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PERFORMANCE CHARACTERISTICS OF 1977 GENERAL MOTORS 350 CID ENGINE

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PREFACE

This report was prepared under PPA HS027, Research and Analysis in Automotive Fuel Economy and Related Areas, sponsored by the Technology Assessment Division of the National Highway Traffic Safety Administration. It presents the results of laboratory testing of the 1977 GM 350 CID engine to determine fuel economy and emissions over a sufficient speed-load range to effectively map the engine.

METRIC CONVERSION FACTORS

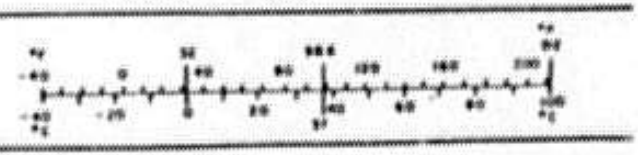
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
	inches	*2.5	centimeters	
	feet	30	centimeters	
	yards	0.9	meters	
	miles	1.6	kilometers	
		AREA		
	square inches	6.5	square centimeters	
	square feet	0.09	square meters	
	square yards	0.8	square meters	
	square miles	2.6	square kilometers	
	acres	0.4	hectares	
		MASS (weight)		
	ounces	28	grams	
	pounds	0.45	kilograms	
	short tons (2000 lb)	0.9	tonnes	
		VOLUME		
	teaspoons	5	milliliters	
	tablespoons	15	milliliters	
	fluid ounces	30	milliliters	
	cups	0.24	liters	
	pints	0.47	liters	
	quarts	0.95	liters	
	gallons	3.8	liters	
	cubic feet	0.03	cubic meters	
	cubic yards	0.76	cubic meters	
		TEMPERATURE (exact)		
	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	

*1 in = 2.54 exactly. For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
	millimeters	0.04	inches	
	centimeters	0.4	inches	
	meters	3.3	feet	
	meters	1.1	yards	
	kilometers	0.6	miles	
		AREA		
	square centimeters	0.16	square inches	
	square meters	1.2	square yards	
	square kilometers	0.4	square miles	
	hectares (10,000 m²)	2.5	acres	
		MASS (weight)		
	grams	0.035	ounces	
	kilograms	2.2	pounds	
	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
	milliliters	0.03	fluid ounces	
	liters	2.1	pints	
	liters	1.06	quarts	
	liters	0.26	gallons	
	cubic meters	35	cubic feet	
	cubic meters	1.3	cubic yards	
		TEMPERATURE (exact)		
	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	



CONTENTS

LIST OF TABLES

1. INTRODUCTION

The purpose of the study was to obtain engine performance data for estimating fuel economy and emissions for varied engine service and duty. This work supports the data base of the VEHSIM (Vehicle Simulator) Computer program at the Transportation Systems Center (TSC).

The data presented in this report are for an 8-cylinder spark ignition 1977 GM 350 CID engine with a catalytic converter, EGR, manifold preheated air inlet system, alternator (driven only, no output) power steering pump, and fan. The engine as equipped is intended for use in a forty-nine state (Federal) vehicle with automatic transmission. The test results present steady-state data sufficient to map the engine for fuel economy and emissions (carbon monoxide, hydrocarbons, and oxides of nitrogen) over the entire operating range of the engine.

2. ENGINE TEST REPORT

The engine test set-up included a complete mean tolerance engine (SAE definition) coupled to Schenck eddy-current dynamometer capable of absorbing 180 horsepower and 250 lb-ft or torque. The alternator was included but not wired into the engine's electrical system. The engine was also equipped with a catalytic converter, EGR, fan, power steering pump, and preheated air inlet system.

The manufacturer's specifications for the engine are given in Table 1.

TABLE 1. MANUFACTURER'S ENGINE SPECIFICATIONS

Year	1977
Manufacturer	General Motors
Displacement	350 CID
No. Cylinders	8
Maximum Horsepower	165 BHP @ 3800 RPM
Maximum Torque	260 lb - ft @ 2400 RPM
Carburetor	4 V
Bore and Stroke	4.00 in. x 3.48 in.
Compression Ratio	8.5

Emissions instrumentation consisted of the following Beckman Instruments Corp. instruments.

CO Model 864 Infrared Analyzer (NDIR)
CO_2 Model 864 Infrared Analyzer (NDIR)
NO/NO_x Model 951 Chemiluminescent Detector
O_2 Model F3 Paramagnetic Analyzer
HC Model 402 Flame Ionization Detector

Prior to testing, the engine break-in consisted of following the schedule shown in Table 2. A single batch of unleaded gasoline was used for break-in and engine testing. The gasoline specifications are shown in Table 3.

TABLE 2. ENGINE BREAK-IN SCHEDULE

PROGRAM 1:	MPH	RPM	DURATION (MINUTES)
	20	935	4
	40	1290	4
	60	1935	4
	50	1615	4
	30	970	4

(37 Cycles for an Accumulated 500 Miles)

PROGRAM 2:	MPH	RPM	DURATION (MINUTES)
	40	1290	4
	60	1935	4
	70	2260	4
	60	1935	4
	70	2260	4
	65	2100	4
	55	1775	4

(18 Cycles for an Accumulated 1000 Miles)

PROGRAM 3:	MPH	RPM	DURATION (MINUTES)
	50	1615	4
	75	2420	4
	85	2740	8
	80	2580	4
	55	1775	4
	65	2100	4

(18 Cycles for an Accumulated Total of 1500 Miles)

TABLE 3. FUEL SPECIFICATIONS

TYPE	AMCO INDOLENE
Specific gravity @ 60°F	.7275
Percent Carbon	83.47
Percent Hydrogen	13.53
Hydrogen/Carbon Molar Ratio	2.0
Upper Heating Valve (BTU/lb)	19,914

During the steady-state test, the engine was operated at the following speed-load modes:

SPEED-RPM	LOADS-TORQUE
595	
700	
1000	15
1500	0
2000	0%, 10%, 20%, 30%, 40%, 55%, 70%, 85%, 100% WOT Torque
2500	
3000	
3600	

Each test point was duplicated and the following data were recorded for each:

Ambient Pressure, mm Hg

Ambient Temperature, °F

Ambient Relative Humidity, %

Engine Speed, RPM

Torque, lb-ft.

Accumulated Fuel, cc (Fluidyne model 1250)

Ignition Timing, °BTDC

Manifold Vacuum, inches Hg

Throttle Angle, degrees

Oil Pump Exit Pressure, psi

Oil Temperature, °F

Coolant Exit Temperature, °F

Exhaust Temperature Before Catalyst, °F

Exhaust Pressure Before Catalyst, inches H_2O

Emissions Concentrations After Catalyst, dry basis:

CO, %

CO_2, %

HC, ppm

NO_x, ppm

Exhaust Temperature After Catalyst, °F.

The following equations were used in calculating corrected torque, corrected horsepower, mass fuel flow rate, corrected brake specific fuel consumption, air-to-fuel ratio based on emissions, mass emission rates of CO, HC, NO_x, and ambient absolute humidity.

CORRECTED TORQUE, Tc (lb-ft)[1] From SAE J245, Spark Ignition Engine Rating Code, adjusted to standard SAE ambient conditions:

$$T_c = \frac{B_d^*}{B_{dt}} \left(\frac{t_t + A}{t^* + A} \right)^{1/2} T_t$$

where

B_d^* = Standard Dry Barometric Pressure (29.00 in Hg, 97.9 kPa)

B_{dt} = Dry Barometric Pressure at Test Conditions

t_t = Ambient Air Temperature at Test Conditions

t^* = Standard Ambient Temperature (85°F, 29.4°C)

A = Absolute Temperature Constant (460°R, 273°K)

T_t = Measured Torque at Test Conditions.

CORRECTED HORSEPOWER, hpc[1] From SAE J245, Spark Ignition Engine Rating Code, adjusted to standard SAE ambient conditions:

$$hp_c = \frac{T_c N}{G}$$

(1)Engines with manifold preheated air inlet systems are designed to control carburetor air inlet temperature to a specific temperature. Excursions in ambient temperature below this value do not appreciably affect the controlled temperature. The engine performance correction factor as described in SAE J245 Engine Rating Code for Spark Ignition Engines has therefore been updated as follows: If ambient temperature is less than or equal to the manufacturer's stated controlled temperatures, no correction component involving carburetor inlet temperature is made. If ambient temperature exceeds the targeted controlled temperature, the normal J245 correction factor is applied with the targeted controlled temperature used in place of the standard ambient temperature.

where

T_c = Corrected Torque (See Above)
N = Engine Speed (RPM)
G = Power Constant (5252 English, 955 SI).

MASS FUEL FLOW RATE (lb/hr) From volumetric measurement (corrected to 60°F per ASTM petroleum tables) and fuel specific gravity:

$$\dot{m}_f = \frac{(SpG)_f \left(\frac{lb\ H_2O}{vol}\right) (vol)_f}{\Delta t_T}$$

where

$\dot{m}_f$ = Fuel Flow Rate lb/hr
$(SpG)_f$ = Specific Gravity of Fuel
$(lb\ H_2O/vol)$ = Pounds of Water per Unit Volume
(vol_f) = Volume of Fuel Measured, corrected to 60°F per ASTM petroleum tables
Δt_T = Time Interval of Volume Measurement (hrs).

CORRECTED BRAKE SPECIFIC FUEL CONSUMPTION (BSFC) (lb/HP-Hr)

$$BSFC_c = \frac{\dot{m}_f}{HP_c}$$

where

$BSFC_c$ = Corrected Brake Specific Fuel Consumption
HP_c = Corrected Horsepower
$\dot{m}f$ - Mass Fuel Flow Rate (lb/hr).

AIR/FUEL RATIO (A/F) Based on emissions measurements from SPINDT, SAE #650507:

$$A/F = F_b \left[11.492\ F_c \left(\frac{1+R/2+Q}{1+R}\right) + \left(\frac{120(1-FC)}{3.5+R}\right) \right]$$

where

$$R = \frac{\%\ CO}{\%\ CO_2} = \frac{\text{Percent CO Concentration}}{\text{Percent } CO_2 \text{ Concentration}}$$

F_c = Mass Fraction of Carbon in Fuel

$$F_b = \frac{\%\ CO + \%\ CO_2}{\%\ CO + \%\ CO_2 + \%\ CH}$$

$$Q = \frac{\%\ O_2}{\%\ CO_2} = \frac{\text{Percent } O_2 \text{ Concentration}}{\text{Percent } CO_2 \text{ Concentration}}$$

CARBON MONOXIDE (CO) MASS EMISSION RATE (Grams/Hr)

$$\text{MASS CO} = (4.383)\,(\dot{m}_f)(A/F+1)(\%CO)\left[\frac{1}{1 + 0.03148\,(\%\,CO_2)\,\frac{\%CO+\%CO_2}{\%CO+3\%CO_2}}\right]$$

where

$\dot{m}_f$ = Mass Fuel Flow Rate
A/F = Air to Fuel Ratio
% CO = Percent CO Concentration
% CO_2 = Percent CO_2 Concentration .

HYDROCARBON (HC) MASS EMISSION RATE (Grams/Hr)

$$\text{Mass HC} = (0.0002207)\,(\dot{m}_f)\,(A/F+1)\,(\text{ppm HC})$$

where

$\dot{m}_f$ = Mass Fuel Flow Rate
A/F = Air to Fuel Ratio
ppm HC = Parts per Million of HC Concentration.

