HDV-78-08

Technical Report

August, 1978

Exhaust Emissions and Fuel Consumption of a Heavy-Duty Gasoline Powered Vehicle Over Various Driving Cycles

361 Cubic Inch 1966 Ford F-600

by

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Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air and Waste Management
U.S. Environmental Protection Agency

Abstract

This report contains the results of exhaust emission tests on one precontrolled heavy-duty gasoline truck. These tests were run on a chassis dynamometer over various driving cycles developed under the CAPE-21 cycle generation program. This effort is a continuation of the test program which initially examined a 1977 GMC truck; it was designed to answer some questions which developed during that testing.

This test sequence was designed to investigate in more detail the effect of various driving cycles upon vehicle emissions and fuel consumption. For this reason, road load drag force was not varied as in the previous experiment. For each driving cycle three tests were run with the vehicle in a fully warmed-up condition. Also, for this test sequence, several new cycles were generated which had not been run during the previous test sequence on the GMC truck. (See Technical Support Report for Regulatory Action, Exhaust Emissions and Fuel Consumption of a Heavy-Duty Gasoline Powered Vehicle over Various Driving Cycles, 427 Cubic Inch 1977 California GMC 6500, June 1978). The final phase was a sequence of four tests to investigate cold and warm start effects.

Much higher levels of HC and NOx were observed (5.8 and 2.4 times, respectively) than for the controlled truck previously tested. CO emissions and fuel consumption were about the same. As would be expected, cold starting doubled HC and CO, increased fuel consumption by one third and slightly decreased NOx. Warm starts (one hour soak) had very little effect on emissions or fuel consumption.

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I. Objectives

The test program had the following objectives:

1. Obtain a rough comparison of the emissions from an uncontrolled heavy-duty truck to the previously tested 1977 California vehicle.

2. Determine if the variability observed in earlier tests also occurred with an uncontrolled truck. It was desired to expand this investigation to include new driving cycles , and also driving cycles which passed different statistical criteria.

3. Characterize the effect of cold starting on emissions and fuel consumption.

II. Summary of Results

1. The uncontrolled truck exhibited exhaust emission levels higher than the 1977 California controlled vehicle. This was expected; approximate differences are as follows:

HC	480% higher
CO	29 % higher
NOx	140% higher
Fuel	9 % lower

2. Emission variability was observed from cycles representing the same category of operation. This variability was greatest for CO and, in several instances, the variability was quite large. Most of the other variations can probably be explained as inherent to the test procedure or the peculiarities of the test vehicle. In general, the magnitude of the variation appears to be about the same as that for the previously tested 1977 GM California truck.

3. As would be expected, HC, CO, and fuel consumption were higher for the cold start tests; NOx was lower. Average changes were:

HC	90% higher
CO	150% higher
NOx	20% lower
Fuel	30% higher

Warm start tests, including engine starting, were about the same as for a hot engine, with the engine idling.

III. Description of Experiment

A. Vehicle

The test vehicle was a 1966 Ford F-600, affectionately known as the EPA "pie wagon". This vehicle has an empty mass of 4920 kilograms and a rated GVW of 10,000 kilograms. It is powered by an eight cylinder gasoline engine with 5.9 litres displacement. The transmission is a manual five speed with two speed axle; tires are 8.25 by 20.

This truck has been extensively used by EPA for a wide variety of short term test programs. It is relatively good mechanical condition with only twenty-seven thousand kilometres on the chassis. (The engine has significantly less service, as it was rebuilt during one or more of the test programs.)

B. Equipment, Test Procedures

This test program was carried out using the same equipment as for the 1977 GM California truck. As this was an abbreviated test sequence, engine operating parameters were not recorded and neither the HFID or dilute CO_2 continuous analyzer were used. With the exception of the large roll dynamometer and large CVS, the truck was tested in a manner similar to light-duty vehicles.

C. Road Load

The dynamometer was adjusted to give the road load force indicated in Figures 1 and 2. This actual dynamometer drag force has been compared with a theoretical drag force derived from empirical relationships. As with the previously tested 1977 GM California truck, the dynamometer underloads the truck at low speeds and overloads it slightly at high speeds. This is not a serious problem. The purpose of this experiment was not to determine precise emission values, only the relative variation between the driving cycles and a rough comparison to the previous vehicle. Further, due to the transient nature of the test cycles, inertia will be the predominant factor contributing to the work done, not the road load force.

All tests were run simulating less than full load.

Figure 1

Road Load Force

Speed	Actual Dynamometer	Theoretical[1]
24 km/h	764 N	1412 N
34	1191	1536
43	1439	1692
53	1777	1892
63	2058	2132
72	2550	2413
82	2896	2733

Mass: 8750 kg

[1]Source: Study of Emissions from Heavy-Duty Vehicles, May 1976, p. 30, EPA-460/3-76-012 (9.3 m^2 frontal area assumed)

D. Driving Cycles

Driving cycles for this experiment were developed from actual in-use data collected and analyzed under the CAPE-21 project. In-use vehicles were instrumented in New York City and Los Angeles. Data was collected for freeway and non-freeway operation; it was later organized into separate data matrices. The combination of two cities and two types of driving gives four operation categories.

