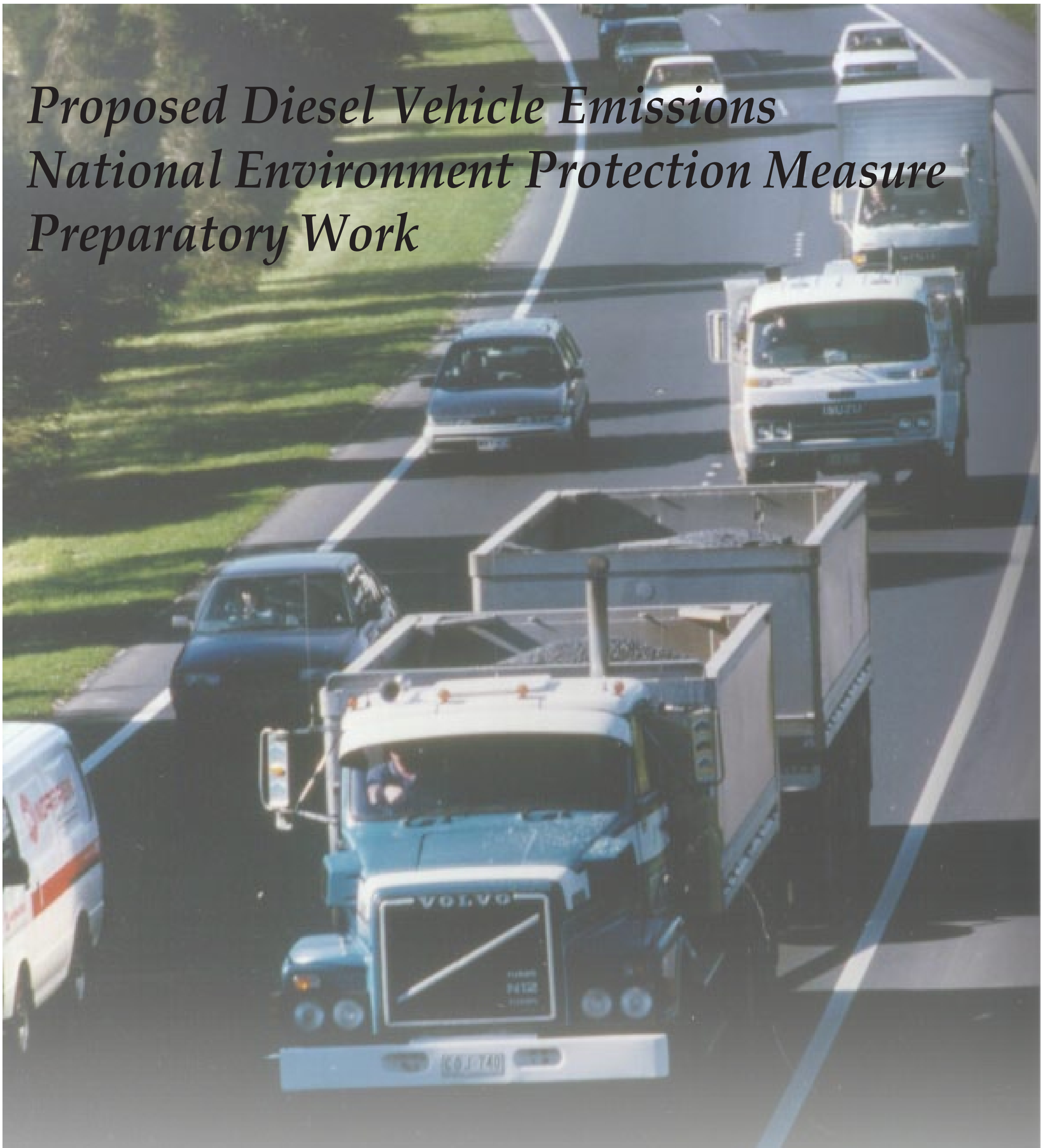
Proposed Diesel Vehicle Emissions
National Environment Protection Measure
Preparatory Work



In-Service Certification Correlation Studies

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A suite of projects have been developed during the preparatory work for a proposed Diesel Vehicle Emissions National Environment Protection Measure. These projects are:

The Australian Diesel Fleet Existing Vehicle Characteristics and the Modelling of Transport Demand, Vehicle Populations and Emissions

In-Service Emissions Performance - Phase 1: Urban Drive Cycle Development

In-Service Emissions Performance - Phase 2: Vehicle Testing

In-Service Certification Correlation Studies

A Review of Dynamometer Correlations, In-Service Emissions and Engine Deterioration

In-Service Emissions Testing – Pilot Study, Fault Identification and Effect of Maintenance

Environment Australia has provided major funding for these projects. The other contributing agencies are the Department of Transport and Regional Services, NSW Roads and Traffic Authority and the National Road Transport Commission.

Electronic copies of these documents are available from:

National Environment Protection Council Service Corporation
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These documents are also available online: http://www.nepc.gov.au

EXECUTIVE SUMMARY

Project 4 forms part of NEPC's Preparatory work in consideration of strategies to reduce in service diesel emissions.

The aim of this project was to:

- measure the emission performance of a sample of diesel powered vehicles when tested on benchmark emission tests and three transient load tests, and;
- establish correlations between the results of the benchmark tests and the transient load tests.

The benchmark tests were:

- the ECE R83 emission test for Light Diesel Vehicles (GVM <3.5 tonnes); and
- the ECE R49 Steady-State 13 Mode Test for Heavy Vehicles (GVM >3.5 tonnes).

The transient tests were the Combined Urban Emission Drive Cycle (CUEDC) and two short in-service emission tests known as the DT 80 and AC 5080.

In conjunction with these tests the ECE R24 smoke test was also performed on each vehicle.

The vehicle sample consisted of 20 Light Vehicles and 12 Heavy Vehicles and included vehicles built prior to the introduction of the current diesel emissions standard, Australian Design Rule (ADR) 70/00 in 1996, and vehicles complying with ADR70/00.

Exhaust emissions of HC, NOx and particulates, were collected during the specified drive cycles using equipment of the type specified, in the ECE regulations.

Both the light and heavy duty tests were performed on (separate) chassis dynamometers, although the heavy duty ECE R49 test specifies an engine dynamometer. However, previous research had shown it was neither necessary nor cost effective to test all the heavy vehicles using an engine dynamometer as the test could be conducted on a chassis dynamometer with acceptable accuracy.

The test results showed that, for light vehicles:

- the correlations, as measured by the "r" coefficient, between the benchmark test and the transient tests was:
  - for NOx , excellent for all tests;
  - for HC, excellent for the CUEDC test and poor for the DT80 and AC5080;
  - for particulates, excellent for the CUEDC and DT80 and fair for the AC5080.
- high and low emitters were identified by all tests;

- small differences in emission scores in the mid-range of test results could change the relative ranking of results between each of the test cycles.

For heavy vehicles:

- the correlation, as measured by the "r" coefficient, between the benchmark test and the transient tests was:
  - for NOx , fair for the CUEDC and very poor for the DT80 and AC5080;
  - for HC, excellent for all tests;
  - for particulates, excellent for the DT80, poor for the AC5080 and very poor for the CUEDC.

- the highest and lowest emitters are in general identified by the DT80 test for all emissions;.

- small differences in emission scores in the mid-range of test results changed the relative ranking of results in each of the test cycles.

The nature of the test and test equipment meant the results for heavy vehicles had more variability than those for light vehicles.

However the results for both classes of vehicles do indicate that the transient tests in general show good correlation with the benchmark test for HC, NOx and particulates and are capable of distinguishing between low and high emitters. The DT80 test was considered the best in this regard.

Despite the good statistical correlations the ranking of vehicles can vary considerably between tests due to small variations in test results. This fact should be taken account of when setting a standard for the in-service tests to ensure the standard is not set at a level that would allow a vehicle capable of passing the benchmark test to fail the in-service test.

There is a poor correlation between both average and peak opacity readings in the benchmark test when compared with the average opacity results of all of the transient tests.

1 INTRODUCTION

The PROJECT 4 objectives, as stipulated by the National Environment Protection Council (NEPC) , were to:

- measure the emission performance of a sample of diesel powered vehicles when tested on benchmark emission tests and three transient load tests, and;

- establish correlations between the results of the benchmark tests and the transient load tests.

The benchmark tests were:

- the ECE R83 emission test for Light Diesel Vehicles (GVM <3.5 tonnes); and

- the ECE R49 Steady-State 13 Mode Test for Heavy Vehicles (GVM >3.5 tonnes).

The transient tests were the Combined Urban Emission Drive Cycle (CUEDC) and two short in-service emission tests known as the DT 80 and AC 5080.

In conjunction with these tests the ECE R24 smoke test was also performed on each vehicle.

The vehicle sample consisted of 20 Light Vehicles and 12 Heavy Vehicles and included vehicles built prior to the introduction of the current diesel emissions standard, Australian Design Rule (ADR) 70/00 in 1996, and vehicles complying with ADR70/00.

Exhaust emissions of HC, NOx and particulates, were collected during the specified drive cycles using equipment of the type specified, in the ECE regulations. The factors that affect the formation of these emissions in diesel engines are outlined in Appendix A.

Both the light and heavy duty tests were performed on (separate) chassis dynamometers, although the heavy duty ECE R49 test specifies an engine dynamometer. However previous research had shown it was neither necessary nor cost effective to test all the heavy vehicles using an engine dynamometer as the test could be conducted on a chassis dynamometer with acceptable accuracy.

Light diesel powered vehicles are categorised as those weighing 3.5 tonnes Gross Vehicle Mass (GVM) or less. Heavy diesel powered vehicles are categorised as vehicles weighing more than 3.5 tonnes GVM.
Diesel fuel with a sulphur content of 1200 ppm (Refer Appendix B for chemical analysis) was used for all tests. This fuel was supplied by Shell as a single batch.

2 METHODOLOGY

2.1 LIGHT VEHICLES

2.1.1 Light Vehicle Categories

Testing was conducted on 20 light vehicles including both pre ADR70/00 (1990-95) models and ADR 70/00 certified models (1996-99).

The light vehicles were vehicles of the ADR categories of MA, MB, MC, MD and NA. These categories are defined as :-

MA: Passenger vehicle, not being an off-road vehicle or forward control passenger vehicle, having up to 9 seating positions, including that of the driver.

MB:- Forward-Control Passenger Vehicle, not being an off-road vehicle, having up to 9 seating positions, including that of the driver, and in which the centre of the steering wheel is in the forward quarter of the vehicles 'total length.'

MC:- Off Road Passenger Vehicle - passenger vehicle having up to 9 seating positions, including that of the driver and being designed with special features for off-road operation.

MD:- Light Omnibus - an omnibus with a GVM not exceeding 5.0 tonnes

NA:- Light Goods Vehicles - goods vehicle with GVM not exceeding 3.5 tonnes.

The vehicles were sourced from a private owners, fleet owners and rental agencies. The vehicles had a reasonable range of odometer readings and featured models typical of the Australian diesel fleet.

2.1.2 Light Vehicle Test Equipment

The ADR70/00 emissions test for light vehicles is a transient test conducted on a chassis dynamometer. Emission testing for light vehicles was performed at the Melbourne Emission Laboratory of Vipac Engineers & Scientists Ltd (Altona). The chassis dynamometer was an inertia simulation, exhaust emission dynamometer (Clayton model CTE-50). The inertia was simulated by selection of flywheels and the power absorption unit was a water brake type. The dynamometer was calibrated to the European inertia and road load settings for ECE R83 for all tests on light vehicles.

