



Fuel System Cleaning Process
by "Mr. Injector" Company

Effects on Emissions and Fuel Consumption
of Petrol and Diesel Vehicles

TEST FACILITY ID No: T614
DATE 29th March, 2001
AUTHORS Nick Serginson, Chris Beatty.
TECHNICIAN Xavier Aerts, Lothar Steinmetz, Roland Dippl

ORBITAL CONSULTING

Emissions Chassis Dynamometer Section
Orbital Engine Company (Australia) Pty. Ltd.
1 Whipple Street Balcatta. Western Australia 6021.

CONTENTS

PAGE NUMBER

Aim 1

Equipment 1

Procedure 2

Comments 2

Appendix 1 – Diesel Results Summary

Appendix 2 – Petrol Results Summary

Appendix 3 – Test Procedure Diesel Vehicles

Appendix 4 – Test Procedure Petrol Vehicles

Appendix 5 – Vehicle Roadload Coefficients

Appendix 6 – Diesel Detailed Results

Appendix 7 – Petrol Detailed Results

Appendix 8 – Petrol Emission Charts

AIM

The aim of this testing was to quantify the effect of a proprietary fuel system cleaning process. The effect on fuel consumption, diesel smoke and engine emissions was evaluated by making measurements before and after the process was performed on a number of vehicles.

No conclusions were to be drawn by Orbital Consulting as to the net overall effect, whether beneficial or detrimental, of the cleaning process.

EQUIPMENT

Vehicles:

The vehicles tested were:

Diesels

Toyota Hilux
Nissan Atlas 150
Nissan Patrol 1993
Holden Rodeo Turbo 1996

Petrol

Nissan 300ZX 1993, manual, 65 000km, lic. 1AUJ-621
Nissan Silvia, 2.0L, auto, 80 000km, lic. 1AUJ-081
Ford Fairlane 1993 4.0L, auto, 136 000km, lic. 8NU-555
Holden Commodore Ute HSV 1998 5.0L, auto, 86 000km, lic. 1AEW-221
BMW 318i 1985, auto, 224 000km, lic 7MH-868

Dynamometer:

Diesel vehicles: Froude mileage accumulation chassis dynamometer, 100kW electrical power absorption, cooling supplied by vehicle speed tracking fan. Dynamometer used in speed control mode for smoke tests, road simulation mode for fuel consumption tests.

Petrol vehicles: MRW 48" single roller DC electric dynamometer with full electrical inertia simulation, heated roller support bearings and roadload definition by up to third order polynomial. Used in road simulation mode for these tests.

Measurement:

Diesel Vehicles: Horiba MEXA-554GE Exhaust gas analyzer, MicroMotion flowmeter for fuel flow measurement logged by Fluke Hydra Data Bucket, Bosch Opacimeter Type 3.010 for smoke measurement.

Petrol Vehicles: Horiba Variable Flow Sampler (VFS) with 4 sample bag pairs and Horiba gas analyzer bench with Horiba 200-series exhaust gas analyzers, data logging via Horiba VETS system.

PROCEDURE

The test procedures used are detailed in Appendix 3 and 4.

The vehicle roadload is an approximation of the load a vehicle would see in use on-road, dependent on the vehicle speed. It is defined according to the coefficients in the equation:

$$\text{Force} = F_0 + (F_1 \times V) + (F_2 \times V^2) + (F_3 \times V^3)$$

where: Force is the force applied by the dyno, in Newtons (N)
F0, F1, F2, F3 are the roadload coefficients
and V is the road speed in kmh.

Roadloads have been defined, where no other data was available, by using the approximate vehicle weight and the ADR37 method for calculating coefficients.

COMMENTS

Diesel Emissions:

For diesel engines, the majority of emissions are in the form of Carbon Dioxide (CO₂) and Smoke (soot particles). Carbon Dioxide is an inherent by-product of burning hydrocarbon fuels, and the amount emitted is directly proportional to the amount of fuel used. Smoke is created due to inefficient combustion, and significant quantities are usually only generated at high engine loads.

Other emissions (carbon monoxide CO and unburnt gaseous hydrocarbons HC) are typically near-zero and considered negligible as an emitted pollutant.

We have measured the CO and HC concentrations during testing, however the results should be regarded as confirming that the emissions are near-negligible, rather than the results used for any sort of pre/post clean emissions comparison.

Petrol Emissions:

The emissions comparison presented in Appendix 2 has been based on averages taken over the same time window as the fuel consumption averaging.

The calculated mass emissions are shown pre/post clean, against the vehicle speed trace over the test time.

The vehicle speed trace has been taken from the pre-clean test, and so corresponds only approximately to the vehicle speed during the post-clean test. i.e. the changes between test speeds may have occurred at a slightly different time for the post-clean results, compared to the pre-clean speed trace displayed.

Whilst the fuel consumption was quite stable over time (at each speed), the emissions (HC, CO, NOx) were quite variable. For this reason the charts presented in Appendix 8 (giving the trace of each mass emission over the whole test time) provide a more accurate comparison than the % Difference in Appendix 2.

The final emissions produced by an engine/catalyst system are subject to many subtle influences, that can combine to make comparative evaluation difficult. Such things as the catalyst condition and temperature, the oxygen sensor condition, thermofan switching and engine control unit decisions about the appropriate engine state to enter, are examples of factors that can influence the final results recorded.

For this testing, we have endeavored to ensure a meaningful comparison of emission results can be made, through making accurate measurements and following a strict test procedure. However the variations seen may indicate some secondary effects are having a significant influence, and are reducing the accuracy of any comparisons made.

Date: 29th March 2001

Author: *Nick Serginson*

Nick Serginson B.E.(Mech)
Test Facility Engineer

Authorised: *Chris Beatty*

Chris Beatty
Test Facility Supervisor

APPENDIX 1 DIESEL RESULTS SUMMARY

Vehicle	Fuel Consumption (g/min)				Smoke (Bosch smoke number)			
	Roadload Test		Smoke Test		Roadload Test		Smoke Test	
	Low Speed	High Speed	Low Speed	High Speed	Low Speed	High Speed	Low Speed	High Speed
Toyota Hilux (No Roadload Test)	-	-	176.40	188.20	-	-	1.63	0.21
	-	-	174.90	173.40	-	-	1.61	0.14
	-	-	-0.9	-7.9	-	-	-1.2	-34.9
Nissan Atlas <i>new system</i>	46.50	89.00	110.20	226.40	0.04	0.05	1.23	1.11
	46.90	89.00	105.70	230.10	0.03	0.05	0.93	0.88
	0.9	0.0	-4.1	1.6	-28.6	0.0	-24.7	-20.2
Nissan Patrol <i>old Smokey</i>	88.30	113.80	226.60	252.80	0.02	0.02	0.56	1.03
	89.80	113.30	228.80	245.10	0.02	0.02	0.54	1.01
	1.7	-0.4	1.0	-3.0	0.0	0.0	-4.3	-1.4
Holden Rodeo <i>Modified Engine.</i>	51.40	89.80	120.40	238.90	0.03	0.02	0.68	0.98
	49.30	91.40	134.10	242.10	0.01	0.04	1.11	1.06
	-4.1	1.8	11.4	1.3	-66.7	100.0	63.2	8.2

APPENDIX 2 PETROL RESULTS SUMMARY

Results Expressed as % Differences

Nissan 300ZX

Speed	Fuel Consumption	CO	HC	NOx
Idle	-3.3	-77.4	-83.2	293.9
30	-0.2	-8.1	-29.0	-58.1
60	-1.1	-36.5	-35.2	70.4
90	-1.9	-39.2	-40.4	-18.9
110	-2.3	88.5	4.5	-56.0

Ford Fairlane

Speed	Fuel Consumption	CO	HC	NOx
Idle	-5.9	-85.1	-86.9	17.5
30	1.0	13.2	-27.2	1.4
60	0.2	9.4	-40.5	0.0
90	0.5	-56.3	-57.4	0.1
110	2.5	23.1	-39.0	2.2

BMW 318i

Speed	Fuel Consumption	CO	HC	NOx
Idle	6.1	42.2	2.4	-3.6
30	-1.2	-42.3	-20.8	25.0
60	2.0	38.0	5.8	0.1
90	1.7	58.7	2.9	-0.1
110	-0.6	-11.1	-3.0	0.0

Nissan Silvia

Speed	Fuel Consumption	CO	HC	NOx
Idle	0.9	-36.5	-3.3	-24.1
30	-0.5	-49.8	-13.5	5.4
60	-1.0	-51.6	-17.9	0.9
90	-0.7	-32.0	-18.1	3.1
110	0.0	-12.4	-14.2	8.3

Commodore Ute

Speed	Fuel Consumption	CO	HC	NOx
Idle	0.0	-71.6	-14.0	43.4
30	0.3	16.9	22.4	24.9
60	0.0	-30.4	-27.6	-5.2
90	0.2	-34.9	-6.3	-0.2
110	1.7	796.9	196.8	-71.6

Expressed as % difference from original baseline numbers
i.e negative is a decrease after cleaning process

APPENDIX 3 TEST PROCEDURE DIESEL VEHICLES

Roadload Test

- Enter roadload coefficients in dyno.
- Two test speeds. One to represent city driving (60kmh) and the second to represent highway driving (90kmh). Gear chosen to represent real world usage.
- Vehicle to be fuelled by customer
- Install vehicle on macd
- Connect Bosch Opacimeter
- Connect MEXA sample probe
- Fuel flow measurement equipment to be installed in the fuel system, with the assistance of the customer.
- Warm vehicle 10 minutes at 80kmh.
- Go to first speed point and let stabilise for 2 minutes.
- Measure/record the following: road speed, force, engine rpm, gear #, fuel consumption, ambient air temp, emissions and smoke.
- Repeat for second speed point.