OXIDES OF NITROGEN (NO_x) MASS EMISSIONS RATE (Gram/Hr)

$$\text{Mass } NO_x = 0.007201\,(\dot{m}_f)\,(A/F+1)\,(\text{ppm } NO_x)\left[\frac{1}{1 + .03148\,(\%\,CO_2)\left(\frac{\%CO+\%CO_2}{\%CO+3\%CO_2}\right)}\right]$$

where

$\dot{m}_f$ = Mass Fuel Flow Rate
A/F = Air to Fuel Ration
ppm NO_x = Parts per Million NO_x Concentration
% CO = Percent CO Concentration
% CO_2 = Percent CO_2 Concentration
K_H = Humidity Correction Factor .

HUMIDITY CORRECTION FACTOR

$$K_H = \frac{1}{1-.0047\,(\text{Absolute Humidity} - 75)}$$

where absolute humidity is in grams/pound of dry air.

ABSOLUTE HUMIDITY (AH) (Grains/lb Dry Air):

$$AH = \frac{(RH)\ P_{SU}}{1.608\ (P_{AMB} - RH \cdot P_{SU})}$$

where

RH = Measured Relative Humidity

P_{SU} = Saturated Vapor Pressure (from Keenan and Keyes Steam Tables)

P_{AMB} = Ambient Barometric Pressure.

3. DISCUSSION OF TEST RESULTS

Appendixes A and B summarize engine map data in tabular and graphical form, respectivley. Each test point is repeated once. Fuel consumption, hydrocarbon mass rates, and oxides of nitrogen mass rates demonstrated excellent repeatability. Air-to-fuel rates, however, were not very repeatable below 1600 RPM.

APPENDIX A TABULAR SUMMARY OF ENGINE MAP DATA

Engine..... GM 350 CID

Test Number.....	3	2	4	5	6	7
Test Date.....	3/29/77	3/29/77	3/29/77	3/29/77	3/29/77	3/29/77
Barometer, mm Hg.....	760.0	761.5	760.0	760.0	760.0	760.2
Humidity, grains/lb.....	54.	53.	63.	58.	58.	56.
Ambient temperature, F....	75.	73.	83.	86.	86.	86.
Engine speed, rpm.....	731.	834.	1000.	1000.	1000.	1000.
Torque, lb-ft*.....	12.8	0.0	221.8	194.5	158.1	124.3
Power, bhp*.....	1.8	0.0	41.8	36.9	29.9	23.5
Fuel rate, lb/hr.....	4.5	4.1	26.2	26.5	16.0	13.8
Ignition timing, deg BTC..	24.0	24.0	6.0	6.0	12.0	14.5
Manifold vacuum, in Hg....	-19.9	-20.9	-0.3	-2.4	-5.8	-7.3
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	2.496	*********	0.628	0.719	0.534	0.586
Oil temperature, F.....	199.	202.	229.	226.	225.	222.
Oil pressure, psi.....	24.	28.	26.	27.	28.	28.
Coolant temperatue, F.....	195.	195.	203.	201.	201.	200.
Before Catalyst						
Exhaust temperature, F....	508.	539.	1026.	978.	965.	927.
Exhaust pressure, in H2O..	-0.1	0.1	36.9	32.2	19.7	15.3
After Catalyst						
Concentrations, dry basis:						
CO, %.....	2.730	2.275	1.464	1.487	0.973	0.014
CO2, %.....	12.87	13.08	10.98	9.61	14.07	13.70
O2, %.....	0.17	0.27	0.00	0.00	0.15	1.42
HC, ppmC.....	6.	12.	1079.	1270.	488.	20.
NOx, ppm.....	81.	60.	436.	138.	845.	388.
Air-fuel ratio.....	13.64	13.89	13.78	13.57	14.31	15.68
Emission rates, g/hr:						
CO.....	684.	528.	2210.	2266.	903.	12.
HC.....	0.1	0.2	92.3	108.2	26.3	1.0
NOx**.....	3.3	2.3	108.1	34.5	128.9	56.1
Exhaust temperature, F....	420.	432.	948.	903.	895.	850.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	8	10	11	12	13	66
Test Date.....	3/29/77	3/30/77	3/30/77	3/30/77	3/30/77	4/ 5/77
Barometer, mm Hg.....	760.2	763.5	763.5	763.3	763.0	750.8
Humidity, grains/lb.....	58.	51.	50.	51.	51.	33.
Ambient temperature, F....	85.	75.	76.	76.	76.	69.
Engine speed, rpm.....	1000.	1000.	1000.	1000.	1000.	1000.
Torque, lb-ft*.....	90.5	64.5	43.5	21.5	0.1	1.7
Power, bhp*.....	17.1	12.2	8.3	4.1	0.0	0.3
Fuel rate, lb/hr.....	11.2	9.0	7.5	6.2	5.7	5.3
Ignition timing, deg BTC..	21.0	24.5	24.5	24.5	24.5	24.0
Manifold vacuum, in Hg....	-10.1	-14.2	-17.9	-19.7	-21.3	-20.9
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.654	0.741	0.911	1.522	*********	17.110
Oil temperature, F.....	218.	212.	212.	209.	206.	202.
Oil pressure, psi.....	28.	28.	28.	28.	28.	31.
Coolant temperatue, F.....	199.	199.	197.	195.	194.	193.
Before Catalyst						
Exhaust temperature, F....	865.	780.	700.	657.	628.	617.
Exhaust pressure, in H2O..	9.7	6.9	4.1	2.5	1.6	1.7
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.013	0.015	0.013	0.020	0.712	0.728
CO2, %.....	13.98	13.86	13.99	14.45	14.12	14.12
O2, %.....	1.16	1.09	0.87	0.16	0.12	0.07
HC, ppmC.....	52.	35.	34.	45.	164.	16.
NOx, ppm.....	182.	358.	517.	182.	66.	58.
Air-fuel ratio.....	15.48	15.44	15.27	14.76	14.43	14.41
Emission rates, g/hr:						
CO.....	9.	8.	6.	7.	239.	224.
HC.....	2.1	1.1	0.9	1.0	3.2	0.3
NOx**.....	21.1	33.5	39.7	11.1	3.6	3.0
Exhaust temperature, F....	798.	693.	635.	616.	575.	554.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	67	68	69	70	71	72
Test Date.....	4/ 5/77	4/ 5/77	4/ 5/77	4/ 5/77	4/ 5/77	4/ 5/77
Barometer, mm Hg.....	751.1	751.1	748.8	748.8	748.3	748.3
Humidity, grains/lb.....	33.	34.	34.	34.	35.	35.
Ambient temperature, F....	69.	70.	72.	74.	74.	75.
Engine speed, rpm.....	1000.	1000.	1000.	1000.	1000.	1000.
Torque, lb-ft*.....	23.0	46.4	68.8	91.7	126.0	162.4
Power, bhp*.....	4.3	8.9	13.1	17.5	23.9	30.8
Fuel rate, lb/hr.....	6.2	7.6	9.3	11.3	13.7	22.1
Ignition timing, deg BTC..	34.0	34.0	33.5	32.0	20.0	13.0
Manifold vacuum, in Hg....	-19.5	-17.5	-13.5	-9.6	-6.9	-5.1
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	1.436	0.851	0.712	0.650	0.573	0.717
Oil temperature, F.....	204.	205.	207.	211.	215.	217.
Oil pressure, psi.....	31.	31.	31.	31.	30.	30.
Coolant temperature, F.....	194.	194.	195.	196.	198.	198.
Before Catalyst						
Exhaust temperature, F....	651.	699.	800.	880.	938.	914.
Exhaust pressure, in H20..	2.4	3.7	6.7	11.1	16.3	22.9
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.027	0.019	0.018	0.015	0.015	1.414
CO2, %.....	14.60	14.15	14.08	13.84	14.07	9.75
O2, %.....	0.24	0.86	0.85	1.20	1.15	0.00
HC, ppmC.....	21.	22.	25.	24.	36.	416.
NOx, ppm.....	202.	553.	339.	362.	801.	134.
Air-fuel ratio.....	14.82	15.26	15.26	15.52	15.47	13.67
Emission rates, g/hr:						
CO.....	10.	9.	10.	10.	13.	1804.
HC.....	0.4	0.6	0.8	1.0	1.8	29.7
NOx**.....	12.4	42.5	32.3	42.6	113.6	28.2
Exhaust temperature, F....	590.	619.	729.	796.	853.	839.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	73	74	14	15	16	17
Test Date.....	4/ 5/77	4/ 5/77	3/30/77	3/30/77	3/30/77	3/30/77
Barometer, mm Hg.....	746.5	746.3	763.0	763.0	763.0	763.0
Humidity, grains/lb.....	35.	36.	52.	49.	47.	44.
Ambient temperature, F....	78.	79.	83.	85.	96.	86.
Engine speed, rpm.....	1000.	1000.	1500.	1500.	1500.	1500.
Torque, lb-ft*.....	196.2	222.6	232.8	199.3	163.6	128.7
Power, bhp*.....	37.2	42.2	66.1	56.7	46.6	36.6
Fuel rate, lb/hr.....	26.0	25.8	40.0	40.7	24.4	20.4
Ignition timing, deg BTC..	10.0	10.5	12.0	12.0	17.0	21.0
Manifold vacuum, in Hg....	-2.1	-0.3	-0.6	-3.3	-6.0	-7.9
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.698	0.610	0.605	0.718	0.524	0.557
Oil temperature, F.....	220.	225.	245.	240.	240.	236.
Oil pressure, psi.....	29.	29.	29.	29.	29.	30.
Coolant temperatue, F.....	200.	201.	203.	202.	202.	200.
Before Catalyst						
Exhaust temperature, F....	986.	1034.	1166.	1086.	1141.	1077.