Exhaust emissions were collected from the light duty diesel vehicles, during the four specified drive cycles. Diesel exhaust emissions were continuously sampled through a dilution tunnel, using CVS and a bag gas sampling system. The gas analysers and particulate sampling equipment were of the type specified in the ECE regulations. The gases were analysed with: non dispersive infrared analyser for carbon monoxide (CO), flame ionisation detector analyser for hydrocarbon (HC), chemiluminescence analyser for oxides of nitrogen (NOX), and a gravimetric filter paper particulate sampler (NOVA MICROTROL 4). Smoke opacity measurements were made using a Bosch opacity meter.

Data was recorded using a personal computer (PC) based automatic data acquisition system. Monitored data representing the continuous samples for gaseous and particulate emissions, were downloaded, for each vehicle, and subsequently analysed to produce emissions in grams/kilometre for each drive cycle. Calibrations for gas analysers, particulate sampling system, gas sampling and dynamometer were performed as required.

2.1.3 Light Vehicle Drive Cycles

The test cycles driven during the emission sampling were the benchmark ECE R83 light vehicle certification test, the Combined Urban Emission Drive Cycle (CUEDC) and two short in-service tests known as the DT 80 and the AC 5080.
The ECE R83 drive cycle consists of an elementary urban cycle repeated four times (part I) with an extra urban cycle (part II). It is a transient cycle with a total cycle time of 1220 seconds.
The CUEDC drive cycles of which there are one for each vehicle category, are also transient cycles, longer in duration (approximately 1700 seconds) than the ECE R83 test cycle. They were developed from data logging of vehicles in commercial operation in Sydney in NEPC Project 2.1. The DT80 and AC5080 were developed as part of NEPC Project 2.2.

The AC 5080 drive cycle consists of:
- an idle period of 10 sec.
- wide open throttle (WOT) acceleration to 50 kph, held at 50 kph for 60 sec.
- accelerate at WOT to 80 kph, held at 80 kph for 60 sec.
- end test.

The DT 80 drive cycle consists of:
- an idle period of 60sec.
- WOT acceleration to 80 kph
- immediate deceleration back to idle for 10 sec.
- WOT acceleration to 80 kph
- immediate deceleration to idle for 10 sec.
- WOT acceleration to 80 kph held at 80 kph for 60 sec.
- end test.

Details of the CUEDC cycles and the DT80 and AC5080 are contained in Appendix C.

The ECE R24 smoke test consists of six nominated steady engine speeds at full load while the smoke readings are taken.

2.1.4 Light Vehicles Test Procedure

Test vehicles when received were drained of fuel or connected to a supply of standard fuel for the duration of testing. A preconditioning drive cycle was then carried out on the dynamometer and the vehicle was then parked in a temperature controlled soak area for the required conditioning time. Prior to testing, the constant volume sampling system (CVS) and inertia dynamometer were calibrated in accordance with ECE R83. The inertia and road loads for each vehicle was as specified in ECE R83.

The testing sequence was:
(i) ECE 83 test from a cold start,
(ii) relevant CUEDC test,
(iii) AC 5080 test
(iv) DT 80 test
(v) ECE R24 smoke test.

2.2 HEAVY VEHICLES

2.2.1 Heavy Vehicle Categories

Heavy vehicle tests were conducted on 12 vehicles covering both pre-ADR 70/00 (1990-95) and current ADR 70/00 (1996-99) models. The ADR vehicle categories were ME, NB and NC. These are defined as :-

ME: Heavy Omnibus: omnibus with a GVM exceeding 5 tonnes

NB: Medium Goods Vehicle: goods vehicle GVM exceeding 3.5 tonnes but not exceeding 12.0 tonnes.

NC: Heavy Goods Vehicle: goods vehicle with a GVM exceeding 12.0 tonnes

For the purpose of the NEPC Projects an additional category was defined as:
NCH: Heavy Goods Vehicle: greater than 25 tonnes GVM or GCM (Gross Combination Mass).

The vehicles were sourced mainly from truck rentals.

2.2.2 Heavy Vehicle Test Equipment

The ADR70/00 emissions test for heavy vehicles is a multi-mode steady state test conducted on an engine dynamometer. Previous research has shown that it is possible to use a chassis dynamometer to replicate, to an acceptable degree of accuracy, the engine dynamometer test specified in ADR 70/00. Testing of heavy vehicles was conducted at the Kangan Batman TAFE Heavy Vehicles & Engine Technology Centre (Coburg). on the College's truck chassis dynamometer testing facility. A schematic of the test equipment layout is at Appendix D.

The dynamometer has two metre diameter rolls with three TELMA eddy-current power absorbers, capable of absorbing 600 Kilowatts continuously. The inertia and road load were simulated electrically and controlled by VIPAC's software on a personal computer. Technical limitation of the Batman Dynamometer Control System would not allow operation with a load applied at speeds below 40 KPH.

The diesel exhaust emissions were sampled through a heated sample line and analysed by a flame ionisation detector for hydrocarbons (HC) and chemiluminescence for oxides of nitrogen (NOx). Opacity measurements were monitored during the test cycles using a Bosch opacity meter. The particulates were sampled gravimetrically by filter paper particulate sampler (NOVA MICROTROL 4), in accordance with the ECE 49 regulation.

The load and speed of the dynamometer was recorded and the emissions were calculated for each drive cycle to give emissions, in terms of grams per kilowatt-hour.

2.2.3 Heavy Vehicle Test Procedure

The heavy vehicles were received and set up on the dynamometer for preconditioning (warm up to normal operating condition) before establishing power and torque measurements. The set-up time for each vehicle varied considerably in terms of exhaust configuration (position, height diameter), intake air for the engine, and whether the vehicle was a single or dual axle. The test parameters were then established and pre-test runs were carried out to ensure proper warm up for stable and repeatable operation of the dynamometer and the vehicle on the dynamometer rolls.

RESULTS

Detailed results are contained in Appendix E. The analysis of the results is discussed below.

2.3 LIGHT VEHICLES

Light Vehicles Hydrocarbons

The HC Emission results for each vehicle are shown in Table 2-1 arranged in order of ranking, highest to lowest emitter, for each test cycle. Vehicle 10 was the second highest emitter for the ECE R83 and the highest emitter for all other drive cycles. Vehicle 15 ranked highest for the ECE R83, second highest for the CUEDC and sixth highest for the DT80 and AC5080 cycles.

In general the emission ranking from the ECE R83 cycle compared to the DT80 showed that vehicle numbers 4,18,9,6,5 and 19, emitted much higher values for the short test. However, the remaining 13 vehicles (not including vehicle No. 1) tend to show emissions ranking that differ from each other by 3 or 4 rankings.

Table 2-2 shows the linear correlation co-efficient "r" for relationships between the HC emissions of the different test cycles. In relation to the benchmark ECE test, the CUEDC has a good correlation, while the DT80 and AC5080 have relatively poor correlations.

Table 2-1: Ranking comparison of HC emissions for light vehicles

Vehicle No.	ECE R83	Vehicle No.	CUEDC	Vehicle No.	DT80	Vehicle No.	AC5080
15na	0.51	10mc	0.35	10mc	0.49	10mc	0.3
10mc	0.41	15na	0.31	19na	0.39	6na	0.28
1na	0.39	17na	0.31	5na	0.27	19na	0.28
17na	0.34	1na	0.28	6na	0.27	9mc	0.27
19na	0.23	19na	0.24	9mc	0.27	1na	0.26
12na	0.21	11na	0.18	15na	0.27	15na	0.19
11na	0.19	9mc	0.17	17na	0.27	17na	0.19
8mc	0.18	5na	0.16	8mc	0.24	8mc	0.16
20na	0.18	20na	0.15	18na	0.23	5na	0.14
5na	0.15	12na	0.13	12na	0.18	12na	0.13
2mc	0.13	18na	0.11	11na	0.11	4na	0.12
18na	0.12	2mc	0.09	4na	0.10	7na	0.10
13na	0.09	4na	0.07	20na	0.1	11na	0.10
14mc	0.08	6na	0.07	2mc	0.09	2mc	0.09
9mc	0.08	13na	0.06	13na	0.08	18na	0.08
6na	0.07	8mc	0.04	14mc	0.06	13na	0.06
4na	0.07	14mc	0.04	3mc	0.05	14mc	0.06
3mc	0.07	16na	0.04	1na	0.04	16na	0.04
7na	0.05	7na	0.03	7na	0.04	3mc	0.03
16na	0.05	3mc	0.02	16na	0.04	20na	0.01

Table 2-2: HC correlation coefficient 'r' by test cycle

	ECE	CUEDC	DT80	AC5080
ECE	1			
CUEDC	.89	1		
DT80	.48	.62	1	
AC5080	.50	.63	.72	1

Light Vehicle NOx

Table 2-3 shows the NOx emission result for each vehicle arranged in relative ranking from highest to lowest emitter for each vehicle on each test. Vehicle 10 was the highest emitter for the ECE R83 cycle whilst vehicle 20 was the highest emitter for all the other cycles.

In comparing the ECE R83 cycle to the DT80 cycle vehicle 10,14,2 and 13 produce emissions above 1.04 g/km for the ECE R83, but below 0.97 g/km for the DT80. Conversely vehicles 20,12,16,7 and 8 have emissions below 0.77 g/km for the ECE R83 and above 1.19 g/km for the DT80 cycle.

Table 2-4 shows the NOx linear correlation co-efficient "r" for relationships between NOx emissions of the different test cycles. All three transient tests correlate well with the benchmark ECE test.

Table 2-3: Ranking comparison of NOx emissions for light vehicles

Vehicle No.	ECE R83	Vehicle No.	CUEDC	Vehicle No.	DT80	Vehicle No.	AC5080
10mc	4.75	**20na**	4.26	**20na**	5.59	**20na**	3.68
14mc	1.65	**12na**	1.11	**1na**	2.08	**1na**	2.02
6na	1.14	**16na**	1.05	**4na**	2.08	**4na**	1.91
4na	1.13	**8mc**	0.96	**6na**	1.78	**6na**	1.52
1na	1.10	**4na**	0.91	**8mc**	1.71	**16na**	1.24
2mc	1.05	**6na**	0.91	**16na**	1.28	**11na**	1.23
13na	1.04	**10mc**	0.85	**12na**	1.26	**13na**	1.22
18na	0.87	**17na**	0.78	**7na**	1.19	**15na**	1.22
11na	0.82	**18na**	0.77	**17na**	1.17	**3mc**	1.15
19na	0.79	**19na**	0.77	**18na**	1.07	**10mc**	0.98
15na	0.79	**1na**	0.73	**11na**	0.97	**12na**	0.93
20na	0.77	**13na**	0.73	**13na**	0.97	**17na**	0.91
12na	0.65	**15na**	0.73	**15na**	0.97	**5na**	0.74
16na	0.64	**11na**	0.71	**19na**	0.91	**8mc**	0.74
17na	0.63	**7na**	0.65	**3mc**	0.89	**19na**	0.68
3mc	0.60	**9mc**	0.61	**2mc**	0.87	**7na**	0.55
7na	0.59	**2mc**	0.57	**14mc**	0.58	**2mc**	0.54
8mc	0.57	**14mc**	0.53	**9mc**	0.56	**14mc**	0.54
9mc	0.52	**3mc**	0.52	**10mc**	0.37	**18na**	0.49
5na	0.37	**5na**	0.47	**5na**	0.05	**9mc**	0.27

Table 2-4: NOx correlation coefficient 'r'

	ECE	CUEDC	DT80	AC5080
ECE	1			
CUEDC	.97	1		
DT80	.89	.92	1	
AC5080	.80	.82	.89	1

2.3.1 Light Vehicle Particulates

The results of Table 2-5 contain the particulate measurements obtained from the dilution tunnel in order of relative ranking, highest to lowest emitters, for each vehicle on each test. The highest particulate emitter in the benchmark test ranked 5 in CUEDC, 4 in DT80 and 6 in AC5080. The second highest, Vehicle 18 was ranked 2 in CUEDC, 1 in DT80 and 3 in AC5080.