Smoke Test

- Test speeds to be defined according to each engine's operating rpm. Two test speeds to be chosen, at approximately 2/5 and 4/5 of peak engine speed. Gear used according to keeping within dyno limits (typically fourth gear)
- Go to first speed point, go to WOT (wide open throttle) and allow engine to stabilise (30secs)
- Measure/record the following: road speed, force, engine rpm, gear #, fuel consumption, ambient air temp, MEXA emissions and smoke.
- Repeat for second speed point

After injector cleaning has been performed, repeat above test procedure including warmup.

CONFIDENTIAL

Report.doc

© Orbital Engine Company (Australia) Pty Ltd 2001

No part of this report to be reproduced except in its entirety

Page 8

APPENDIX 4 TEST PROCEDURE PETROL VEHICLES

Roadload Test

- Vehicle will be fuelled by customer
- Calculate ADR37 roadload and create on dyno.
- Install vehicle on dyno, connect exhaust to CVS system, check tire pressures
- Set up test on VETS. Initialize test but do not start.
- Warm vehicle fully, 10 minutes at 90kmh. Choose cooling fan speed to keep engine temperature stable.
- Go to 110kmh using speed on dyno screen for speed measurement. Once speed is stable press "Start Test".
- Maintain speed for 2 minutes.
- Go to 90kmh, maintain for 2 minutes.
- Repeat for 60kmh and 30kmh.
- Go to idle in neutral for 2 minutes.
- Shut engine off.
- Allow test to finish on VETS.

After injector cleaning has been performed, repeat above test procedure including warmup.

Processing Data

- Fuel consumption calculated according to U.S. CFR calculations, based on exhaust mass emissions. Average calculated for each test speed.

CONFIDENTIAL

Report.doc

© Orbital Engine Company (Australia) Pty Ltd 2001

No part of this report to be reproduced except in its entirety.

Page 9

APPENDIX 5 ROADLOAD COEFFICIENTS

Diesel Vehicles

Vehicle	Test Mass kg	Force Coefficients		
		F0	F1	F2
Nissan Atlas	1650	4	0.79	0.0590
Nissan Patrol	2000	4	0.85	0.0639
Holden Rodeo	1590	4	0.79	0.0592

Petrol Vehicles

Vehicle	Test Mass kg	Force Coefficients			
		F0	F1	F2	F3
Nissan 300ZX	1700	3.7	0.755	0.056772	0
Nissan Silvia	1361	3.3	0.676	0.050796	0
Ford Fairlane	1758	3.8	0.771	0.057963	0
Holden Commodore Ute	1530	143.7	-3.245	0.114211	-0.000318
BMW 318i	1077	2.925	0.596	0.045	0

TOYOTA Hilux 4WD Turbo

Test Date 06-Mar-01

Comments Road simulation fuel consumption test not done.

Smoke test	2000rpm, 4th gear 57kmh, WOT, Speed limiting mode						3500rpm, 4th gear 97kmh, WOT, Speed limiting mode											
	Fuel consumption			Emissions			Force Ambient Imp Opacimeter			Fuel consumption			Emissions			Force Ambient Imp Opacimeter		
	V o/p	0-400 g/min	CO %	HC ppmC	CO2 %	O2 %	N	Deg C	Opacimeter	V o/p	0-400 g/min	CO %	HC ppmC	CO2 %	O2 %	N	Deg C	Opacimeter
Pre clean	2.764	176.4	0.04	7	12.92	3.62	2025	27	1.63	2.882	188.2	0.02	7	6.93	10.82	720	26	0.21
Post clean	2.749	174.9	0.04	9	13.00	3.44	1950	27	1.61	2.734	173.4	0.01	6	7.01	10.79	723	25	0.14
Difference %		-0.85	-12.5	28.6	0.6	-5.0	-3.7		-1.2	-7.86	-50.0	-14.3	1.2	-0.3		0.4		-34.9

APPENDIX 6-4 DIESEL DETAILED RESULTS: HOLDEN RODEO

HOLDEN Rodeo 4WD

Test Date 08-Mar-01

Comments Tested OK

Road test	60km/h, 4th gear, 2250rpm, Road simulation mode						90km/h, 5th gear, 2700rpm, Road simulation mode											
	Fuel consumption			Emissions			Force Ambient tmp Opacimeter			Fuel consumption			Emissions			Force Ambient tmp Opacimeter		
	V o/p	g/min	0-400	CO %	HC ppmC	CO2 %	O2 %	N	Deg C	V o/p	g/min	0-400	CO %	HC ppmC	CO2 %	O2 %	N	Deg C
Pre clean	1.514	51.4		0.02	22.00	3.46	15.82	205	15	1.898	89.8		0.01	12.00	4.98	13.91	560	15
Post clean	1.493	49.3		0.01	11.00	3.47	15.84	283	15	1.914	91.4		0.01	10.00	5.07	13.83	566	15
Difference %		-4.09		-50.0	-50.0	0.3	0.1	-0.7			1.78		0.0	-16.7	1.8	-0.6	1.1	

Smoke test	2000rpm, 4th gear, 55km/h, WOT, Speed limiting mode						3500rpm, 4th gear, 100km/h, WOT, Speed limiting mode											
	Fuel consumption			Emissions			Force Ambient tmp Opacimeter			Fuel consumption			Emissions			Force Ambient tmp Opacimeter		
	V o/p	g/min	0-400	CO %	HC ppmC	CO2 %	O2 %	N	Deg C	V o/p	g/min	0-400	CO %	HC ppmC	CO2 %	O2 %	N	Deg C
Pre clean	2.204	120.4		0.06	10.67	8.79	9.03	1924	15	3.389	238.9		0.05	4.00	8.05	10.50	1270	15
Post clean	2.341	134.1		0.05	8.00	8.15	10.13	2040	15	3.421	242.1		0.05	8.00	8.15	10.13	1300	15
Difference %		11.38		-16.7	-25.0	-7.3	12.2	6.0			1.34		0.0	100.0	1.2	-3.5	2.4	

APPENDIX 7 PETROL DETAILED RESULTS

Nissan 300ZX

	Idle			30kmh			60kmh			90kmh			110kmh		
	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff
Fuel Consumption L/sec	0.00112	0.00108	-3.3	0.00172	0.00172	-0.2	0.0025976	0.0026	-1.09	0.00390	0.00382	-1.9	0.00510	0.00499	-2.3
Emissions CO g/sec	0.00375	0.00085	-77.4	0.00976	0.00696	-8.1	0.0072382	0.0046	-36.45	0.01275	0.00775	-39.2	0.00753	0.01419	88.5
HC g/sec	0.00155	0.00026	-83.2	0.00051	0.00036	-29.0	0.0006783	0.0004	-35.20	0.00119	0.00071	-40.4	0.00172	0.00179	4.5
NOx g/sec	0.00019	0.00073	293.9	0.00007	0.00003	-58.1	0.0006781	0.0012	70.37	0.00348	0.00282	-18.9	0.03238	0.01425	-56.0

Ford Fairlane

	Idle			30kmh			60kmh			90kmh			110kmh		
	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff
Fuel Consumption L/sec	0.00129	0.0012	-5.9	0.00233	0.00235	1.0	0.00303	0.00304	0.20	0.00375	0.00377	0.5	0.00543	0.005567	2.5
Emissions CO g/sec	0.16799	0.0250	-85.1	0.02401	0.0218	13.2	0.02672	0.02924	9.44	0.00107	0.00047	-56.3	0.06290	0.077419	23.1
HC g/sec	0.01527	0.0020	-86.9	0.00118	0.00086	-27.2	0.00245	0.00146	-40.49	0.00440	0.00187	-57.4	0.00530	0.003230	-39.0
NOx g/sec	0.00026	0.0003	17.5	0.00646	0.00655	1.4	0.03389	0.03388	-0.01	0.13374	0.13390	0.1	0.17740	0.181300	2.2

BMW 318i

	Idle			30kmh			60kmh			90kmh			110kmh		
	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff
Fuel Consumption L/sec	0.00104	0.00110	6.1	0.00137	0.00135	-1.2	0.00179	0.00182	2.00	0.00274	0.00279	1.7	0.00377	0.00375	-0.6
Emissions CO g/sec	0.21780	0.30970	42.2	0.29492	0.17021	-42.3	0.11391	0.15721	38.02	0.09817	0.15576	58.7	0.48260	0.42920	-11.1
HC g/sec	0.01525	0.01561	2.4	0.01558	0.01235	-20.8	0.01701	0.01799	5.79	0.02669	0.02745	2.9	0.03671	0.03561	-3.0
NOx g/sec	0.00188	0.00181	-3.6	0.00469	0.00586	25.0	0.04690	0.04897	0.14	0.09290	0.09285	-0.1	0.12105	0.12109	0.0

Nissan Silvia

	Idle			30kmh			60kmh			90kmh			110kmh		
	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff
Fuel Consumption L/sec	0.00036	0.00036	0.9	0.00141	0.00141	-0.5	0.00201	0.00199	-0.96	0.00286	0.00284	-0.7	0.00345	0.00344	0.0
Emissions CO g/sec	0.00014	0.00009	-36.5	0.00011	0.00006	-49.8	0.00021	0.00010	-51.56	0.00042	0.00029	-32.0	0.00100	0.00087	-12.4
HC g/sec	0.00046	0.00044	-3.3	0.00092	0.00080	-13.5	0.00136	0.00112	-17.87	0.00201	0.00164	-18.1	0.00259	0.00222	-14.2
NOx g/sec	0.00077	0.00059	-24.1	0.01906	0.02009	5.4	0.04281	0.04321	0.95	0.08454	0.08720	3.1	0.09609	0.10410	8.3

