CHAPTER 2

Transport Department

Environmental Protection Department

Diesel vehicle emission controls

Audit Commission
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DIESEL VEHICLE EMISSION CONTROLS

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PART 1: INTRODUCTION

1.1 This PART describes the background to the audit and outlines its objectives and scope.

Background

1.2 Clean air is essential for good health. A recent study conducted by the University of Hong Kong and the Chinese University of Hong Kong indicated that, of those patients admitted to public hospitals because of respiratory and cardiovascular illnesses in 2000, 7,700 (10%) would have been related to air pollution. Polluted air can damage not only human health but also buildings, plants, and even soil and water. Millions of dollars were spent every year on combating air pollution and on rectifying its effects.

1.3 In 1987, the Government established 14 air quality objectives (AQOs) under the Air Pollution Control Ordinance (Cap. 311) to provide a framework for air quality management in Hong Kong. The AQOs spell out the maximum safe levels of major air pollutants in the ambient air. Table 1 shows the 14 AQOs and the associated health effects if they are not met.

Table 1

Hong Kong's air quality objectives

Pollutant	**Average concentration in micrograms per cubic metre (μg/m³)**					**Associated health effects**
	1 hour (Note 1)	**8 hours (Note 2)**	**24 hours (Note 2)**	**3 months (Note 3)**	**1 year (Note 3)**	
Total suspended particulates			260		80	Respirable fraction of total suspended particulates has effects on health (see below).
Respirable suspended particulates			180		55	Respirable illness, reduced lung function, risk of cancer, and increase in morbidity and mortality rates.
Sulphur dioxide	800		350		80	Respirable illness, reduced lung function, and increase in morbidity and mortality rates.
Nitrogen dioxide	300		150		80	Respirable irritation, increased respiratory infection, and lung development impairment.
Carbon monoxide	30,000	10,000				Coordination impairment, and deleterious to pregnant women and those with heart and circulatory damage.
Ozone	240					Eye irritation, cough, reduced athletic performance, and possible chromosome damage.
Lead				1.5		Body processes affected, likely neuro-psychological effects, likely effects on heart attacks, strokes, and hypertension.

Source: EPD records

Note 1: The concentration of the pollutants averaged over any 1 hour should not exceed the specified value for more than three times a year.

Note 2: The concentration of the pollutants averaged over a period of 8 hours or 24 hours should not exceed the specified value for more than once a year.

Note 3: The concentration of the pollutants averaged over a period of 3 months or 1 year should not exceed the specified value.

1.4 Since 1987, the Government has implemented a number of measures to improve the air quality in Hong Kong (see Appendix A). However, the relatively high concentration of air pollutants at roadside level, particularly respirable suspended particulates (RSPs) and nitrogen dioxide, is still a major concern for public health (see also para. 1.9).

1.5 RSPs are small particles of less than 10 microns in diameter that remain suspended in the air for weeks. Once inhaled, they penetrate deep into the lungs and lymphatic system, aggravate respiratory conditions like asthma, decrease lung functions, increase respiratory stress, and may even cause premature death.

1.6 Nitrogen dioxide is formed from the oxidation of nitric oxide emitted from fuel combustion. Nitrogen dioxide and nitric oxide are often collectively referred to as nitrogen oxides. Short-term exposure to nitrogen oxides aggravates respiratory illnesses while long-term exposure can lower a person's resistance to respiratory infections and aggravate existing chronic respiratory diseases.

1.7 The high concentration of RSPs and nitrogen oxides at roadside level is mainly caused by diesel vehicle emissions. These emissions are often trapped by high-rise buildings and hilly surroundings. Diesel vehicles in Hong Kong are mainly commercial vehicles. They cover about 40% of the total distance travelled on the roads, and account for about 90% each of RSPs and nitrogen oxides emitted by all vehicles throughout the territory. Reduction of emissions from diesel vehicles is therefore vital to the prevention and abatement of roadside air pollution in Hong Kong.

Government programme to reduce diesel vehicle emissions

1.8 In 1999, the Chief Executive announced in his Policy Address that the Government would allocate HK$1.4 billion to implement a comprehensive programme to reduce RSP emissions from vehicles by 80% and nitrogen oxides emissions from vehicles by 30% by 2005. The Government's main strategies for implementing this programme are to:

(a) adopt tighter fuel and vehicle emission standards;

(b) adopt cleaner alternatives (e.g. liquefied petroleum gas) to diesel where appropriate;

(c) control emissions from the remaining diesel vehicles with devices that reduce RSPs;

(d) strengthen vehicle inspections and enforcement against smoky vehicles; and

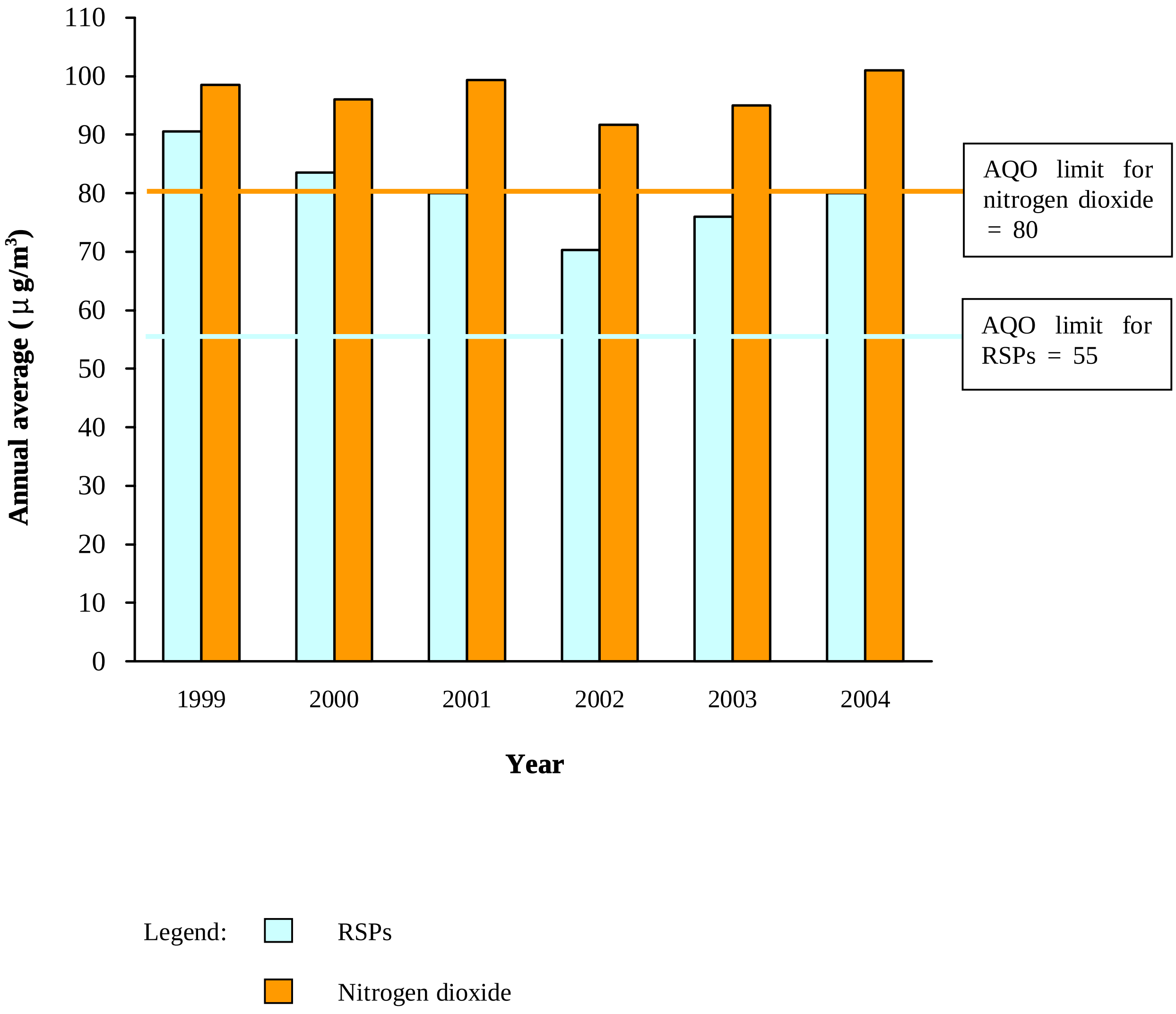
(e) promote better vehicle maintenance and eco-driving habits.

Level of pollutants still exceeds Air Quality Objectives

1.9 Despite the implementation of the programme mentioned in paragraph 1.8, in 2004, the annual averages of RSPs and nitrogen dioxide at roadside level still exceeded the respective maximum safe levels as laid down in the AQOs by a considerable margin (45% and 26%). Figure 1 shows the annual averages of RSPs and nitrogen dioxide at roadside level between 1999 and 2004.