Table 2-6 shows the linear correlation co-efficient for the particulate measurements of Table 2-5. The correlations between the benchmark test and the CUEDC and DT80 are generally good, exhibiting values of "r" greater than 0.8. For the AC5080, the correlation is less strong at 0.66.

Table 2-5: Cycle ranking of particulate emissions for light vehicles

Vehicle No.	ECE R83	Vehicle No.	CUEDC	Vehicle No.	DT80	Vehicle No.	AC5080
17na	4.27	**10mc**	4.84	**18na**	3.44	**16na**	0.58
18na	2.71	**18na**	3.44	**3mc**	3.40	**14mc**	0.53
14mc	2.32	**14mc**	3.15	**14mc**	3.15	**18na**	0.45
12na	1.95	**9mc**	2.91	**17na**	2.91	**12na**	0.33
3mc	1.70	**17na**	2.91	**16na**	2.58	**3mc**	0.3
10mc	1.61	**7na**	2.64	**10mc**	2.20	**17na**	0.25
16na	1.48	**16na**	2.58	**12na**	2.19	**19na**	0.23
2mc	0.53	**12na**	2.19	**2mc**	0.68	**10mc**	0.23
13na	0.52	**8mc**	1.57	**13na**	0.67	**8mc**	0.17
20na	0.52	**1na**	1.46	**20na**	0.66	**5na**	0.14
15na	0.39	**3mc**	1.18	**19na**	0.27	**6na**	0.14
19na	0.34	**2mc**	1.12	**15na**	0.16	**4na**	0.13
1na	0.09	**6na**	0.72	**9mc**	0.15	**13na**	0.1
11na	0.09	**4na**	0.67	**11na**	0.09	**20na**	0.1
8mc	0.09	**5na**	0.67	**1na**	0.08	**15na**	0.10
4na	0.08	**13na**	0.67	**5na**	0.07	**1na**	0.09
5na	0.07	**20na**	0.66	**4na**	0.06	**2mc**	0.09
6na	0.05	**19na**	0.27	**8mc**	0.04	**11na**	0.08
7na	0.05	**15na**	0.16	**7na**	0.04	**9mc**	0.07
9mc	0.05	**11na**	0.09	**6na**	0.04	**7na**	0.04

Table 2-6: Particulate correlation coefficient 'r' by test cycle

	ECE	CUEDC	DT80	AC5080
ECE	1			
CUEDC	.89	1		
DT80	.84	.89	1	
AC5080	.66	.82	.80	1

2.3.2 Light Vehicles Smoke

Table 2-7 shows the correlation for average opacity readings for each test cycle. The correlation with the benchmark test is generally very poor, except for the AC5080, which has a reasonable correlation of 0.7.

The light vehicles ECE R24 smoke results are presented in Appendix E. No specific trends in the smoke results are evident from the results, with some vehicles exhibiting relatively consistent and low readings at all ECE R24 test speeds. Other vehicles had higher emissions at low speeds decreasing with increased engine speeds whilst others exhibited the opposite trend exhibiting high emissions at higher engine speeds.

Table 2-7: Average smoke opacity correlation coefficient 'r' by test cycle

	ECE	CUEDC	DT80	AC5080
ECE	1			
CUEDC	.16	1		
DT80	.22	-.16	1	
AC5080	.70	.00	.73	1

2.4 HEAVY VEHICLES

Vehicle 5, a Leyland bus, had emissions that were much higher than the results from other vehicles. Results from this vehicle were not used in establishing correlations due their disproportionate impact. Results for Vehicle 5 are provided in the Appendix F for reference.

2.4.1 Heavy Vehicles Hydrocarbons

Table 2-8 shows the HC emission result for each vehicle arranged in relative ranking from highest to lowest emitter for each vehicle on each test. Vehicles 8 and 12 are the two lowest HC emitters in all tests and all but the DT80 show vehicles 1 and 3 as the highest two emitters. Vehicle 3, the highest emitter in the benchmark ECE R49 test was ranked highest emitter in the AC5080, third highest in the DT80 and second highest in the CUEDC cycles. Vehicle 1, the second highest emitter in the ECE R49 ranked second highest in the AC5080, highest in DT80 and CUEDC cycles.

Table 2-9 indicates that all three cycles correlate well with the benchmark test in terms of "r" correlation.

Table 2-8: Cycle Ranking comparison of HC emissions for Heavy Vehicles

Vehicle	ECE R49		Vehicle	AC5080		Vehicle	DT80		Vehicle	CUEDC
3	1.47		3	1.28		1	0.88		1	2.47
1	1.38		1	1.02		4	0.79		3	1.04
			4	0.84		3	0.73		4	0.90
4	0.96		6	0.83		6	0.61			
11	0.74								2	0.71
2	0.67		7	0.62		7	0.46		11	0.63
7	0.65		9	0.61		2	0.44		6	0.57
6	0.58		11	0.54		11	0.42		9	0.50
9	0.45		10	0.48		9	0.33		7	0.46
10	0.37		2	0.46		10	0.29		10	0.40
8	0.32		8	0.34		8	0.23		12	0.40
12	0.23		12	0.21		12	0.22		8	0.28

Table 2-9: HC Correlation Coefficient 'r' By Test Cycle

	ECE	CUEDC	DT80	AC5080
ECE	1.00			
CUEDC	.91	1.00		
DT80	.90	0.88	1.00	
AC5080	.79	0.64	0.79	1.00

2.4.2 Heavy Vehicle NOx

Table 2-10 shows the NOx emission result for each vehicle arranged in relative ranking from highest to lowest emitter for each vehicle on each test. Vehicle 1, the highest emitter in the benchmark test exhibited poor correlation in relative rankings with the short test. The AC5080 ranked it fifth highest, the DT80 ranked it eighth highest, but had good correlation with CUEDC, ranking third highest emitter in this test. Vehicle 12, the third highest emitter in the benchmark test, shows good correlation, ranking second highest in all other tests.

Table 2-11 shows that there was no correlation, as measured by the "r" correlation factor, between the DT80 and AC5080 tests and the ECE test. There was some correlation of the CUEDC results with the ECE test.

Table 2-10: Cycle ranking comparison of NOx emissions for heavy vehicles

Vehicle	ECE R49		Vehicle	AC5080		Vehicle	DT80		Vehicle	CUEDC
1	15.02		12	18.24		12	8.05		12	18.66
12	11.89		9	10.52		6	7.63		1	15.41
9	11.73		6	8.11		4	7.57		2	9.62
2	11.06		1	7.91		9	7.50		11	9.42
4	9.40		11	7.83		11	6.17		4	9.38
6	9.16		10	7.65		7	5.90		9	9.07
7	9.10		8	6.56		1	5.16		3	8.26
3	8.97		4	6.33		10	5.06		10	7.45
11	8.09		7	6.00		8	4.96		6	7.19
10	7.63		3	5.17		2	4.42		8	6.97
8	7.45		2	3.29		3	3.91		7	6.55

Table 2-11: NOx correlation coefficient 'r' by test cycle

	ECE	AC5080	DT80	CUEDC
ECE 49	1.00			
AC5080	.33	1.00		
DT80	.15	.67	1.00	
CUEDC	.74	.72	.30	1.00

2.4.3 Heavy Vehicle Particulate

Table 2-12 shows that the highest emitter of particulates in the benchmark ECE R49 test was ranked second highest emitter for AC 5080 and DT 80, but ranked eighth highest for the CUEDC cycle. Vehicle 9, the third highest emitter in the benchmark test, ranked eighth highest for AC 5080, seventh highest for DT 80 and ninth highest for CUEDC cycle.

Table 2-13 illustrates a good correlation between the benchmark test and the DT80 test, poor correlation with the AC5080 test and no correlation with the CUEDC.

Table 2-12: Cycle ranking comparison of particulate emissions for heavy vehicles

Vehicle	ECE R49		Vehicle	AC5080		Vehicle	DT80		Vehicle	CUEDC
5	4.78		5	21.43		5	33.27		5	32.78
3	2.86		3	1.20		3	0.93		1	0.61
9	2.15		7	0.78		1	0.68		2	0.55
1	2.03		11	0.62		6	0.63		11	0.41
11	1.69		4	0.51		11	0.60		10	0.30
2	1.23		1	0.49		2	0.58		6	0.29
7	1013		6	0.33		9	0.56		4	0.26
8	4.46		9	0.33		10	0.50		3	0.22

Vehicle	ECE R49		Vehicle	AC5080		Vehicle	DT80		Vehicle	CUEDC
10	0.87		10	0.28		4	0.29		9	0.20
6	0.84		2	0.26		7	0.37		12	0.17
4	0.58		12	0.22		8	0.37		8	0.11
12	0.09		8	0.14		12	0.16		7	0.10

Table 2-13: Filtered particulates correlation coefficient 'r' by test cycle

	ECE 49	AC5080	DT 80	CUEDC
ECE49	1			
AC5080	.63	1		
DT 80	.85	.60	1	
CUEDC	.23	-.10	.43	1

2.4.4 Heavy Vehicles Smoke

The heavy vehicle ECE R24 smoke results are presented in Table 2-14. Table 2-15 illustrates that the DT80 correlates well with the ECE 24 benchmark test for both average and maximum emissions, while the CUEDC and AC5080 have weaker correlations. The DT80 also correlates well with average opacity readings taken during the ECE 49 emissions test.

The correlations between particles and smoke opacity were poor for all tests. The ECE24 average opacity test did correlate reasonably well with ECE 49 particle emissions.

Table 2-14: Average smoke opacity and ECE24 smoke results by vehicle

	Opacity Average %				ECE 24 Average
Vehicle No	ECE 49	AC5080	DT 80	CUEDC	ECE24
1	3.2	2.4	2.77	2.57	1.31
2	1.29	1.34	1.86	2.52	0.63
3	3.5	4.71	3.07	2.97	2.47
4	3.08	2.86	3.1	2.55	1.31
5	4.13	3.85	2.93	5.1	3.11
6	1.31	2.0	2.48	2.82	0.62
7	2.68	1.3	2.05	1.8	1.07
8	1.56	2.6	1.66	1.94	0.50
9	1.37	1.54	2.05	2.21	1.25
10	1.75	4.25	1.75	1.82	0.83
11	1.99	1.61	1.99	3.58	0.70
12	0.77	1.1	1.5	0.95	0.20

Table 2-15: Average smoke opacity and ECE24 smoke correlation coefficient 'r' by test cycle

	ECE 49	AC5080	DT 80	CUEDC	ECE24 Avg	ECE24 Max
ECE49	1					
AC5080	.53	1				
DT 80	.82	46	1			
CUEDC	.42	.20	.56	1		
ECE24 Avg	.82	.63	.78	.41	1	
ECE24 Max	.85	.66	.85	.46	.92	1

3 SUMMARY

The test results showed that, for light vehicles:

- the correlations, as measured by the "r" coefficient, between the benchmark test and the transient tests was:
  - for NOx , excellent for all tests;
  - for HC, excellent for the CUEDC test and poor for the DT80 and AC5080;
  - for particulates, excellent for the CUEDC and DT80 and fair for the AC5080.