Holden Commodore Ute

	Idle			30kmh			60kmh			90kmh			110kmh		
	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff	Pre-Clean	Post-Clean	% Diff
Fuel Consumption L/sec	0.000756	0.00076	0.0	0.002525	0.00253	0.3	0.003065	0.00307	0.05	0.003379	0.00349	0.2	0.004773	0.00485	1.7
Emissions CO g/sec	0.000726	0.00021	-71.6	0.109186	0.12769	16.9	0.150821	0.13290	-30.35	0.000226	0.00015	-34.9	0.011314	0.12838	796.9
HC g/sec	0.000717	0.00062	-14.0	0.002871	0.00352	22.4	0.005209	0.00377	-27.57	0.000842	0.00079	-6.3	0.001186	0.00141	196.8
NOx g/sec	0.000591	0.00085	43.4	0.003552	0.00693	24.9	0.011406	0.01081	-5.22	0.092249	0.09210	-0.2	0.049124	0.01394	-71.6

APPENDIX 7 PETROL DETAILED RESULTS

PETROL VEHICLES: TESTED ROAD SPEED, GEAR AND ENGINE SPEED

Vehicle	30kmh		60kmh		90kmh		110kmh	
	Gear	RPM	Gear	RPM	Gear	RPM	Gear	RPM
Nissan 300ZX	2	2000	3	2500	4	3000	5	2800
Nissan Silvia	1, no overdrive	3000	2, no overdrive	3400	2, overdrive	3250	3, no overdrive	2800
Ford Fairlane	1	2000	2	2500	3	2500	3	3000
Holden Commodore Ute	1	2500	2	2800	3	2500	3	3000
BMW 318i	2	1600	3	2800	4	2500	4	3000

APPENDIX 8 PETROL EMISSION CHARTS

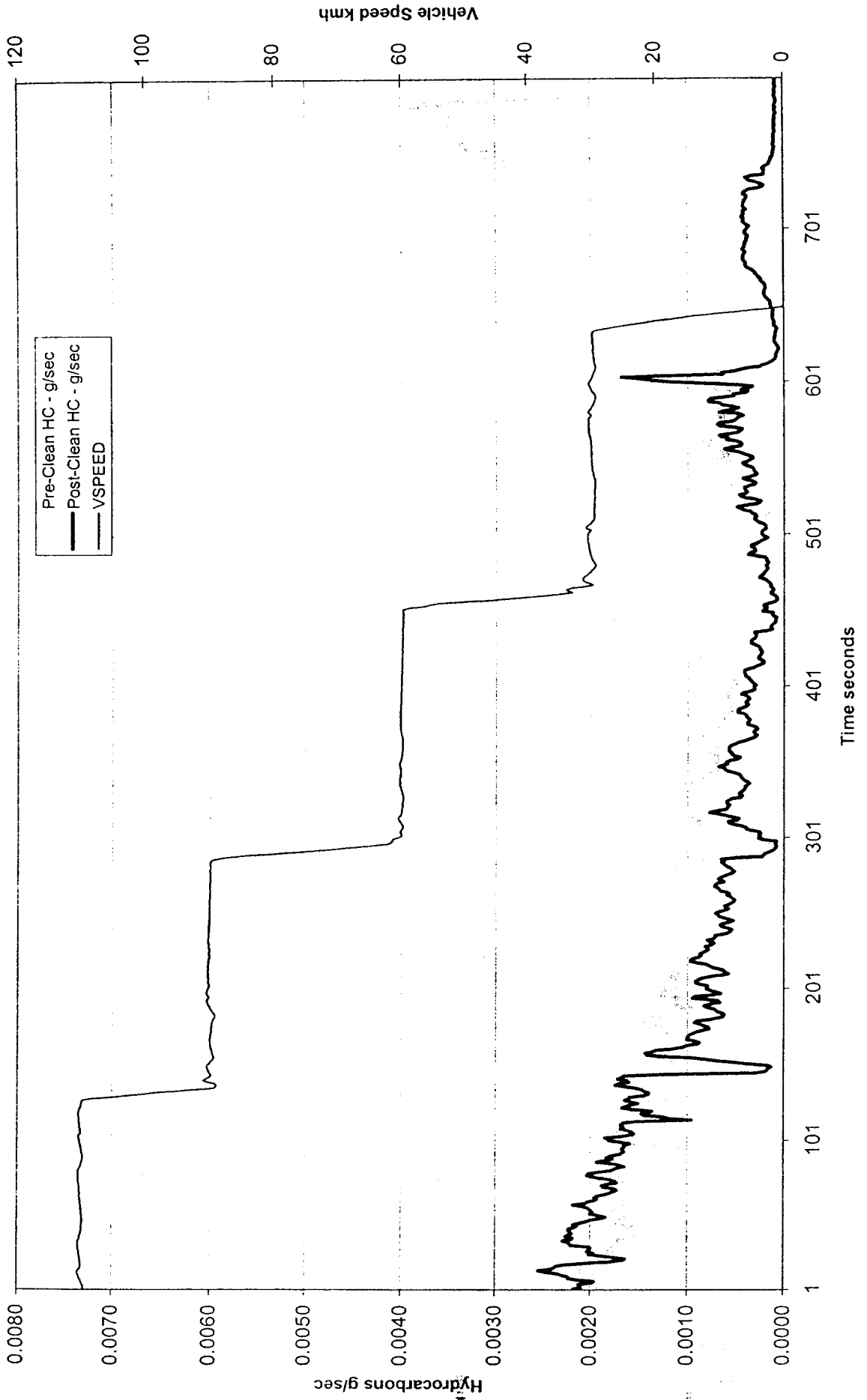
CONFIDENTIAL

Report.doc

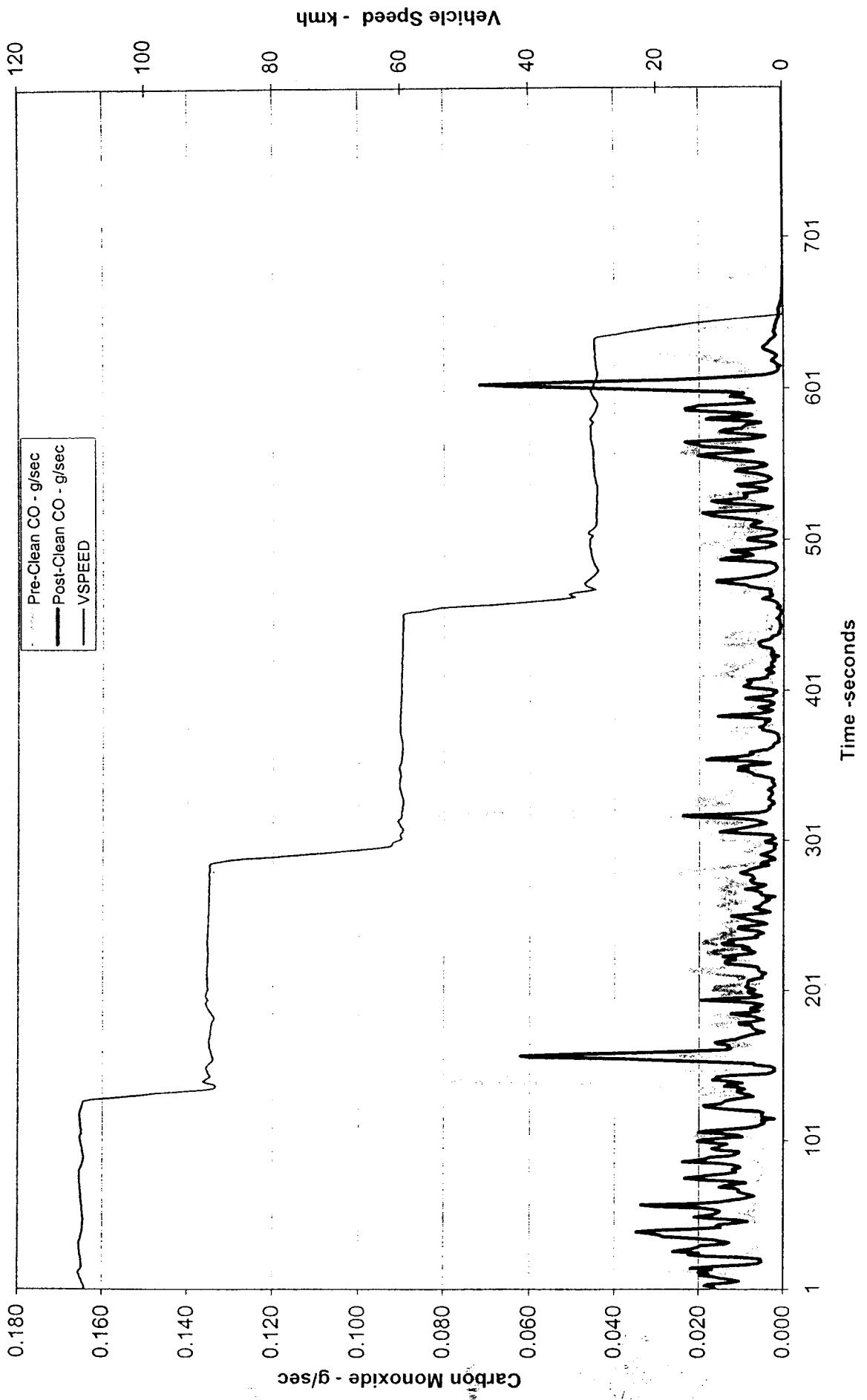
© Orbital Engine Company (Australia) Pty Ltd 2001

No part of this report to be reproduced except in-its entirety.