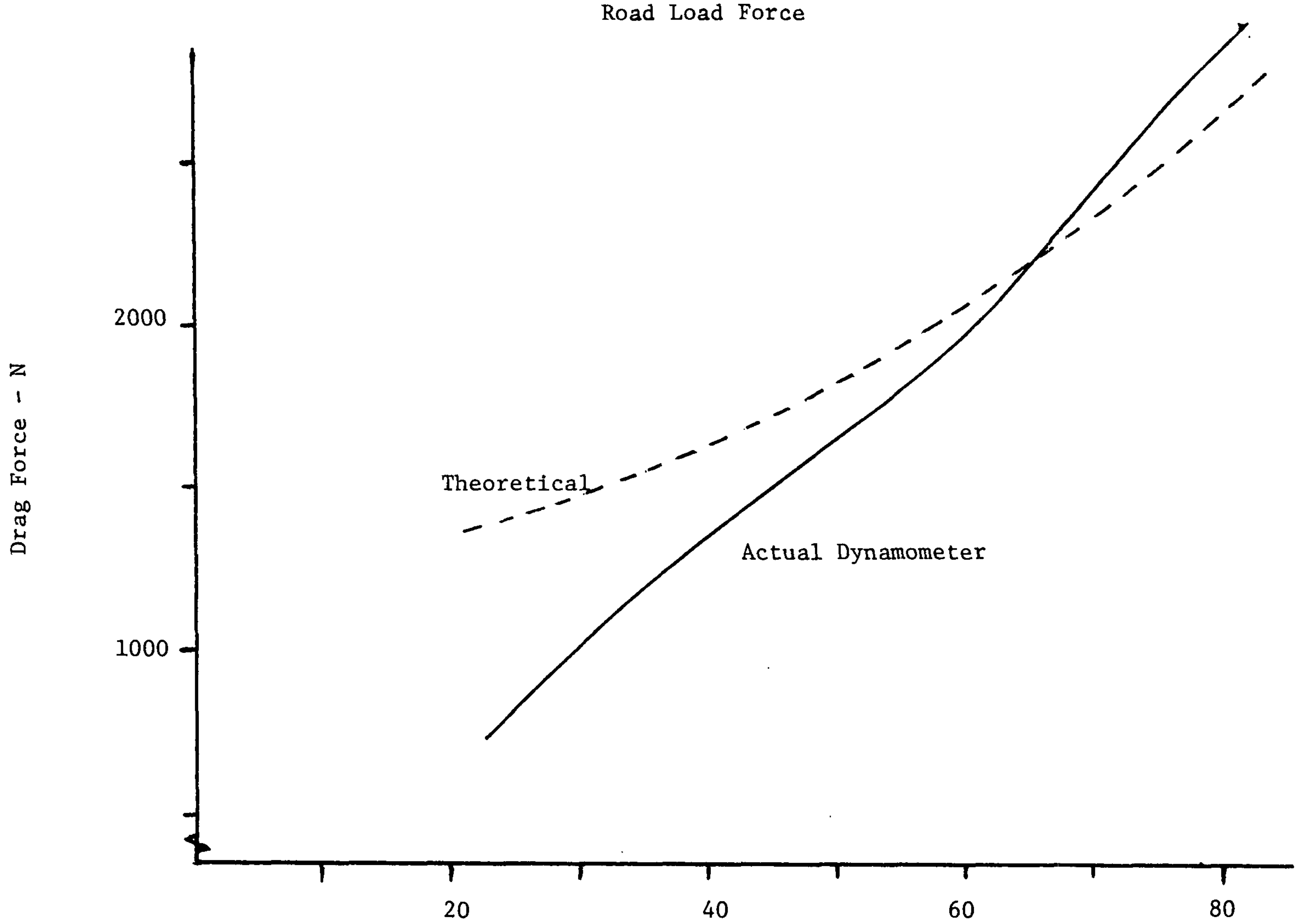
For each category of operation, a data matrix was compiled. This matrix contains information concerning speed, rate of change, and frequency of occurance. (Several other parameters relating to engine operation were also included in the data matrix; however, these are of no concern here.) Since the data logger operated every 0.864 seconds, the data matrix also reflected that time basis. Driving cycles were generated using computer programs developed under the CAPE-21 project.

In addition to operational category (e.g. New York-Freeway), driving cycles are divided into four types. (Not all types were used in the testing for this report. Their inclusion in this discussion is simply to describe the cycle generation process.) These types represent the method used in generation, and not the category of truck operation:

1. Non-Interpolated: These cycles were generated using the 0.864 second time basis which was assumed to be one second. That is, the computer-generated speed versus time sequence should have been plotted into drivers traces with 0.864 seconds between each data point. However, for convenience, it was decided to assume that the in-use data was collected on a 1.0 second basis, and to generate driver's traces accordingly. The result of this technique is to slightly "stretch out" the acceleration and deceleration ramps. (Non-interpolated cycles were not used in this program.)

Figure 2

Road Load Force



2. Interpolated: These cycles are like those above, except that the results have been interpolated. The 0.864 second based speed versus time listing was converted to a 1.0 second basis by linear interpolation. The result of this process is to very slightly shave some of the "peaks and valleys" out of the original cycle. It is thought that this very minor deviation is of no significance.

3. Hand Generated: An attempt was made to "hand generate", without the aid of a computer, two driving cycles from the Los Angeles Non-Freeway input matrix. This was done to achieve the best possible match to the input data speed distribution.

4. Speed Screened: These cycles are interpolated cycles subject to an additional statistical test. The computer program was modified to ensure that cycles generated would more accurately reflect the speed distribution of the data matrix. Original cycles, both interpolated and non-interpolated, were accepted on the basis of percentage acceleration, deceleration, cruise and idle. Speed distribution was not considered. This modification insures that the resulting cycles are more representative of the input data.

All driving cycles were "manufactured" into a speed versus time graph used during the test. (This process was carried out using a minicomputer and strip chart recorder.) The vehicle driver would use this graph as a guide when running the test.

The different driving cycles are described in Figure 3. Cycles 41 to 46 were used on the previous test program in Non-Interpolated form. In Figures 4 and 5 they are refered to as "Interpolated/Original."

E. Test Matrix

For the first part of the test program, the vehicle was operated on all the driving cycles indicated in Figure 3, except cycles 53 and 54. Three back-to-back runs were made for each cycle. All tests began with the engine fully warmed up and idling. This phase of the test program was to investigate the emission characteristics of the various cycles.