Figure 1

Annual averages of RSPs and nitrogen dioxide at roadside level (1999 to 2004)



Source: *EPD records*

Remarks: *One of the roadside air quality monitoring stations (i.e. the Mongkok station) was relocated in 2001.*

Audit review

1.10 Established in 1987, the current annual average RSPs and nitrogen dioxide AQOs are 18 years old, and are generally less stringent as compared to those in other countries (see Appendix B). However, these annual average AQOs are still exceeded at roadside level. The Audit Commission (Audit) has recently conducted a review to examine whether there is room for further reducing the concentration of RSPs and nitrogen dioxide at roadside level. This audit focused on the following areas:

(a) diesel vehicle inspection and maintenance programme;

(b) smoky vehicle control programme; and

(c) use of liquefied petroleum gas.

1.11 Audit has found that there are areas where further improvements can be made and has made a number of recommendations.

Acknowledgement

1.12 Audit would like to acknowledge with gratitude the full cooperation of the staff of the Transport Department (TD) and the Environmental Protection Department (EPD) during the course of the audit review.

PART 2: DIESEL VEHICLE INSPECTION AND MAINTENANCE PROGRAMME

2.1 This PART examines the effectiveness of the diesel vehicle inspection and maintenance programme.

Background

2.2 To ensure a reasonable level of vehicle maintenance and proper functioning of vehicle emission controls, Japan, the United States, some countries in Europe and an increasing number of developing countries have established periodic inspection and maintenance programmes for vehicles. Inspection and maintenance serve the following two purposes in a vehicle emission control programme:

(a) to identify vehicles in which malfunction or other mechanical problems are causing high emissions. According to a study conducted by the United Nations, a worn or damaged fuel injection system of a diesel vehicle can increase emissions of particulate matter at least twenty-fold; and

(b) to discourage tampering with emission control equipment or engine. One common cause of high-smoke emissions from diesel engines is tampering with the maximum fuel setting on the fuel injection pump. This provides more fuel to the engine, thus increasing power output and smoke.

2.3 A study conducted by the United Kingdom (UK) Department of Trade and Industry in 2000 also indicated that:

(a) a thorough inspection system would make owners maintain their vehicles better; and

(b) inspection and maintenance of vehicles could result in average reduction of RSP emission by 9%.

2.4 At present, all diesel vehicles in Hong Kong are subject to a regular inspection programme on emission as part of their annual inspection and roadworthiness test. Section 25 of the Road Traffic Ordinance (Cap. 374) empowers the Commissioner for Transport to refuse to license or cancel the licence of a vehicle if it is found to be not roadworthy, including non-compliance with the requirements made under section 43(1) of the Air Pollution Control Ordinance in relation to the prohibition or control of the emission of air pollutants from motor vehicles. In this PART, Audit examines the effectiveness of the diesel vehicle inspection and maintenance programme in the following areas:

(a) the TD smoke test procedures;

(b) the use of dynamometer in smoke tests; and

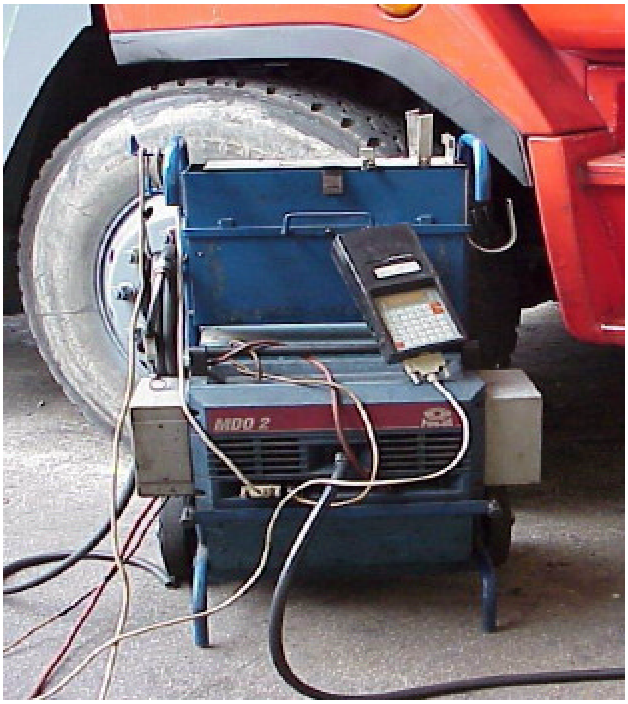
(c) the smoke opacity standard adopted.

Transport Department smoke test procedures

2.5 Presently, the TD is using the free acceleration smoke test procedures to test smoke emissions from diesel vehicles. During the test, the vehicle's accelerator pedal is pressed firmly to its full-throttle position, accelerating the engine from low idle speed to its maximum governed engine speed. This procedure is repeated several times until the emission of a similar density for three successive tests is recorded by the smokemeter (see Photograph 1). It is worth noting that during the test, the vehicle's transmission gear is not engaged i.e. the engine is unloaded. Consequently, the smoke emitted during the free acceleration smoke test can be far less than that in actual driving conditions.

Photograph 1

Smokemeter



Source: TD records

International standards

2.6 The World Bank has been reviewing the air quality management in South Asia for a number of years. It has found that the free acceleration smoke test procedures are very sensitive to tester style. For example, slight differences in the time taken to accelerate the engine from low idle speed to maximum governed engine speed can lead to different smoke opacity readings. It also notes that high-emission vehicles can pass the free acceleration smoke test by unorthodox practices, such as engine tampering (Note 1) or exhaust diluting (Note 2). To address these limitations, it has suggested that free acceleration smoke test needs a set of carefully defined test protocols that are to be followed strictly. In this connection, Audit notes that the United States Environmental Protection Agency (US EPA) has recommended a set of standards (Note 3) which specify how the free acceleration smoke test should be carried out.

Transport Department procedures
different from US EPA recommended standards

2.7 Audit compared the TD free acceleration smoke test procedures (laid down in the TD tester manual, standing instructions and technical bulletins) with the US EPA recommended standards. In doing so, Audit staff visited two of the TD vehicle examination centres to attend 10 free acceleration smoke tests. Audit noted that the TD tester manual, standing instructions and technical bulletins were issued in the 1980s and the early 1990s. Compared to the US EPA recommended standards (which were issued in 1996), differences were found in a number of areas. Table 2 shows the main differences between the TD procedures and the US EPA recommended standards in test repeatability and prevention of malpractice.

Note 1: *For a diesel engine, decreasing the fuel delivery of the fuel injection pump and resetting the engine's speed governor to a lower revolution per minute are two common practices which can produce less smoke emissions at the expense of lower engine power output. Often, the engine will be re-adjusted to its former state after the free acceleration smoke test.*

Note 2: *Exhaust smoke can be diluted with clean air by partially withdrawing the smoke sampling probe (see Photograph 2 in para. 2.11) from the exhaust pipe or by exhaust pipe leakage. Another way of reducing visible smoke is putting a handful of gravel in the exhaust pipe just before the smoke test.*

Note 3: *The US EPA recommended standards are the Society of Automotive Engineers J1667. The standards specify the procedures of the free acceleration smoke test, the instruments, and correction factors for ambient conditions.*

Table 2

Comparison between TD procedures and US EPA recommended standards

Test procedure	TD procedures	US EPA recommended standards
Check that all installed devices that may alter the normal acceleration characteristics of the engine are deactivated	**Not required**	Required
Check the engine speed limiting capacity of the engine governor	**Not required (Note 1)**	Required
Check that the engine is within its normal operating conditions	**Not required**	Required
The manner and sequence of actuating vehicle throttle are clearly described	**Required (Note 2)**	Required
The positioning of the sampling probe of the smokemeter is specified	**Not required**	Required
Engine speed is monitored using a tachometer	**Not required**	Required
Smoke opacity readings need to be adjusted according to the ambient air test conditions	**Not required**	Required

Source: Audit analysis

Note 1: According to the TD, since 2000, the maximum governed engine speed has been checked to guard against any tampering with engine setting to achieve better results.

Note 2: The TD allows the vehicle driver to actuate the vehicle throttle, while the US EPA recommended standards stipulate that the actuating of vehicle throttle should be carried out by the tester.

2.8 In response to Audit enquiries, the TD stated that:

(a) the TD smoke test was carried out as part of the annual roadworthiness test;

(b) most of the smoke test procedures required by the US EPA recommended standards were being carried out by TD vehicle testers at different stages of the roadworthiness test prior to the smoke test. The seven items referred to in Table 2 were followed one way or the other. For instance, the TD ensured that:

(i) the devices that might affect engine acceleration (such as air-conditioner) were turned off;

(ii) the engine had been warmed up to a certain extent;

(iii) the air-tank-recharge test of the braking system was carried out before the free acceleration smoke test; and

(iv) the position of the probe inside the tailpipe was fixed through the use of specific clamp;

(c) every TD vehicle tester had been trained by the smokemeter suppliers on the correct operation of the equipment. All the required steps were followed as a matter of course, though not specifically set out in the tester manual; and

(d) nevertheless, the TD agreed to revise and update its smoke test procedures, where appropriate.