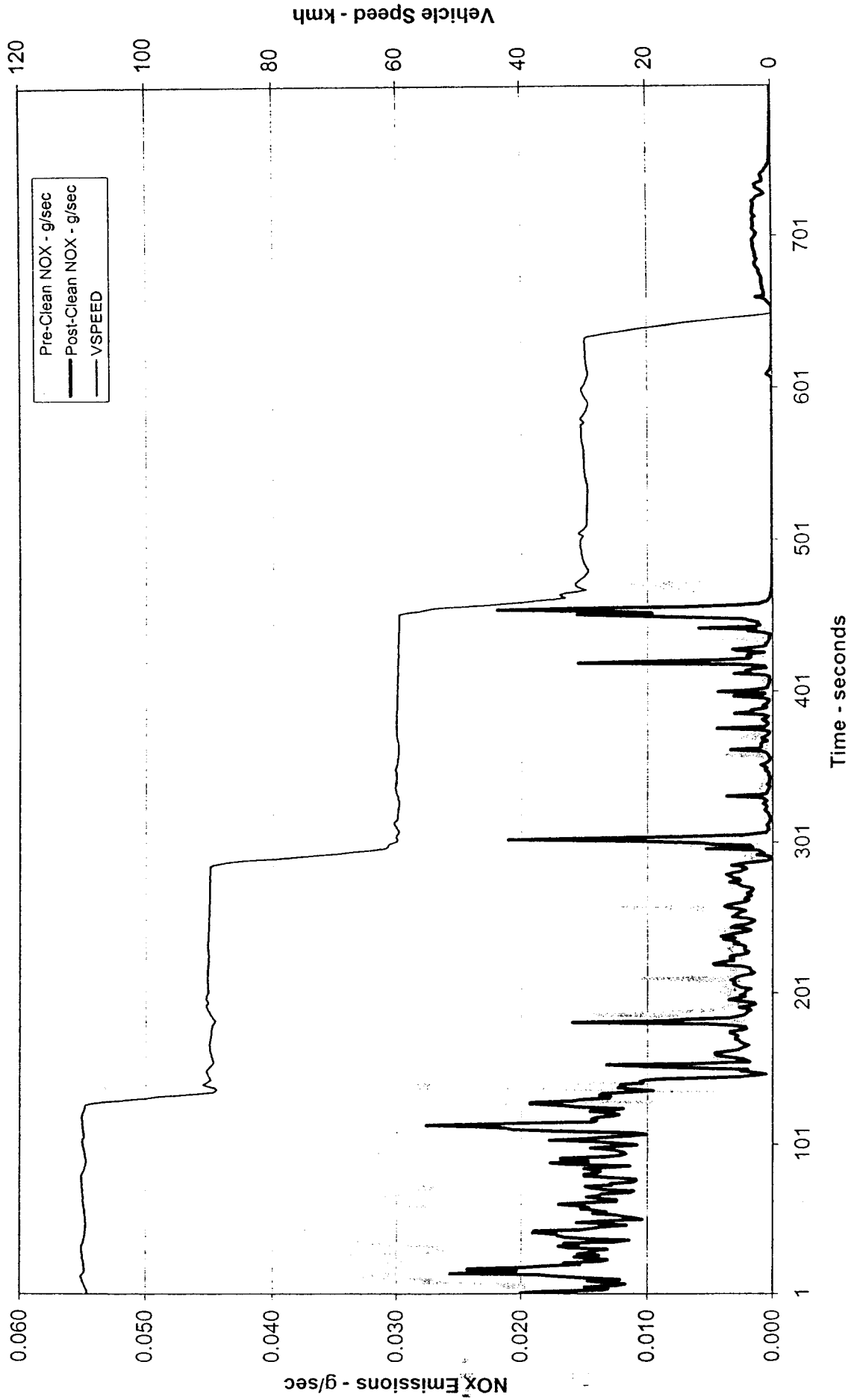
Nissan 300ZX Hydrocarbon Emissions



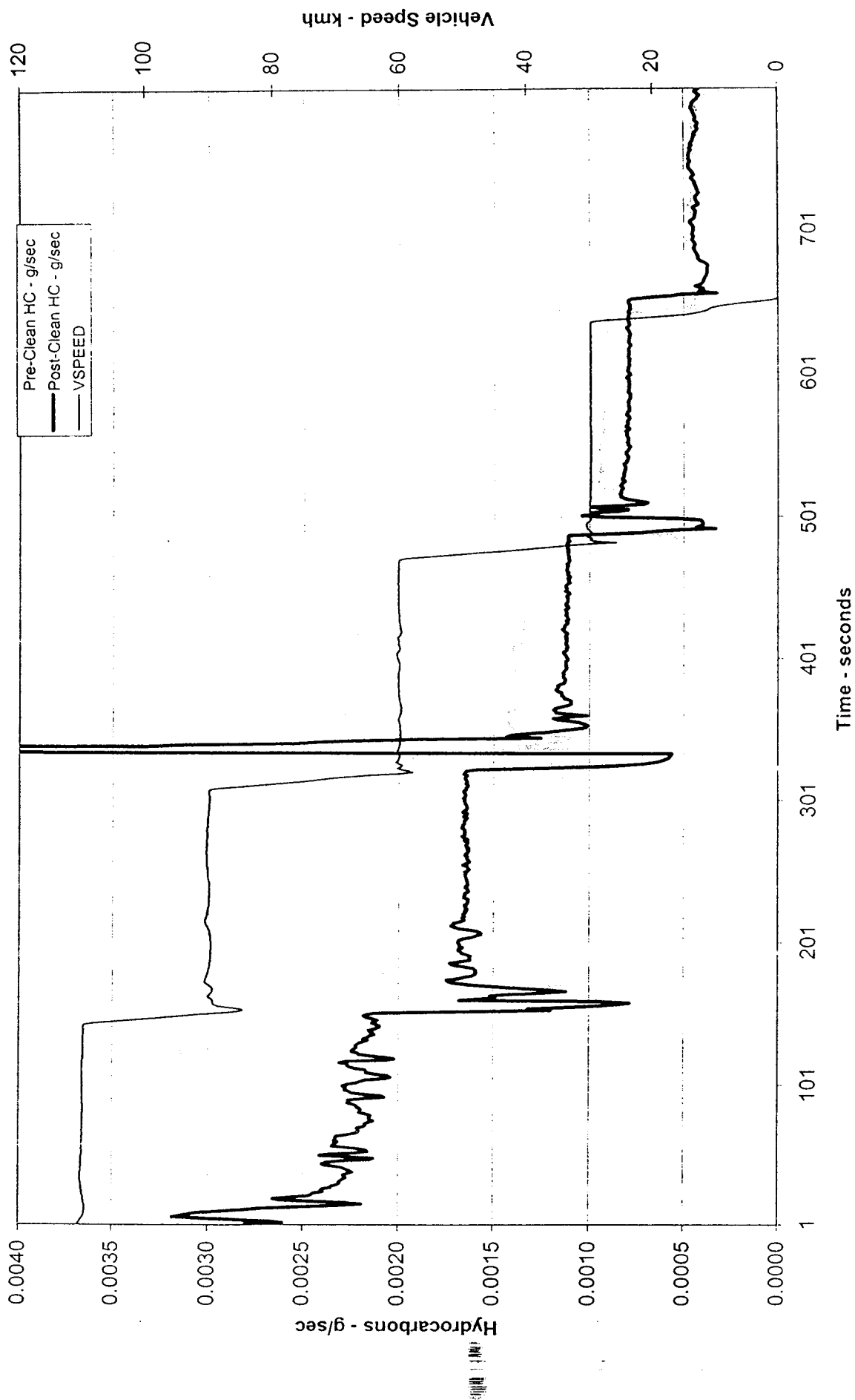
Nissan 300ZX Carbon Monoxide Emissions



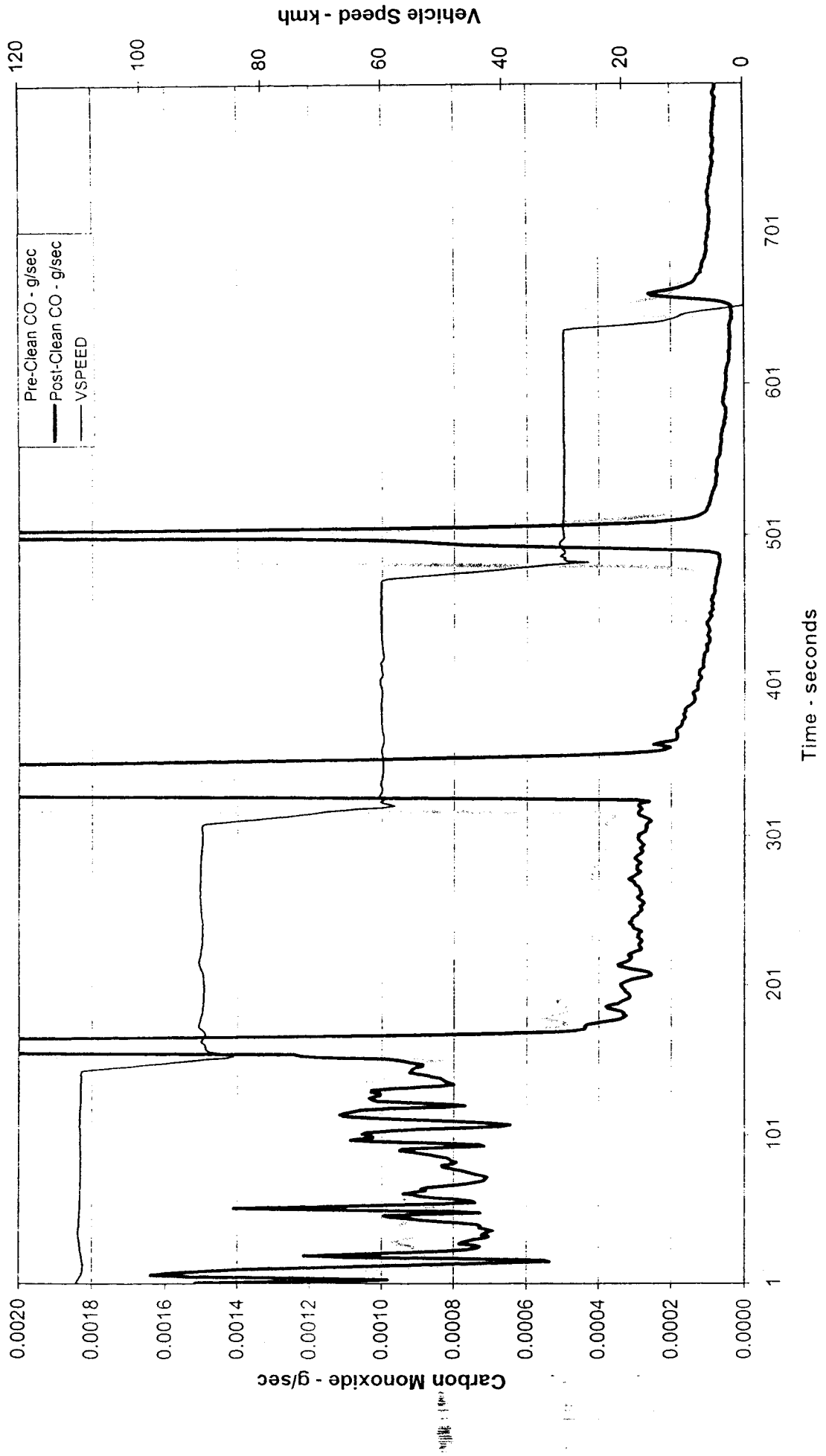