Several months after the initial phase, it was decided to investigate the effect of engine temperature on emissions. In the meantime, one cycle (nominal 5 minutes) from each category had been selected as most closely approximating the input data (cycles 31, 32, 53, and 54). These cycles were used in a brief experiment to determine the difference between cold, warm, and hot engine emissions. The following test sequence was employed:

Figure 3

Driving Cycles

No.	Description	Length	Time	Idle	Average Speed[1]	Notes
20	LA Non-Fwy	3.63 km	544s	31%	34.9 km/h	Interpolated
21	LA Non-Fwy	3.75	544	28.1	34.5	Interpolated
22	LA Non-Fwy	3.69	544	31.6	35.8	Interpolated
23	NY Non-Fwy	1.86	544	49.4	24.3	Interpolated
24	NY Non-Fwy	1.68	515	49.3	23.1	Interpolated
25	NY Non-Fwy	1.70	537	49.4	22.4	Interpolated
26	NY Fwy	6.68	544	14.5	51.7	Interpolated
27	NY Fwy	6.37	525	13.5	50.5	Interpolated
28	LA Fwy	10.76	530	2.1	74.6	Interpolated
29	LA Fwy	10.90	538	2.2	74.8	Interpolated
30	LA Fwy	10.73	529	2.1	74.6	Interpolated
31*	NY Fwy	3.36	279	15.4	51.3	Speed screened.
32*	NY Non-Fwy	0.85	254	60.2	30.4	Speed screened.
33	NY Non-Fwy	1.00	273	48.0	25.3	Speed screened.
34	NY Non-Fwy	0.92	259	50.1	26.0	Speed screened.
35	NY Non-Fwy	0.93	285	52.3	24.7	Speed screened.
36	NY Non-Fwy	0.80	254	49.6	22.6	Speed screened.
37	NY Non-Fwy	1.03	285	49.8	25.9	Speed screened.
38	No Cycle					No cycle.
39	NY Non-Fwy	0.97	302	50.3	23.2	Hand generated.
40	NY Non-Fwy	0.97	299	50.2	23.5	Hand generated.
41	NY Non-Fwy	0.87	260	50.8	24.4	Interpolated 01.
42	NY Non-Fwy	0.93	285	52.6	24.9	Interpolated 02.
43	NY Non-Fwy	0.87	285	53.0	23.3	Interpolated 03.
44	NY Fwy	3.43	289	14.9	50.2	Interpolated 04.
45	NY Fwy	3.40	285	14.7	50.3	Interpolated 05.
46	NY Fwy	3.36	214	15.3	52.2	Interpolated 06.
53*[2]	LA Fwy	5.38	267	2.6	74.5	Interpolated
54*[2]	LA Non-Fwy	1.85	285	28.6	32.9	Interpolated 08.

All cycles are interpolated to a 1.0 second time basis.

[1] Average speed does not include idle time.

[2] Not included in original testing, added for cold, hot, warm start sequence.

* Cycle tentatively selected as most representative, used in cold, hot, warm start sequence.

1. Overnight soak at room temperature. The dynamometer was warmed up by motoring the vehicle in neutral at 50 km/h for 15 minutes.

2. Cold start sequence. The vehicle was started as in a light-duty certification test. The manual choke was pulled out for starting, then pushed in halfway after 30 seconds. As soon as the vehicle would run smoothly, about the end of the first acceleration the choke was turned off completely. Three driving cycles were run "back to back".

3. Hot sequence. After the third test in the cold start sequence, the engine was allowed to idle for 60 seconds. Three additional driving cycles were run. (It was assumed that the vehicle was now fully warmed; the averages for these three runs would be the stabilized emission and fuel consumption levels.)

4. Hot soak. For one hour the vehicle was not driven and the auxiliary cooling fan was turned off. This was to simulate a "lunch stop" during the truck's day.

5. Warm start sequence. The vehicle was started and driven for three additional cycles. The choke was not used.

IV. Results

For the various cycle categories, the following average emission and fuel consumption values were observed:

Category	g/km HC	g/km CO	g/km NOx	1/100 km Fuel
NY - NF	21.0	177	11.3	66
LA - NF	13.2	122	10.9	51
NY - FWY	8.7	94	11.0	45
LA - FWY	3.5	50	14.1	38
AVERAGE	11.6	110	11.8	50

This table does not reflect any of the results from the cold, hot, warm test sequence. Only the originally planned testing on cycles 20 through 46, see Figure 3, is included.

The results are fully listed by cycle category, cycle number and test run in Figure 4 and 5 and the Appendix.

Figure 4

Summary of Results

Category	Type Cycles	Emissions g/km HC	CO	NOx	Fuel litre/100 km
NY Non-Fwy	Interpolated/ Original	21.61	182.3	10.65	63.2
	Interpolated	19.63	156.4	8.79	57.0
	Sp. Screened	20.75	193.2	12.43	72.8
	Hand Generated	23.16	152.0	12.77	62.8
NY Fwy	Interpolated/ Original	8.79	90.0	12.39	42.7
	Interpolated	7.18	87.6	9.58	38.2
	Sp. Screened	12.99	121.6	10.81	68.9
LA Non-Fwy	Interpolated	13.15	121.5	10.93	51.1
LA Fwy	Interpolated	3.51	49.6	14.14	38.0

Results presented are the average for all runs of the same type and category driving cycle.