Exhaust pressure, in H2O..	33.0	37.1	87.6	72.8	47.5	35.2
After Catalyst						
Concentrations, dry basis:						
CO, %.....	1.439	1.505	1.473	1.419	0.013	0.012
CO2, %.....	9.51	11.18	10.79	8.92	14.70	13.77
O2, %.....	0.00	0.00	0.21	0.00	0.00	1.69
HC, ppmC.....	473.	427.	1119.	1362.	47.	35.
NOx, ppm.....	134.	419.	367.	101.	955.	872.
Air-fuel ratio.....	13.73	13.78	13.94	13.58	14.66	15.87
Emission rates, g/hr:						
CO.....	2175.	2228.	3436.	3346.	20.	16.
HC.....	39.9	35.9	147.6	178.4	4.0	2.6
NOx**.....	33.2	101.8	140.7	39.1	227.8	188.9
Exhaust temperature, F....	908.	955.	1087.	1015.	1088.	982.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	18	19	20	21	22	76
Test Date.....	3/30/77	3/30/77	3/30/77	3/30/77	3/30/77	4/ 6/77
Barometer, mm Hg.....	761.2	761.0	761.0	760.7	760.7	754.6
Humidity, grains/lb.....	37.	39.	39.	39.	39.	25.
Ambient temperature, F....	83.	85.	85.	85.	85.	71.
Engine speed, rpm.....	1500.	1500.	1500.	1500.	1500.	1500.
Torque, lb-ft*.....	93.9	67.9	46.1	22.0	0.1	1.7
Power, bhp*.....	26.7	19.3	13.1	6.2	0.0	0.5
Fuel rate, lb/hr.....	16.3	14.1	12.2	9.8	7.2	6.5
Ignition timing, deg BTC..	29.0	29.0	29.5	29.5	29.5	29.5
Manifold vacuum, in Hg....	-11.6	-13.7	-15.3	-18.2	-21.6	-21.6
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.608	0.732	0.926	1.526	*********	14.310
Oil temperature, F.....	231.	228.	225.	222.	218.	216.
Oil pressure, psi.....	30.	30.	30.	31.	31.	34.
Coolant temperatue, F.....	200.	199.	198.	196.	195.	197.
Before Catalyst						
Exhaust temperature, F....	984.	958.	934.	876.	761.	761.
Exhaust pressure, in H2O..	20.8	15.1	11.2	6.6	2.9	3.3
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.015	0.015	0.022	0.019	0.017	0.017
CO2, %.....	13.72	13.72	13.67	13.65	13.98	14.01
O2, %.....	2.59	1.30	1.38	1.27	0.93	3.18
HC, ppmC.....	33.	38.	33.	21.	15.	18.
NOx, ppm.....	522.	125.	72.	142.	83.	103.
Air-fuel ratio.....	16.53	15.60	15.65	15.58	15.30	16.90
Emission rates, g/hr:						
CO.....	17.	13.	17.	12.	8.	7.
HC.....	2.1	2.0	1.5	0.8	0.4	0.5
NOx**.....	93.7	18.5	9.2	14.5	6.1	7.5
Exhaust temperature, F....	897.	867.	847.	778.	659.	648.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	77	78	79	81	82	83
Test Date.....	4/ 7/77	4/ 7/77	4/ 7/77	4/ 8/77	4/ 8/77	4/ 8/77
Barometer, mm Hg.....	812.8	812.8	812.8	759.2	759.5	761.7
Humidity, grains/lb.....	16.	17.	17.	29.	29.	29.
Ambient temperature, F....	73.	79.	80.	72.	74.	77.
Engine speed, rpm.....	1500.	1500.	1500.	1500.	1500.	1500.
Torque, lb-ft*.....	16.6	42.1	62.6	93.9	131.0	164.6
Power, bhp*.....	4.7	12.0	17.8	26.9	37.2	47.0
Fuel rate, lb/hr.....	6.5	12.4	14.2	16.4	20.9	25.0
Ignition timing, deg BTC..	35.0	30.0	29.0	28.5	21.0	18.0
Manifold vacuum, in Hg....	-17.7	-15.2	-13.6	-11.4	-7.4	-5.8
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	1.403	1.034	0.798	0.609	0.564	0.531
Oil temperature, F.....	218.	223.	226.	227.	231.	237.
Oil pressure, psi.....	33.	33.	33.	33.	32.	32.
Coolant temperatue, F.....	197.	199.	200.	200.	201.	203.
Before Catalyst						
Exhaust temperature, F....	909.	944.	957.	998.	1102.	1151.
Exhaust pressure, in H20..	8.3	11.6	15.4	22.0	37.5	47.3
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.025	0.023	0.021	0.017	0.015	0.516
CO2, %.....	13.40	13.15	13.08	13.64	13.61	14.37
O2, %.....	2.08	3.81	3.01	1.48	1.60	0.00
HC, ppmC.....	4.	10.	16.	9.	51.	98.
NOx, ppm.....	85.	14.	30.	635.	993.	1249.
Air-fuel ratio.....	16.14	17.52	16.93	15.73	15.82	14.43
Emission rates, g/hr:						
CO.....	11.	20.	20.	18.	20.	756.
HC.....	0.1	0.5	0.9	0.5	4.0	8.0
NOx**.....	6.0	5.0	4.8	109.7	220.2	300.6
Exhaust temperature, F....	754.	848.	869.	905.	1000.	1076.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	84	85	24	25	26	27
Test Date.....	4/ 8/77	4/ 8/77	3/31/77	3/31/77	3/31/77	3/31/77
Barometer, mm Hg.....	761.7	759.5	753.4	752.9	752.9	752.9
Humidity, grains/lb.....	28.	26.	58.	58.	59.	59.
Ambient temperature, F....	79.	82.	80.	81.	83.	84.
Engine speed, rpm.....	1500.	1500.	2000.	2000.	2000.	2000.
Torque, lb-ft*.....	205.2	235.3	1.5	26.1	50.5	75.8
Power, bhp*.....	58.6	67.1	0.6	9.9	19.2	28.8
Fuel rate, lb/hr.....	41.8	40.7	10.4	13.2	15.6	18.6
Ignition timing, deg BTC..	16.0	13.5	37.0	38.0	37.0	37.0
Manifold vacuum, in Hg....	-2.7	-0.8	-19.9	-17.7	-15.9	-13.8
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.713	0.607	20.250	1.333	0.814	0.644
Oil temperature, F.....	237.	241.	228.	231.	235.	239.
Oil pressure, psi.....	31.	31.	35.	35.	35.	34.
Coolant temperatue, F.....	203.	203.	198.	199.	199.	201.
Before Catalyst						
Exhaust temperature, F....	1118.	1173.	921.	962.	999.	1029.
Exhaust pressure, in H2O..	77.0	86.9	8.2	13.2	19.8	28.3
After Catalyst						
Concentrations, dry basis:						
CO, %.....	1.393	1.411	0.018	0.014	0.018	0.022
CO2, %.....	9.08	10.65	13.95	13.58	13.50	13.44
O2, %.....	0.00	0.00	1.13	1.36	2.68	6.48
HC, ppmC.....	650.	555.	39.	37.	35.	32.
NOx, ppm.....	110.	263.	125.	110.	70.	87.
Air-fuel ratio.....	13.56	13.85	15.46	15.65	16.62	19.42
Emission rates, g/hr:						
CO.....	3360.	3337.	12.	12.	19.	32.
HC.....	87.3	74.0	1.5	1.8	2.1	2.7
NOx**.....	83.6	102.2	13.5	15.2	12.2	20.8
Exhaust temperature, F....	1042.	1096.	814.	870.	906.	945.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	28	29	30	59	60	61
Test Date.....	3/31/77	3/31/77	3/31/77	4/ 2/77	4/ 2/77	4/ 2/77
Barometer, mm Hg.....	752.1	752.1	752.1	771.9	771.7	771.9
Humidity, grains/lb.....	58.	58.	58.	22.	22.	23.
Ambient temperature, F....	86.	88.	89.	90.	90.	90.
Engine speed, rpm.....	2000.	2000.	2000.	2000.	2000.	2000.
Torque, lb-ft*.....	100.3	136.7	173.2	-0.9	22.0	46.6
Power, bhp*.....	38.1	52.0	65.9	-0.3	8.4	17.8
Fuel rate, lb/hr.....	21.6	26.9	33.3	10.6	13.0	15.6
Ignition timing, deg BTC..	34.5	30.0	28.0	36.0	38.0	36.0
Manifold vacuum, in Hg....	-11.6	-7.9	-5.7	-20.4	-18.3	-16.5
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.567	0.518	0.505	-33.090	1.550	0.881
Oil temperature, F.....	243.	248.	253.	227.	230.	233.
Oil pressure, psi.....	34.	34.	33.	35.	35.	35.
Coolant temperatue, F.....	201.	202.	203.	198.	200.	200.
Before Catalyst						
Exhaust temperature, F....	1065.	1157.	1210.	937.	974.	1008.
Exhaust pressure, in H2O..	38.6	61.9	81.6	6.9	12.0	18.1
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.021	0.019	0.880	0.014	0.013	0.013
CO2, %.....	13.38	13.58	13.64	13.55	13.51	13.61
O2, %.....	5.81	6.81	4.52	1.38	1.58	1.41
HC, ppmC.....	39.	45.	405.	17.	19.	46.
NOx, ppm.....	92.	103.	115.	126.	237.	459.
Air-fuel ratio.....	18.94	19.61	17.32	15.67	15.82	15.68
Emission rates, g/hr:						
CO.....	35.	41.	2047.	10.	11.	13.
HC.....	3.7	5.5	54.5	0.7	0.9	2.7
NOx**.....	25.0	36.1	43.8	14.1	32.6	82.0
Exhaust temperature, F....	986.	1071.	1135.	831.	878.	912.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... C8 350 CID