Nissan 300ZX Nitrogen Oxides Emissions



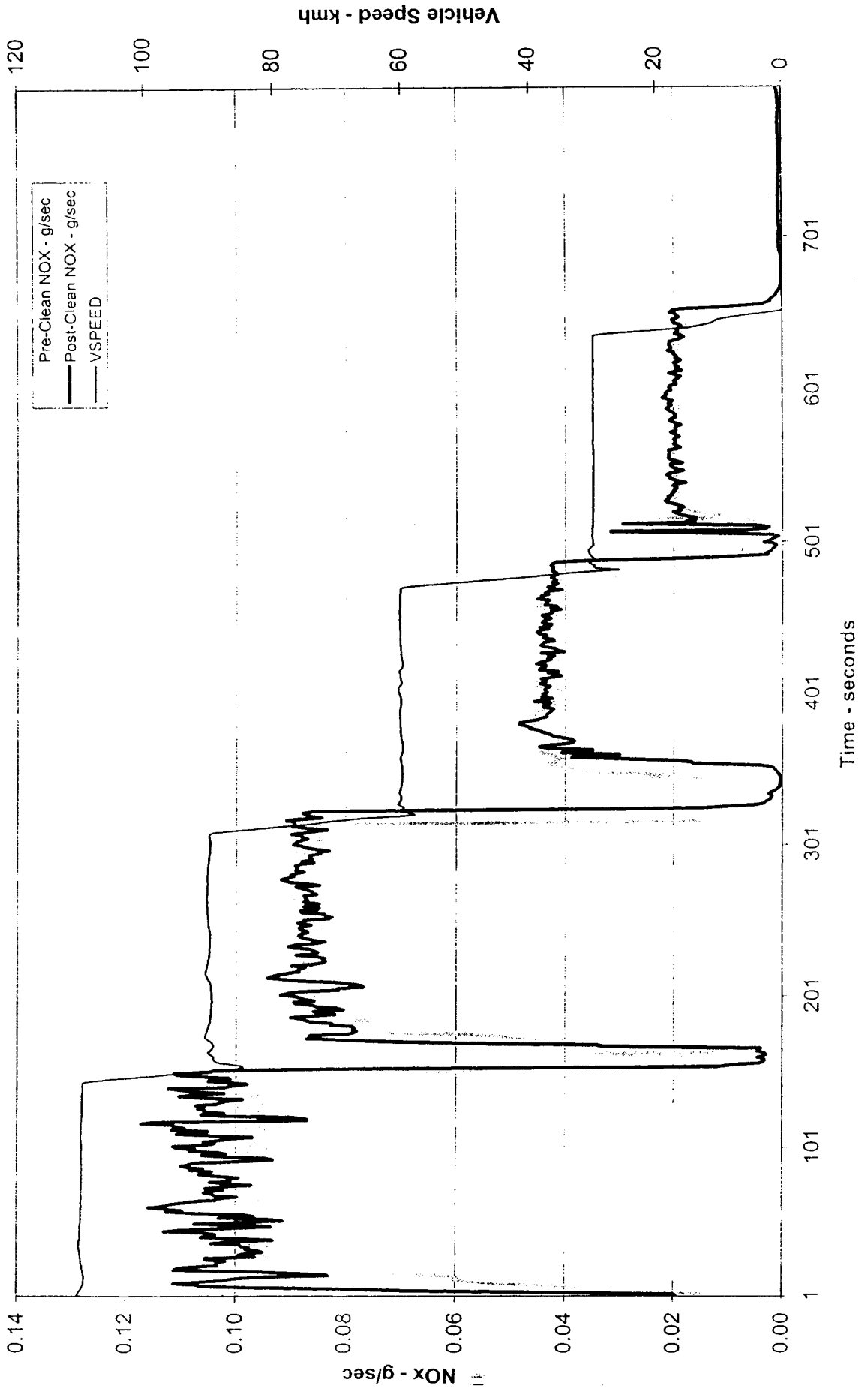
Nissan Silvia Hydrocarbon Emissions



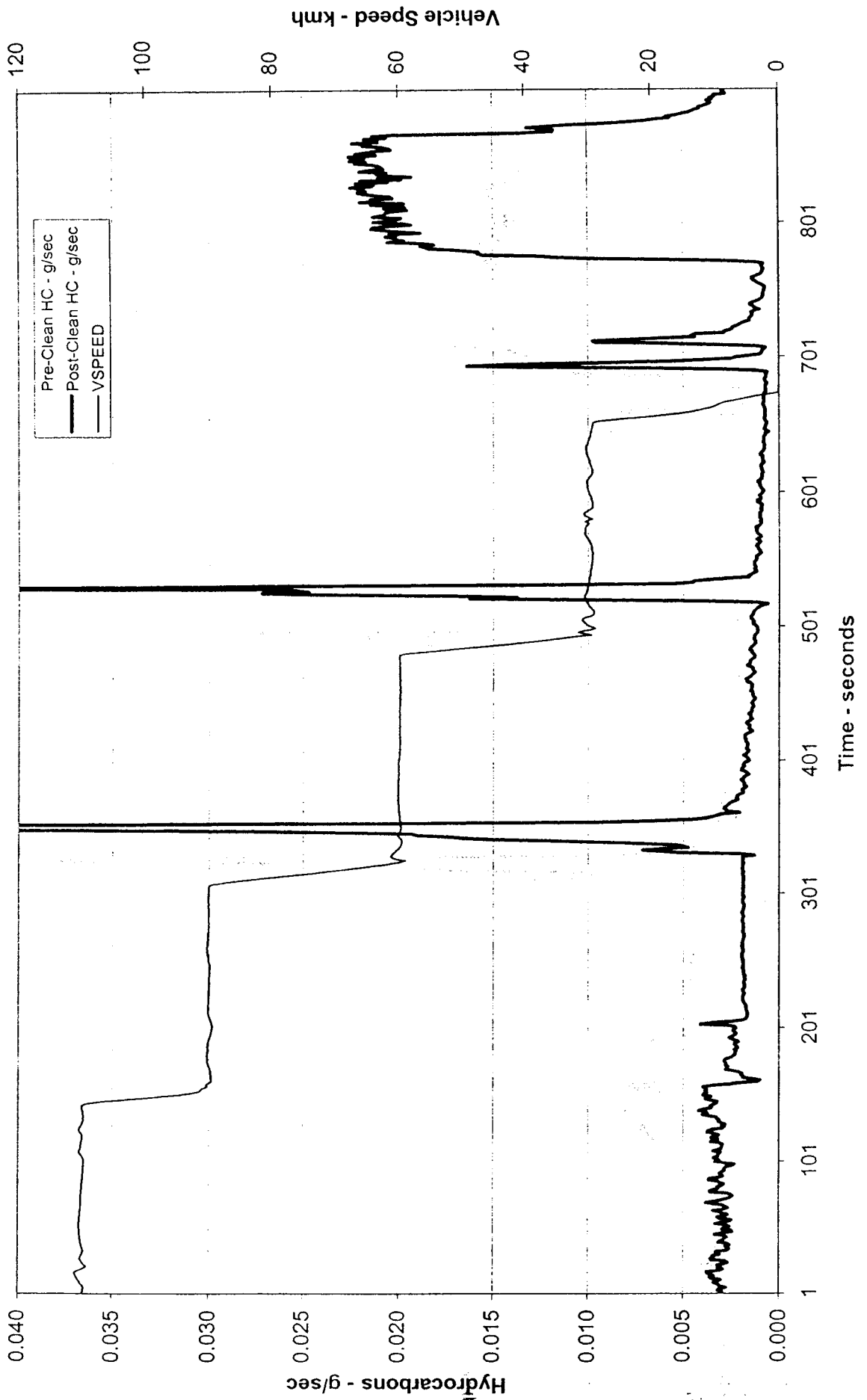
Nissan Silvia Carbon Monoxide Emissions