Figure 5

Results

Category	Type Cycles	No.	Emissions g/km HC	CO	NOx	Fuel litre/100 km
NY Non-Fwy	Interpolated/ Original	41	21.87	165.9	10.16	60.8
		42	22.49	184.1	12.34	69.6
		43	20.47	197.0	9.45	59.3
		Ave	21.61	182.3	10.65	63.2
	Interpolated	23	19.64	182.8	11.30	67.7
		24	20.91	144.5	9.27	58.4
		25	18.33	142.0	5.80	45.0
		Ave	19.63	156.4	8.79	57.0
	Sp. Screened	32	21.13	230.5	12.81	86.3
		33	22.58	187.3	13.78	75.1
		34	21.99	208.4	12.99	75.5
		35	18.89	156.9	14.83	67.4
		36	19.42	184.9	10.32	67.7
		37	20.51	191.0	9.83	65.0
		Ave	20.75	193.2	12.43	72.8
	Hand Generated	39	22.28	152.8	12.53	61.7
		40	24.04	151.1	13.01	63.8
		Ave	23.16	152.0	12.77	62.8
NY Fwy	Interpolated/ Original	44	9.52	88.3	12.13	42.6
		45	7.54	80.9	13.39	43.2
		46	9.31	100.9	11.66	42.4
		Ave	8.79	90.0	12.39	42.7
	Interpolated	26	6.99	68.3	5.59	25.5
		26	7.59	75.1	14.44	45.1
		27	6.97	119.4	8.70	44.0
		Ave	7.18	87.6	9.58	38.2
	Sp. Screened	31	12.99	121.6	10.81	68.9
LA Non-Fwy	Interpolated	20	15.47	138.5	9.40	50.4
		21	10.55	92.7	11.02	47.6
		22	13.43	133.3	12.38	55.4
		Ave	13.15	121.5	10.93	51.1
LA Fwy	Interpolated	28	3.69	56.6	14.18	38.1
		29	3.52	44.3	14.31	37.7
		30	3.33	47.9	13.92	38.3
		Ave	3.51	49.6	14.14	38.0

Each run is the average of three replicate tests. "Original" cycles were used on the previous test sequence in Non-Interpolated form.

Results of this experiment can be compared, on a rather loose basis, to those observed for the 1977 GM California truck. Direct comparison is not strictly possible because of the slightly different inertia and road load settings. (For half load, GM truck was tested at 7000 kg inertia; this test sequence was run at 8750 kg with correspondingly higher road load.) Even with these discrepancies, it is readily apparent that the uncontrolled vehicle has much higher emissions.

	g/km			1/100 km
	HC	CO	NOx	Fuel
1977 California	2.0	101	4.9	55
Uncontrolled	11.6	110	11.8	50
Change	+480%	+9%	+140%	-9%

The higher fuel consumption for the 1977 California vehicle is probably due to the numerically higher axel (7.17 vs. 5.57) the larger engine (7.0 vs. 5.9 litre) and its automatic transmission.

As with the 1977 GMC California truck, different driving cycles from the same category gave different emission and fuel consumption values. This testing confirmed earlier conclusions; no theory is available to explain this variability.

The second part of the test program addressed the impact of cold and warm starting on emissions and fuel economy. Results are contained in Figures 6 to 10. Generally, all pollutants and fuel consumption increase with a cold start. (The base condition is a test with the engine warmed up and idling at the start.) The one exception to this rule are cold start NOx emissions, which tend to be lower. Effects of "warm" (as opposed to "cold") starting are much less pronounced and may be a result of test variability. Choke procedure can contribute greatly to the overall variability on cold starts.

Figure 6 lists cold and warm start ratios. This ratio is obtained by dividing the results of the first cycle in the appropriate sequence (cold or warm) by the average of the three hot cycles. It gives the relative impact of a cold or warm start in comparison to a fully warmed-up and idling engine. Figures 7 through 10 give a sequential history and also portray the differences between the cycle categories. Some idea of cycle variability can be gleaned from these graphs.

Figure 6

Cold and Warm Start Ratios

No.	Category	Start Temp.	HC	CO	NOx	Fuel
32	NY - NF	Cold	1.03	1.24	1.67	1.45
		Warm	0.80	1.33	0.96	1.19
54	LA - NF	Cold	2.72	1.79	0.96	1.33
		Warm	1.04	0.94	1.16	1.05
31	NY - FWY	Cold	1.75	4.18	0.12	1.18
		Warm	1.07	0.76	0.98	0.90
53	LA - FWY	Cold	2.21	2.64	0.58	1.26
		Warm	1.16	1.09	1.08	1.12
AVERAGES		Cold	1.93	2.46	0.83	1.31
		Warm	1.02	1.03	1.05	1.07

Results are comparisons to the average of three "hot" tests with engine idling at the start. "Cold" and "Warm" refer to the first cycle of the cold and warm sequences.