Test Number.....	62	63	64	86	87	88
Test Date.....	4/ 2/77	4/ 2/77	4/ 2/77	4/ 8/77	4/ 8/77	4/ 8/77
Barometer, mm Hg.....	771.1	770.9	770.6	760.0	760.5	760.7
Humidity, grains/lb.....	24.	24.	25.	20.	21.	21.
Ambient temperature, F....	90.	91.	92.	80.	85.	86.
Engine speed, rpm.....	2000.	2000.	2000.	2000.	2000.	2000.
Torque, lb-ft*.....	71.2	95.5	130.4	168.3	211.6	242.7
Power, bhp*.....	27.0	36.0	49.1	63.3	80.0	91.7
Fuel rate, lb/hr.....	18.4	21.3	26.7	32.1	55.8	56.0
Ignition timing, deg BTC..	36.0	36.0	31.0	25.0	21.5	20.5
Manifold vacuum, in Hg....	-14.4	-12.3	-8.5	-5.9	-3.3	-1.3
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.684	0.595	0.546	0.507	0.698	0.611
Oil temperature, F.....	237.	241.	245.	248.	247.	252.
Oil pressure, psi.....	34.	34.	34.	34.	33.	33.
Coolant temperatue, F.....	200.	201.	202.	203.	202.	202.
Before Catalyst						
Exhaust temperature, F....	1038.	1071.	1163.	1239.	1166.	1236.
Exhaust pressure, in H2O..	26.4	36.8	59.6	83.3	131.0	153.9
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.015	0.010	0.015	0.021	1.416	1.418
CO2, %.....	13.65	13.63	13.62	14.45	8.48	9.96
O2, %.....	1.40	1.37	1.35	0.28	0.00	0.00
HC, ppmC.....	89.	91.	94.	36.	551.	442.
NOx, ppm.....	917.	1343.	1476.	1525.	79.	196.
Air-fuel ratio.....	15.67	15.65	15.68	14.85	13.52	13.80
Emission rates, g/hr:						
CO.....	18.	19.	26.	40.	4581.	4624.
HC.....	6.0	7.3	9.2	4.3	98.6	80.8
NOx**.....	177.5	300.7	413.4	484.3	42.0	104.9
Exhaust temperature, F....	951.	991.	1073.	1168.	1104.	1167.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	100	101	31	32	33	34
Test Date.....	4/ 9/77	4/ 9/77	3/31/77	3/31/77	3/31/77	3/31/77
Barometer, mm Hg.....	771.1	771.1	752.3	752.9	753.1	753.6
Humidity, grains/lb.....	26.	25.	46.	47.	44.	40.
Ambient temperature, F....	94.	94.	83.	85.	86.	87.
Engine speed, rpm.....	2000.	2000.	2400.	2400.	2400.	2400.
Torque, lb-ft*.....	207.6	234.4	0.9	24.0	51.6	73.2
Power, bhp*.....	78.2	89.3	0.4	11.0	23.5	33.1
Fuel rate, lb/hr.....	58.3	55.6	12.3	15.2	18.9	22.2
Ignition timing, deg BTC..	19.0	20.0	37.0	38.0	39.0	39.0
Manifold vacuum, in Hg....	-2.5	-0.6	-19.7	-18.1	-16.0	-14.2
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.750	0.623	32.980	1.388	0.805	0.671
Oil temperature, F.....	248.	251.	236.	240.	244.	247.
Oil pressure, psi.....	33.	33.	37.	36.	36.	36.
Coolant temperatue, F.....	201.	201.	199.	200.	200.	200.
Before Catalyst						
Exhaust temperature, F....	1165.	1241.	995.	1019.	1074.	1096.
Exhaust pressure, in H2O..	148.0	164.0	12.1	18.6	29.3	40.5
After Catalyst						
Concentrations, dry basis:						
CO, %.....	1.465	1.466	0.021	0.018	0.018	0.019
CO2, %.....	8.50	10.61	13.70	13.79	13.78	13.59
O2, %.....	0.00	0.00	1.29	1.32	1.28	1.60
HC, ppmC.....	224.	181.	8.	23.	23.	54.
NOx, ppm.....	62.	186.	77.	144.	144.	92.
Air-fuel ratio.....	13.51	13.78	15.59	15.61	15.58	15.82
Emission rates, g/hr:						
CO.....	4946.	4707.	16.	17.	21.	28.
HC.....	41.8	32.8	0.4	1.3	1.6	4.4
NOx**.....	34.6	98.0	9.9	22.9	28.4	21.6
Exhaust temperature, F....	1107.	1174.	882.	920.	972.	1007.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	35	54	55	56	57	58
Test Date.....	3/31/77	4/ 2/77	4/ 2/77	4/ 2/77	4/ 2/77	4/ 2/77
Barometer, mm Hg.....	753.6	772.2	772.4	772.4	772.7	772.2
Humidity, grains/lb.....	38.	20.	20.	20.	21.	22.
Ambient temperature, F....	89.	89.	88.	89.	90.	91.
Engine speed, rpm.....	2400.	2400.	2400.	2400.	2400.	2400.
Torque, lb-ft*.....	98.1	0.4	21.9	47.2	70.1	94.4
Power, bhp*.....	44.7	0.2	10.1	21.2	31.9	43.1
Fuel rate, lb/hr.....	26.0	12.2	15.6	19.1	22.1	26.1
Ignition timing, deg BTC..	40.0	38.5	38.0	38.0	38.0	38.0
Manifold vacuum, in Hg....	-12.0	-20.3	-18.6	-16.6	-14.6	-12.4
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.583	*********	1.553	0.902	0.695	0.605
Oil temperature, F.....	252.	235.	238.	242.	246.	250.
Oil pressure, psi.....	36.	36.	36.	36.	35.	35.
Coolant temperatue, F.....	201.	199.	200.	201.	201.	202.
Before Catalyst						
Exhaust temperature, F....	1134.	1030.	1024.	1070.	1104.	1137.
Exhaust pressure, in H2O..	57.6	11.8	18.4	28.1	40.3	56.2
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.021	0.012	0.018	0.010	0.013	0.015
CO2, %.....	13.62	13.64	13.68	13.55	13.68	13.67
O2, %.....	1.34	1.46	1.32	1.42	1.41	1.35
HC, ppmC.....	54.	18.	30.	61.	66.	55.
NOx, ppm.....	150.	169.	374.	806.	1266.	1531.
Air-fuel ratio.....	15.62	15.72	15.62	15.69	15.68	15.64
Emission rates, g/hr:						
CO.....	35.	9.	18.	13.	18.	25.
HC.....	5.2	0.8	1.7	4.3	5.4	5.3
NOx**.....	40.7	21.8	61.0	161.9	293.6	418.4
Exhaust temperature, F....	1052.	888.	925.	970.	1014.	1057.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	89	90	91	92	102	103
Test Date.....	4/ 8/77	4/ 8/77	4/ 8/77	4/ 8/77	4/ 9/77	4/ 9/77
Barometer, mm Hg.....	761.0	761.5	761.7	762.0	771.1	771.1
Humidity, grains/lb.....	21.	22.	22.	23.	24.	23.
Ambient temperature, F....	87.	89.	90.	92.	93.	94.
Engine speed, rpm.....	2400.	2400.	2400.	2400.	2400.	2400.
Torque, lb-ft*.....	131.0	168.7	209.6	248.4	129.9	167.7
Power, bhp*.....	59.0	75.6	94.8	110.4	59.3	75.8
Fuel rate, lb/hr.....	31.8	40.0	68.3	68.5	32.9	41.0
Ignition timing, deg BTC..	33.0	26.0	22.5	23.0	31.0	26.0
Manifold vacuum, in Hg....	-9.4	-6.0	-3.2	-0.8	-8.5	-5.6
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.541	0.533	0.723	0.623	0.555	0.543
Oil temperature, F.....	251.	257.	256.	263.	253.	259.
Oil pressure, psi.....	35.	35.	35.	34.	35.	34.
Coolant temperatue, F.....	201.	202.	202.	203.	202.	203.
Before Catalyst						
Exhaust temperature, F....	1255.	1352.	1239.	1306.	1269.	1341.
Exhaust pressure, in H2O..	87.1	132.8	196.7	233.7	99.2	139.4
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.006	0.020	1.362	1.389	0.010	1.095
CO2, %.....	13.93	14.61	8.53	10.13	14.53	14.69
O2, %.....	1.27	0.15	0.00	0.00	1.23	0.02
HC, ppmC.....	36.	52.	581.	568.	34.	55.
NOx, ppm.....	1520.	1479.	75.	225.	1451.	1353.
Air-fuel ratio.....	15.56	14.76	11.51	13.36	15.50	14.23
Emission rates, g/hr:						
CO.....	12.	48.	5388.	5367.	21.	2580.
HC.....	4.2	7.3	127.2	123.2	4.1	7.6
NOx**.....	503.0	582.7	48.6	143.0	492.7	523.7
Exhaust temperature, F....	1157.	1314.	1172.	1239.	1169.	1277.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	104	118	37	38	39	40
Test Date.....	4/ 9/77	4/12/77	4/ 1/77	4/ 1/77	4/ 1/77	4/ 1/77
Barometer, mm Hg.....	770.9	764.0	765.0	765.0	765.0	765.0
Humidity, grains/lb.....	14.	42.	21.	21.	22.	22.
Ambient temperature, F....	90.	81.	82.	85.	87.	89.
Engine speed, rpm.....	2400.	2400.	3000.	3000.	3000.	3000.
Torque, lb-ft*.....	204.6	240.9	1.6	21.7	45.5	69.2
Power, bhp*.....	92.4	109.9	0.9	12.4	25.8	38.6
Fuel rate, lb/hr.....	67.8	68.5	16.1	19.8	23.9	28.6
Ignition timing, deg BTC..	22.5	23.3	41.0	41.0	41.0	41.0
Manifold vacuum, in Hg....	-3.0	-0.8	-20.2	-18.6	-16.7	-14.6
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.737	0.623	18.850	1.598	0.929	0.745
Oil temperature, F.....	257.	261.	248.	251.	255.	260.
Oil pressure, psi.....	34.	34.	38.	37.	37.	36.