Maximum engine speed check not carried out

2.9 According to the Code of Practice on free acceleration smoke test issued by the TD for EPD designated vehicle emission testing centres (DVETCs), the engine idling speed and maximum speed attainable shall be checked using an approved tachometer. However, Audit noted that the TD tester manual, standing instructions and technical bulletins did not provide for such a requirement. During visits to the TD vehicle examination centres, Audit staff found that no maximum governed engine speed check had been carried out. In response to Audit enquiries, the TD explained that:

(a) after the Code of Practice was issued for the DVETCs, the TD tried to use tachometers (such as Roto Phon and AVL diSpeed 490) to enhance the check to guard against any tampering with engine setting. However, problems such as interference and inaccuracy were noted with the equipment. The check was thus resumed to visual and audible check; and

(b) the TD would continue to source suitable tachometer for the test.

Relying solely on tester experience to guard against malpractices

2.10 Apart from checking leakage of the exhaust pipe (which is a possible cause of exhaust diluting), the TD tester manual, standing instructions and technical bulletins did not specify any other checks to guard against malpractices. During Audit visits to the TD vehicle examination centres, the test centre supervisors informed Audit staff that:

(a) no specific checks were carried out to screen out those vehicles, of which the engine settings had been tampered with; and

(b) the testers were experienced and could screen out those vehicles by listening to the engine sound.

Drivers were involved in free acceleration smoke tests

2.11 According to the TD technical bulletins, drivers are allowed to be involved in free acceleration smoke tests by actuating the engine throttle according to the instructions given by the testers. During their visits to the TD vehicle examination centres, Audit staff found that drivers were also involved in the setting up of the smokemeter. Of the 10 free acceleration smoke tests attended by Audit, the drivers inserted the smoke sampling probe (see Photograph 2) into the exhaust pipe in 9 tests (Note 4). The testers responsible did not verify whether the sampling probe was properly inserted. In this connection, it is worth noting that the US EPA recommended standards have specified very stringent requirements on the positioning of the sampling probe because this can affect the test results significantly.

Note 4: *In one test, Audit could not identify the person who inserted the smoke sampling probe.*

Photograph 2

Smoke sampling probe

Source: Photograph taken by Audit

Audit observations

2.12 Audit findings in paragraphs 2.7 to 2.11 indicate that some procedural aspects of the TD free acceleration smoke test can be improved. **Audit considers that the TD should:**

(a) **update the free acceleration smoke test procedures;**

(b) **take action to ensure that the free acceleration smoke test procedures are strictly followed, particularly the procedures for preventing/detecting malpractices (e.g. alteration of maximum engine speed).** This could be done by providing training for testers, and carrying out surprise verification inspections periodically; and

(c) **ensure that drivers are not involved in the free acceleration smoke test.**

Audit recommendations

2.13 **In order to improve the effectiveness of the free acceleration smoke test, Audit has *recommended* that the Commissioner for Transport should:**

(a) **update the TD smoke test procedures with reference to relevant standards of advanced countries;**

(b) **provide testers with appropriate training so that they are aware of the limitations of the free acceleration smoke test procedures, and are alert to common malpractices;**

(c) **conduct periodic verification inspections to ensure that the procedures and standards laid down in the TD tester manual are strictly followed; and**

(d) **prohibit drivers from participating in setting up the test equipment, and ensure that they are not involved in the test procedures, unless under proper supervision.**

Response from the Administration

2.14 The **Commissioner for Transport** generally agrees with the audit recommendations. He has said that:

(a) the free acceleration smoke test is an internationally accepted method, and is the most common procedure for testing emissions from in-use diesel vehicles in Europe and North America;

(b) the TD will revise the tester procedures and manual as appropriate to spell out clearly the procedural requirements;

(c) training and refresher course will be provided to TD vehicle testers to update their knowledge on inspection work;

(d) close supervision and surprise checks will be arranged as appropriate;

(e) the current arrangement of TD supervising the vehicle driver to actuate the vehicle throttle would avoid disputes over liability, should any damage to the engine arise during the test; and

(f) the TD will take additional monitoring measures to reduce the chance of malpractices and strengthen the supervision on driver action in the free acceleration smoke test.

Use of dynamometer in smoke emission test

2.15 In late 2000, the TD installed a chassis dynamometer at the Kowloon Bay Vehicle Examination Centre to enhance the effectiveness of smoke tests (see Photograph 3). The dynamometer consists a set of rollers. During the dynamometer smoke test, the vehicle is driven on rollers (see Figure 2). One of the rollers transmits power from the vehicle to the dynamometer. The dynamometer applies braking resistance to retard roller rotation to simulate the road load of the vehicle (i.e. inertia of the vehicle as well as drag and friction).

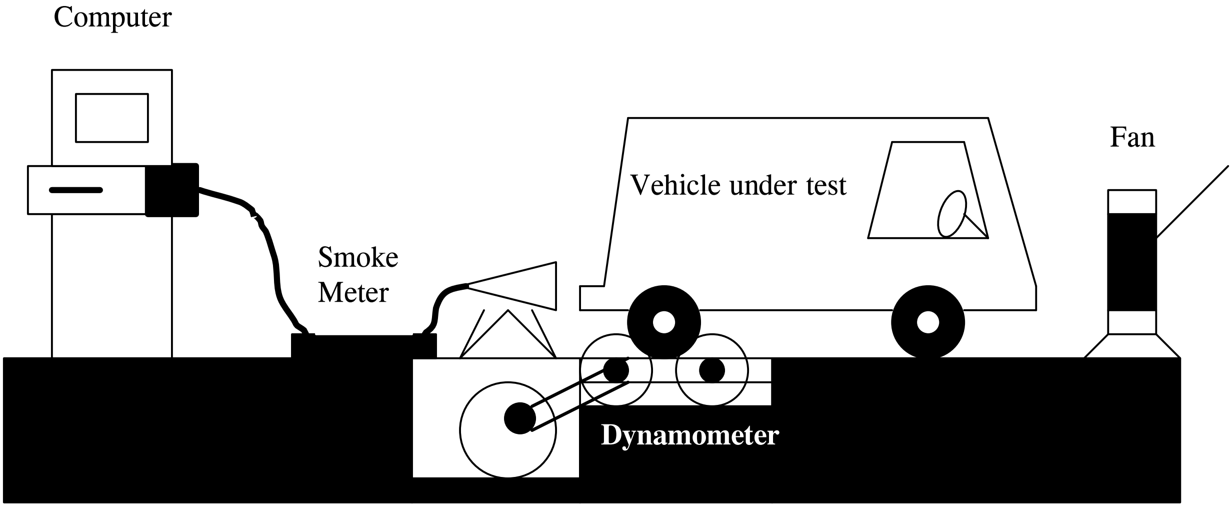
Photograph 3

Vehicle smoke-tested using dynamometer

Source: TD records

Figure 2

Typical set-up of dynamometer smoke test equipment



Source: Audit drawing

2.16 The dynamometer smoke test assesses a vehicle's emissions under almost actual driving conditions and helps screen out those vehicles with tampered engines. For this reason, it is widely accepted that the dynamometer smoke test is more effective. Statistics kept by the TD also confirm that this test is more effective in screening out smoky vehicles (Note 5).

2.17 When the dynamometer became fully operative in 2002 (Note 6), the TD pledged that 10% of the diesel vehicles presented for the annual roadworthiness test at the Kowloon Bay Vehicle Examination Centre would be randomly selected to undergo the

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Note 5: *When dynamometer was first used, the TD noted that the smoke test passing rate gap between the free acceleration test (90%) and the dynamometer test (15%) was 75%. The gap has since been narrowed. Nevertheless, the 2003 figures still show a gap of 34%. Audit had not compared the passing rates of 2004 because the small number of dynamometer smoke tests conducted in 2004 (see Table 3 in para. 2.18) might not be representative.*

Note 6: *The dynamometer was installed in late 2000 and became fully operative in 2002. The dynamometer smoke tests carried out in 2001 were mainly for training and trial purposes.*

dynamometer smoke test. Audit notes that the TD is installing another dynamometer at this centre to expand its dynamometer smoke test capacity.

Audit observations

Very few smoke tests were carried out using dynamometer

2.18 Audit examination of the smoke test records of the Kowloon Bay Vehicle Examination Centre for the period 2002 to 2004 indicated that:

(a) 2002 was the year in which the largest number (i.e. 2,566) of dynamometer smoke tests was conducted; and

(b) 9.4% of the smoke tests conducted in 2002 used the dynamometer (see Table 3).

Table 3

Number of smoke tests conducted at the Kowloon Bay Vehicle Examination Centre (2002 to 2004)

Year	Number of smoke tests	Number of dynamometer smoke tests
2002	27,277	2,566 (9.4%)
2003	25,808	902 (3.5%)
2004	26,535	114 (0.4%)

Source: TD records

2.19 The test centre supervisors of the Kowloon Bay Vehicle Examination Centre informed Audit staff that the small number of dynamometer smoke tests conducted in 2003 and 2004 was due to the renovation works carried out at the centre and shortage of staff.

2.20 According to the TD, the average time required to complete a dynamometer smoke test was about 23 minutes. On this basis, Audit estimates that, if the dynamometer was fully utilised, at least 4,700 tests could be conducted in a year (Note 7). Based on this figure, the dynamometer utilisation rate (Note 8) was low. In 2002 when the largest number (i.e. 2,566) of tests was conducted, the utilisation rate of the dynamometer was only 55%. The utilisation rates were 19% in 2003 and 2.4% in 2004.