Figure 7

HC Emissions as a Function of Warm-up

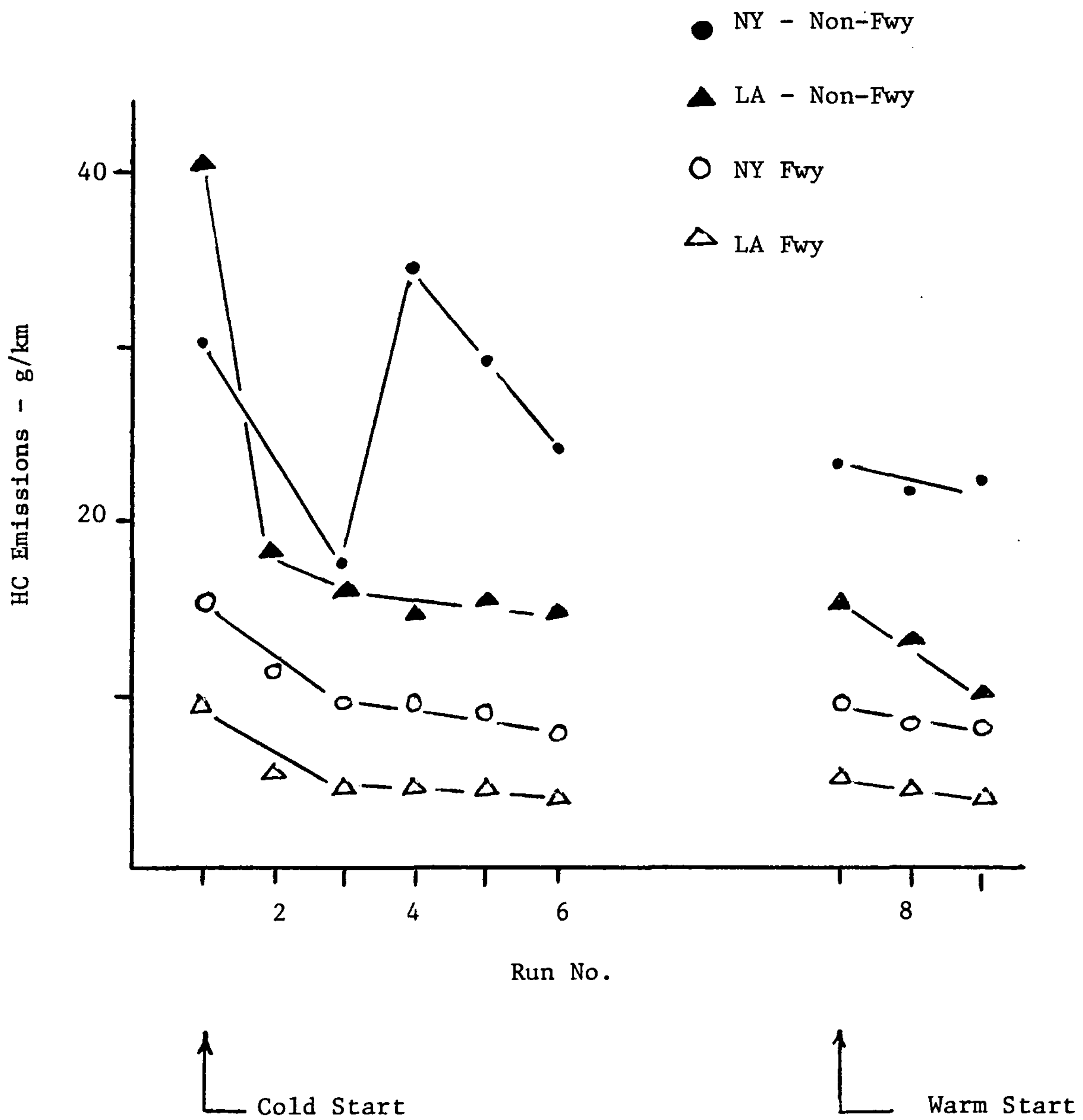


Figure 8

CO Emissions as a Function of Warm-up