- high and low emitters were identified by all tests;

- small differences in emission scores in the mid-range of test results could change the relative ranking of results between each of the test cycles.

For heavy vehicles:

- the correlation, as measured by the "r" coefficient, between the benchmark test and the transient tests was:
  - for NOx , fair for the CUEDC and very poor for the DT80 and AC5080;
  - for HC, excellent for all tests;
  - for particulates, excellent for the DT80, poor for the AC5080 and very poor for the CUEDC.

- the highest and lowest emitters are in general ranked high and low by the DT80 test for all emissions;

- small differences in emission scores in the mid-range of test results could change the relative ranking of results in each of the test cycles.

The nature of the test and test equipment meant that there was more variation in the results for heavy vehicles than in the results for light vehicles.

However the results for both classes of vehicles do indicate that the transient tests in general show good correlation with the benchmark test for HC, NOx and particulates and are capable of distinguishing between low and high emitters. Despite the good statistical correlations the ranking of vehicles can vary considerably between tests due to small variations in test results. This fact should be taken account of when setting a standard for the in-service tests to ensure the standard is not set at a level that would allow a vehicle capable of passing the benchmark test to fail the in-service test.

For heavy vehicles here was a good correlation between both average and peak opacity readings on the benchmark test when compared with the results of the DT80 test. For light vehicles there was no correlation between the results of the benchmark test and the transient tests for either average or peak opacity readings.

APPENDIX 1: DIESEL ENGINE EMISSIONS

Diesel engine exhaust emissions consist of a range of harmful substances including unburnt or partially burnt hydrocarbons (HC), oxides of nitrogen (NOx), particulates and carbon monoxide (CO).

In the diesel engine, the fuel is injected into the cylinder just before combustion; the time interval between the start of injection and ignition is known as ignition delay. Fuel injected during the ignition delay will mix with air to produce a wide range of air-fuel ratios. The pollutant formation processes are strongly dependent on the fuel distribution and how that distribution changes with time due to mixing.

The sample vehicles were tested for exhaust gas emissions of HC, NOx, particulates and smoke. A brief overview of the mechanisms of formation of each pollutant now follows as a primer to the analysis of results.

HYDROCARBON EMISSIONS

Hydrocarbon (HC) emissions are the consequence of incomplete combustion of organic fuels. There are several paths which allow fuel to escape the combustion process. Diesel combustion is a complex process: fuel evaporation, unburnt fuel-air mixture and burned gas mixing, and combustion can occur simultaneously. Further, the oxidation process can be affected by many engine design and operation parameters such as combustion chamber shape, static compression ratio, injector type, injector timing and so on.

Hydrocarbon emission levels from diesels vary widely with operating conditions, and different HC formation mechanisms are likely to be most important at different operating modes. There are three major mechanisms for HC formation under normal operating conditions:

(i) Fuel mixed to leaner than the lean combustion limit during ignition delay.

(ii) Incomplete mixing of fuel-air mixture resulting in a wide range of equivalent ratios from locally over lean to over rich.

(iii) Quenching of the combustion process by combustion chamber walls.

Of the possible mechanisms, the over lean condition is considered to be the most important contributor to HC emissions. Diesel engines always run on excess air and the general range is ~16:1 air-fuel ratio for maximum power to ~50:1 for idle. Engine idle and light-load conditions produce significantly higher HC emissions than full-load conditions. However, when the engine is over fuelled at full-load HC emissions increase substantially.

OXIDES OF NITROGEN EMISSIONS

Oxides of nitrogen (NOx) form in the high-temperature burned gas regions within the combustion chamber. As explained in the previous section, fuel-air ratio distributions within the combustion chamber are non-uniform and formation ratios are highest in the close to stoichiometric regions where local high peak pressures and hence temperatures occur.

Maximum NOx levels occur just lean of stoichiometric overall air fuel ratio (maximum power), and decrease gradually with a decrease in overall equivalence ratio to their minimum value at engine idle. NOx levels generally fall by approximately thirty percent from maximum power setting to engine idle.

Though the amount of fuel injected decreases proportionally as the overall equivalence ratio is decreased, much of the fuel still burns close to stoichiometric due to the non-uniform fuel distribution in the diesel engine. Thus NOx emissions should be roughly proportional to the mass of fuel injected providing burned gas pressures and temperatures do not change greatly.

Dilutents added to the intake air such as recycled exhaust, are effective at reducing NOx emissions, the primary effect is one of reducing the burned gas temperature. As injection timing is retarded, so the combustion process is retarded, NOx formation occurs later, and concentrations are reduced due to lower peak temperatures.

PARTICULATE EMISSIONS

Diesel particulates consist of carbon, sulfates and a mixture of hydrocarbons known as the soluble organic fraction.

Most particular material results from incomplete combustion of fuel; the lubricating oil contributes some. The flame in a diesel engine is highly non-uniform, some of the reaction will be as a lean mixture, some will be at close to stoichiometric and some will be in a rich mixture. In the very fuel rich zones, where there is marginal combustibility, very large amounts of solid carbon particles are generated. As the combustion process proceeds and the air-fuel mixture in the combustion chamber is further mixed by turbulence, most of the carbon particles further react, and only a small percent are emitted from the exhaust.

As the overall air-fuel ratio in the diesel engine is lean, most of the carbon will react with excess oxygen present. Additional reactions take place in the exhaust system, further reducing the amount of solid carbon, and as such the exhaust gas temperature has a significant effect on particulate emissions.

Particulate emissions can be minimised by ensuring that the engine is operated with:

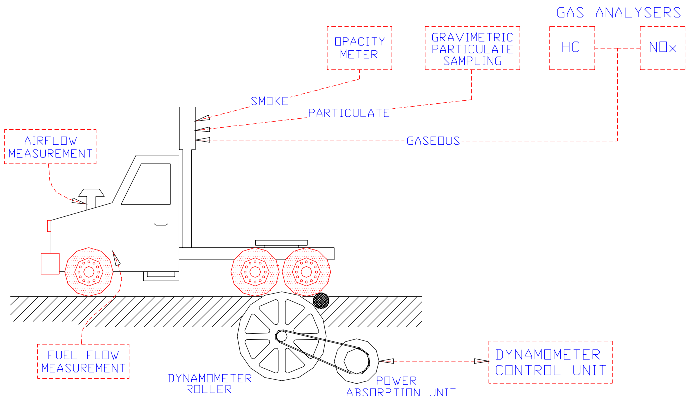
- an overall lean air-fuel ratio,
- by advancing the injection timing,
- increasing the exhaust gas temperature,
- injecting a finer fuel spray or greater turbulence in the combustion chamber.

: Test Fuel Parameters

Property	Units	Method	Result	Spec Limit
Appearance		D4176	1	Rating 1
Appearance		Insp	C&B	Clear and Bright
Colour		D1500	<1.5	2.0 max
Ash	%m	D482	<0.01	<0.01 max
Carbon Residue	%m	D4530	0.01	0.01 max
Cloud Point	C	D2500	0	0 max
Copper Corrosion		D130	1	1 max
10% rec	C	D86	248	Report
50% rec	C	D86	280	Report
90% rec	C	D86	329	357 max
Flash point	C	D93	91	65 mion
Sulphur	%m	D2622	0.12	0.50 max
Water	%v	D95	<0.05	0.05 max
Sediment	%m	D473	<0.01	0.01 max
Viscosity @40 C	mm^2/s	D445	3.44	1.90-4.80
Strong acid number	mg KOH/g	D974	NIL	NIL
Total acid number	mg KOH/g	D974	0.1	0.5 max
Filter blocking tendency		D2068	1.00	1.20 max
Static disipator additive (s450)	mg/L		160	3 max

NOTE: DIESEL FUEL PROVIDED BY SHELL AUSTRALIA PTY LTD

APPENDIX 2: : SAMPLING SYSTEM



APPENDIX 3:

DT80 Short Test

This test has been designed to evaluate vehicle emissions during typical "real-world" operating modes and conditions. There are three simple modes:

(i) Three idle Periods
(ii) Acceleration to 80km/h three times
(iii) Cruise at 80km/h

The graph below illustrates the modes of operation. Modes B-D and E-G and H-I have no specific time interval. Note this may be changed as a result of further test refinement to provide a specific test duration.

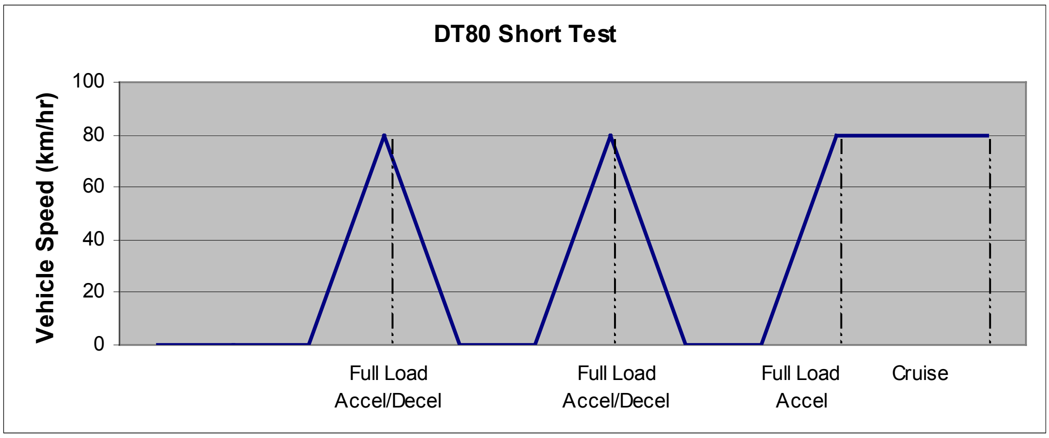
The vehicle is accelerated rapidly to 80km/h three times by applying wide-open throttle.

The driver selects the most appropriate gear change points for the vehicle being tested to achieve the correct speed.

The dynamometer must be capable of applying transient, real-time tractive resistance in response to instantaneous speed and acceleration. System response time to changes in speed/acceleration shall not exceed 100ms. The vehicle test mass for road load and inertia settings shall be equal to the mass of the vehicle when operating with ½ it's nominal payload, ie: (GVM+TARE MASS) ÷2.

The vehicle's rolling resistance (based on tyre and bearing losses, frontal area and drag coefficient) must also be calculated and continuously factored into the dynamometer tractive effort calculations to ensure correct loading. (Note: Empirical algorithms, based on vehicle test mass, GVM or other known parameters, may be used to automatically calculate realistic coefficients for these variables).

Figure A4 1:DT80 Short Test



Steps

(i) Secure vehicle on dynamometer.

(ii) Set dynamometer to simulate the correct load and inertia for the vehicle under test.

(iii) A-start sampling.

(iv) A to B – Idle for 60 seconds.

(v) B to C – Accelerate rapidly to 80km/h under simulated inertia using wide open throttle.

(vi) C to D – decelerate by removing all pressure from the accelerator pedal and gently applying brakes to standstill.

(vii) D to E – Idle for 10 seconds.

(viii) E to F - Accelerate rapidly to 80km/h under simulated inertia using wide open throttle.

(ix) F to G – Decelerate by removing all pressure from the accelerator pedal and gently applying brakes to standstill.

(x) G to H – Idle for 10 seconds.

(xi) H to I – Accelerate rapidly to 80km/h under simulated inertia using wide open throttle.

(xii) I to J – Maintain speed at 80km/h for 60 seconds – stop sampling. Bring vehicle to rest. If vehicle passes – test completed. If vehicle fails repeat steps from A to J treating the first test as pre-conditioning.