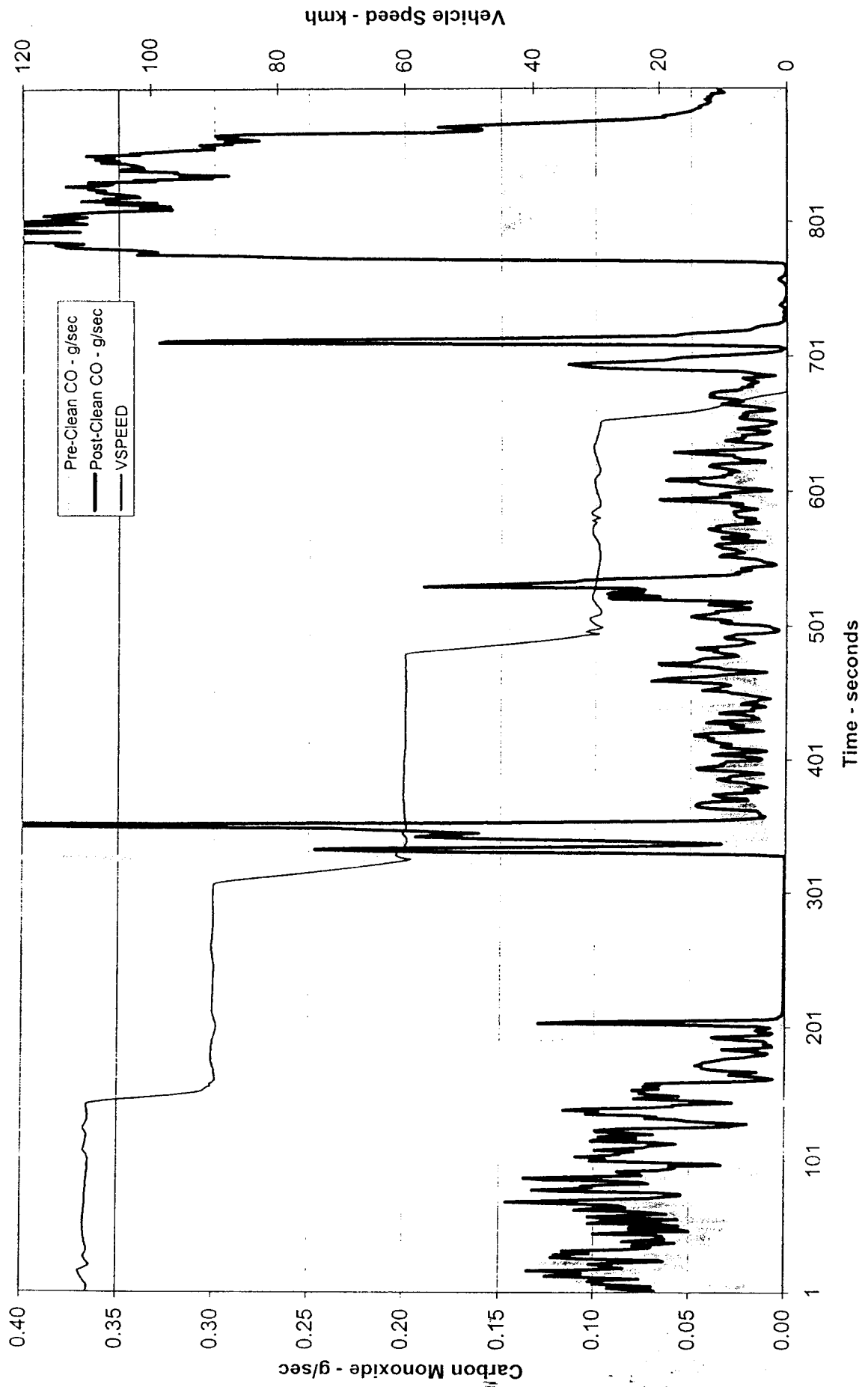
Nissan Silvia Nitrogen Oxides Emissions



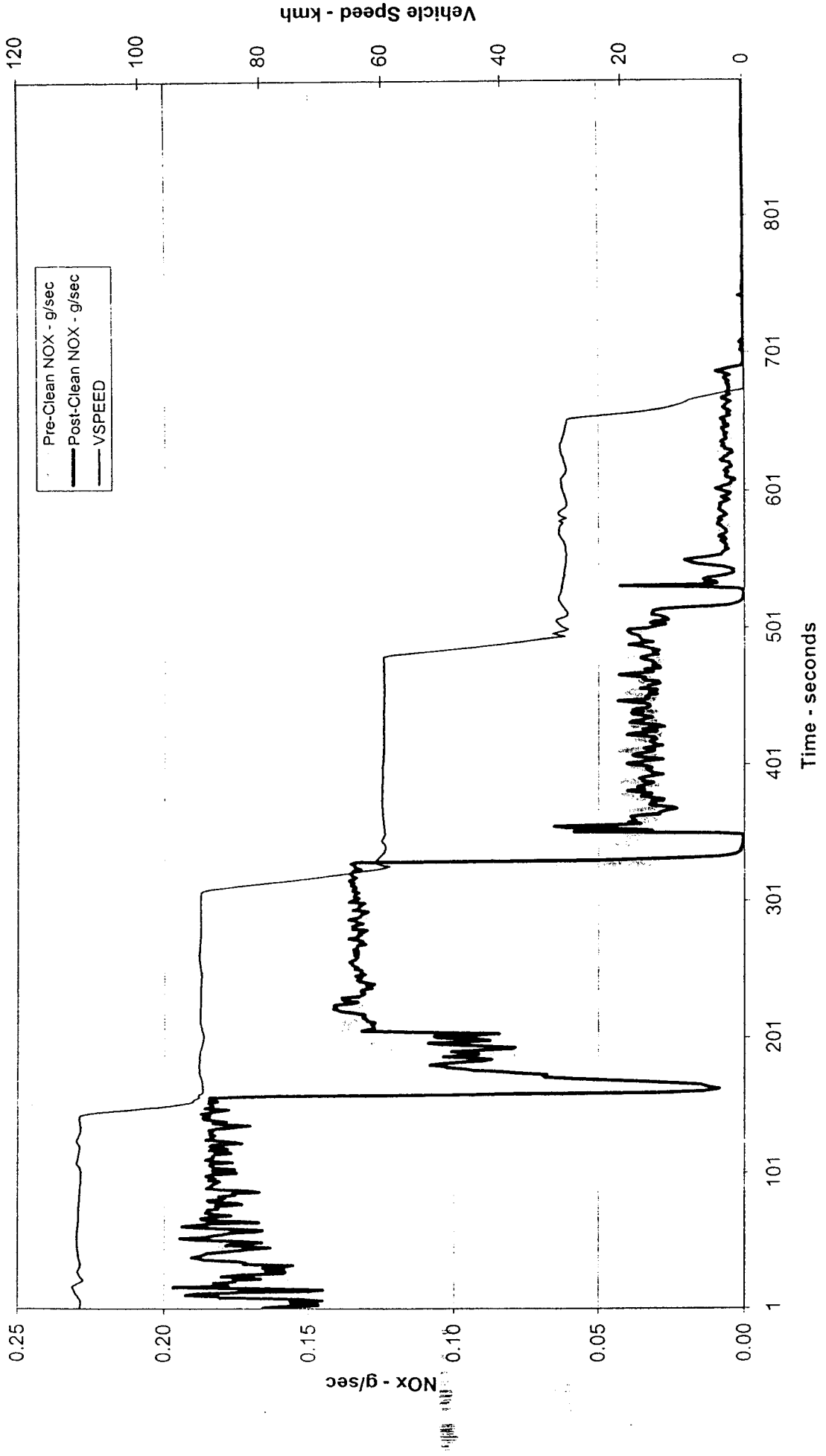
Ford Fairlane Hydrocarbon Emissions



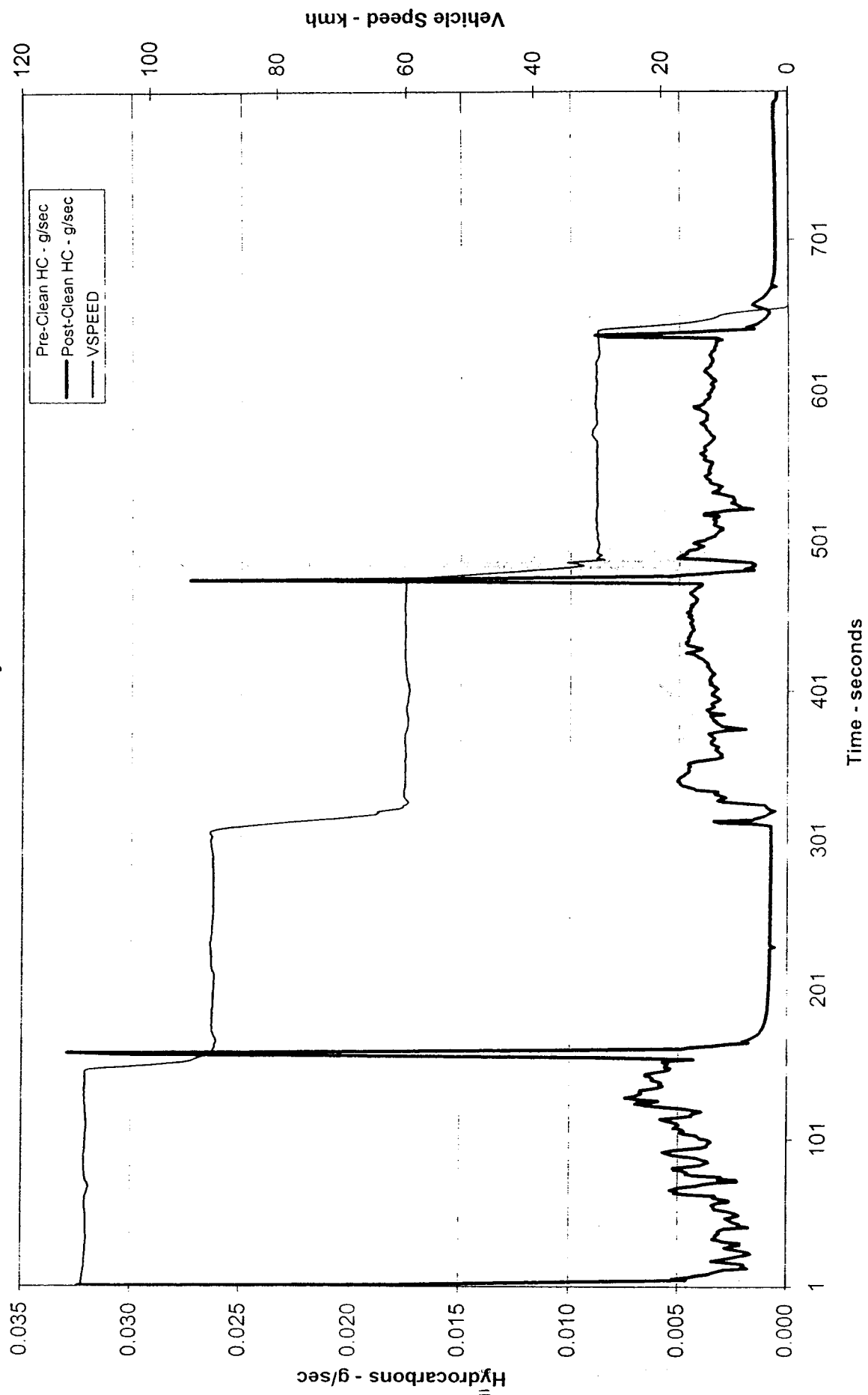