2.21 Smoke tests using dynamometer are more effective and reliable. **Audit considers that it is desirable to increase the number of dynamometer smoke tests. The low utilisation of the dynamometer indicates a waste of resources. The TD needs to address this problem before the installation of the second dynamometer is completed.**

Repeated dynamometer tests

2.22 Audit examination of the 114 dynamometer smoke test records of 2004 indicated that:

(a) the 114 tests were conducted on 79 vehicles. Of these vehicles, 22 (28%) were tested at least twice. Sixteen of these 22 vehicles failed the initial test because of insufficient power output. In response to Audit enquiries, the testing centre supervisor explained that, if a vehicle failed the initial test, the tester would repeat the test if asked by the drivers, provided that the subsequent test was conducted on the same day; and

(b) repeated tests were free of charge, if conducted on the same day. However, it is worth noting that the EPD DVETCs charge vehicle owners for every smoke test carried out, including repeated tests (see para. 3.3).

2.23 In response to Audit enquiries, the TD stated that:

(a) the dynamometer smoke test was more challenging; and

(b) the vehicle repair trade would take time to develop the right vehicle repair skill, especially the engine tuning skill.

Note 7: *Taking into account the need for maintenance and inspection, Audit assumes that the dynamometer is used 7 hours a day and 260 days a year. If 23 minutes (or 2.6 tests per hour) are allowed for each test, the maximum number of dynamometer smoke tests that can be conducted annually is 4,732 (7 hours per day × 260 days × 2.6 per hour).*

Note 8: *The utilisation rate is calculated as follows:*

(*Number of dynamometer smoke tests carried out ÷ 4,700) × 100%*

2.24 **Audit considers that the TD should require vehicle owners to pay for repeated dynamometer smoke tests, unless it is demonstrated that the initial test has not been properly carried out.**

Engine power output check

2.25 Dynamometer smoke test is considered to be more reliable than free acceleration smoke test. One of the reasons is that, during the dynamometer smoke test, the maximum engine power output is checked. This check enables testers to screen out those vehicles, the engines of which have been tampered with.

2.26 Audit examination of the dynamometer smoke test records also indicated that:

(a) a lenient standard was adopted for the maximum engine power output check. The TD would pass a vehicle if its maximum engine power output during the dynamometer smoke test exceeded 50% of that specified by the vehicle manufacturer; and

(b) of the 79 vehicles that were dynamometer smoke-tested in 2004, 70 passed the smoke test. However, during the tests, only one of these 70 vehicles produced 80% or more of their maximum engine power output. Forty-nine percent of the vehicles that passed the test produced only 60% or less of their maximum engine power output (see Appendix C).

2.27 **Audit considers that the adoption of a lenient standard for maximum engine power output check has created a loophole. A smoky vehicle could easily pass the test by reducing its maximum engine power output beforehand.** The audit observation mentioned in paragraph 2.26(b) suggests that some of the 70 vehicles might have passed the dynamometer smoke test by this means.

2.28 **In order to ensure that the dynamometer smoke test is properly conducted and to screen out malpractices such as engine tampering, Audit considers that it is important that a stringent standard is adopted for the maximum engine power output check.**

Audit recommendations

2.29 **Audit has *recommended* that the Commissioner for Transport should:**

(a) **ensure that more vehicles undergo the dynamometer smoke test to improve the utilisation of the dynamometer;**

(b) **ascertain the reasons for those cases in which repeated dynamometer smoke tests were conducted on the same vehicle;**

(c) **require vehicle owners to pay for repeated smoke tests, unless the initial test has not been properly carried out; and**

(d) **consider adopting stringent standards for the maximum engine power output check.**

Response from the Administration

2.30 The **Commissioner for Transport** generally agrees with the audit recommendations. He has said that:

(a) subject to the availability of resources, the TD will arrange for more vehicles to undergo the dynamometer smoke test to improve the utilisation of the dynamometer;

(b) the current fee charged by the TD is the annual vehicle examination fee and smoke test is only a part of the annual vehicle examination. On the issue of charging vehicle owners for repeated smoke tests, the TD will explore with relevant parties on the proposed requirements; and

(c) the TD and the EPD have been using the same engine output requirement for the dynamometer smoke test. According to the EPD, the current standard for the maximum engine output is already stringent. Since the introduction of the dynamometer smoke test under the EPD's smoky vehicle control programme, the general vehicle maintenance condition has improved considerably. The TD will, in conjunction with the EPD, review the situation with the trade.

Smoke test standard

2.31 Presently, the TD smoke test standard is 60 Hartridge Smoke Units (HSUs) (Note 9). According to the EPD, smoke that reaches 60 HSUs should be visible against the background of asphalt.

TD standard is lenient

2.32 The current 60-HSU standard adopted by the TD was set in the 1970s. In 1992, the EPD proposed to tighten this standard to 50 HSUs. It commented that the 60-HSU standard was easy to pass. In 1993, the Motor Trade Association of Hong Kong also commented that vehicles that were manufactured in 1990 and thereafter, if properly maintained, should have no difficulties in complying with the proposed 50-HSU standard throughout their useful life.

Note 9: *HSU is a unit to measure smoke opacity, i.e. the level of light that is being blocked by the smoke emitted. Sixty HSUs mean that about 60% of light is blocked by the smoke emitted.*

International comparison of smoke opacity standard

2.33 Table 4 summarises the smoke opacity standards that are currently adopted by Hong Kong and other Asian countries. It shows clearly that Hong Kong's 60-HSU standard is less stringent.

Table 4

Smoke opacity standards of Asian countries and Hong Kong

Country/Territory	Smoke opacity standard	Remarks
1. Pakistan	40 HSUs	
2. Thailand	45 HSUs	
3. Cambodia	50 HSUs	
4. Indonesia	50 HSUs	
5. Malaysia	50 HSUs	
6. Singapore	50 HSUs	
7. Korea	25% opacity for buses	Approximately equivalent to 50 HSUs
	30% opacity for other diesel vehicles	Approximately equivalent to 55 HSUs
8. Hong Kong	60 HSUs	
9. Bangladesh	65 HSUs	
10. India	65 HSUs	

Source: Audit research and EPD records

Audit observations

2.34 A key objective of the vehicle smoke test is to ensure that vehicles are properly maintained. It is important that the standard used is periodically reviewed and updated to ensure that it is suitable for the purpose. Audit findings mentioned in paragraphs 2.32 and 2.33 show that the current 60-HSU standard appears too lenient and is not effective in screening out vehicles that are not properly maintained. Taking into consideration the fact that the standard presently adopted by the EPD is 50 HSUs (see para. 3.6), **Audit considers that the TD needs to tighten the smoke opacity standard.**

Audit recommendations

2.35 **Audit has *recommended* that the Commissioner for Transport should:**

(a) **tighten the smoke opacity standard; and**

(b) **in coordination with the Director of Environmental Protection, consider establishing a mechanism to review regularly the standard for smoke tests.**

Response from the Administration

2.36 The **Commissioner for Transport** agrees with the audit recommendations and has said that the TD will work together with the EPD on this issue.

PART 3: SMOKY VEHICLE CONTROL PROGRAMME

3.1 This PART examines the effectiveness of the smoky vehicle control programme (SVCP).

Background

3.2 The SVCP is operated by the EPD. It was started in 1988. Under the SVCP, trained spotters (Note 10) would spot smoky vehicles and report them to the EPD. The EPD, under the delegated authority from the Commissioner for Transport, would serve an emission testing notice (ETN) on the owners of the spotted smoky vehicles, requiring them to bring their vehicles to one of the EPD DVETCs for smoke tests.

3.3 The objective of the SVCP is to ensure that every spotted smoky vehicle has its smoke defects rectified. The licence of a vehicle that has not been presented for the smoke test or has failed the smoke test within a specified period may be cancelled. The owners of the spotted vehicles are allowed to repair and present their vehicles to smoke test as many times as they wish, upon payment of an inspection fee for each test.

3.4 In this PART, Audit examines the effectiveness of the SVCP in the following areas:

- (a) the EPD smoke test;
- (b) SVCP administrative procedures;
- (c) monitoring the performance of DVETCs;
- (d) joint operations with the Police; and
- (e) the recruitment of spotters.

Note 10: *Trained spotters include EPD officers and accredited persons. All spotters are volunteers, with the exception of those EPD and Police officers and staff of tunnel companies who perform spotting work as part of their normal duties.*

Environmental Protection Department smoke test

3.5 The DVETCs are privately owned and managed. In conducting the EPD smoke test, these centres are required, under the Tenth Schedule of the Road Traffic Ordinance, to comply with the Code of Practice issued by the Commissioner for Transport. The Code of Practice covers various aspects including:

(a) the appointment and authority of approved testers and their supervisors;

(b) the physical layout and test facilities of the DVETCs;

(c) the test procedures;

(d) the smoke test standards and passing criteria; and

(e) quality control, staffing and general management of the DVETCs.

As at 31 December 2004, there were 11 DVETCs.