Coolant temperatue, F.....	202.	203.	200.	200.	201.	202.
Before Catalyst						
Exhaust temperature, F....	1230.	1309.	1092.	1123.	1168.	1202.
Exhaust pressure, in H2O..	201.1	188.2	21.9	32.8	48.9	69.6
After Catalyst						
Concentrations, dry basis:						
CO, %.....	1.447	1.364	0.016	0.019	0.019	0.012
CO2, %.....	8.87	9.59	13.63	13.50	13.36	13.41
O2, %.....	0.00	0.00	1.47	1.60	1.53	1.53
HC, ppmC.....	243.	172.	0.	23.	43.	39.
NOx, ppm.....	86.	183.	199.	167.	178.	219.
Air-fuel ratio.....	13.65	13.91	15.73	15.93	15.79	15.79
Emission rates, g/hr:						
CO.....	5691.	5484.	17.	24.	29.	22.
HC.....	53.1	38.6	0.0	1.7	3.8	4.2
NOx**.....	55.5	123.0	13.9	35.0	45.2	66.2
Exhaust temperature, F....	1169.	1233.	967.	1010.	1055.	1104.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	50	51	52	53	94	95
Test Date.....	4/ 2/77	4/ 2/77	4/ 2/77	4/ 2/77	4/ 9/77	4/ 9/77
Barometer, mm Hg.....	772.2	772.2	772.2	772.2	771.4	771.7
Humidity, grains/lb.....	20.	20.	20.	20.	17.	18.
Ambient temperature, F....	87.	87.	88.	90.	72.	76.
Engine speed, rpm.....	3000.	3000.	3000.	3000.	3000.	3000.
Torque, lb-ft*.....	-0.2	20.0	44.1	67.3	90.9	125.9
Power, bhp*.....	-0.1	11.4	24.9	38.2	51.9	71.9
Fuel rate, lb/hr.....	16.0	19.8	24.2	28.8	33.3	41.6
Ignition timing, deg BTC..	41.0	41.0	41.0	41.5	41.0	35.5
Manifold vacuum, in Hg....	-20.3	-18.6	-16.7	-14.7	-12.5	-8.9
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	-123.300	1.736	0.976	0.756	0.640	0.578
Oil temperature, F.....	247.	250.	254.	258.	258.	263.
Oil pressure, psi.....	38.	37.	37.	36.	36.	36.
Coolant temperatue, F.....	200.	201.	201.	202.	201.	203.
Before Catalyst						
Exhaust temperature, F....	1091.	1124.	1175.	1209.	1249.	1334.
Exhaust pressure, in H2O..	21.1	32.9	48.9	69.2	96.7	148.3
After catalyst						
Concentrations, dry basis:						
CO, %.....	0.011	0.015	0.017	0.017	0.015	0.016
CO2, %.....	13.53	13.66	13.67	13.70	13.52	13.62
O2, %.....	1.44	1.48	1.38	1.30	1.51	1.11
HC, ppmC.....	17.	34.	48.	48.	53.	55.
NOx, ppm.....	256.	522.	1036.	1401.	1484.	1521.
Air-fuel ratio.....	15.72	15.73	15.66	15.60	15.76	15.45
Emission rates, g/hr:						
CO.....	11.	20.	26.	30.	33.	42.
HC.....	1.0	2.5	4.3	5.1	6.5	8.3
NOx**.....	43.1	108.9	263.0	421.2	521.8	653.7
Exhaust temperature, F....	974.	1017.	1065.	1111.	1155.	1252.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	96	97	106	107	108	110
Test Date.....	4/ 9/77	4/ 9/77	4/ 9/77	4/ 9/77	4/ 9/77	4/11/77
Barometer, mm Hg.....	770.6	769.6	769.9	769.6	769.1	773.4
Humidity, grains/lb.....	19.	21.	12.	11.	11.	24.
Ambient temperature, F....	80.	83.	87.	83.	85.	84.
Engine speed, rpm.....	3000.	3000.	3000.	3000.	3000.	3000.
Torque, lb-ft*.....	161.4	196.4	90.8	122.7	162.5	196.0
Power, bhp*.....	92.2	112.2	52.0	70.1	92.8	111.7
Fuel rate, lb/hr.....	52.0	80.5	33.6	41.2	53.1	82.1
Ignition timing, deg BTC..	29.5	25.0	40.8	35.0	28.0	26.5
Manifold vacuum, in Hg....	-5.7	-3.0	-12.5	-9.0	-5.6	-3.2
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.564	0.717	0.647	0.588	0.572	0.734
Oil temperature, F.....	269.	270.	260.	265.	271.	270.
Oil pressure, psi.....	35.	35.	36.	36.	36.	36.
Coolant temperatue, F.....	204.	203.	202.	203.	204.	203.
Before Catalyst						
Exhaust temperature, F....	1407.	1327.	1266.	1335.	1409.	1322.
Exhaust pressure, in H2O..	205.0	295.4	104.6	150.4	212.0	259.1
After Catalyst						
Concentrations, dry basis:						
CO, %.....	1.024	1.407	0.009	0.014	1.286	1.367
CO2, %.....	13.93	9.57	13.98	14.03	13.92	9.20
O2, %.....	0.00	0.00	1.56	1.17	0.00	0.00
HC, ppmC.....	94.	528.	21.	25.	77.	358.
NOx, ppm.....	1436.	184.	1448.	1465.	1402.	116.
Air-fuel ratio.....	14.22	13.67	15.77	15.49	14.06	13.75
Emission rates, g/hr:						
CO.....	3080.	6560.	20.	37.	3903.	6560.
HC.....	16.4	137.5	2.6	3.7	13.7	95.8
NOx**.....	709.6	140.9	512.5	624.4	699.0	91.5
Exhaust temperature, F....	1350.	1268.	1174.	1248.	1342.	1263.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	111	119	41	42	43	44
Test Date.....	4/11/77	4/12/77	4/12/77	4/11/77	4/12/77	4/11/77
Barometer, mm Hg.....	775.2	764.8	771.1	765.8	772.2	765.8
Humidity, grains/lb.....	26.	47.	12.	18.	21.	16.
Ambient temperature, F....	88.	94.	66.	89.	88.	91.
Engine speed, rpm.....	3000.	3000.	3800.	3800.	3800.	3800.
Torque, lb-ft*.....	224.9	229.9	1.6	20.3	41.7	64.6
Power, bhp*.....	128.5	131.5	1.2	14.6	30.1	46.8
Fuel rate, lb/hr.....	88.4	87.5	21.8	26.3	31.8	37.6
Ignition timing, deg BTC..	23.0	23.5	44.0	44.0	44.0	44.0
Manifold vacuum, in Hg....	-0.9	-0.8	-19.6	-17.8	-15.8	-13.6
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel conn*.	0.688	0.666	20.710	1.808	1.056	0.803
Oil temperature, F.....	275.	274.	263.	272.	271.	278.
Oil pressure, psi.....	35.	35.	39.	38.	38.	37.
Coolant temperatue, F.....	204.	203.	202.	202.	202.	203.
Before Catalyst						
Exhaust temperature, F....	1360.	1388.	1216.	1235.	1287.	1321.
Exhaust pressure, in H2O..	306.9	292.9	40.9	59.2	87.8	120.8
After Catalyst						
Concentrations, dry basis:						
CO, %.....	1.368	1.416	0.017	0.020	0.017	0.022
CO2, %.....	9.68	9.92	13.53	13.61	13.72	13.74
O2, %.....	0.00	0.00	1.44	1.42	1.26	1.18
HC, ppmC.....	360.	226.	34.	26.	53.	48.
NOx, ppm.....	172.	183.	205.	245.	1295.	268.
Air-fuel ratio.....	13.81	13.77	15.71	15.69	15.57	15.50
Emission rates, g/hr:						
CO.....	7065.	7206.	24.	34.	34.	53.
HC.....	104.1	64.4	2.7	2.5	6.2	6.6
NOx**.....	146.2	153.3	46.9	67.8	430.0	104.5
Exhaust temperature, F....	1301.	1309.	1077.	1116.	1173.	1216.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	45	46	47	48	99	112
Test Date.....	4/11/77	4/12/77	4/11/77	4/11/77	4/19/77	4/11/77
Barometer, mm Hg.....	765.8	771.4	766.6	766.6	770.4	775.7
Humidity, grains/lb.....	16.	20.	17.	17.	25.	25.
Ambient temperature, F....	91.	84.	96.	96.	92.	89.
Engine speed, rpm.....	3800.	3800.	3800.	3800.	3800.	3800.
Torque, lb-ft*.....	0.7	20.2	42.6	64.1	117.9	83.3
Power, bhp*.....	0.5	14.6	30.8	46.4	84.8	60.2
Fuel rate, lb/hr.....	20.7	26.4	31.6	37.5	55.7	43.6
Ignition timing, deg BTC..	44.0	44.0	43.5	43.5	35.0	44.0
Manifold vacuum, in Hg....	-19.8	-17.8	-15.8	-13.6	-7.4	-11.9
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	39.910	1.806	1.026	0.808	0.657	0.723
Oil temperature, F.....	264.	267.	272.	277.	234.	277.
Oil pressure, psi.....	39.	38.	38.	38.	36.	37.
Coolant temperatue, F.....	201.	202.	202.	203.	204.	203.
Before Catalyst						
Exhaust temperature, F....	1203.	1243.	1291.	1324.	1478.	1385.
Exhaust pressure, in H2O..	35.8	60.6	86.0	119.8	264.7	151.1
After catalyst						
Concentrations, dry basis:						
CO, %.....	0.018	0.015	0.021	0.026	0.128	0.022
CO2, %.....	13.56	13.58	13.82	13.83	14.95	14.16
O2, %.....	1.39	2.66	1.21	1.07	0.00	0.96
HC, ppmC.....	18.	34.	35.	56.	61.	32.
NOx, ppm.....	264.	583.	349.	385.	1228.	1561.
Air-fuel ratio.....	15.67	16.59	15.52	15.42	14.61	15.33
Emission rates, g/hr:						
CO.....	24.	27.	41.	60.	421.	60.
HC.....	1.4	3.5	4.0	7.6	11.8	5.0
NOx**.....	57.2	170.8	114.7	149.1	664.4	696.1
Exhaust temperature, F....	1058.	1125.	1173.	1220.	1443.	1296.

* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

Engine..... GM 350 CID

Test Number.....	113	114	115	116	121	122
Test Date.....	4/11/77	4/11/77	4/11/77	4/11/77	4/12/77	4/12/77
Barometer, mm Hg.....	775.2	775.5	775.2	775.5	764.5	767.1
Humidity, grains/lb.....	25.	27.	30.	31.	45.	47.
Ambient temperature, F....	92.	94.	98.	100.	95.	100.
Engine speed, rpm.....	3800.	3800.	3800.	3800.	3800.	3800.
Torque, lb-ft*.....	116.5	154.0	183.0	183.6	88.6	153.3
Power, bhp*.....	83.8	111.3	132.3	132.8	63.5	109.6
Fuel rate, lb/hr.....	54.8	91.4	98.0	105.8	45.5	88.8
Ignition timing, deg BTC..	36.0	27.0	26.0	26.0	42.0	27.0
Manifold vacuum, in Hg....	-7.8	-4.0	-1.5	-0.9	-10.7	-3.7
Throttle angle, deg.....	0.0	0.0	0.0	0.0	0.0	0.0
Brake specific fuel cons*.	0.655	0.821	0.741	0.796	0.717	0.812
Oil temperature, F.....	282.	285.	292.	290.	279.	286.
Oil pressure, psi.....	37.	37.	36.	36.	37.	36.
Coolant temperatue, F.....	204.	205.	206.	205.	203.	204.
Before Catalyst						
Exhaust temperature, F....	1472.	1386.	1467.	1443.	1413.	1420.
Exhaust pressure, in H2O..	222.8	319.6	396.1	421.5	142.5	295.2
After Catalyst						
Concentrations, dry basis:						
CO, %.....	0.016	1.448	1.331	1.403	0.013	1.407
CO2, %.....	14.48	9.47	10.51	9.60	14.34	9.92
O2, %.....	0.38	0.00	0.00	0.00	0.73	0.00
HC, ppmC.....	39.	304.	292.	273.	19.	159.
NOx, ppm.....	1565.	169.	263.	288.	1622.	188.
Air-fuel ratio.....	14.92	13.59	13.85	13.73	15.17	13.75
Emission rates, g/hr:						
CO.....	52.	7631.	7584.	8633.	38.	7252.
HC.....	7.6	89.3	93.8	93.8	3.1	46.0
NOx**.....	854.2	146.2	246.2	291.0	746.2	159.1
Exhaust temperature, F....	1416.	1316.	1399.	1380.	1334.	1345.

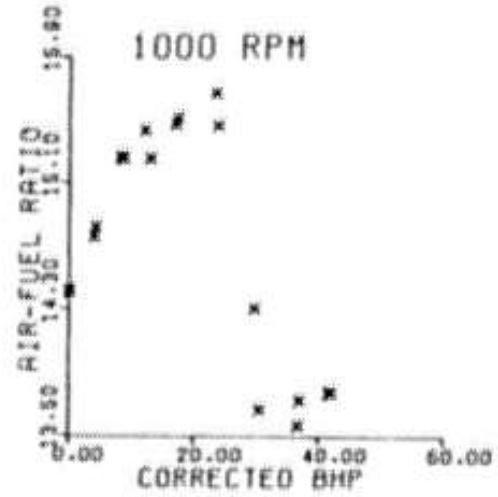
* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

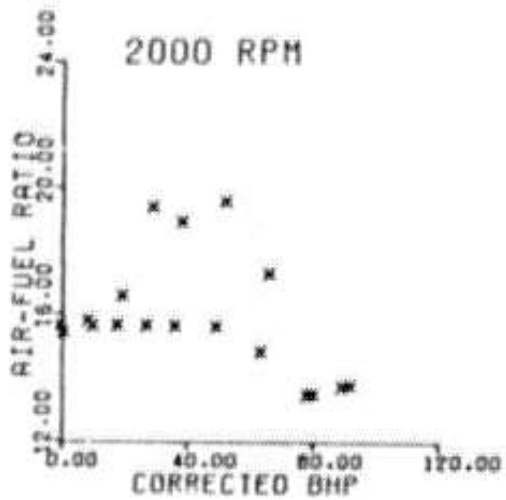
Engine..... GM 350 CID

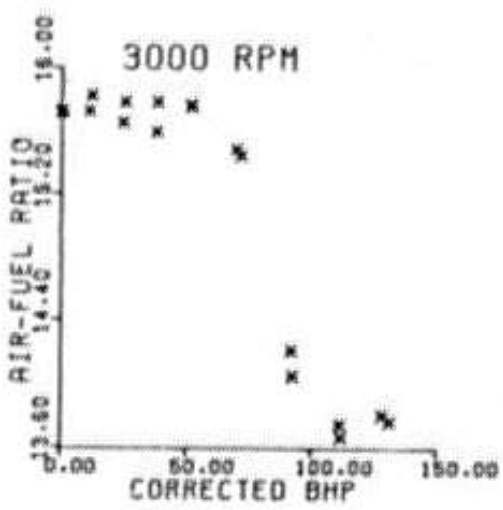
Test Number.....	123	
Test Date.....	4/12/77	
Barometer, mm Hg.....	764.5	
Humidity, grains/lb.....	50.	
Ambient temperature, F....	104.	
Engine speed, rpm.....	3800.	
Torque, lb-ft*.....	189.1	
Power, bhp*.....	134.9	
Fuel rate, lb/hr.....	99.4	
Ignition timing, deg BTC..	26.0	
Manifold vacuum, in Hg....	-1.1	
Throttle angle, deg.....	0.0	
Brake specific fuel cons*.	0.739	
Oil temperature, F.....	292.	
Oil pressure, psi.....	36.	
Coolant temperatue, F.....	205.	
Before Catalyst		
Exhaust temperature, F....	1470.	
Exhaust pressure, in H2O..	373.5	
After Catalyst		
Concentrations, dry basis:		
CO, %.....	1.380	
CO2, %.....	10.40	
O2, %.....	0.00	
HC, ppmC.....	163.	
NOx, ppm.....	260.	
Air-fuel ratio.....	13.86	
Emission rates, g/hr:		
CO.....	7990.	
HC.....	53.3	
NOx**.....	246.9	
Exhaust temperature, F....	1400.	

