.

Equipment for the IM 240 includes:

- a transient dynamometer that can achieve speeds of up to 57 miles per hour (equivalent to 91.6 kilometres per hour)
- maintenance and calibration gases
- a critical flow venturi—a choked orifice that maintains a constant high flow rate of 350 cubic feet per minute through a venturi
- a constant volume sampling system that converts exhaust concentration levels into mass emissions
- exhaust gas analysers that can measure low diluted exhaust levels
- a flame ionisation detector to measure total HC, a NDIR analyser to measure CO and CO₂, and a chemiluminescent analyser to measure NO_x
- computer support
- specific vehicle bays.

The high cost of the IM 240 system restricts its application to centralised programmes. In practice, this means that repairs must be carried out at separate repair-only facilities. A number of states in the USA have also complained about the cost and complexity of this test relative to perceived benefits in terms of air quality control. For this reason, many states in the USA use variations of the IM 240 test that include 'fast/pass' or a 'fast/fail' procedures and shortened versions that reduce the testing time by several minutes and use slightly cheaper equipment.

ASM 50/15 and ASM 25/25—Acceleration simulation mode (or loaded static) tests

The ASM test procedure is easier to conduct than the IM 240 and is often used as an alternative to the more comprehensive IM 240 test, mainly for decentralised test programmes. The test involves running vehicles on a fixed high load at a low speed of 15 to 25 miles per hour (equivalent to 24.1 to 40.2 kilometres per hour) on a chassis dynamometer that simulates both vehicle inertia and road load. There are two ASM modes:

- 50/15—vehicles operated on a dynamometer for 90 seconds at 15 miles per hour while loaded with 50 percent of the maximum FTP load for that vehicle type
- 25/25—vehicles operated at 25 miles per hour while loaded with 25 percent of the maximum FTP load for that vehicle type.

The different speed and load conditions for the 50/15 and 25/25 tests exercise different aspects of the vehicle emission-control system so some programmes run both tests sequentially, and vehicles must pass both in order to pass the emissions test. The different sets of results for failing vehicles also assist technicians in fault diagnosis. Unlike the IM 240, these tests do not simulate deceleration load but they do enable detection of most emission control problems.

ASM equipment is estimated to cost between one-quarter to one-third the cost of the transient IM 240 equipment.

Equipment for the ASM test includes:

- a dynamometer
- maintenance and calibration gases
- a constant volume sampling system that converts exhaust concentration levels into mass emissions

- exhaust gas analysers (BAR 90/BAR 97 that incorporate extensive automation of the inspection process)
- computer support
- specific vehicle bays.

Idle / High Idle (or simple) test

This is a relatively simple test that provides an approximate representation of overall engine operating condition but does not require a dynamometer facility. Although simple tests are unlikely to detect emissions control device problems that occur only under engine load conditions (or identify when an exhaust catalyst is starting to fail), they can identify ‘gross emitting’ vehicles. For instance, vehicles’ fuel-mixture preparation systems can be checked by inspecting the performance of the idle mixture orifice in the idle test and the main fuel-metering orifice in the fast-idle test. A car emitting too much at idle and/or increased idle speed is likely to be a high emitter at almost any operating point of the engine.

The simple test is not effective in detecting high NO_x emissions, as meaningful measurements of NO_x require the engine to be under load.²⁵

The test’s relative accuracy is reflected by the unsophisticated pass/fail measures that must necessarily apply for in-service emission standards. However, the Idle / High Idle test is easily applied and produces fewer false passes and false fails when used to target the worst emitters in a vehicle fleet.

Equipment required for the simple test includes:

- exhaust gas analysers
- maintenance/ calibration gases
- exhaust pipe probe and associated sampling system.

The main advantage of the simple test is that depending on the range of emissions checks included, the equipment requirements are significantly less than other tests.

Comparison of emission testing methods

The following table compares the effectiveness of the three principal test types in their ability to detect common emissions component failures.²⁶ The ability to detect particular failures may be determined by the pass/fail cut-off points set in the in-service emissions standard. For example, emissions from a vehicle with a degrading oxygen sensor may successfully pass the simple test but not an ASM or IM 240 test.

Test type	Test and diagnostic efficiency and ability to detect component failures							
	FTP correlation	O2 sensors failure	Bad EGR valve	Bad catalytic converter	Bad PCV	Ignition problem	Carburettor problem	Others
Simple idle	Poor	Good	Poor	Good	Fair	Fair	Fair	Fair

²⁵ Air Pollution from Motor Vehicles—Standards and Technologies for Controlling Emissions

²⁶ The Importance of the “M” in Vehicle Inspection & Maintenance (I/M), Tom Cross, Environmental Systems Products Inc, USA

ASM	Poor to fair	Good	Good	Good	Very good	Very good	Good	Good
IM 240	Very good	Very good	Very good	Good	Very good	Very good	Very good	Very good

Equipment costs

A study carried out for the Roads and Traffic Authority (RTA) of New South Wales on the cost-effectiveness of different options for vehicle testing was carried out in the major urban areas of Sydney, Newcastle, and Wollongong in 1997. This study provided the following estimated equipment costs for three different test types.²⁷ These were derived from estimates provided by the RTA and the Environmental Protection Agency based on their experiences of purchasing equipment.