3.6 Audit examination of the Code of Practice issued to the DVETCs by the TD indicated that the smoke test under the SVCP was more stringent than the smoke test under the TD's vehicle inspection programme. First, all smoke tests under the SVCP were required to be conducted using a dynamometer (Note 11). Second, the standard adopted for the SVCP was 50 HSUs. Under the TD's vehicle inspection programme, the standard was 60 HSUs.

Audit observations

3.7 Audit supports the wider use of dynamometer and the adoption of a more stringent smoke test standard (see PART 2). **However, Audit considers that the use of different procedures (the TD mainly uses free acceleration smoke test, and the EPD DVETCs use dynamometer smoke test) and the existence of two standards (the 60 HSUs of the TD and the 50 HSUs of the EPD) for the smoke test are unsatisfactory as they may cause confusion.**

Note 11: *In cases where it is considered that the dynamometer smoke test is inappropriate, the DVETCs are allowed to use free acceleration smoke test procedures for conducting the EPD smoke test. In 2004, only 22 vehicles were tested using the free acceleration smoke test procedures.*

Audit recommendation

3.8 **Audit has *recommended* that the Commissioner for Transport and the Director of Environmental Protection should consider adopting a uniform set of smoke test procedures and a common smoke test standard for the TD and the EPD.**

Response from the Administration

3.9 The **Commissioner for Transport** and the **Director of Environmental Protection** generally agree with the audit recommendation. They have said that:

(a) the current practice of using a combination of free acceleration smoke test and dynamometer smoke test for diesel vehicle annual examination is a cost-effective means to control smoke emissions. With the installation of an additional dynamometer, the TD will increase the use of dynamometer to test smoke emissions from diesel vehicles. The TD will, in conjunction with the EPD, consider the feasibility of requiring vehicles with outstanding ETNs to have their smoke emissions checked by a dynamometer;

(b) the EPD and the TD consulted the transport trades in 2003 about harmonising the smoke test standards to 50 HSUs (the current EPD standard). The trades objected to the proposed harmonisation. They also did not consider the existence of two standards confusing; and

(c) the EPD and the TD have agreed to consult the transport trades again about the harmonisation proposal.

Smoky vehicle control programme administrative procedures

Suspected smoky vehicles are allowed to remain on the road for too long

3.10 Under the SVCP, once a smoky vehicle is reported to the EPD, an ETN should be issued to its owner within three working days. The vehicle owner concerned would have to take his vehicle to one of the DVETCs for the EPD smoke test within 14 days. Therefore, under the current practice, a suspected smoky vehicle may remain on the road for up to 17 days.

3.11 In 2003 and 2004, the EPD issued 17,810 ETNs. Audit examination of these cases indicated that:

(a) about 99% of the ETNs were issued within three working days; and

(b) all owners were allowed more than 14 days to take their vehicles to the DVETCs for the EPD smoke test. In 3,156 cases (or 18%), the time allowed was more than 30 days (see Table 5).

Table 5

Time allowed for owners to take their vehicles to the DVETCs for EPD smoke test in 2003 and 2004

Time allowed	Number of cases		
14 days	—	0%	
15 to 20 days	13,284	74%	
21 to 30 days	1,370	8%	
More than 30 days	3,156	18%	(Note)
Total	**17,810**	**100%**	

Source: *EPD records*

Note: *Of these 3,156 cases, the owners of 10 vehicles were allowed more than 200 days.*

3.12 In response to Audit enquiries, the EPD stated that its current practice allowed vehicle owners 14 working days (Note 12) to have their vehicles passed the EPD smoke test at the DVETCs. The EPD estimated that about 17% of the cases in 2003 and 2004 were allowed more than 14 working days.

Withdrawal of ETNs

3.13 The EPD may withdraw an ETN if:

Note 12: *According to the EPD, the prescribed period for a smoky vehicle to pass the smoke test at a DVETC had been tightened progressively from 18 working days in 1992 to 14 working days in 1997, which is also the EPD's current requirement.*

(a) the vehicle concerned has passed the TD smoke test (see PART 2) before the EPD smoke test due date stipulated in the ETN; or

(b) the vehicle owner can prove that his vehicle was wrongly spotted.

3.14 The scenario mentioned in paragraph 3.13(b) was rare. Of the 3,592 withdrawal cases in 2003 and 2004, 3,522 (98%) were due to the fact that the vehicles concerned had passed the TD smoke test.

Audit observations

3.15 **Audit considers that a suspected smoky vehicle should be smoke-tested as soon as possible. This is because there will be a risk to the environment if such a vehicle is allowed to remain on the road for an unduly long period.** The EPD needs to ensure that the period that vehicle owners are allowed to repair and test their vehicles should be adhered to as far as possible.

3.16 Given that the EPD smoke test procedures and standard are more stringent than the TD's, smoky vehicle owners would choose to undergo the TD smoke test instead (Note 13). The current practice of withdrawing ETNs if the vehicles concerned have passed the TD smoke test, before the EPD smoke test due date, may have created a loophole in the SVCP. **Audit considers that a uniform set of smoke test procedures and standard could overcome this anomaly (see the audit recommendation in para. 3.8).**

Audit recommendation

3.17 **Audit has *recommended* that the Director of Environmental Protection should review the time allowed for smoky vehicle owners to have their vehicles passed the EPD smoke test.**

Response from the Administration

3.18 The **Director of Environmental Protection** agrees with the audit recommendation. He has said that as the vehicle repair and the transport trades have now

Note 13: *Of the 10 cases that were allowed more than 200 days to take the EPD smoke test (see Table 5 in para. 3.11), 3 were eventually withdrawn because the vehicles concerned had passed the TD smoke test before the EPD smoke test due date.*

become more experienced with the dynamometer smoke test, the EPD will consider the feasibility of further shortening the 14-working-day period.

Monitoring the performance of designated vehicle emission testing centres

3.19 To ensure that smoke tests are conducted properly by the DVETCs, EPD inspectors conduct monitoring inspections of all the DVETCs quarterly. During an inspection, the inspectors check, among other things, that the test equipment is properly maintained. They also observe the conduct of smoke tests to ensure conformity with the Code of Practice and competence of the testers.

Audit observations

3.20 Audit examination of the DVETC inspection records of 2004 indicated that:

(a) the DVETC quarterly inspection cycle was not complied with. The 11 DVETCs were inspected only three times in 2004; and

(b) in 25 (76%) of the 33 inspections, EPD smoke test procedures were not observed as no vehicle was presented for smoke test at the DVETCs concerned at the time the inspections were conducted.

3.21 EPD inspections of the DVETCs are supposed to be conducted on a surprise basis. However, Audit notes that, in the current inspections for observation of smoke test procedures, the testers are aware of the presence of the EPD inspectors. Without a surprise element, the effectiveness of observing these procedures is limited. **In Audit's view, the EPD should consider adopting a different approach which can provide a surprise element for conducting the inspections.** For example, the EPD may consider sending a vehicle to the DVETCs for the purpose of testing the compliance of the smoke test procedures.

Audit recommendations

3.22 **Audit has *recommended* that the Director of Environmental Protection should:**

(a) **ensure that the DVETCs are inspected quarterly;**

(b) **ensure that the DVETC concerned is re-inspected, in cases where the smoke test procedures cannot be observed in the first visit; and**

(c) **consider adopting a different approach which can provide a surprise element for observing the smoke test procedures.**

Response from the Administration

3.23 The **Director of Environmental Protection** agrees with the audit recommendations. He has said that:

(a) the introduction of the dynamometer smoke test has reduced the resources for inspecting the DVETCs because of the efforts required to prepare the relevant trades for the test. Moreover, the dynamometer test has also made the inspection technically more complicated and more resource-intensive. As the trades are getting more experienced with the test, the EPD has been able to increase the number of inspections of the DVETCs from 26 in 2002 to 33 in 2004. The EPD will endeavour to further increase the inspection frequency of the DVETCs to quarterly;

(b) as a result of the Government's enhanced efforts to reduce motor vehicle emissions, the number of smoky vehicles has been reduced by about 80%. In 2004, only about 12,000 smoke tests (i.e. about five tests per day per centre) were carried out at the DVETCs. Hence, the chance of inspecting a DVETC when it is conducting a smoke test is low. Nevertheless, the EPD will follow up on those DVETCs where the smoke test procedures are not observed in the first visit; and

(c) the EPD will explore other approaches that can provide a surprise element for observing the smoke test procedures.

Joint operations with the Police

3.24 Both TD and EPD smoke tests are scheduled tests. If the engine of a vehicle has been tampered with to generate more power and smoke, the owner of the vehicle can re-adjust the engine to a lower setting to pass the smoke test and can re-set the engine to higher power afterwards. The smoke problem remains unabated. There are other unorthodox ways to pass the scheduled smoke test, such as exhaust diluting (see para. 2.6). Therefore, unscheduled surprise roadside smoke tests are necessary.