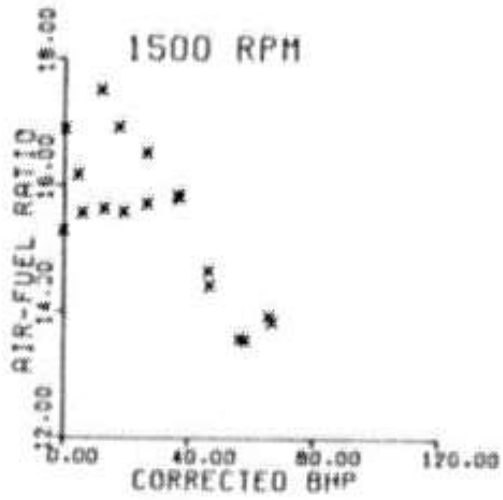
* Corrected - SAE J245 Spark ignition engine rating code
** Corrected for humidity

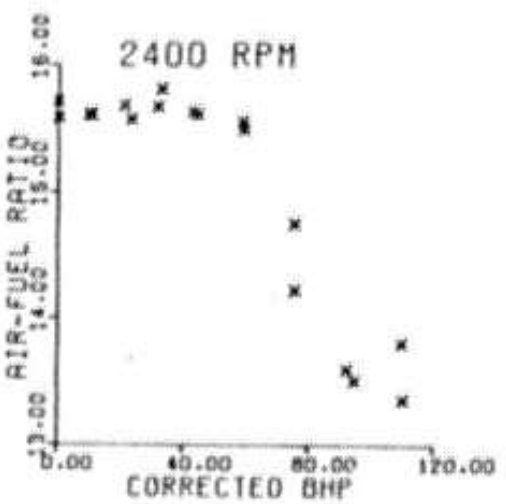
APPENDIX B GRAPHICAL SUMMARY OF ENGINE MAP DATA

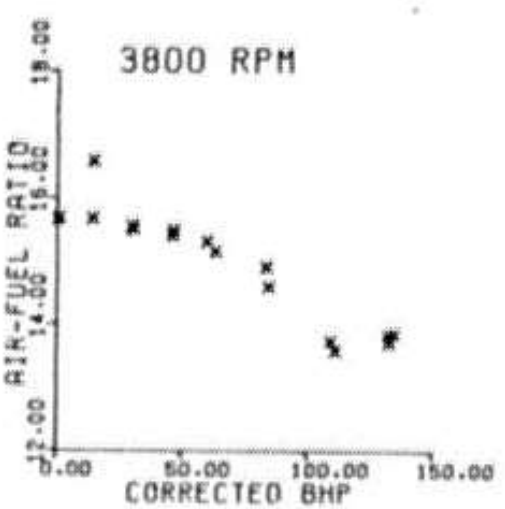

1000 RPM
AIR-FUEL RATIO
13.60
14.30
15.00
15.60
0.00
20.00
40.00
60.00
CORRECTED BHP

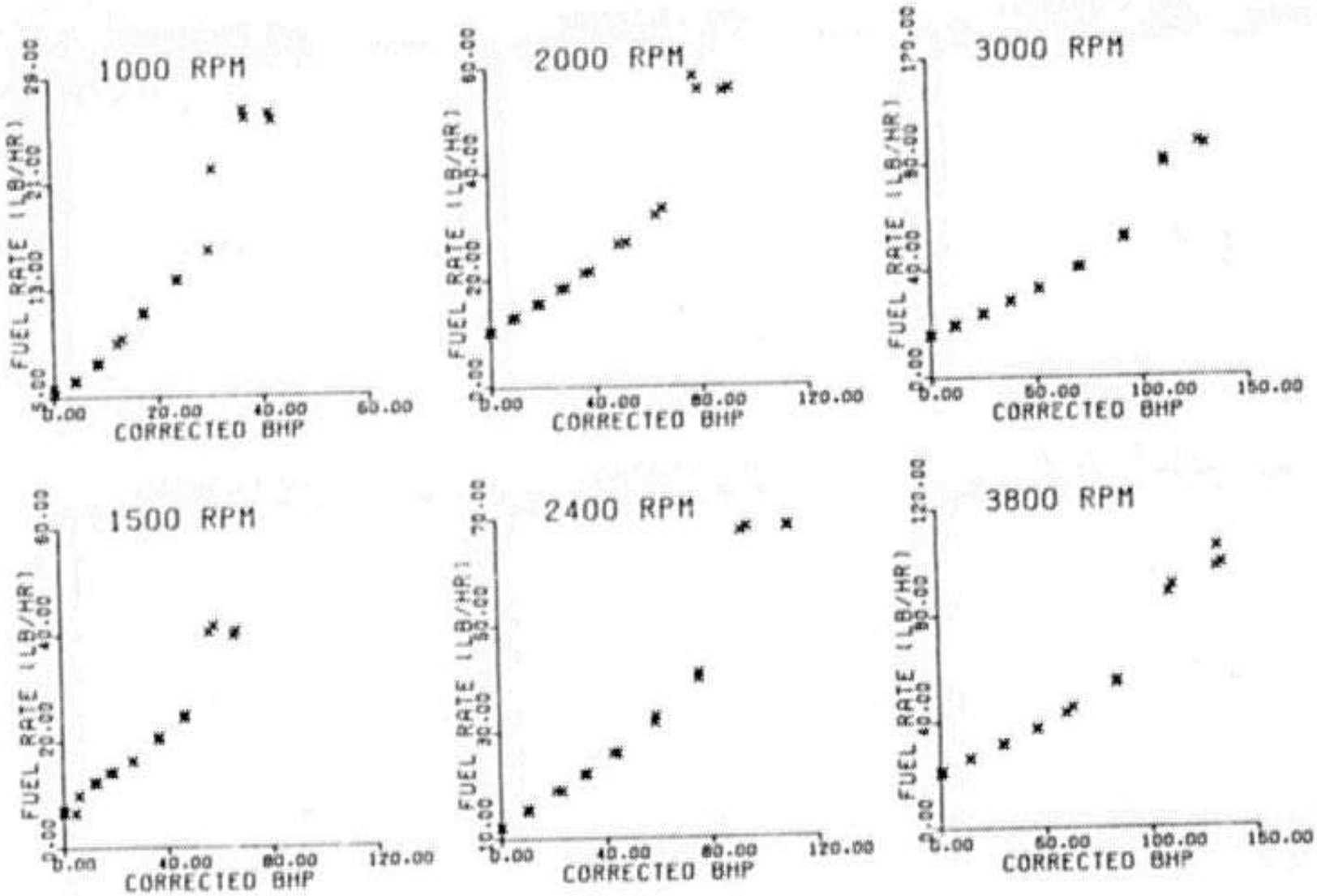

2000 RPM
AIR-FUEL RATIO
12.00
16.00
20.00
24.00
0.00
40.00
80.00
120.00
CORRECTED BHP

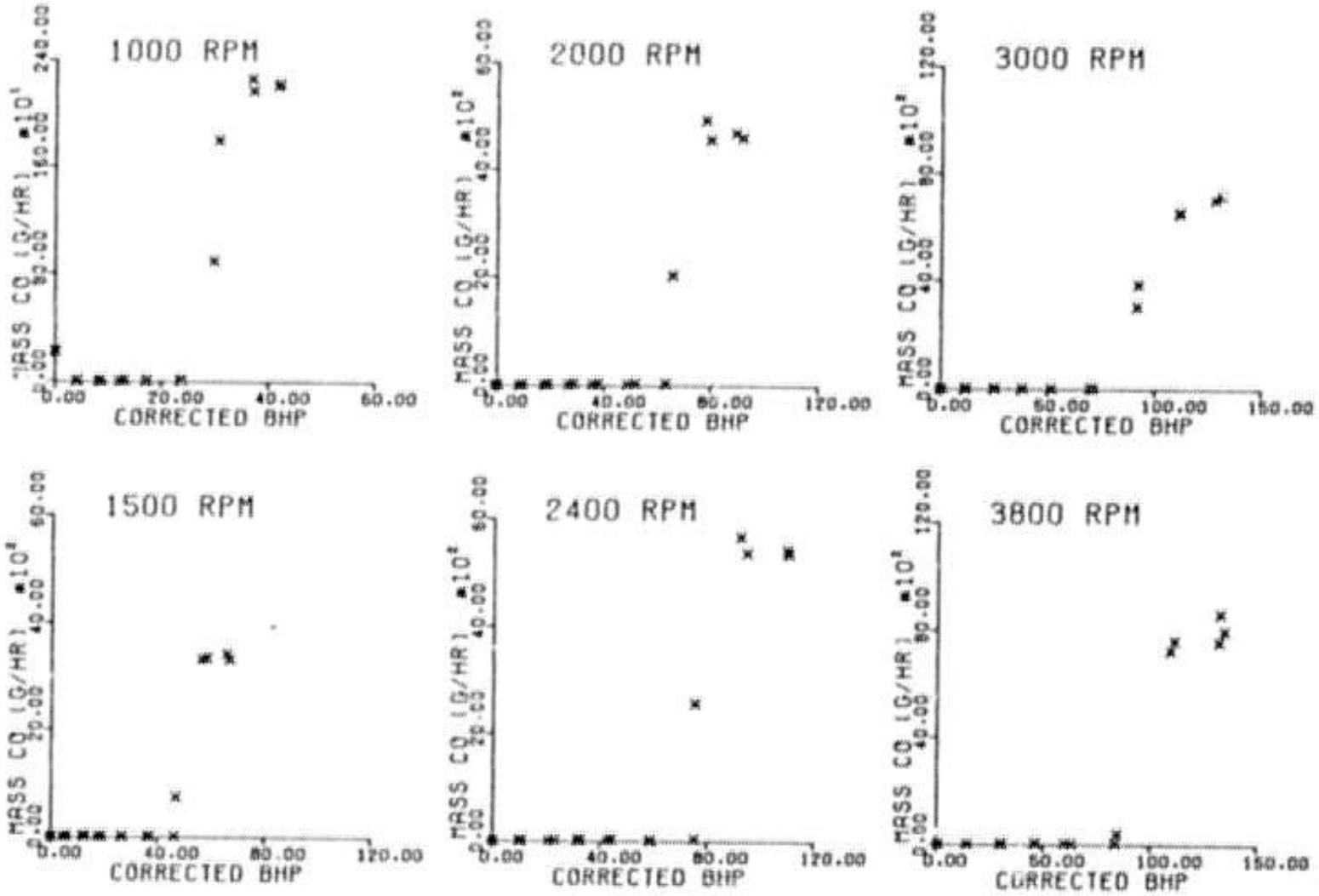

3000 RPM
AIR-FUEL RATIO
13.60
14.40
15.20
16.00
0.00
50.00
100.00
150.00
CORRECTED BHP

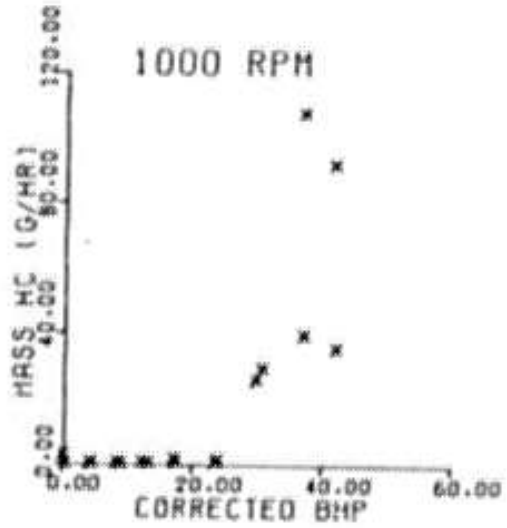

1500 RPM
AIR-FUEL RATIO
12.00
14.00
16.00
18.00
0.00
40.00
80.00
120.00
CORRECTED BHP

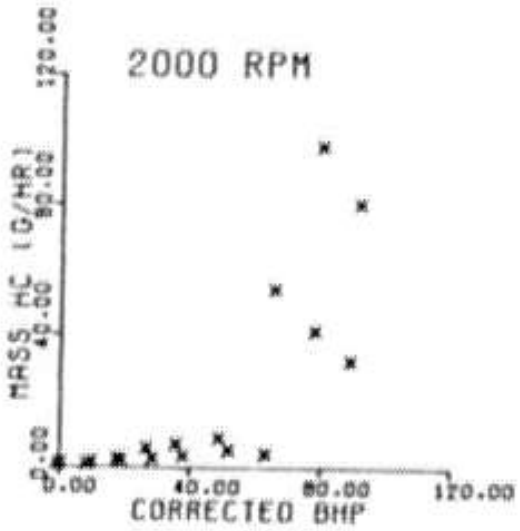

2400 RPM
AIR-FUEL RATIO
13.00
14.00
15.00
16.00
0.00
40.00
80.00
120.00
CORRECTED BHP

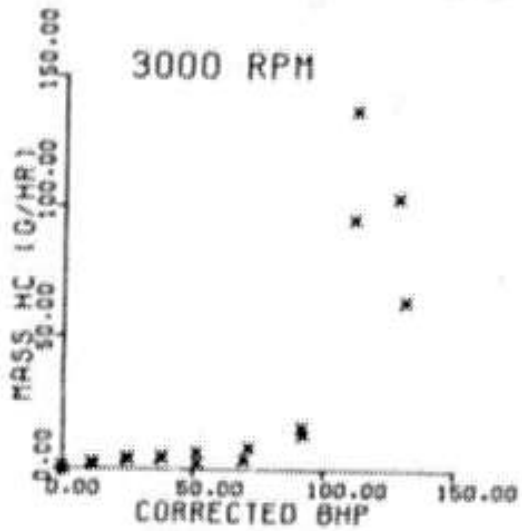

3800 RPM
AIR-FUEL RATIO
12.00
14.00
16.00
18.00
0.00
50.00
100.00
150.00
CORRECTED BHP

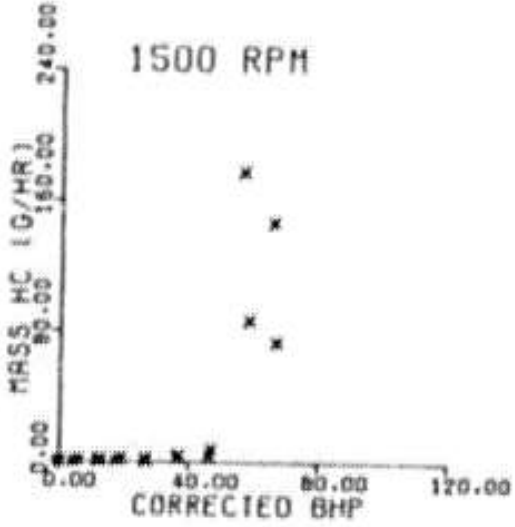

1000 RPM
FUEL RATE (LB/HR)
5.00
13.00
21.00
29.00
0.00
20.00
40.00
60.00
CORRECTED BHP
2000 RPM
FUEL RATE (LB/HR)
0.00
20.00
40.00
60.00
0.00
40.00
80.00
120.00
CORRECTED BHP
3000 RPM
FUEL RATE (LB/HR)
0.00
40.00
80.00
120.00
0.00
50.00
100.00
150.00
CORRECTED BHP
1500 RPM
FUEL RATE (LB/HR)
0.00
20.00
40.00
60.00
0.00
40.00
80.00
120.00
CORRECTED BHP
2400 RPM
FUEL RATE (LB/HR)
10.00
30.00
50.00
70.00
0.00
40.00
80.00
120.00
CORRECTED BHP
3800 RPM
FUEL RATE (LB/HR)
0.00
40.00
80.00
120.00
0.00
50.00
100.00
150.00
CORRECTED BHP