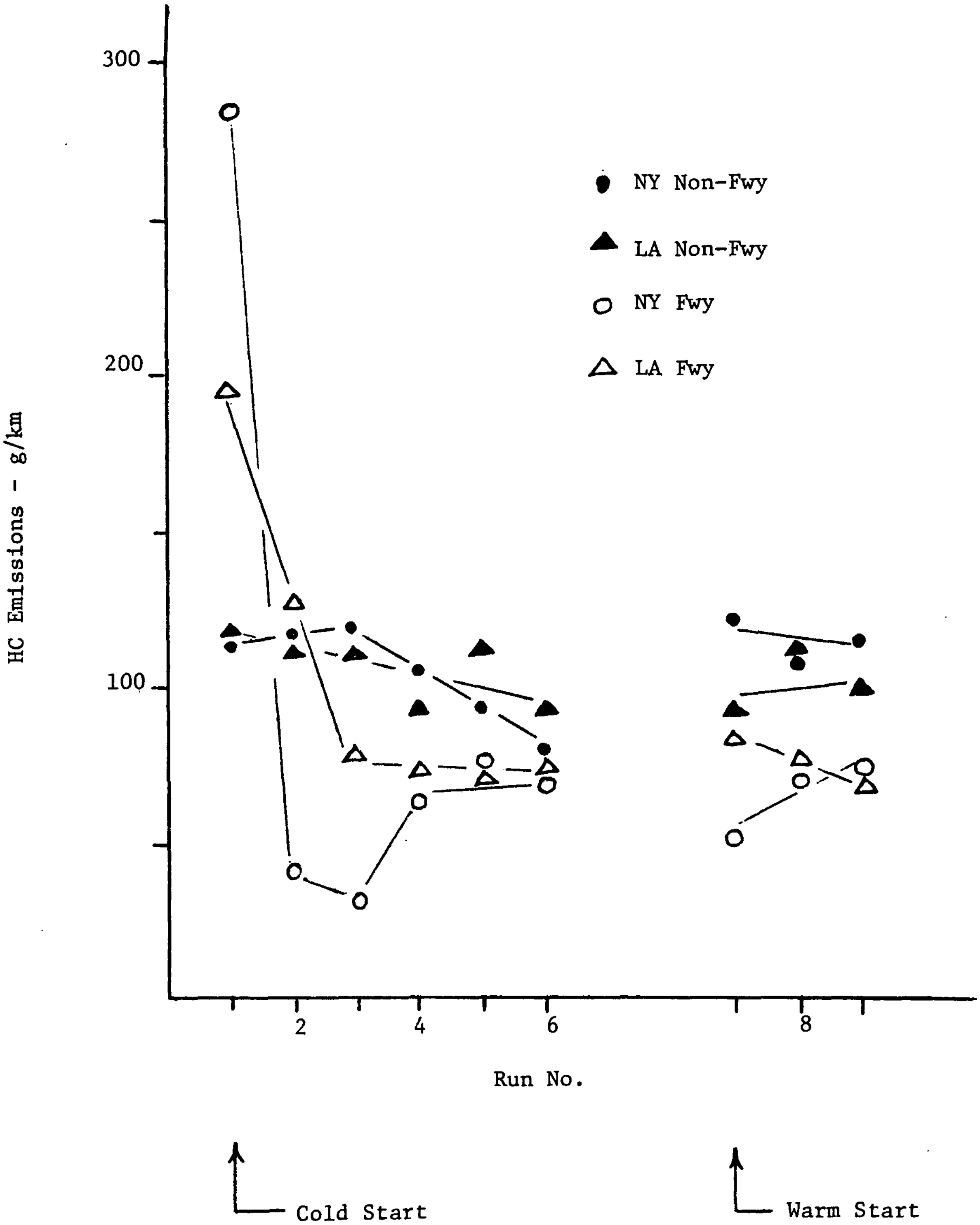


Figure 9

NOx Emissions as a Function of Warm-up

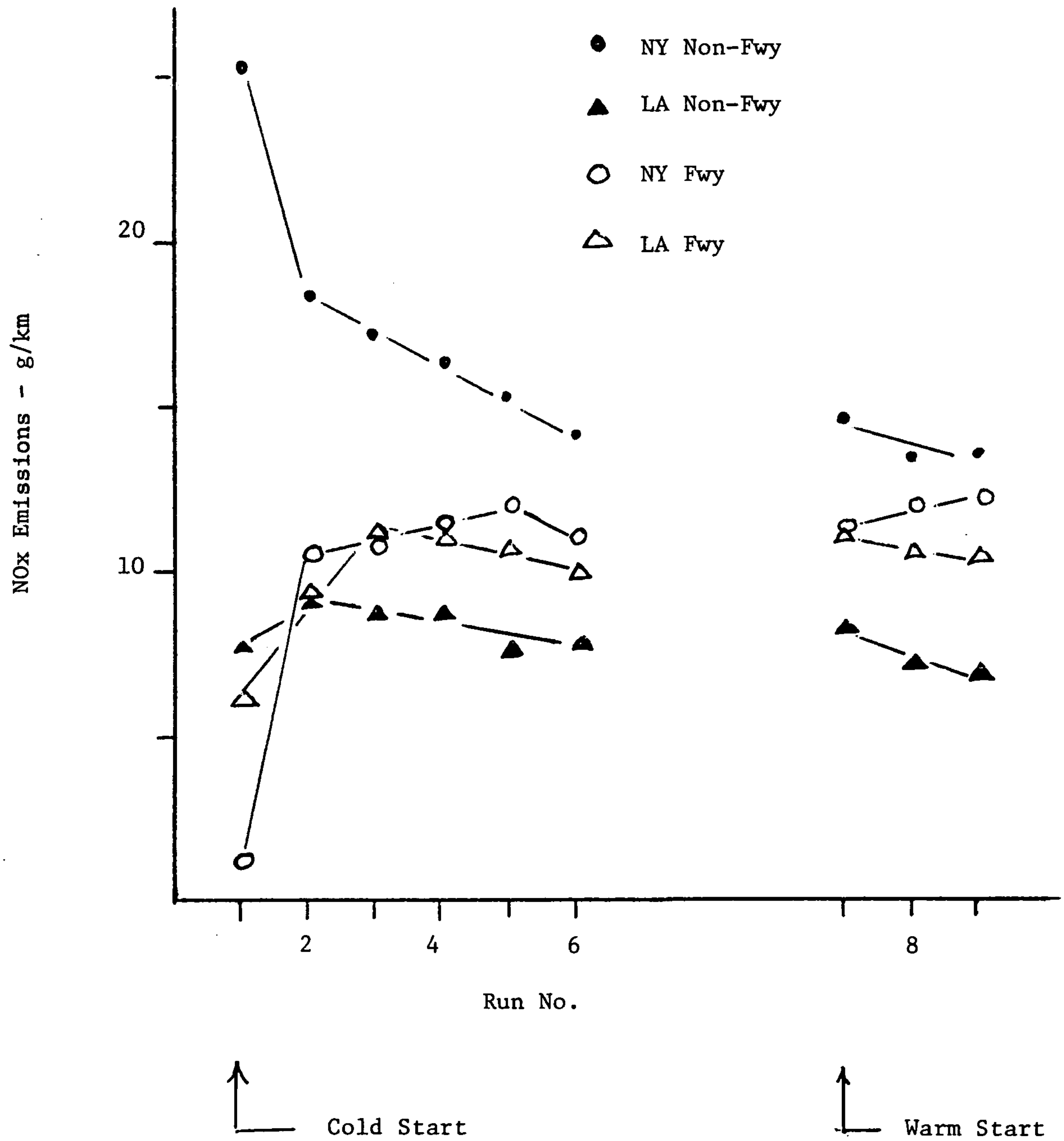
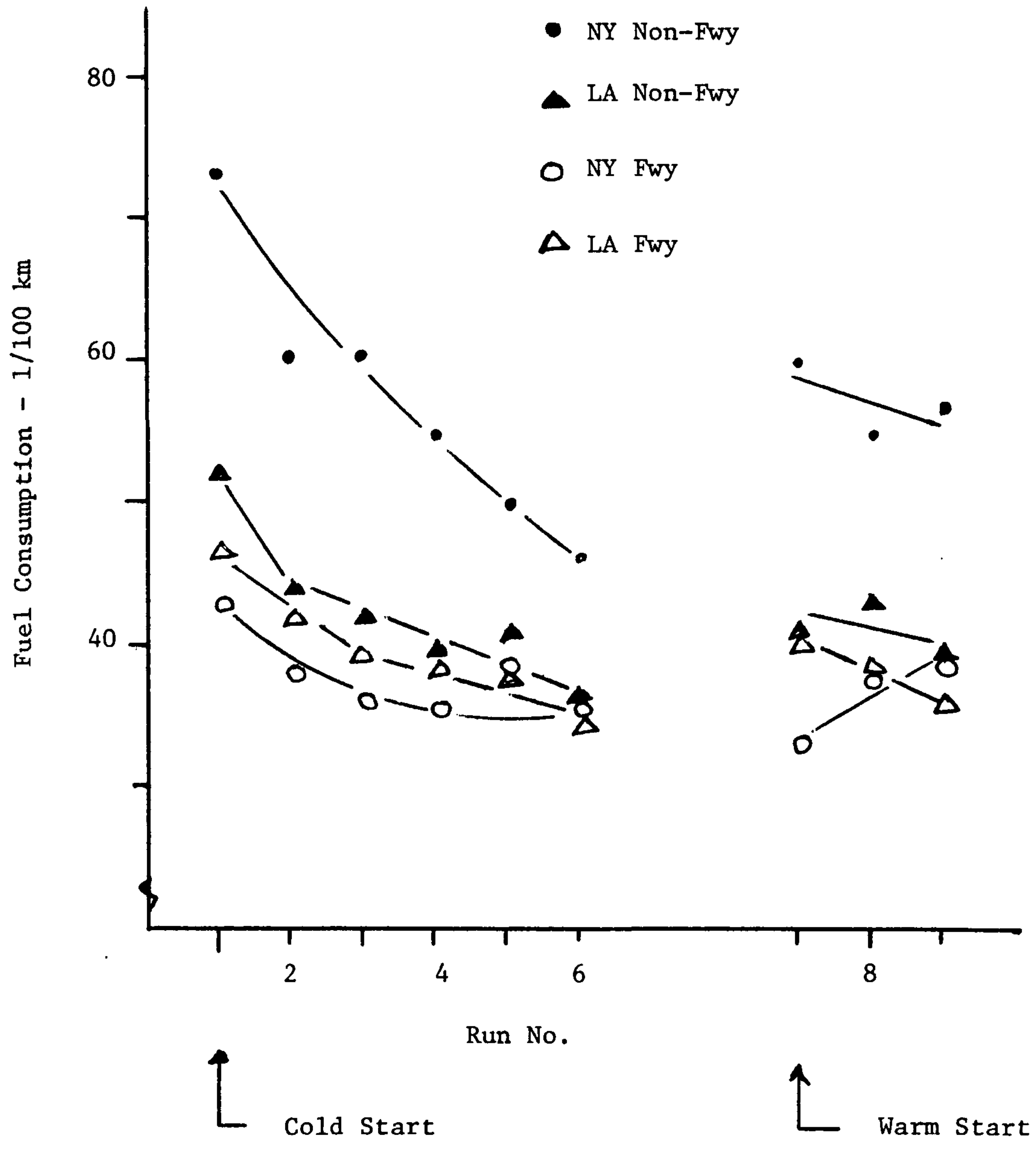