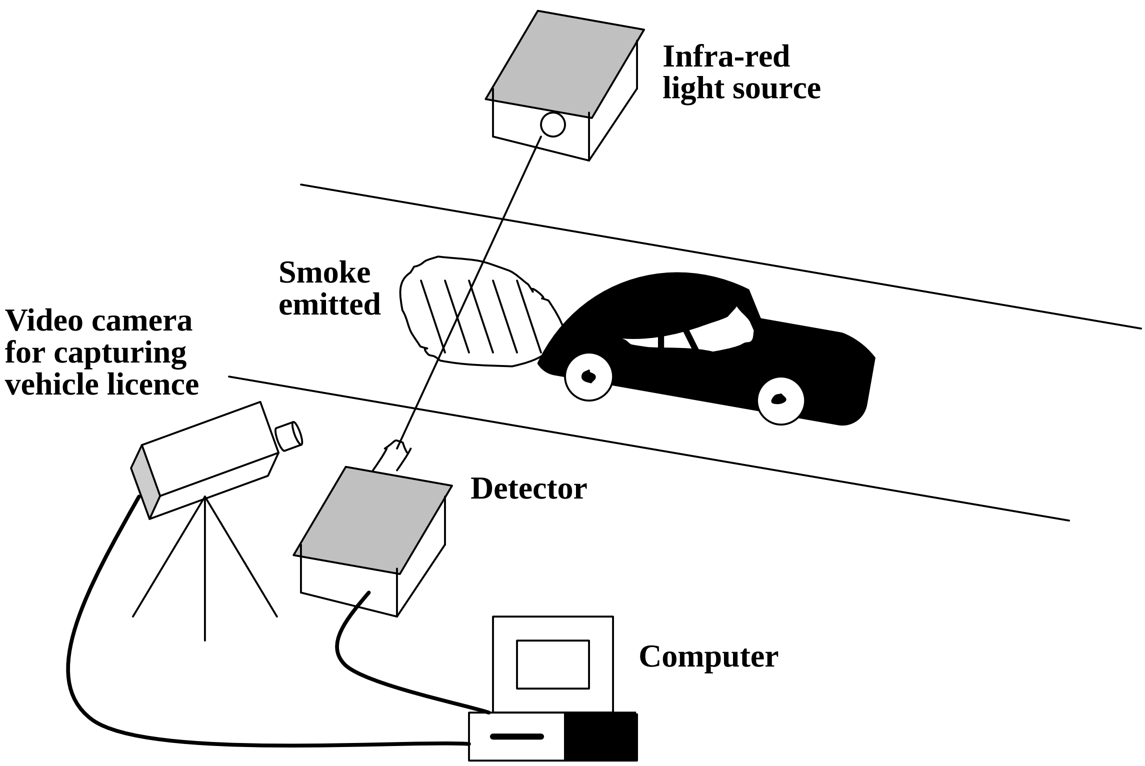
3.25 Since 1998, the EPD and the Police have, from time to time, conducted roadside free acceleration smoke tests jointly. Smoky vehicles are each issued with a Fixed Penalty Ticket (by the Police) and an ETN (by the EPD). In 2004, the EPD and the Police conducted 72 joint operations.

Remote sensing of smoky vehicles

3.26 Audit notes that a new technology is being tested in the State of Virginia in the United States to conduct roadside smoke tests without requiring the smoky vehicles to stop. The device works by measuring the absorption of an infra-red light beam by the smoke emitted from a vehicle (see Figure 3). Simultaneously, a connected computer calculates the smoke level at the instant the vehicle passes the remote-sensing device, and activates a video camera to capture the licence plate if the smoke level detected is excessive. Authorities in New Zealand and the UK are also exploring the feasibility of using similar technology.

Figure 3

Typical set-up of remote-sensing devices



Source: Audit drawing

3.27 The remote-sensing technology mentioned in paragraph 3.26 helps target smoky vehicles more efficiently. This could take the form of a comprehensive surveillance system of unattended smoke detectors placed at different locations throughout the territory. Owners of smoky vehicles detected will be notified to present their vehicles for smoke tests.

Audit observations

3.28 Smoke test is the key measure used by the EPD and the TD to ensure that vehicles on the road are properly maintained. A major concern is that smoky vehicle owners may evade scheduled smoke tests by various means. **Audit considers that there is a need to continue the EPD/Police joint operations.** In order to enhance the cost-effectiveness of such operations, the new remote-sensing technology is worthy of exploration.

Audit recommendation

3.29 **Audit has *recommended* that the Director of Environmental Protection should explore the feasibility of introducing smoky vehicle remote-sensing technology to Hong Kong.**

Response from the Administration

3.30 The **Director of Environmental Protection** agrees with the audit recommendation. He has said that:

(a) the EPD has been using the remote-sensing technology to monitor petrol vehicle emissions since 1993. The technology is not yet mature for handling the complexity in detecting diesel vehicle smoke emissions, particularly the many different orientations of diesel vehicle exhaust pipes. Some discharge upwards while some discharge sideways; and

(b) the EPD will continue to monitor the remote-sensing technology's development, and when it becomes proven, the EPD will explore the feasibility of introducing it to Hong Kong.

Recruitment of spotters

3.31 The effectiveness of the SVCP depends on the number and enthusiasm of spotters. As at 31 December 2004, there were 4,718 spotters, mainly volunteers.

3.32 Audit examination of EPD records showed that the number of new spotters joining the SVCP decreased by 71%, from 301 in 2001 to 86 in 2004.

Audit observations

Publicity

3.33 Audit noted that the EPD had done little to promote the recruitment of spotters. There was neither advertisement nor other forms of publicity. An environmental protection enthusiast might have difficulties in finding out how and where to apply to become a spotter. The EPD should consider making more effort to promote the spotters recruitment programme and making the relevant information easily available to the public (e.g. through its website).

Enthusiasm of spotters

3.34 As spotters are mainly volunteers, it is important that their enthusiasm is maintained. Otherwise, they may become inactive. As reported in the Director of Audit's Report No. 29 published in 1997, the number of inactive spotters (spotters who did not make a single report in a year) was increasing. The figures of 2004 show that 90% (i.e. 4,223 out of 4,718) of spotters were inactive. **Audit considers that the EPD could have done more to promote the enthusiasm of spotters.** For example, the EPD may wish to consider:

(a) informing the spotters of the outcome of their reports;

(b) giving recognition to the more productive spotters; and

(c) organising discussion sessions for spotters and setting up a forum in its website for experience sharing.

Audit recommendation

3.35 **In order to further improve the effectiveness of the SVCP, Audit has *recommended* that the Director of Environmental Protection should take action to publicise the recruitment of spotters and to promote their enthusiasm.**

Response from the Administration

3.36 The **Director of Environmental Protection** agrees with the audit recommendation. He has said that the EPD will explore the possibility of making use of its website for publicising the recruitment of spotters and promoting spotter enthusiasm.

PART 4: USE OF LIQUEFIED PETROLEUM GAS

4.1 This PART examines the feasibility of further increasing the number of liquefied petroleum gas (LPG) vehicles in Hong Kong.

Background

4.2 One of the Government's main strategies to reduce the levels of ambient RSPs and nitrogen oxides is to adopt cleaner alternatives (e.g. LPG) to diesel (see para. 1.8(b)). LPG is a non-renewable gaseous fossil fuel which turns into liquid under moderate pressure. The LPG used in Hong Kong consists of mainly butane, and is produced either as a by-product of oil refining or from natural gas fields.

4.3 The technology of LPG vehicles is mature. LPG vehicles have been widely used in some countries for over 60 years. Using LPG instead of diesel as fuel is beneficial:

(a) to the environment because LPG is a cleaner fuel. LPG vehicles emit almost negligible RSPs and 75% to 85% less nitrogen oxides than diesel vehicles. According to the EPD, such comparative advantages of LPG vehicles over diesel vehicles will persist, albeit at a lesser scale, even after the introduction of more environmental-friendly Euro IV diesel vehicles in 2006 and Euro V diesel vehicles in 2009; and

(b) to vehicle owners because LPG is cheaper. As at 20 December 2004, the pump price differential between diesel and LPG was about 63% (see Appendix D).

4.4 In 1997, the Government launched a one-year LPG taxis trial scheme. In 1998, the Government concluded that the performance of LPG taxis was comparable to that of diesel taxis, and that LPG taxis were suitable for use in Hong Kong. In 2000, the Government announced the LPG taxis grant scheme. Under this scheme, a one-off grant of HK$40,000 was provided to taxi owners for each diesel taxi replaced. A similar scheme was introduced in 2002 to encourage public and private light bus owners to replace their vehicles with LPG vehicles (Note 14).

4.5 Currently, under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations (Cap. 311J), LPG can only be used in taxis and public and private

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Note 14: *Under the LPG light bus scheme, public light bus owners are provided with a one-off grant of HK$60,000 for each diesel light bus that is replaced with an LPG light bus. Private light bus owners are exempted from paying the first registration tax for the LPG light buses purchased to replace their diesel light buses.*

light buses. As at 31 December 2004, about 99.8% of the entire fleet of taxis (i.e. 18,100 of 18,138) and about 23% of the public and private light buses (i.e. 1,412 of 6,200) were powered by LPG. The total number (about 20,000) of LPG vehicles was small, compared to about 129,000 of diesel vehicles on the road.