Test type	Capital cost per unit (AUD)	Annual maintenance charges (AUD)	Installation costs per unit (AUD)
Idle test	\$15,000	10%	-
ASM test	\$45,000	10%	\$4000
IM 240 test	\$200,000	10%	\$4000

The equipment costs calculated for this Australian study cannot be directly compared to the costs of similar test systems set up within New Zealand as part of the proposed emissions screening programme. Many factors in the design of the programme will influence overall costs. They do, however, give an indication of the differences in scale between the establishment costs associated with each test type.

Alternative fuels

The tests used to measure emissions from vehicles fuelled by alternative fuel sources such as CNG and LPG are the same as those used for vehicles with petrol engines. If the vehicle is a dual system (is equipped with a CNG system as well as a petrol system), the emissions test can be carried out with the use of the petrol only.

Emissions tests for diesel-fuelled vehicles

Diesel engines are not designed to produce excess visible smoke; if they do, it is a direct and obvious sign that the engine requires maintenance. In-service emissions tests for diesel-fuelled vehicles involve the measurement of exhaust-smoke densities using an opacimeter. This is an instrument that measures the amount of light that can be transmitted through an exhaust plume. The opacimeter can measure either smoke density (the percentage opacity) or the light absorption coefficient ('K' value) depending on the type of opacimeter used. Essentially, there are two types used:

- full-flow opacimeters measure the opacity of a cross-section of the full exhaust plume just as the plume exits a vehicle exhaust pipe; as exhaust pipes are not uniform (not a standard size and shape) the result must be corrected for the path length across which the transmitted light passes

²⁷ Cost Effectiveness of Vehicle Emissions Testing Programs—4 June 1997

- partial-flow opacimeters measure the opacity of the exhaust gas sample taken from inside the exhaust pipe within a cell of fixed path length. With this method, all measurements are consistent but generally still corrected to a standard tailpipe diameter for consistency with full-flow smoke meter readings.

Emission test methods for diesel-fuelled vehicles can be broken into two types: transient tests and steady-state tests.

Transient tests

Transient tests provide an effective means of identifying a variety of common emissions system defects. There are two common transient tests used internationally:

- on-road acceleration test—the vehicle is either started from standstill or is rolling at low speed, following which the accelerator is depressed to a maximum for 6–10 seconds or more
- snap acceleration (or snap idle) test—when the transmission is in neutral and the engine at normal idle the accelerator pedal is depressed to a maximum for five seconds or until the engine reaches the governed speed, the pedal is then released and the engine returned to normal idle; although simple and convenient, this does not always give a reliable measure of smoke emissions in actual use, so it is necessary to set a somewhat looser in-service emission standard to avoid failing vehicles that are functioning properly. This technique must also be carefully applied so as not to risk engine damage.

Although a minority of seriously malfunctioning diesel vehicles exhibit measurable smoke opacity under idle (or light-load) conditions, these test types are generally considered more suitable for identifying gross emitters of particulate matter and for this reason, any in-service emissions performance limits would be required to take this into account.

Equipment typically required for transient tests includes:

- an opacimeter sampling probe
- a sample chamber
- a data-processing and reporting system.

Steady-state tests

Steady-state tests are carried out with the engine under load and provide a better indicator of engine condition. There are four common steady-state tests:

- stall test—the engine is operated with a wide-open throttle with the automatic transmission engaged in drive and the brakes engaged to prevent vehicle motion
- lug-down test—the engine is operated at wide-open throttle with the vehicle mounted on a dynamometer; the dynamometer load is increased to reduce engine speed (lug-down) from rated revolutions per minute to some fraction (usually around 70 percent) of rated revolutions per minute—. In the absence of a dynamometer, the vehicle can be artificially loaded (lugged down) by the careful application of the vehicle brakes
- cruise mode test—the vehicle is tested by applying a single load, while operated at a constant speed on a dynamometer
- DT80 short test—the Australian National Environment Protection Council developed this test for in-service diesel vehicles; the DT80 test is a relatively aggressive mixed-mode transient test having three full load accelerations to 80 kilometres per hour and a steady-state 80 kilometres per hour cruise, it requires a dynamometer with inertia simulation; with the exception of the sample used for opacity measurement, the vehicle exhaust is diluted and emissions analysed

from samples from the dilution tunnel. This test is the only test that measures exhaust emissions for NO_x and particulate as well as exhaust opacity.

Equipment typically required for steady-state tests includes:

- a chassis dynamometer
- a sample-handling system
- emissions instrumentation (a laser-light photometer, opacimeter, analysers, and so on)
- a data acquisition and processing and reporting system.