Figure 10

Fuel Consumption as a Function of Warm-up



APPENDIX A

Raw Test Results

No.	Cycle	Run	HC (g/km)	CO (g/km)	NOx (g/km)	Fuel (litre/100 km)
1	20	1	17.07	139.9	8.81	50.0
		2	14.39	132.1	9.65	50.0
		3	14.94	143.6	9.74	51.1
		Ave	15.47	138.5	9.40	50.4
2	21	1	10.46	85.3	12.27	49.3
		2	10.20	85.6	11.03	46.1
		3	10.97	105.2	9.76	47.5
		Ave	10.55	92.7	11.02	47.6
3	22	1	13.59	128.2	12.21	55.3
		2	14.19	141.7	12.29	56.2
		3	12.50	130.5	12.64	54.8
		Ave	13.43	133.3	12.38	55.4
4	23	1	19.60	181.0	11.34	68.1
		2	19.90	184.4	11.45	67.6
		3	19.42	183.0	11.10	67.4
		Ave	19.64	182.8	11.30	67.7
5	24	1	21.02	135.4	9.58	58.9
		2	22.16	186.7	9.24	62.8
		3	19.57	111.4	8.98	53.4
		Ave	20.91	144.5	9.27	58.4
6	25	1	20.16	149.0	6.24	49.1
		2	18.80	148.9	5.99	46.0
		3	16.03	128.1	5.19	40.0
		Ave	18.33	142.0	5.80	45.0
7	26	1	8.91	77.2	6.28	29.0
		2	6.07	63.2	4.95	22.8
		3	6.00	64.4	5.54	24.6
		Ave	6.99	68.3	5.59	25.5
8	26	1	8.06	77.0	13.47	44.1
		2	7.13	68.6	15.48	46.2
		3	7.59	79.7	14.37	45.0
		Ave	7.59	75.1	14.44	45.1
9	27	1	8.41	135.9	8.19	45.4
		2	6.36	119.3	8.31	43.2
		3	6.14	102.9	9.60	43.3
		Ave	6.97	119.4	8.70	44.0