Scope of extending the use of LPG to other diesel vehicles

4.6 In 2003, the Government informed the Legislative Council that it was impracticable to extend the use of LPG to light vans and light goods vehicles having a permitted gross vehicle weight not exceeding 5.5 tonnes (hereinafter referred to as light vehicles — Note 15). This was based on a consultancy report which suggested that:

(a) the existing LPG terminal throughput capacity could not provide adequate support to the entire fleet of light vehicles in Hong Kong;

(b) there were inadequate LPG filling stations; and

(c) stretching the LPG throughput further would increase the risk to the population in the LPG terminal area. There would be an unacceptable increase in marine and road transport risk due to transporting LPG to the terminals and filling stations.

4.7 Audit review of the consultancy report found that, while the existing infrastructure could support additional LPG light vehicles on top of the entire fleet of taxis and public and private light buses, it was insufficient to extend the use of LPG to the entire fleet of light vehicles. Audit findings are reported in paragraphs 4.8 to 4.17.

LPG terminal throughput capacity

4.8 Currently, tankers enter Hong Kong waters through the East Lamma Channel for unloading LPG at the Tsing Yi LPG terminals. The storage and handling capacity of the terminals determines the throughput capacity. The consultancy report stated that:

(a) after taking into account the typhoon reserve requirements, the existing annual throughput capacity of the Tsing Yi LPG terminals was about 579,000 tonnes; and

(b) if the entire fleet of taxis and public and private light buses was powered by LPG, the annual LPG consumption in Hong Kong (including both domestic and industrial use) would be about 472,000 tonnes.

Note 15: *As at 31 December 2004, the number of light vehicles was about 65,000.*

4.9 Paragraph 4.8 shows that the existing LPG terminals have a spare capacity of 107,000 (i.e. 579,000 − 472,000) tonnes. This spare capacity may be used to support additional LPG vehicles.

The existing LPG filling stations can support additional vehicles

4.10 A few years ago, the lack of LPG filling stations limited the number of LPG vehicles in Hong Kong. However, the number of LPG filling stations has increased. As at 31 December 2004, there were 50 LPG filling stations with a total of 378 nozzles. These numbers will further increase by early 2006 as six new LPG filling stations with a total of 32 nozzles are being planned.

4.11 In the first half of 2004, Audit staff visited 15 LPG filling stations and found that:

(a) the daily peak hours of the LPG filling stations were about an hour or two in the afternoon and in the early morning; and

(b) business was light during the rest of the day.

4.12 With the assistance of a major LPG supplier, Audit reviewed the filling records of March, June and September 2004 of a number of dedicated LPG filling stations (Note 16). Audit found that the average number of vehicles refilled by each nozzle at the busiest LPG filling station during the peak hours (i.e. 3:00 pm to 5:00 pm) was 14.5. The average numbers of vehicles refilled by each nozzle during non-peak hours at other LPG filling stations ranged from 0.6 to 9.4 (the median was 1.9). This indicates that the existing LPG filling stations have spare capacity to support additional LPG vehicles. This spare capacity will further increase when the six new LPG filling stations (with 32 nozzles) commence business.

4.13 In response to Audit enquiries, the Environment, Transport and Works Bureau (ETWB) informed Audit that it agreed with the observation that the existing LPG infrastructure had spare capacity to support additional LPG vehicles. However, the spare capacity was insufficient to support the entire fleet of light vehicles. The ETWB added that allowing some but not all light vehicle operators to use LPG vehicles would create unfair competition within the trade for the following reasons:

Note 16: *Dedicated LPG filling stations supply only LPG. The pump price of LPG at dedicated LPG filling stations is subject to a ceiling which is revised by the Government every six months. During the period covered by this audit, the LPG pump price at dedicated LPG filling stations was lower than that at non-dedicated LPG filling stations. Hence, dedicated LPG filling stations were busier than non-dedicated LPG filling stations.*

(a) LPG light vehicles would operate at fuel costs lower than their diesel counterparts; and

(b) if the right to use LPG light vehicles was regulated by a quota system, the quota would be subject to financial speculation and dominated by large light vehicle operators. In the end, small light vehicle operators would lose out.

The ETWB considered that, in the interests of equity, the Government should not extend the use of LPG to light vehicles until the LPG infrastructure could support the entire light vehicle fleet to use LPG.

Safety concern

4.14 LPG is heavier than air. If leaked into the air, LPG will sink to the ground and accumulate in low-lying areas, and may be difficult to disperse. The consultancy report considered that extending the use of LPG to all light vehicles would stretch the existing throughput capacity, which in turn would increase the risk to the population in the LPG terminal area. Transport risk would also be increased (see para. 4.6(c)).

4.15 It is vital that the risks associated with the storage and distribution of LPG are contained. Otherwise, it would not be desirable to increase the number of LPG vehicles. Audit notes that the consultancy report has suggested a number of risk mitigation measures. Of these measures, two are worthy of exploration, namely importing LPG from Shenzhen and building additional LPG terminals.

4.16 ***Importing LPG from Shenzhen.*** The consultant considered that it was practicable to import LPG from Shenzhen. This would improve the sources of LPG supply. The consultant said that:

(a) LPG from Shenzhen met Hong Kong's specifications;

(b) the transport risk of supplying LPG to filling stations in the north of the New Territories would be lower, if LPG was supplied from Shenzhen instead of the Tsing Yi LPG terminals;

(c) supplying LPG from Shenzhen might be a longer-term option to reduce the risk of the existing LPG supply;

(d) the additional transport cost involved was about $50 per tonne (i.e. three cents per litre); and

(e) the increase in cross-border vehicular traffic due to additional LPG deliveries by road-tankers was insignificant.

4.17 ***Building additional LPG terminals.*** The consultant has suggested a number of sites for building additional LPG terminals. One of these sites is at the waste disposal facility in Kennedy Town. Audit considers that an LPG terminal on Hong Kong Island can offer a number of benefits. First, the risk to the population in Tsing Yi will be reduced because less quantities of LPG will be stored at the Tsing Yi LPG terminals. Second, the transport risk of supplying LPG to filling stations on Hong Kong Island will be reduced. Third, according to the Road Tunnels (Government) Regulations (Cap. 368A), LPG road-tankers are not allowed to use tunnels. There is a risk that the supply of LPG would run out on Hong Kong Island in the event of a disruption of vehicular ferry service. An LPG terminal on Hong Kong Island could reduce such risk.

Audit observations

4.18 In view of the environmental benefits, Audit considers that it is worth considering extending the use of LPG to diesel light vehicles as soon as possible. Audit has found that the existing LPG infrastructure could support additional light vehicles (see paras. 4.8 to 4.12). On the issue of whether the use of LPG can be extended to diesel light vehicles, the impact on government revenue should also be looked into.

Implications on government revenue

4.19 Throughout this audit, a duty of HK$1.11 per litre was levied on diesel. On the other hand, LPG was duty-free. Further extending the use of LPG would result in the loss of a considerable amount of government diesel duty.

4.20 Audit notes that, in other countries where LPG and diesel are both available, duty is levied on LPG. For this reason, the pump price differentials between LPG and diesel in many countries are significantly less than the 63% differential in Hong Kong (see Appendix D). In response to Audit enquiries, the Financial Services and the Treasury Bureau (FSTB) stated that:

(a) no duty had been levied on LPG for vehicular use after its introduction in order to encourage taxis and public light buses to switch from diesel to LPG and thus to help improve air quality; and

(b) the FSTB would review at an appropriate juncture, in consultation with the ETWB, as to when duty should be imposed on vehicular LPG, and if so, having regard, among others, to the price of different fuels and the need for continuing provision of an incentive for owners to switch their vehicles to ones powered by LPG.

Audit recommendations

4.21 **Audit has *recommended* that the Secretary for the Environment, Transport and Works should:**

(a) **consider inviting the LPG importers to supply LPG from Shenzhen to filling stations in the north of the New Territories to reduce the transport risks;**

(b) **examine the feasibility of building a new LPG terminal on Hong Kong Island; and**

(c) **consider extending the use of LPG to other diesel vehicles, after the relevant issues, including the readiness of LPG infrastructure and implications on government revenue (see paras. 4.19 and 4.20) have been properly addressed.**

Response from the Administration

4.22 The **Secretary for the Environment, Transport and Works** generally agrees with the audit recommendations. She has said that:

(a) the Administration is open-minded as to where LPG suppliers are to source their LPG. However, there are practical issues that need to be carefully considered before importing LPG from Shenzhen. As the consultant has pointed out, the heavy traffic at the boundary would cause delay to LPG delivery by road-tankers and hence reduce its reliability to supply LPG to filling stations. The impact on cross-boundary traffic due to LPG road-tanker incidents (such as gas leakage or vehicle breakdown) that may take considerable time to clear should also be carefully assessed;

(b) the EMSD has examined the feasibility of building a new LPG terminal on Hong Kong Island. Preliminarily, no suitable sites have been identified. However, the EMSD will, in conjunction with relevant departments, continue to examine the feasibility of building a new LPG terminal on Hong Kong Island; and

(c) she is keen to promote a wider use of LPG vehicles. However, the constraint of the existing LPG infrastructure, particularly the LPG filling network, does not allow the light vehicle trade to use LPG vehicles. The Government is making efforts to expand the LPG filling network and, when the LPG infrastructure is ready, will consider extending the use of LPG to other vehicle classes.