(xiii) D to E – Accelerate to 80km/h under simulated inertia
(xiv) E to f – Maintain speed at 80km/h for 60 seconds.

The dynamometer must be capable of applying transient, real-time tractive resistance in response to instantaneous speed and acceleration. System response time to changes in speed/acceleration shall not exceed 100ms. The vehicle test mass for road load and inertia settings shall be equal to the mass of the vehicle when operating with ½ it's nominal payload, ie: (GVM+TARE MASS)÷2.

The vehicle's rolling resistance (based on tyre and bearing losses, frontal area and drag coefficient) must also be calculated and continuously factored into the dynamometer tractive effort calculations to ensure correct loading. (Note: Empirical algorithms, based on vehicle test mass, GVM or other known parameters, may be used to automatically calculate realistic coefficients for these variables).

AC5080 Short Test

This test has been designed to evaluate vehicle emissions during typical "real-world" operating modes and conditions. There are five simple modes:

(i) Idle.
(ii) Acceleration to 50km/h.
(iii) Cruise at 50km/h.
(iv) Acceleration to 80km/h.
(v) Cruise at 80km/h.

The graph below illustrates the modes of operation. Modes B-C and D-E have no specific time interval. Note this may be changed as a result of further test refinement to provide a specific test duration.

The Vehicle is accelerated rapidly to each of the cruise speeds by applying wide-open throttle.

The driver selects the most appropriate gear change points for the vehicle being tested to achieve each mode of operation.

Steps

(i) Secure vehicle on dynamometer.

(ii) Set dynamometer to simulate the correct load and inertia for the vehicle under test.

(iii) Idle vehicle and commence sampling. Vehicle in neutral with brakes on.

(iv) Release brake and accelerate using wide open throttle through the gears to 50 km/h.

(v) Maintain 50km/h for 60 seconds.

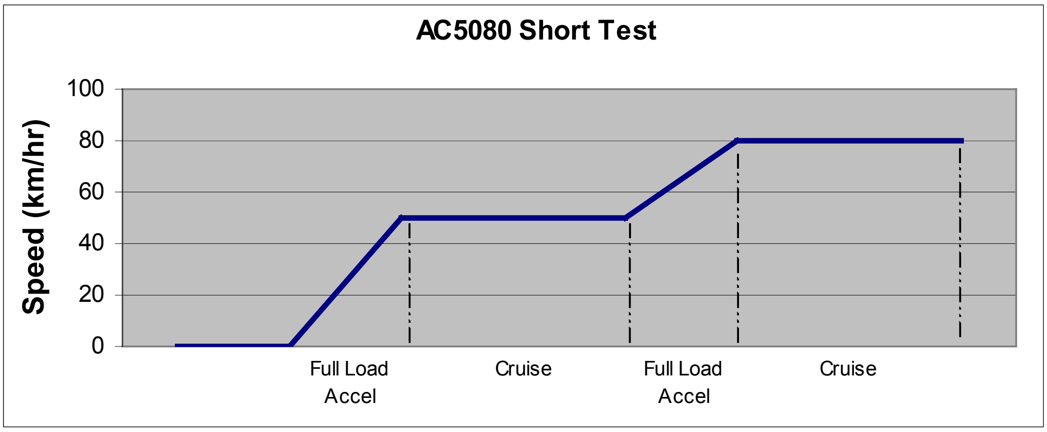
(vi) Accelerate to 80km/h using wide open throttle and the most appropriate gear changes for the vehicle.

(vii) Maintain speed at 80km/h for 60 seconds – then stop sampling.

(viii) Return vehicle to idle.

(ix) If vehicle passes – Test completed – if it fails, then repeat steps 3 to 8 and treat the first test as a precondition.

Figure A4 2:AC5080 Short Test



A – Start sampling
A to B – Idle for 10 seconds.
B to C – Accelerate to 50km/h under simulated inertia.
C to D – Maintain speed at 50 km/h for 60 seconds.

Complex CUEDC and Simplified CUEDC drive cycles

Table A4 1: CUEDC Details for NA Category Vehicles

Mode	Duration (seconds)	Percentage (Time)	Av Speed (km/h)	Distance (km)	Percentage (km)
Congested	334	18.6%	12.9	1.2	6.9%
Minor	504	28.1%	32.8	4.6	26.3%
Arterial	447	24.9%	32.0	4.0	22.8%
Highway	508	28.3%	54.4	7.7	44.0%
Total	1793	100.0%	33.0	17.4	100.0%

Figure A4 3: CUEDC for NA Category vehicles – Light goods vehicle ≤ 3.5 tonnes gvm

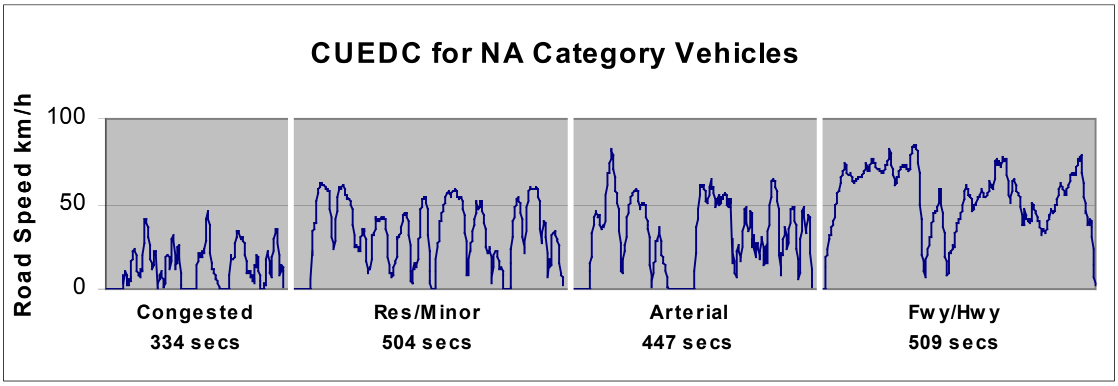


Table A4 2: CUEDC Details for NB Category Vehicles

Mode	Duration (seconds)	Percentage (Time)	Av Speed (km/h)	Distance (km)	Percentage (km)
Congested	319	18.7%	10.9	1.0	4.7%
Minor	405	23.8%	35.7	4.0	19.6%
Arterial	390	22.9%	29.8	3.2	15.7%
Highway	591	34.7%	75.1	12.3	60.0%
Total	1705	100.0%	37.9	20.5	100.0%

Figure A4 4:CUEDC for NB Category vehicles - Medium goods vehicle > 3.5 ≤ 12 tonnes gvm

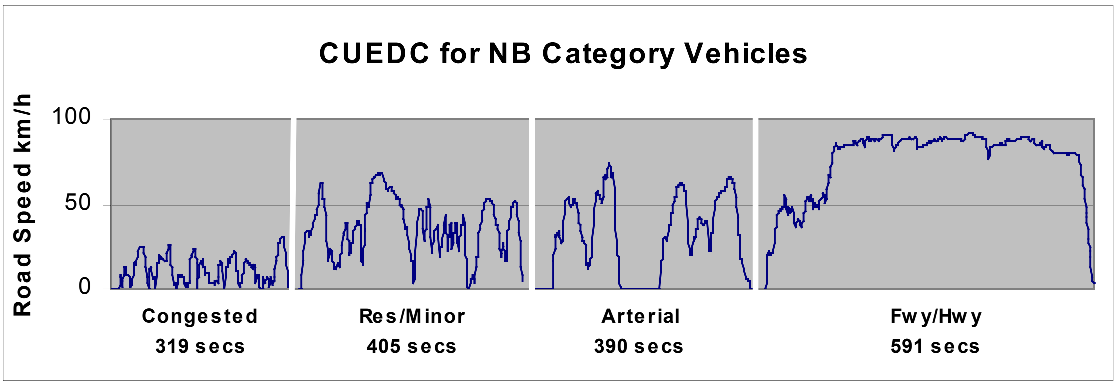


Table A4 3: CUEDC Details for ME Category Vehicles

Mode	Duration (seconds)	Percentage (Time)	Av Speed (km/h)	Distance (km)	Percentage (km)
Congested	322	19.2%	11.1	1.0	6.9%
Minor	506	30.2%	33.3	4.7	32.6%
Arterial	435	25.9%	23.7	2.9	19.9%
Highway	414	24.7%	50.8	5.8	40.6%
Total	1677	100.0%	29.7	14.4	100.0%

Figure A4 5: CUEDC for ME Category vehicles – Heavy buses > 5 tonnes gvm

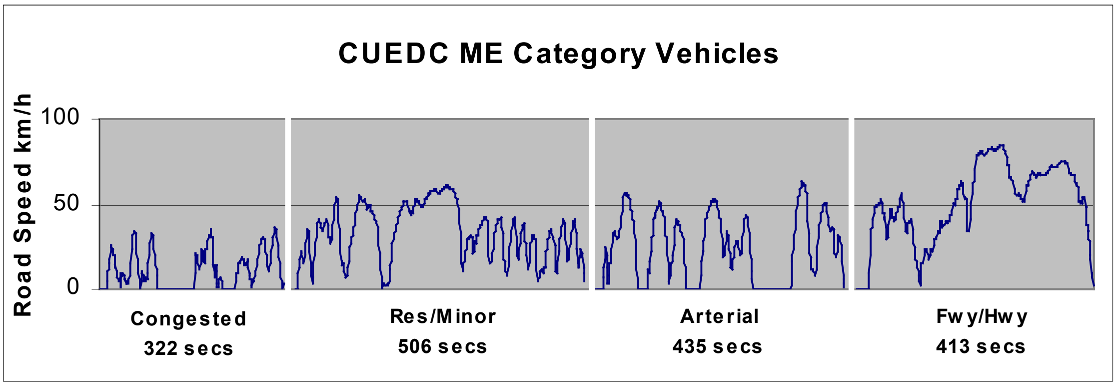


Table A4 4: CUEDC Details for NC Category Vehicles

Mode	Duration (seconds)	Percentage (Time)	Av Speed (km/h)	Distance (km)	Percentage (km)
Congested	328	18.3%	7.9	0.7	4.2%
Minor	509	28.3%	32.4	4.6	26.8%
Arterial	431	24.0%	31.5	3.8	22.2%
Highway	528	29.4%	54.3	8.0	46.8%
Total	1796	100.0%	31.6	17.0	100.0%

Figure A4 6: CUEDC for NC Category vehicles – Heavy goods vehicles > 12 ≤ 25 tonnes gvm or gcm