No.	Cycle	Run	HC (g/km)	CO (g/km)	NOx (g/km)	Fuel (litre/100 km)
10	28	1	3.93	56.7	14.17	39.7
		2	3.62	48.1	14.35	37.5
		3	3.53	52.9	14.03	37.2
		Ave	3.69	56.6	14.18	38.1
11	29	1	3.78	44.0	14.62	38.4
		2	3.51	45.4	13.92	37.0
		3	3.27	43.5	14.39	37.8
		Ave	3.52	44.3	14.31	37.7
12	30	1	3.63	51.1	12.66	37.4
		2	3.35	45.3	14.39	38.5
		3	3.01	47.3	14.72	39.0
		Ave	3.33	47.9	13.92	38.3
13	31	1	14.28	122.9	9.85	65.6
		2	12.71	122.0	11.22	71.2
		3	11.98	119.8	11.36	70.0
		Ave	12.99	121.6	10.81	68.9
14	32	1	20.45	210.6	13.38	84.1
		2	20.38	235.6	12.34	84.8
		3	22.57	245.3	12.70	90.1
		Ave	21.13	230.5	12.81	86.3
15	33	1	25.20	194.5	15.44	81.4
		2	21.61	186.4	12.52	69.8
		3	20.94	181.0	13.37	74.0
		Ave	22.58	187.3	12.78	75.1
16	34	1	24.05	201.0	13.25	76.3
		2	20.49	214.2	13.06	75.7
		3	21.42	210.0	12.67	74.6
		Ave	21.99	208.4	12.99	75.5
17	35	1	17.85	137.9	15.38	66.3
		2	19.42	175.7	13.61	67.2
		3	19.39	157.2	15.50	68.6
		Ave	18.89	156.9	14.83	67.4
18	36	1	18.63	186.1	10.06	70.9
		2	19.31	183.0	10.11	63.3
		3	20.32	185.5	10.78	66.0
		Ave	19.42	184.9	10.32	66.7
19	37	1	23.88	208.5	8.73	65.5
		2	19.40	194.3	10.46	66.8
		3	18.25	170.3	10.29	62.6
		Ave	20.51	191.0	9.83	65.0

No.	Cycle	Run	HC (g/km)	CO (g/km)	NOx (g/km)	Fuel (litre/100 km)
	38		--- No Cycle ---			
20	39	1	22.16	156.2	12.11	60.2
		2	21.77	145.6	12.85	62.1
		3	22.91	156.6	12.62	62.7
		Ave	22.28	152.8	12.53	61.7
21	40	1	22.98	157.8	12.12	62.6
		2	24.21	147.2	12.79	62.5
		3	24.92	148.4	14.10	66.4
		Ave	24.04	151.1	13.01	63.8
22	41	1	20.55	186.0	8.82	62.2
		2	21.45	158.4	10.32	57.8
		3	23.60	153.2	11.35	62.4
		Ave	21.87	165.9	10.16	60.8
23	42	1	22.64	189.0	11.98	69.9
		2	19.77	183.7	13.86	72.9
		3	25.06	179.5	11.18	66.0
		Ave	22.49	184.1	12.34	69.6
24	43	1	21.67	192.9	8.78	56.7
		2	19.65	173.0	11.54	59.0
		3	20.10	225.1	8.01	62.2
		Ave	20.47	197.0	9.45	59.3
25	44	1	9.91	95.6	12.97	46.4
		2	8.84	87.7	10.83	40.4
		3	9.80	81.5	12.60	41.1
		Ave	9.52	88.3	12.13	42.6
26	45	1	8.42	84.6	13.04	43.2
		2	7.23	82.3	12.83	41.8
		3	6.98	75.7	14.31	44.7
		Ave	7.54	80.9	13.39	43.2
27	46	1	7.83	88.7	10.47	37.7
		2	10.48	104.9	12.46	44.8
		3	9.63	109.2	12.05	44.6
		Ave	9.31	100.9	11.66	42.4

No.	Cycle	Run	HC (g/km)	CO (g/km)	NOx (g/km)	Fuel (litre/100 km)
28	32	1 C	30.0	113	25.4	73.0
		2	26.1	116	18.4	60.1
		3	17.3	117	17.3	60.6
		4 H	34.5	104	16.2	54.8
		5 H	29.1	92	15.4	49.7
		6 H	24.1	78	14.1	46.1
		7 W	23.4	121	14.6	59.9
		8	21.5	107	13.4	54.5
		9	22.2	115	13.6	56.8
		Ave Hot	29.2	91	15.2	50.2
29	54	1 C	40.5	117	7.8	52.1
		2	18.2	113	9.1	43.9
		3	15.8	112	8.8	42.1
		4 H	14.4	92	8.8	39.8
		5 H	15.4	113	7.7	41.1
		6 H	15.0	91	7.8	36.4
		7 W	15.5	93	9.4	41.2
		8	13.0	109	8.4	42.8
		9	10.0	98	8.0	39.5
		Ave Hot	14.9	99	8.1	39.1
30	31	1 C	15.2	284	1.4	42.9
		2	11.2	40	10.5	37.7
		3	9.4	32	10.9	35.9
		4 H	9.4	61	11.6	35.4
		5 H	8.9	74	12.1	38.5
		6 H	7.7	69	11.1	35.7
		7 W	9.3	52	11.4	33.0
		8	8.3	69	12.0	37.6
		9	8.1	72	12.1	38.6
		Ave Hot	8.7	68	11.6	36.5
31	53	1 C	9.5	195	6.2	46.5
		2	5.3	126	9.3	41.9
		3	4.6	77	11.2	39.3
		4 H	4.5	73	11.0	38.1
		5 H	4.4	76	10.8	37.7
		6 H	3.9	74	10.0	35.0
		7 W	5.0	81	11.4	41.1
		8	4.4	76	10.7	37.9
		9	4.1	69	10.6	36.0
		Ave Hot	4.3	74	10.6	36.8

APPENDIX B

Driving Cycle Identification

Code No.	Identification No.
20	213 884 237 5
21	252 141 511
22	214 709 248 5
23	155 897 487
24	212 824 238 1
25	104 940 581
26	448 526 301
27	211 317 052 7
28	131 162 575 9
29	814 877 133
30	168 565 423
31	203 708 236 5
32	212 012 741 3
33	211 373 494 3
34	210 952 317 5
35	202 167 539 7
36	213 923 722 9
37	213 153 035 7
38	No cycle
39	WYSOR I
40	WYSOR II
41	123 667 645 7
42	179 960 930 5
43	104 736 920 3
44	741 286 985
45	209 279 083 3
46	137 610 363