Appendix A
(para. 1.4 refers)

Major air quality improvement measures implemented since the establishment of Air Quality Objectives in 1987

Date	Measures
1987	• Establishment of Statutory AQOs for declared Air Control Zones
1989	• Declaration of eight additional Air Control Zones to cover the whole territory
1990	• Implementation of the Air Pollution Control (Fuel Restriction) Regulations to limit the sulphur content and viscosity of fuel oils
1991	• Introduction of unleaded petrol on 1 April 1991
	• Enactment of the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations to require all new vehicles up to 2.5 tonnes to comply with stringent emission standards, and all new vehicles with petrol engines to operate only on unleaded petrol, as from 1 January 1992
1994	• Introduction of Technical Memoranda for specifying AQOs for Hong Kong
	• Enactment of the Air Pollution Control (Motor Vehicle Fuel) Regulations to require the use of better quality automotive diesel with a sulphur content not exceeding 0.2%
1995	• Introduction of cleaner diesel fuel with sulphur content not exceeding 0.2% under the Air Pollution Control (Motor Vehicle Fuel) Regulations
	• Introduction of stringent diesel vehicle emission standards under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations
	• Launching of Hong Kong's first Air Pollution Index and forecast system by the EPD to provide the community with a guide to the air pollution levels to which they are exposed

Date	Measures
1997	• Tightening of vehicle emission standards for all newly registered diesel vehicles over four tonnes to Euro II Standards under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations
	• Reduction of the sulphur content of auto diesel from 0.2% to 0.05% under the Air Pollution Control (Motor Vehicle Fuel) Regulations
1998	• Introduction of more stringent emission standards for diesel private cars to restrict them from registration and for light-duty diesel vehicles, other than taxis, under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations
	• Enhancement of the Air Pollution Index system and introduction of a new Roadside Air Pollution Index
	• Successful completion of the liquefied petroleum gas (LPG) taxis pilot scheme launched in 1997
1999	• Introduction of more stringent emission standards for diesel vehicles and new evaporative emission standards for petrol vehicles under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations
	• Introduction of an advanced smoke test method (with the aid of chassis dynamometer) for diesel vehicles below 5.5 tonnes
2000	• Commencement of one-off grants to help diesel taxi operators replace their vehicles with LPG taxis
	• Commencement of preferential fuel duty to make ultra-low sulphur diesel the only diesel on sale in all petrol filling stations
	• Implementation of a programme to retrofit pre-Euro diesel vehicles (up to 4 tonnes) with particulate traps or diesel oxidation catalysts
	• Introduction of emission checks in vehicle roadworthiness test for petrol and LPG vehicles
	• Increasing the fixed penalty fine against smoky vehicles from HK$450 to HK$1,000

Date	**Measures**
2001	• Introduction of Euro III emission standards for newly registered vehicles
	• Tightening of motor vehicle fuel requirements to meet Euro III emission standards
	• Introduction of requirement that newly-registered taxis be fuelled by LPG or petrol
2002	• Commencement of chassis dynamometer test for heavy vehicles emitting smoke, after it was earlier made mandatory for lighter vehicles
	• Mandatory requirement that petrol stations supply only ultra-low sulphur diesel
	• Approval of HK$600 million by the Finance Committee of the Legislative Council to help vehicle owners retrofit particulate removal devices in pre-Euro heavy diesel vehicles that are not required to undertake long idling duties
	• Commencement of grants to help public light buses switch to LPG or electric vehicles
	• Commencement of grants to help heavy pre-Euro diesel vehicles install particulate removal devices

Source: EPD records

Appendix B
(para. 1.10 refers)

Comparison of the annual average RSPs and nitrogen dioxide Air Quality Objectives between Hong Kong and other countries

	Air Quality Objectives of	
Country / Territory	**RSPs** ($\mu g/m^3$)	**Nitrogen dioxide** ($\mu g/m^3$)
Australia	(Note 1)	57
European Union	42	52
Hong Kong	55	80
New Zealand	20	(Note 2)
Singapore	50	40
United Kingdom	40	40
United States	50	100

Source: Government publications

Note 1: There is no annual average RSPs AQO in Australia.

Note 2: There is no annual average nitrogen dioxide AQO in New Zealand.

Appendix C
(para. 2.26(b) refers)

Analysis of engine power output of the 70 vehicles that passed dynamometer smoke test in 2004

Vehicle number	Maximum engine power recorded in dynamometer smoke test (a) (Kilowatt)	Maximum engine power according to manufacturer (b) (Kilowatt)	Percentage of engine power output $(c) = \frac{(a)}{(b)} \times 100\%$ (%)	
1	137	272	50.4%	34 vehicles (49%)
2	135	265	50.9%	
3	109	213	51.2%	
4	36	70	51.4%	
5	36	70	51.4%	
6	97	187	51.9%	
7	117	225	52.0%	
8	52	100	52.0%	
9	130	250	52.0%	
10	111	213	52.1%	
11	134	257	52.1%	
12	120	228	52.6%	
13	29	55	52.7%	
14	132	250	52.8%	
15	37	70	52.9%	
16	38	70	54.3%	
17	38	70	54.3%	
18	46	84	54.8%	
19	155	283	54.8%	
20	129	235	54.9%	
21	39	70	55.7%	
22	119	213	55.9%	
23	108	192	56.3%	
24	40	70	57.1%	
25	40	70	57.1%	
26	131	225	58.2%	
27	161	275	58.5%	
28	41	70	58.6%	
29	41	70	58.6%	
30	161	272	59.2%	
31	157	265	59.2%	
32	157	265	59.2%	
33	42	70	60.0%	
34	39	65	60.0%	

Appendix C
(Cont'd)
(para. 2.26(b) refers)

Vehicle number	Maximum engine power recorded in dynamometer smoke test	Maximum engine power according to manufacturer	Percentage of engine power output	
	(a)	(b)	$(c) = \frac{(a)}{(b)} \times 100\%$	
	(Kilowatt)	(Kilowatt)	(%)	
35	172	283	60.8%	24 vehicles (34%)
36	137	225	60.9%	
37	158	257	61.5%	
38	62	100	62.0%	
39	62	100	62.0%	
40	156	250	62.4%	
41	161	257	62.6%	
42	44	70	62.9%	
43	44	70	62.9%	
44	198	314	63.1%	
45	143	225	63.6%	
46	173	272	63.6%	
47	68	105	64.8%	
48	151	231	65.4%	
49	174	265	65.7%	
50	46	70	65.7%	
51	46	70	65.7%	
52	46	70	65.7%	
53	165	250	66.0%	
54	185	280	66.1%	
55	149	225	66.2%	
56	150	225	66.7%	
57	47	70	67.1%	
58	152	221	68.8%	
59	187	265	70.6%	12 vehicles (17%)
60	164	231	71.0%	
61	190	265	71.7%	
62	203	280	72.5%	
63	194	265	73.2%	
64	141	192	73.4%	
65	151	205	73.7%	
66	171	231	74.0%	
67	196	257	76.3%	
68	219	283	77.4%	
69	208	265	78.5%	
70	179	210	85.2%	
Total **70**				

Source: TD records

Appendix D
(paras. 4.3(b) and
4.20 refer)

Pump price differential between diesel and LPG in Hong Kong and other countries (20 December 2004)

Country / Territory	Diesel price (a) (HK$ / litre)	LPG price (b) (HK$ / litre)	Price differential (c) = (a) - (b) (HK$ / litre)	LPG duty (d) (HK$ / litre)
France	8.34	6.44	1.90 (23%)	1.68
Spain	7.23	5.49	1.74 (24%)	1.09
Italy	8.80	5.76	3.04 (35%)	2.59
Germany	8.82	5.45	3.37 (38%)	1.71
Slovenia	9.15	5.67	3.48 (38%)	1.75
Hungary	10.74	6.25	4.49 (42%)	2.35
Slovakia	9.75	5.43	4.32 (44%)	2.03
The Netherlands	9.57	5.23	4.34 (45%)	1.41
Poland	9.74	4.99	4.75 (49%)	1.94
Belgium	8.42	4.21	4.21 (50%)	0.73
United Kingdom	13.05	5.93	7.12 (55%)	0.99
Hong Kong	7.15	2.65	4.50 (63%)	—

Source: *Audit research*

Remarks: *Prices in other countries were converted to Hong Kong dollars using the prevailing exchange rates.*

Acronyms and abbreviations

AQO	Air quality objective
Audit	Audit Commission
DVETCs	Designated vehicle emission testing centres
EPD	Environmental Protection Department
ETWB	Environment, Transport and Works Bureau
ETN	Emission testing notice
FSTB	Financial Services and the Treasury Bureau
HSU	Hartridge Smoke Unit
LPG	Liquefied petroleum gas
RSP	Respirable suspended particulate
SVCP	Smoky vehicle control programme
TD	Transport Department
$\mu g/m^3$	Micrograms per cubic metre
UK	United Kingdom
US EPA	United States Environmental Protection Agency