Ford Fairlane Carbon Monoxide Emissions



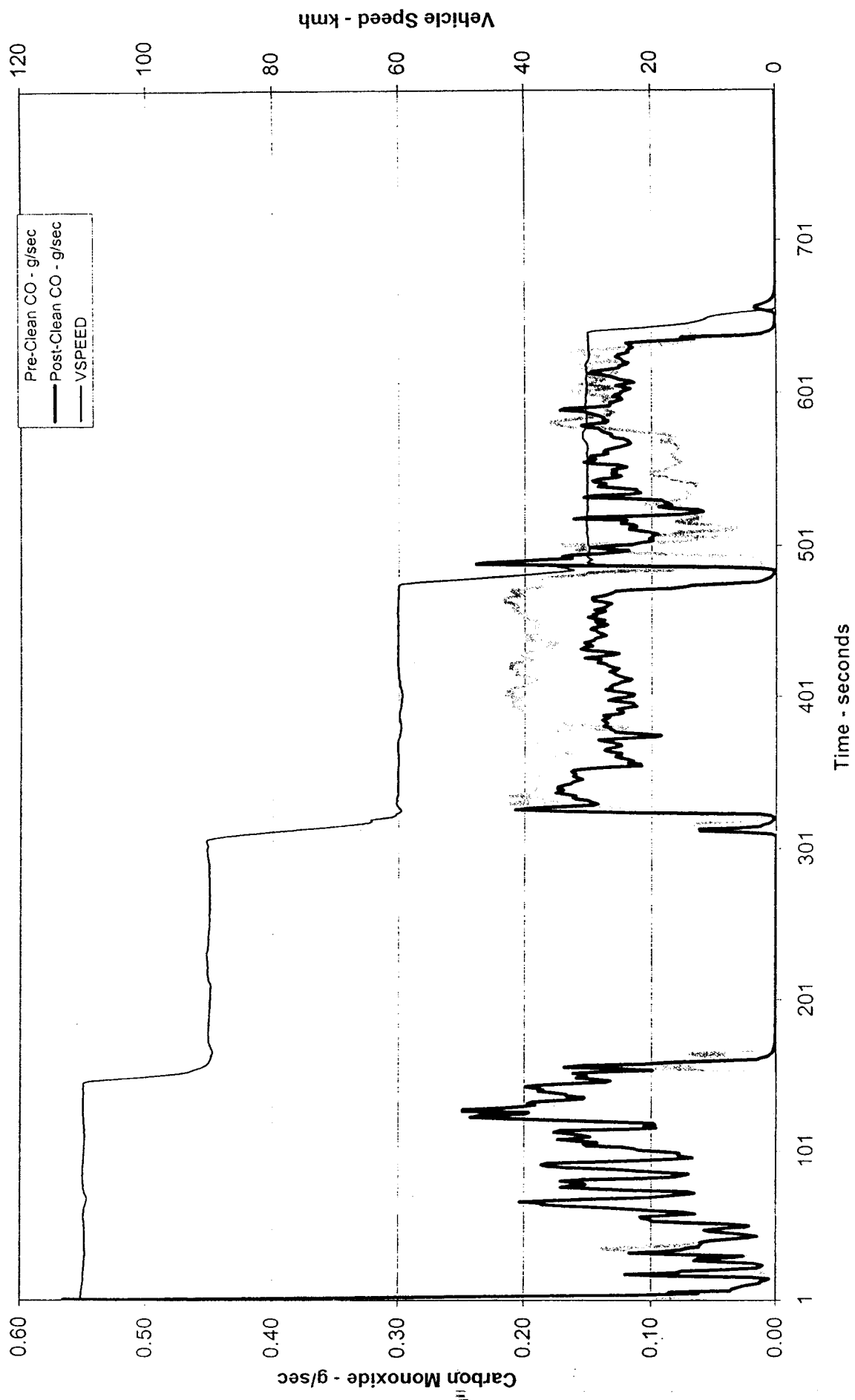
Ford Fairlane Nitrogen Oxides Emissions



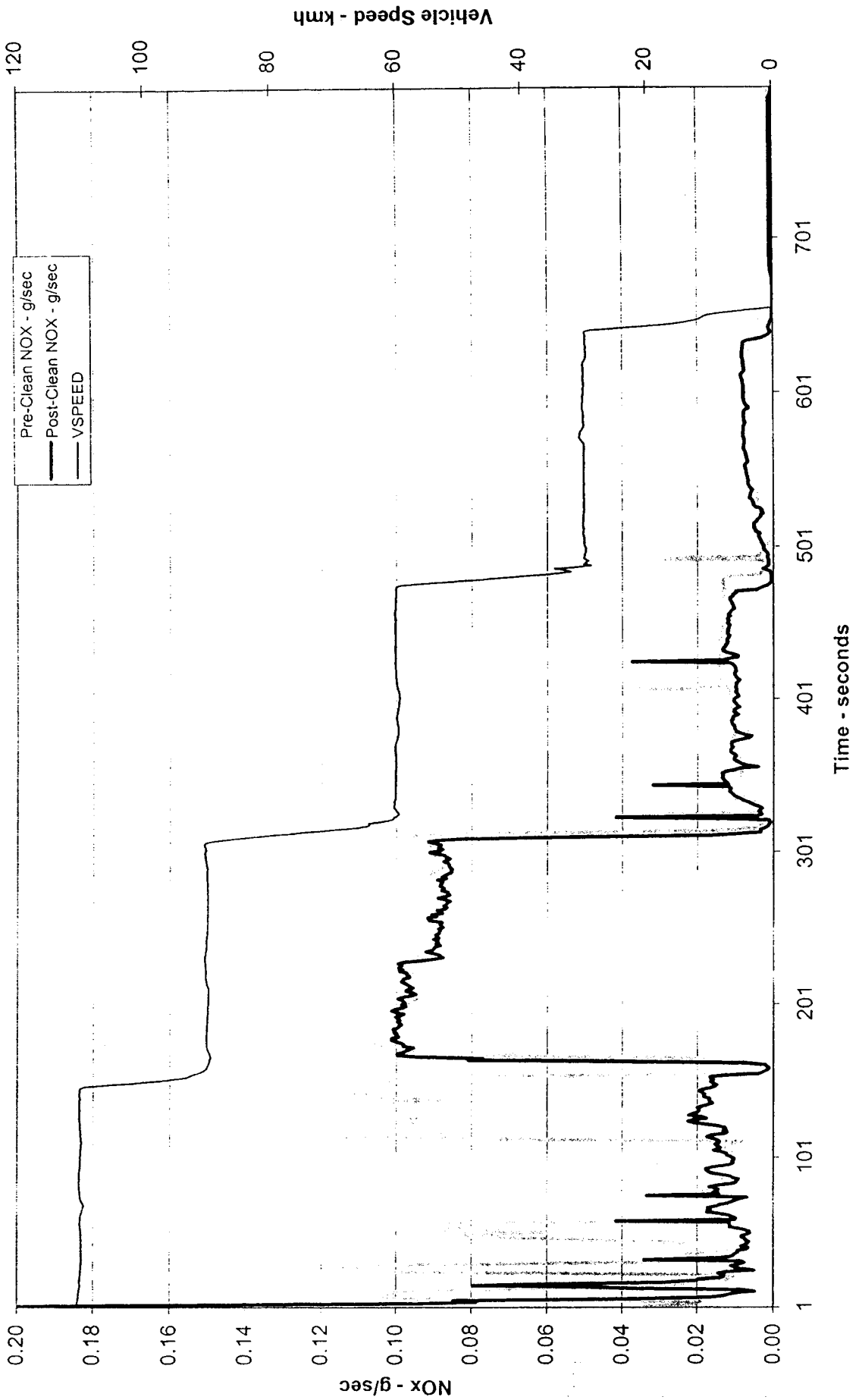
Holden Commodore Ute Hydrocarbon Emissions