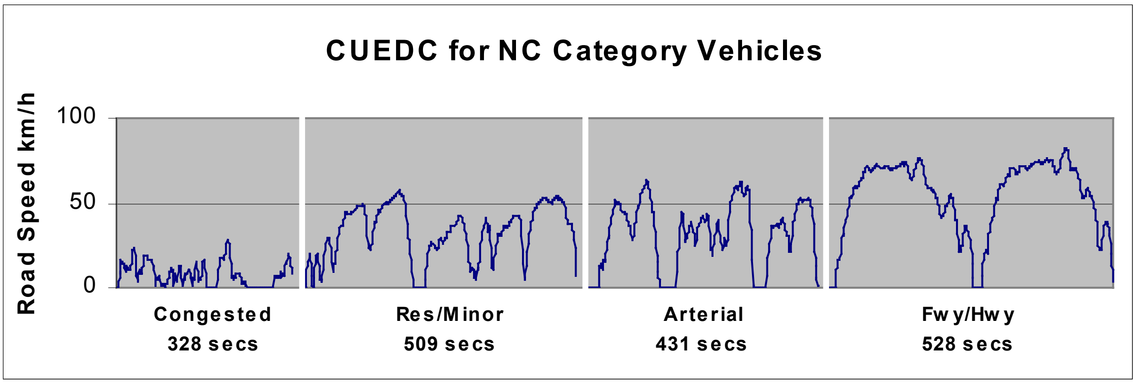
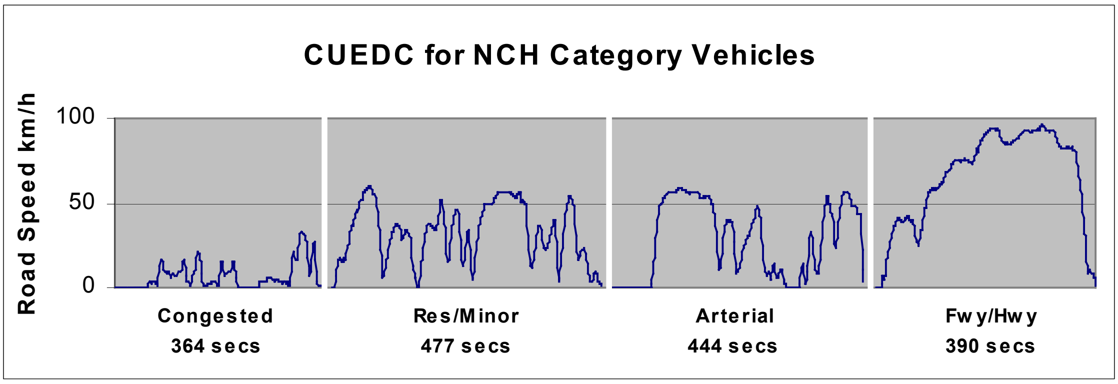


Table A4 5: CUEDC Details for NCH Category Vehicles

Mode	Duration (seconds)	Percentage (Time)	Av Speed (km/h)	Distance (km)	Percentage (km)
Congested	364	21.7%	6.7	0.7	4.4%
Minor	477	28.5%	32.6	4.3	27.8%
Arterial	444	26.5%	28.1	3.5	22.4%
Highway	390	23.3%	65.2	7.1	45.5%
Total	1675	100.0%	33.1	15.5	100.0%

Figure A4 7: CUEDC for NCH Category vehicles – Heavy goods vehicles > 25 tonnes gvm or gcm



APPENDIX 4: STATISTICAL RESULTS

Table A5 1: Light Vehicles ECE R83 Emission Results Summary

No.	Date	Vehicle	Year	GVM-Tare	Dist.Km	HC g/km	NOx g/km	CO ppm	CO_2%	Part. g/km ece	Av. Opac %	Tot. Opac %
1na	28/4/00	Ford Transit	2000	3300-1780	41	0.39	1.10	76.4	1.7	0.09	3.10	7.90
2mc	10/5/00	1005 Nissan Patrol 3L Auto	Mar-00	3000-1400	1400	0.13	1.05	18.3	1.1	0.53	2.68	13.50
3mc	10/5/00	Nissan Patrol 3L Man	Mar-00	3000-1400	3473	0.07	0.60	84.2	0.9	1.70	3.02	15.00
4na	2/5/00	Toyota Troop Carrier	1998	3200-2360	3788	0.07	1.13	43.6	1.2	0.08	1.31	14.30
5na	20/4/00	Ford Courier	2000	2680-1645	7043	0.15	0.37	39.3	0.9	0.07	3.10	7.90
6na	4/5/00	Nissan Patrol 4.2	1999	3040-1980	9724	0.07	1.14	65.0	1.2	0.05	0.80	1.60
7na	2/5/00	Toyota Hilux 3.0	1998	2730-1870	10808	0.05	0.59	29.4	1	0.05	2.68	13.50
8mc	2/5/00	Toyota Land Cruiser	1996	3180-2140	11606	0.18	0.57	27.4	1.1	0.09	1.34	5.60
9mc	2/5/00	Nissan Patrol 2.8	1999	2800-1700	11912	0.08	0.52	34.7	1.1	0.05	1.60	2.90
10mc	26/5/00	Holden Rodeo	Apr-96	2740-1600	15031	0.41	4.75	59.6	0.9	1.61	1.40	16.00
11na	27/4/00	Mazda Bravo	1999	2680-1645	20726	0.19	0.82	34.5	1.1	0.09	3.10	7.90
12na	24/5/00	Ford Transit	May-96	2830-1800	73372	0.21	0.65	63.4	1	1.95	6.17	26.00
13na	11/5/00	1105 Toyota Hilux	Feb-97	2730-1500	92357	0.09	1.04	84.2	0.9	0.52	2.68	13.50
14mc	2/6/00	Mitsubishi Pajero	2000	2950-1490	97012	0.08	1.65	34.2	1.2	2.32	0.95	17.10
15na	6/5/00	Nissan Patrol	1994	2800-1650	99868	0.51	0.79	66.0	1	0.39	1.84	25.70
16na	23/5/00	2305 Toyota Hilux	Aug-94	2730-1470	128509	0.05	0.64	82.8	0.1	1.48	1.96	21.00
17na	24/5/00	Mitsubishi Express	n/a	n/a	160321	0.34	0.63	82.8	0.1	4.27	2.77	18.00
18na	26/5/00	Mazda B220	Mar-91	2495-1295	170228	0.12	0.87	82.8	0.1	2.71	2.40	14.00
19na	5/5/00	Toyota Hiace	1992	2800-1710	174837	0.23	0.79	81.6	0.9	0.34	2.33	43.30
20na	12/5/00	Nissan Navara	Aug-90	2730-1400	366362	0.18	0.77	84.2	0.9	0.52	2.68	13.50

Table A5 2: Light Vehicles CUEDC Emission Results Summary

No.&Test	Date	Vehicle	Year	GVM-Tare	Dist.Km	HC g/km cued	NOx g/km cued	CO ppm	CO_2%	Part. g/km cuedc	Av. Opac %	Tot. Opac %
1na	28/4/00	Ford Transit	2000	3300-1780	41	0.28	0.85	62.50	1	0.08	2.91	16.00
2mc	36804	1005 Nissan Patrol 3L Auto	36586	3000-1400	1378	0.09	0.96	8.90	1.1	0.68	1.35	6.90
3mc	36804	Nissan Patrol 3L Man	36586	3000-1400	3473	0.02	0.65	25.00	1.1	3.40	1.04	6.70
4na	36561	Toyota Troop Carrier	1998	3200-2360	3788	0.07	0.91	42.70	1.2	0.06	1.9	9.40
5na	20/4/00	Ford Courier	2000	2680-1645	7043	0.16	0.47	36.30	0.9	0.07	2.91	16.00
6na	36621	Nissan Patrol 4.2	1999	3040-1980	9724	0.07	0.91	40.70	1.2	0.04	1.1	25.70
7na	36561	Toyota Hilux 3.0	1998	2730-1870	10808	0.03	0.52	25.00	1.1	0.04	1.35	6.90
8mc	36561	Toyota Land Cruiser	1996	3180-2140	11606	0.04	0.57	27.40	1.1	0.04	1.34	5.60
9mc	36561	Nissan Patrol 2.8	1999	2800-1700	11912	0.17	0.73	97.30	1.1	0.15	4.3	2.90
10mc	26/5/00	Holden Rodeo	35156	2740-1600	15031	0.35	4.26	40.00	0.8	2.20	1.57	14.00
11na	27/4/00	Mazda Bravo	1999	2680-1645	20726	0.18	0.77	38.60	1.2	0.09	2.3	14.70
12na	24/5/00	Ford Transit	35186	2830-1800	73372	0.13	0.77	40.30	0.9	2.19	2.55	22.00
13na	36835	1105 Toyota Hilux	35462	2730-1500	92357	0.06	0.78	25.00	1.1	0.67	1.35	6.90
14mc	36562	Mitsubishi Pajero	2000	2950-1490	97012	0.04	1.05	30.10	1.1	3.15	1.97	18.00
15na	36682	Nissan Patrol	1994	2800-1650	99868	0.31	0.73	64.40	1.1	0.16	1.21	12.80
16na	23/5/00	2305 Toyota Hilux	Aug-94	2730-1470	128509	0.04	0.53	35.50	0.9	2.58	2.40	26.00
17na	24/5/00	Mitsubishi Express	n/a	n/a	160321	0.31	0.73	64.40	1.1	2.91	1.97	16.90
18na	26/5/00	Mazda B220	Mar-91	2495-1295	170228	0.11	1.11	67.70	1.1	3.44	0.00	15.80
19na	5/5/00	Toyota Hiace	1992	2800-1710	174837	0.24	0.71	59.20	0.9	0.27	2.05	43.30
20na	36865	Nissan Navara	Aug-90	2730-1400	366362	0.15	0.61	80.00	0.9	0.66	1.35	6.90

Table A5 3: Light Vehicles DT 80 Emission Results Summary

No.	Date	Vehicle	Year	GVM-Tare	Dist.Km	HC g/km dt80	NOx g/km dt80	CO ppm	CO_2%	Part. g/km dt80	Av. Opac %	Tot. Opac %
1na	28/4/00	Ford Transit	2000	3300-1780	41	0.04	0.37	40.7	1.5	0.17	2.57	5.90
2mc	10/5/00	1005 Nissan Patrol 3L Auto	Mar-00	3000-1400	1378	0.09	1.71	1.4	1.6	0.22	1.80	6.60
3mc	10/5/00	Nissan Patrol 3L Man	Mar-00	3000-1400	3473	0.05	1.19	37.7	1.8	0.73	1.80	6.60
4na	2/5/00	Toyota Troop Carrier	1998	3200-2360	3788	0.10	1.78	123.7	3.1	0.32	2.82	16.90
5na	20/4/00	Ford Courier	2000	2680-1645	7043	0.27	0.05	41.1	1.5	0.26	2.57	5.90
6na	4/5/00	Nissan Patrol 4.2	1999	3040-1980	9724	0.27	2.08	37.7	1.8	0.20	0.80	5.90
7na	2/5/00	Toyota Hilux 3.0	1998	2730-1870	10808	0.04	0.89	37.7	1.8	0.13	1.80	6.60
8mc	2/5/00	Toyota Land Cruiser	1996	3180-2140	11606	0.24	0.87	27.4	1.1	0.35	2.57	22.70
9mc	2/5/00	Nissan Patrol 2.8	1999	2800-1700	11912	0.27	2.08	37.7	1.8	0.29	1.60	2.90
10mc	26/5/00	Holden Rodeo	Apr-96	2740-1600	15031	0.49	5.59	39.0	1.2	0.54	2.22	5.70
11na	27/4/00	Mazda Bravo	1999	2680-1645	20726	0.11	0.91	28.0	1.5	0.10	2.57	5.90
12na	24/5/00	Ford Transit	May-96	2830-1800	73372	0.18	1.07	48.4	1.3	0.58	3.74	12.20
13na	11/5/00	1105 Toyota Hilux	Feb-97	2730-1500	92357	0.08	1.17	51.2	1	0.25	1.80	6.60
14mc	2/6/00	Mitsubishi Pajero	2000	2950-1490	97012	0.06	1.28	34.2	1.7	0.65	2.72	8.70
15na	6/5/00	Nissan Patrol	1994	2800-1650	99868	0.27	0.97	125.8	1.5	0.36	3.43	20.40
16na	23/5/00	2305 Toyota Hilux	Aug-94	2730-1470	128509	0.04	0.58	53.8	1.2	0.58	3.30	4.30
17na	24/5/00	Mitsubishi Express	n/a	n/a	160321	0.27	0.97	125.8	1.5	0.74	2.72	11.10
18na	26/5/00	Mazda B220	Mar-91	2495-1295	170228	0.23	1.26	90.3	1.2	0.88	5.58	13.80
19na	5/5/00	Toyota Hiace	1992	2800-1710	174837	0.39	0.97	125.8	1.3	0.54	5.10	25.10
20na	12/5/00	Nissan Navara	Aug-90	2730-1400	366362	0.1	0.56	175.6	1.3	0.26	1.8	6.6