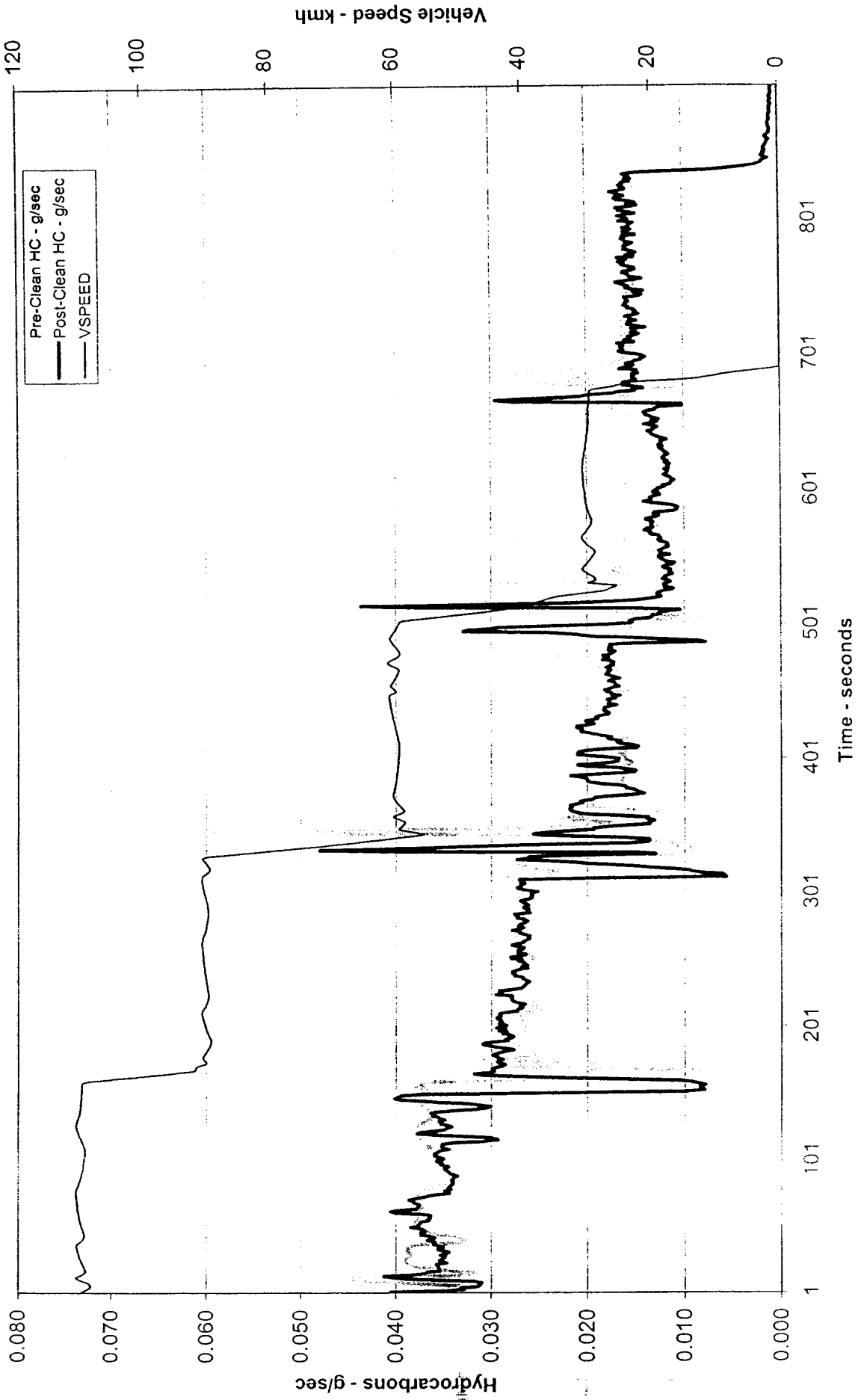
Holden Commodore Ute Carbon Monoxide Emissions



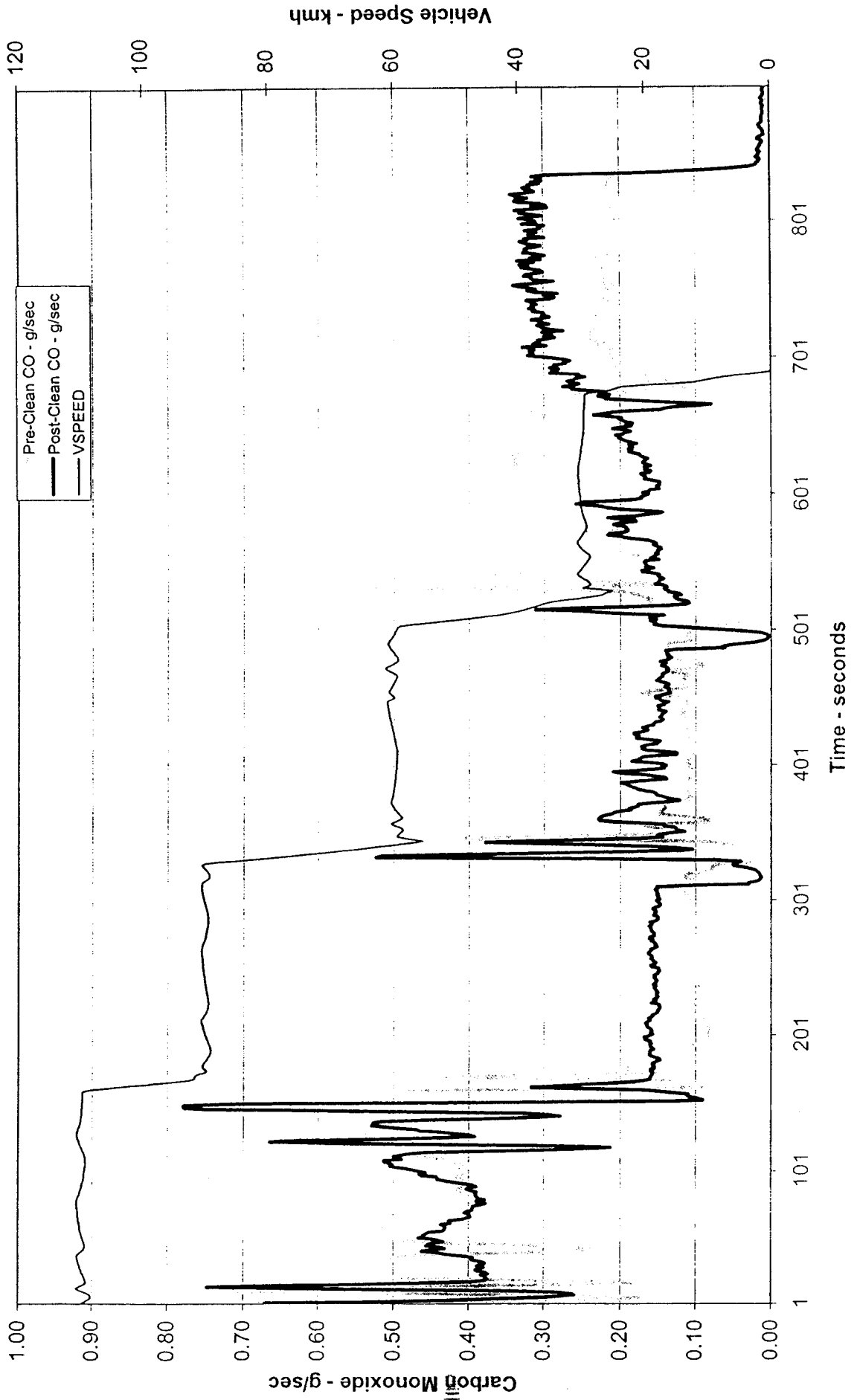
Holden Commodore Ute Nitrogen Oxides Emissions



BMW 318i Hydrocarbon Emissions



BMW 318i Carbon Moxide Emissions



BMW 318i Nitrogen Oxides Emissions