Table A5 4: Light Vehicles AC 5080 Emission Results Summary

No.	Date	Vehicle		GVM-Tare	Dist.Km	HC g/km	NOx g/km	CO ppm	CO_2%	Part. g/km	Av. Opac %	Tot. Opac %
1na	28/4/00	Ford Transit	2000	3300-1780	41	0.26	0.98	90.3	2	0.09	2.67	4.10
2mc	10/5/00	1005 Nissan Patrol 3L Auto	Mar-00	3000-1400	1378	0.09	0.74	19.8	1.6	0.09	2.05	5.6
3mc	10/5/00	Nissan Patrol 3L Man	Mar-00	3000-1400	3473	0.03	0.55	55.9	1.6	0.3	2.05	5.6
4na	2/5/00	Toyota Troop Carrier	1998	3200-2360	3788	0.12	1.52	119.9	3.1	0.13	2.48	14.40
5na	20/4/00	Ford Courier	2000	2680-1645	7043	0.14	0.74	49.8	1.5	0.14	3.10	7.90
6na	4/5/00	Nissan Patrol 4.2	1999	3040-1980	9724	0.28	1.91	54.1	3.1	0.14	1.10	1.80
7na	2/5/00	Toyota Hilux 3.0	1998	2730-1870	10808	0.10	1.15	55.9	1.6	0.04	2.05	5.60
8mc	2/5/00	Toyota Land Cruiser	1996	3180-2140	11606	0.16	0.54	49.8	1.5	0.17	1.91	6.40
9mc	2/5/00	Nissan Patrol 2.8	1999	2800-1700	11912	0.27	2.02	54.1	3.1	0.07	1.60	2.90
10mc	26/5/00	Holden Rodeo	Apr-96	2740-1600	15031	0.3	3.68	50.8	1.4	0.23	1.63	6.8
11na	27/4/00	Mazda Bravo	1999	2680-1645	20726	0.10	0.68	47.3	1.8	0.08	2.67	4.10
12na	24/5/00	Ford Transit	May-96	2830-1800	73372	0.13	0.49	90.6	1.3	0.33	5.26	11.2
13na	11/5/00	1105 Toyota Hilux	Feb-97	2730-1500	92357	0.06	0.91	87.6	1.5	0.1	2.05	5.6
14mc	2/6/00	Mitsubishi Pajero	2000	2950-1490	97012	0.06	1.24	51.3	2	0.53	1.88	7.4
15na	6/5/00	Nissan Patrol	1994	2800-1650	99868	0.19	1.22	90.6	1.3	0.10	1.84	17.80
16na	23/5/00	2305 Toyota Hilux	Aug-94	2730-1470	128509	0.04	0.54	47.9	1.4	0.58	2.8	5.8
17na	24/5/00	Mitsubishi Express	n/a	n/a	160321	0.19	1.22	90.6	1.3	0.25	1.88	12.5
18na	26/5/00	Mazda B220	Mar-91	2495-1295	170228	0.08	0.93	93.8	1.3	0.45	4.7	14.6
19na	5/5/00	Toyota Hiace	1992	2800-1710	174837	0.28	1.23	118.2	1.4	0.23	2.98	12.20
20na	12/5/00	Nissan Navara	Aug-90	2730-1400	366362	0.01	0.27	141.5	0.3	0.1	2.05	5.6

Table A5 5: Light Vehicle ECE R24 Summary Limit & LAC

1		2		3		4		5		6		7		8		9		10	
#1 FORD TRANSIT		#2 N PATROL 3L/A		#3 N PATROL 3L MAN		#4 T TROOP CARRIER		#5 FORD COURIER		#6 NISSAN PATROL 4.2		#7 TOY HILUX 3.0		#8 LANDCRUISER		#9 N PATROL 2.8		#10 HOLDEN RODEO	
Limit	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**
2.26	0.65	2.19	0.45	2.19	0.60	2.19	0.68	2.26	2.50	1.99	0.41	2.26	0.52	2.19	0.54	2.26	0.54	2.26	1.48
2.26	0.71	2.08	0.40	2.08	0.85	1.99	0.85	2.19	0.65	1.78	0.31	2.08	0.68	1.99	0.54	2.19	0.57	2.08	0.97
1.99	0.65	1.78	0.56	1.78	0.65	1.84	1.49	2.08	0.65	1.62	0.35	1.985	0.92	1.84	0.61	1.87	0.61	1.90	1.02
1.84	0.68	1.67	0.56	1.67	0.85	1.72	1.64	1.90	0.67	1.50	0.41	1.84	0.68	1.72	0.80	1.72	0.67	1.78	0.92
1.72	0.61	1.58	0.56	1.58	0.75	1.62	1.70	1.84	0.84	1.43	0.55	1.72	0.63	1.62	0.80	1.62	0.80	1.67	0.97
1.62	0.68	1.50	0.55	1.50	0.93	1.54	3.00	1.72	0.89	1.35	0.55	1.62	0.65	1.54	1.54	1.54	0.80	1.58	1.70

11		12		13		14		15		16		17		18		19		20	
MAZDA BRAVO		96 FORD TRANSIT		#TOYOTA HILUX		#15 MITS PAJERO		#15 N PATROL UTE		#16 TOY HILUX 94		#17 MITS EXPRESS		#18 MAZDA B2200		#19 TOYOTA HIACE		#20 NISSAN NAVARA	
Limit	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**	**Limit**	**LAC (/m)**
2.26	0.84	2.26	0.60	2.26	3.40	2.26	1.65	1.84	1.72	2.26	2.00	2.26	1.35	2.26	2.21	2.26	0.85	2.26	3.42
2.19	0.56	2.08	0.68	1.99	3.11	2.19	1.55	1.78	1.72	1.99	1.35	1.99	2.00	2.19	2.21	1.99	2.95	2.19	3.10
2.08	0.36	1.90	0.75	1.90	1.45	1.87	0.80	1.54	1.72	1.90	1.03	1.90	1.80	2.08	2.00	1.84	3.45	1.90	4.10
1.90	0.41	1.78	1.24	1.78	0.66	1.78	0.67	1.43	1.89	1.78	0.92	1.78	2.50	1.99	2.35	1.72	1.80	1.78	5.50
1.78	0.45	1.67	1.36	1.67	1.72	1.62	0.67	1.35	0.70	1.62	1.62	1.67	3.45	1.84	2.45	1.62	2.25	1.67	>8.0
1.72	0.57	1.58	1.62	1.58	1.57	1.54	0.80	1.27	1.72	1.54	1.80	1.58	3.10	1.72	2.45	1.54	1.49	1.58	2.80

Table A5 6: Light Vehicle ECE R24 Summary RPM & LAC

1		2		3		4		5		6		7		8		9		10	
FORD TRANSIT		N PATROL 3L AUTO		N PATROL 3L MAN		T TROOP CARRIER		FORD COURIER		NISSAN PATROL 4.2		TOYOTA HILUX 3.0		LANDCRUISER		N PATROL 2.8		HOLDEN RODEO	
RPM	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**
1800	0.65	1800	0.45	1800	0.60	1710	0.68	1575	2.50	1620	0.41	1800	0.52	1710	0.54	1800	0.54	1710	1.48
2000	0.71	2300	0.40	2000	0.85	2200	0.85	2000	0.65	2000	0.31	2400	0.68	2200	0.54	2000	0.57	2200	0.97
2680	0.65	2700	0.56	2680	0.65	2546	1.49	2345	0.65	2412	0.35	2680	0.92	2546	0.61	2680	0.61	2546	1.02
3120	0.68	3100	0.56	3120	0.85	2964	1.64	2730	0.67	2808	0.41	3120	0.68	2964	0.80	3120	0.67	2964	0.92
3560	0.61	3560	0.56	3560	0.75	3382	1.70	3115	0.84	3204	0.55	3560	0.63	3382	0.80	3560	0.80	3382	0.97
4000	0.68	4000	0.55	4000	0.93	3800	3.00	3500	0.89	3600	0.55	4000	0.65	3800	1.54	4000	0.80	3800	1.70

12		13		14		15		16		17		18		19		20		21	
MAZDA BRAVO		96 FORD TRANSIT		TOYOTA HILUX		MITS PAJERO		N PATROL UTE		94 TOYOTA HILUX		MITS EXPRESS		MAZDA B2200		TOYOTA HIACE		NISSAN NAVARA	
RPM	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**
1575	0.84	1890	0.60	4010	1.57	1800	1.65	1800	1.72	1800	2.00	1890	1.35	1800	2.21	1800	0.85	1935	3.42
2000	0.56	2500	0.68	1780	3.40	2000	1.55	2000	1.72	2400	1.35	2500	2.00	2400	2.21	2400	2.95	2200	3.10
2345	0.36	2814	0.75	2650	1.45	2680	0.80	2680	1.72	2680	1.03	2814	1.80	2680	2.00	2680	3.45	2881	4.10
2730	0.41	3276	1.24	3100	0.66	3120	0.67	3120	1.89	3120	0.92	3276	2.50	3120	2.35	3120	1.80	3354	5.50
3115	0.45	3738	1.36	3500	1.72	3560	0.67	3560	0.70	3560	1.62	3738	3.45	3560	2.45	3560	2.25	3827	>8.0
3500	0.57	4200	1.62	2400	3.11	4000	0.80	4000	1.72	4000	1.80	4200	3.10	4000	2.45	4000	1.49	4300	2.80

APPENDIX 5:

Table A6 1: HEAVY VEHICLES DETAILS

No.	Date	Vehicle	Category	Year	GVM-Tare kg	Dist.Km	Power kW	@RPM	Torque Nm	@RPM	Engine Model	Engine Size L
1	25/7/00	Isuzu FSR	NB (TRAY)	1990	8000-3100	102304	100	3200	353	2000	L21	5.7
2	28/7/00	Mitsubishi FM557	NC (TRAY)	1994	15000-6900	191353	154	2700	626	1400	6D	7.545
3	31/7/00	Scania 112M	NC (PRIME)	1996	30000-15000	98323	206	2000	1165	1300	DS 1114	11.02
4	1/8/00	Scania 112M	NC (PRIME)	1996	30000-15000	98323	206	2000	1165	1300	DS 1114	11.02
5	3/8/00	Leyland	ME (BUS)	1993	24000-12920	298200	156	1900	655	1400	Gardener 6LXCT	10.0
6	4/8/00	Mitsubishi Canter	NB (TRAY)	1995	6000-2990	124334	81	3200	265	1800	4D34B	4.214
7	7/8/00	Mitsubishi Canter	NB (TRAY)	1999	6000-2990	10040	85	3200	304	1800	4D33-4A	4.214
8	8/8/00	Hino FG1J Turbo Intercooler	NC (TRAY)	2000	15000-7040	1200	166	2500	700	1500	JO8CT	7.961
9	9/8/00	Isuzu FTR	NC (TRAY)	1994	13900-6240	209670	129	3000	471	1800	6HE1	6.2
10	10/8/00	Mitsubishi Fighter	NC (VAN)	1999	16000-8120	13808	112	2900	452	1700	6D162A	7.5
11	11/8/00	Nissan Diesel UDCK320	NC(PRIME)	1998	36000-6100	108595	235	2100	1323	1200	PF6TA	12.503
12A	14/8/00	International 3600 Chassis Dyno	NCH (PRIME)	1998	42500-12980	295493	276	1600	1830	1200	Cummins M11-370E	10.8
12B	18/8/00	International 3600 Engine Dyno	NCH (PRIME)	1998	42500-12980	295493	276	1600	1830	1200	Cummins M11-370E	10.8

Table A6 2: Heavy Vehicle ECE49 Emissions Summary

Vehicle Number	Vehicle	Category	HC g/kWh	NOx g/kWh	Particulates g/kWh	Avg. % Opacity
1	Isuzu FSR	NB (TRAY)	1.38	15.02	2.03	3.20
2	Mitsubishi FM557	NC (TRAY)	0.67	11.06	1.23	1.29
3	Scania 112M	NC (PRIME)	1.47	8.97	2.86	3.50
4	Scania 112M	NC (PRIME)	0.96	9.40	0.58	3.08
5	Leyland	ME (BUS)	1.00	31.06	4.78	4.13
6	Mitsubishi Canter	NB (TRAY)	0.58	9.16	0.84	1.31
7	Mitsubishi Canter	NB (TRAY)	0.65	9.10	1.13	2.68
8	Hino FG1J Turbo Intercooler	NC (TRAY)	0.32	7.45	1.13	1.56
9	Isuzu FTR	NC (TRAY)	0.45	11.73	2.15	1.37
10	Mitsubishi Fighter	NC (VAN)	0.37	7.63	0.87	1.75
11	Nissan Diesel UDCK320	NC(PRIME)	0.74	8.09	1.69	1.99
12A	International 3600 Chassis Dyno	NCH (PRIME)	0.23	11.89	0.09	0.77
12B	International 3600 Engine Dyno	NCH (PRIME)	0.14	9.14	0.09	0.79

Table A6 3: Heavy Vehicle AC5080 Emissions Summary

Vehicle Number	Vehicle	Category	HC g/kWh	NOx g/kWh	Particulates g/kWh	Avg. % Opacity
1	Isuzu FSR	NB (TRAY)	1.02	7.91	0.49	2.40
2	Mitsubishi FM557	NC (TRAY)	0.46	3.29	0.26	1.34
3	Scania 112M	NC (PRIME)	1.28	5.17	1.20	4.71
4	Scania 112M	NC (PRIME)	0.84	6.33	0.51	2.86
5	Leyland	ME (BUS)	0.77	23.97	21.43	3.85
6	Mitsubishi Canter	NB (TRAY)	0.83	8.11	0.33	2.00
7	Mitsubishi Canter	NB (TRAY)	0.62	6.00	0.78	41.30
8	Hino FG1J Turbo Intercooler	NC (TRAY)	0.34	6.56	0.14	2.60
9	Isuzu FTR	NC (TRAY)	0.61	10.52	0.33	1.54
10	Mitsubishi Fighter	NC (VAN)	0.48	7.65	0.28	4.25
11	Nissan Diesel UDCK320	NC(PRIME)	0.54	7.83	0.62	1.61
12A	International 3600 Chassis Dyno	NCH (PRIME)	0.21	18.24	0.22	1.10

Table A6 4: Heavy Vehicle DT80 Emissions Summary

Vehicle Number	Vehicle	Category	HC g/kWh	NOx g/kWh	Particulates g/kWh	Avg. % Opacity
1	Isuzu FSR	NB (TRAY)	0.88	5.16	0.68	2.77
2	Mitsubishi FM557	NC (TRAY)	0.44	4.42	0.58	1.86
3	Scania 112M	NC (PRIME)	0.73	3.91	0.93	3.07
4	Scania 112M	NC (PRIME)	0.79	7.57	0.39	3.10
5	Leyland	ME (BUS)	0.52	18.61	33.27	2.93
6	Mitsubishi Canter	NB (TRAY)	0.61	7.63	0.63	2.48
7	Mitsubishi Canter	NB (TRAY)	0.46	5.90	0.37	2.05
8	Hino FG1J Turbo Intercooler	NC (TRAY)	0.23	4.96	0.37	1.66
9	Isuzu FTR	NC (TRAY)	0.33	7.50	0.56	2.05
10	Mitsubishi Fighter	NC (VAN)	0.29	5.06	0.50	1.75
11	Nissan Diesel UDCK320	NC(PRIME)	0.42	6.17	0.60	1.99
12A	International 3600 Chassis Dyno	NCH (PRIME	0.22	8.05	0.16	1.50

Table A6 5: Heavy Vehicle CUEDC Emissions Summary

Vehicle Number	Vehicle	Category	HC g/kWh	NOx	Particulates	Avg. %
1	Isuzu FSR	NB (TRAY)	2.47	15.41	0.61	2.57
2	Mitsubishi FM557	NC (TRAY)	0.71	9.62	0.55	2.52
3	Scania 112M	NC (PRIME)	1.04	8.26	0.22	2.97
4	Scania 112M	NC (PRIME)	0.90	9.38	0.26	2.55
5	Leyland	ME (BUS)	0.78	32.38	32.78	5.10
6	Mitsubishi Canter	NB (TRAY)	0.57	7.19	0.29	2.82
7	Mitsubishi Canter	NB (TRAY)	0.46	6.55	0.10	1.80
8	Hino FG1J Turbo Intercooler	NC (TRAY)	0.28	6.97	0.14	1.94
9	Isuzu FTR	NC (TRAY)	0.50	9.07	0.20	2.21
10	Mitsubishi Fighter	NC (VAN)	0.40	7.45	0.30	1.82
11	Nissan Diesel UDCK320	NC(PRIME)	0.63	9.42	0.41	3.58
12A	International 3600 Chassis Dyno	NCH (PRIME)	0.40	18.66	0.17	0.95

Table A6 6: Heavy Vehicle Emissions Summary (g/km)

Vehicle	AC5080 HC g/km	DT80 HC g/km	CUEDC HC g/km	AC5080 NOx g/km	DT80 NOx g/km	CUEDC NOx g/km	AC5080 Particles g/km	DT80 Particles g/km	CUEDC Particles g/km
1 Isuzu FSR	0.47	0.73	0.77	3.35	4.32	4.83	2.27	6.68	0.19
2 Mitsubishi FM 557	0.26	0.45	0.52	1.84	4.53	7.08	1.39	6.39	0.51
3 Scania 112M	1.32	1.22	1.08	5.34	6.55	8.55	11.71	16.72	0.29
4 Scania 112M	0.87	1.32	0.93	6.55	12.67	9.71	4.93	7.01	0.34
5 Leyland	1.87	1.62	1.65	0.71	0.93	0.79	153.70	469.87	38.18
6 Mitsubishi Canter	0.27	0.33	0.32	2.60	4.07	4.05	1.00	3.63	0.16
7 Mitsubishi Canter	0.21	0.26	0.26	2.06	3.31	3.69	2.69	2.27	0.06
8 Hino FG1 Turbo Intercooler	0.27	0.34	0.25	5.24	7.45	6.09	1.03	6.04	0.16
9 Isuzu FTR	0.35	0.41	0.33	5.95	9.28	6.05	1.77	7.67	0.17
10 Mitsubishi Fighter	0.32	0.39	0.35	5.17	6.80	6.51	1.77	7.24	0.33
11 Nissan Diesel UDCK320	0.46	0.70	0.62	6.72	10.22	9.32	5.06	10.66	0.52
12A International 3600 - Chassis Dyno Test	0.20	0.35	0.26	17.74	12.67	12.01	2.03	2.60	0.14

Table A6 7: Heavy Vehicle ECE R24 Summary Limit & LAC

1		2		3		4		5		6		7		8		9		10		11		12	
Vehicle #1 Isuzu		Vehicle #2 Mitsubishi		Vehicle #3 Scania		Vehicle #4 Scania		Leyland Bus #5		Vehicle #6 Canter		Vehicle#7 Canter		Vehicle#8 Hino		Vehicle#9 Isuzu FTR		Veh #10 Mits Fighter		Vehicle#11 UDCK320		Veh#12 Inter.Cummins	
Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)	Limit	LAC (/m)
1.78	2.80	1.72	1.70	1.58	5.50	1.58	1.14	2.19	0.60	2.08	0.67	2.08	1.35	1.72	1.35	1.72	1.50	1.72	1.25	1.58	1.35	1.84	0.20
1.54	1.24	1.62	0.60	1.40	3.40	1.40	0.50	2.08	0.85	1.84	0.35	1.84	1.50	1.50	0.43	1.50	1.62	1.50	0.92	1.54	0.85	1.54	0.20
1.45	1.00	1.41	0.30	1.32	2.20	1.32	0.50	1.78	0.65	1.72	0.40	1.72	0.85	1.43	0.28	1.43	1.62	1.43	1.00	1.32	0.46	1.43	0.00
1.37	0.70	1.32	0.35	1.25	1.42	1.25	0.46	1.67	0.85	1.60	0.60	1.60	0.60	1.35	0.28	1.35	1.05	1.35	0.68	1.23	0.41	1.40	0.00
1.30	0.92	1.23	0.41	1.17	1.10	1.17	1.47	1.58	0.75	1.50	0.92	1.50	0.85	1.25	0.30	1.25	0.72	1.25	0.60	1.16	0.55	1.30	0.00
1.23	1.17	1.16	0.41	1.11	1.22	1.11	3.80	1.50	0.93	1.41	0.80	1.41	1.25	1.19	0.35	1.19	1.00	1.19	0.55	1.10	0.60	1.25	0.00

Table A6 8: Heavy Vehicle ECE R24 Summary RPM & LAC

Vehicle #1 Isuzu		Vehicle #2 Mitsubishi		Vehicle #3 Scania		Vehicle #4 Scania		Leyland Bus #5		Vehicle #6 Canter		Vehicle#7 Canter		Vehicle#8 Hino		Vehicle#9 Isuzu FTR		Veh #10 Mits Fighter		Vehicle#11 UDCK320		Veh#12 Inter.Cummins	
RPM	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**	**RPM**	**LAC (/m)**
1440	2.80	1000	5.50	1000	5.50	1000	1.14	1800	0.60	1440	0.67	1440	1.35	1111	1.35	1305	1.50	1305	1.25	1000	1.35	720	0.20
2000	1.24	1268	3.40	1268	3.40	1268	0.50	2000	0.85	1800	0.35	1800	1.50	1506	0.43	1800	1.62	1800	0.92	1077	0.85	1075	0.20
2144	1.00	1400	2.20	1400	2.20	1400	0.50	2680	0.65	2144	0.40	2144	0.85	1650	0.28	1943	1.62	1943	1.00	1440	0.46	1200	0.00
2496	0.70	1600	1.42	1600	1.42	1600	0.46	3120	0.85	2496	0.60	2496	0.60	1926	0.28	2262	1.05	2262	0.68	1660	0.41	1285	0.00
2848	0.92	1800	1.10	1800	1.10	1800	1.47	3560	0.75	2848	0.92	2848	0.85	2198	0.30	2581	0.72	2581	0.60	1880	0.55	1495	0.00
3200	1.17	2000	1.22	2000	1.22	2000	3.80	4000	0.93	3200	0.80	3200	1.25	2470	0.35	2900	1.00	2900	0.55	2100	0.60	1600	0.00

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