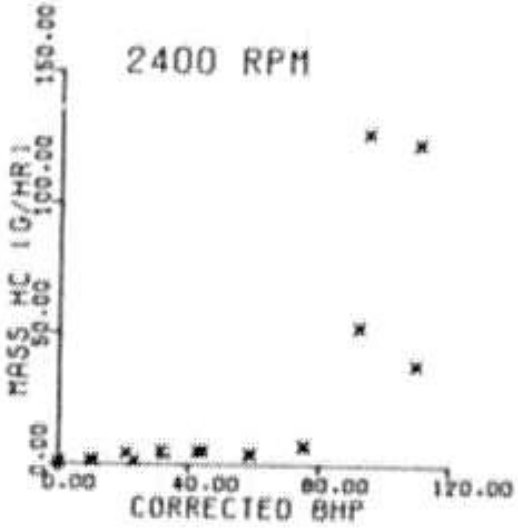

1000 RPM
2000 RPM
3000 RPM
1500 RPM
2400 RPM
3800 RPM
MASS CO (G/HR)
CORRECTED BHP

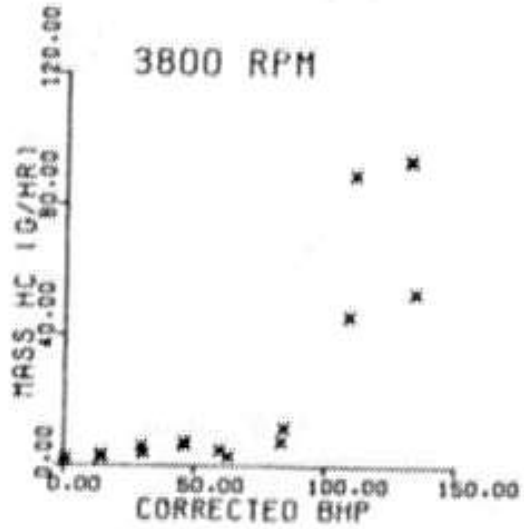

1000 RPM
MASS HC (G/HR)
0.00
40.00
80.00
120.00
0.00
20.00
40.00
60.00
CORRECTED BHP


2000 RPM
MASS HC (G/HR)
0.00
40.00
80.00
120.00
0.00
40.00
80.00
120.00
CORRECTED BHP

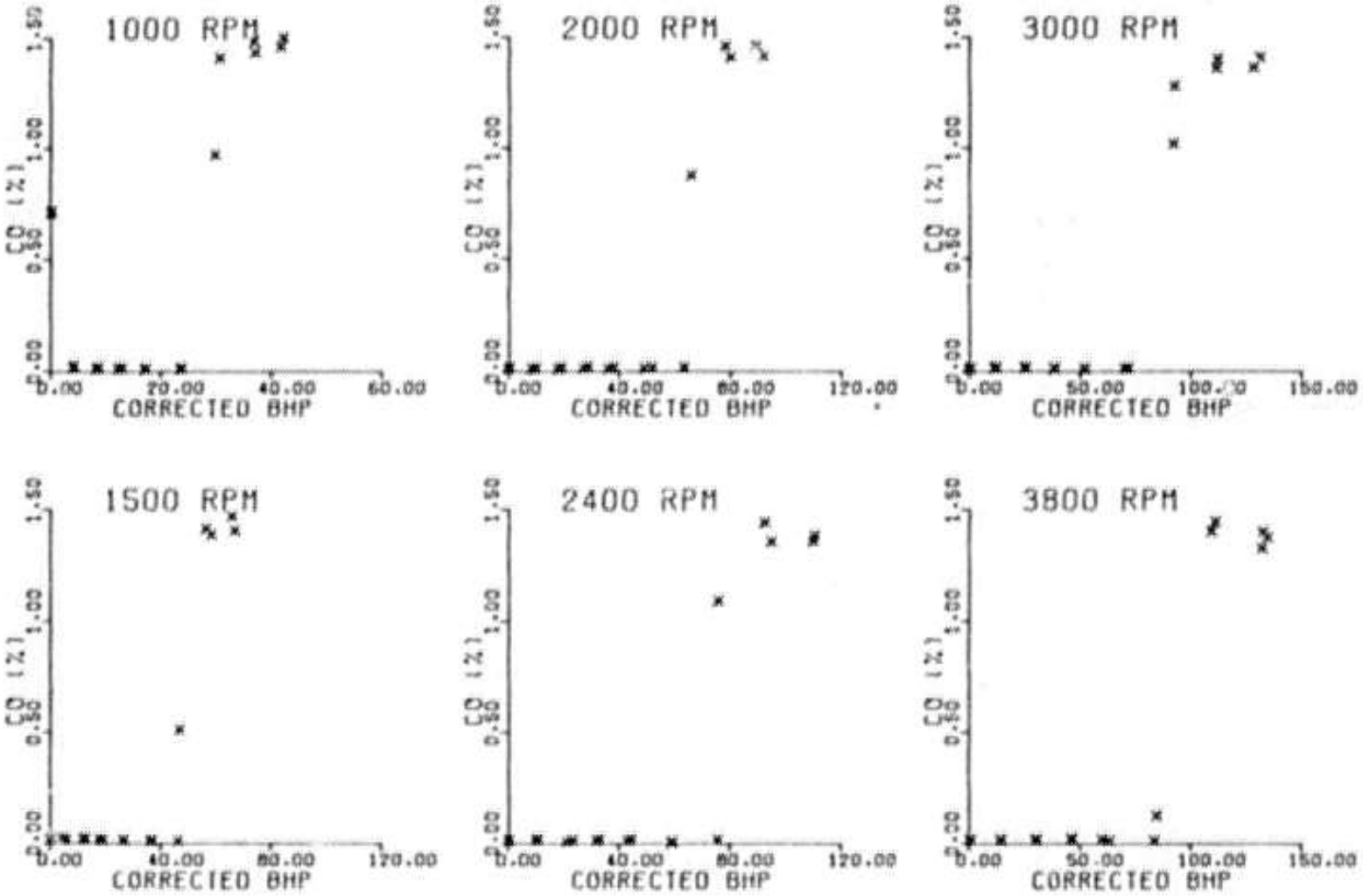

3000 RPM
MASS HC (G/HR)
0.00
50.00
100.00
150.00
0.00
50.00
100.00
150.00
CORRECTED BHP

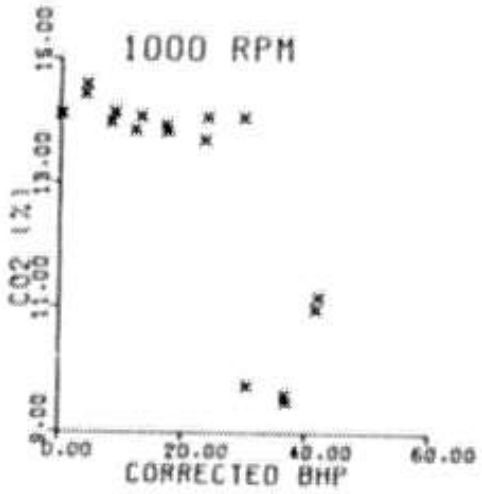

1500 RPM
MASS HC (G/HR)
0.00
80.00
160.00
240.00
0.00
40.00
80.00
120.00
CORRECTED BHP

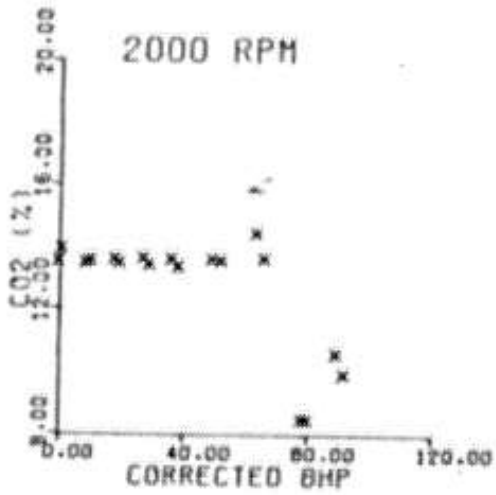

2400 RPM
MASS HC (G/HR)
0.00
50.00
100.00
150.00
0.00
40.00
80.00
120.00
CORRECTED BHP

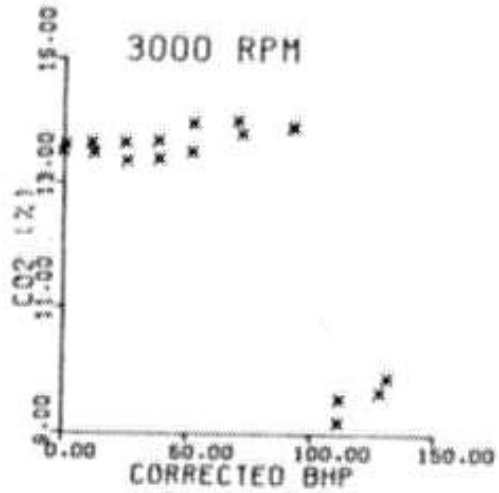

3800 RPM
MASS HC (G/HR)
0.00
40.00
80.00
120.00
0.00
50.00
100.00
150.00
CORRECTED BHP

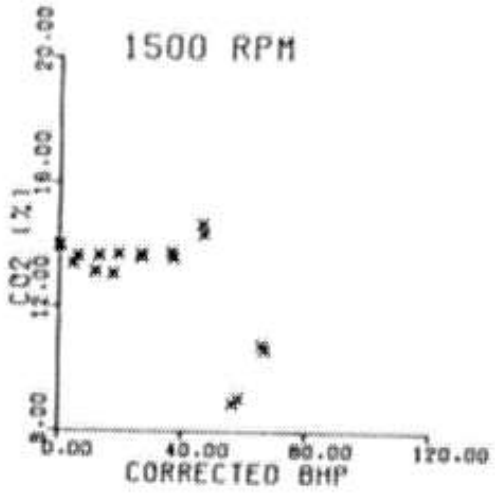
3000 RPM
MASS NOX (G/HR) *10'
CORRECTED BHP
2000 RPM
MASS NOX (G/HR) *10'
CORRECTED BHP
1000 RPM
MASS NOX (G/HR)
CORRECTED BHP
3800 RPM
MASS NOX (G/HR) *10'
CORRECTED BHP
2400 RPM
MASS NOX (G/HR) *10'
CORRECTED BHP
1500 RPM
MASS NOX (G/HR) *10'
CORRECTED BHP

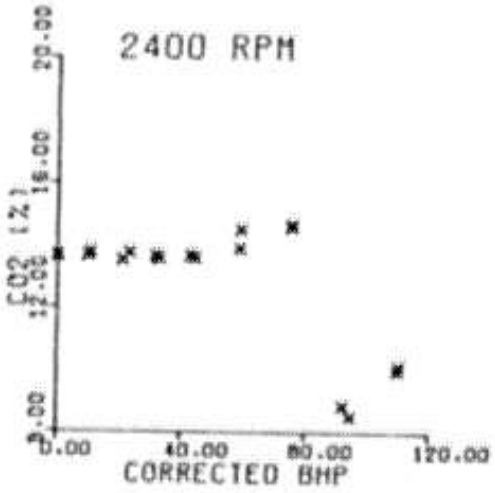

1000 RPM
CO (%)
0.00
0.50
1.00
1.50
0.00
20.00
40.00
60.00
CORRECTED BHP
2000 RPM
CO (%)
0.00
0.50
1.00
1.50
0.00
40.00
80.00
120.00
CORRECTED BHP
3000 RPM
CO (%)
0.00
0.50
1.00
1.50
0.00
50.00
100.00
150.00
CORRECTED BHP
1500 RPM
CO (%)
0.00
0.50
1.00
1.50
0.00
40.00
80.00
120.00
CORRECTED BHP
2400 RPM
CO (%)
0.00
0.50
1.00
1.50
0.00
40.00
80.00
120.00
CORRECTED BHP
3800 RPM
CO (%)
0.00
0.50
1.00
1.50
0.00
50.00
100.00
150.00
CORRECTED BHP

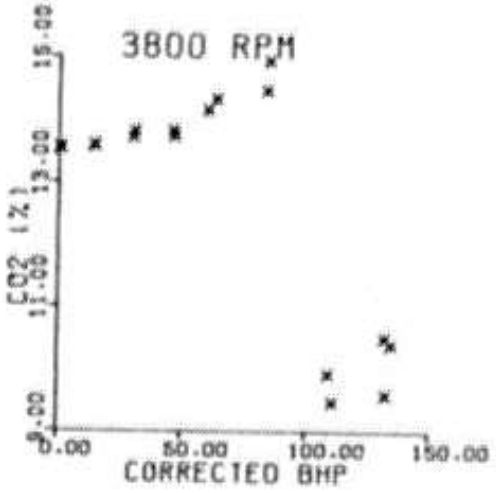

1000 RPM
CO2 (%)
15.00
13.00
11.00
9.00
0.00
20.00
40.00
60.00
CORRECTED BHP

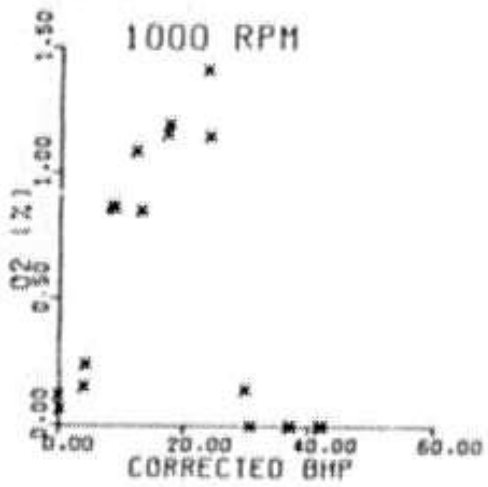

2000 RPM
CO2 (%)
20.00
16.00
12.00
8.00
0.00
40.00
80.00
120.00
CORRECTED BHP

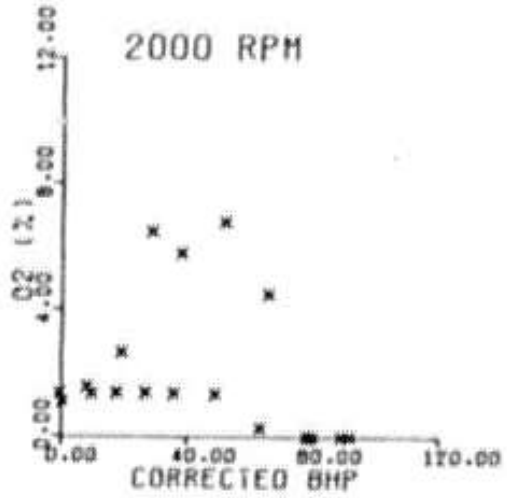

3000 RPM
CO2 (%)
15.00
13.00
11.00
9.00
0.00
50.00
100.00
150.00
CORRECTED BHP

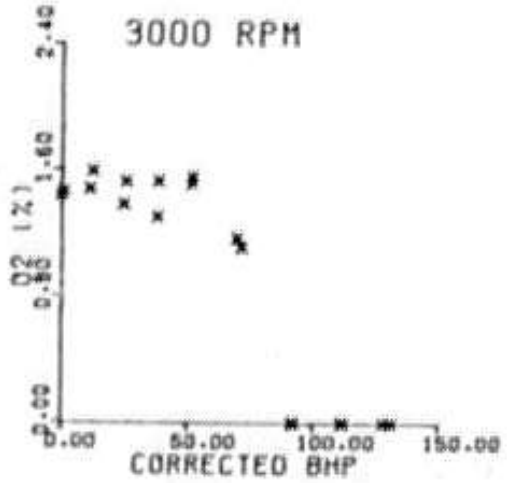

1500 RPM
CO2 (%)
20.00
16.00
12.00
8.00
0.00
40.00
80.00
120.00
CORRECTED BHP

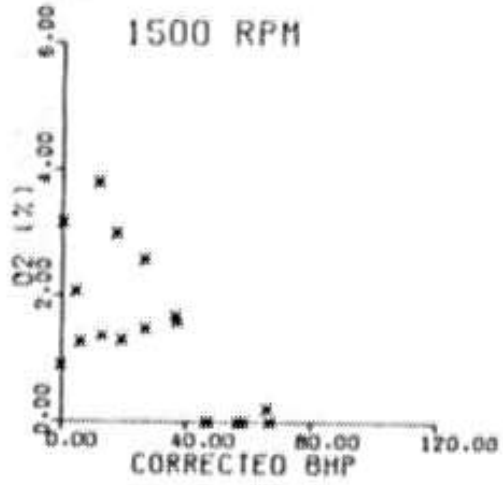

2400 RPM
CO2 (%)
20.00
16.00
12.00
8.00
0.00
40.00
80.00
120.00
CORRECTED BHP

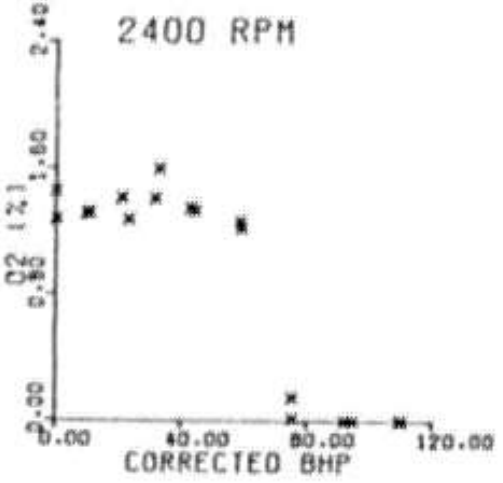

3800 RPM
CO2 (%)
15.00
13.00
11.00
9.00
0.00
50.00
100.00
150.00
CORRECTED BHP

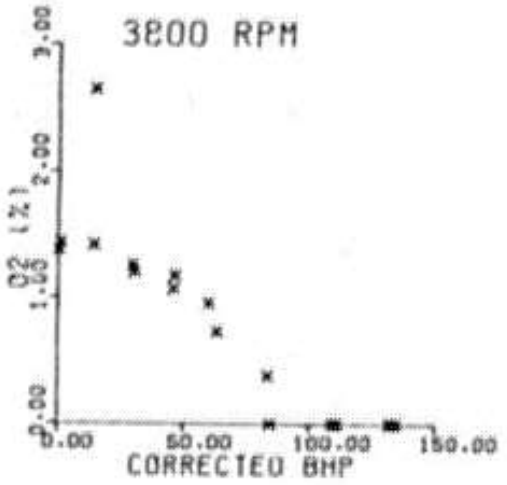

1000 RPM
O2 (%)
0.00
0.50
1.00
1.50
0.00
20.00
40.00
60.00
CORRECTED BHP

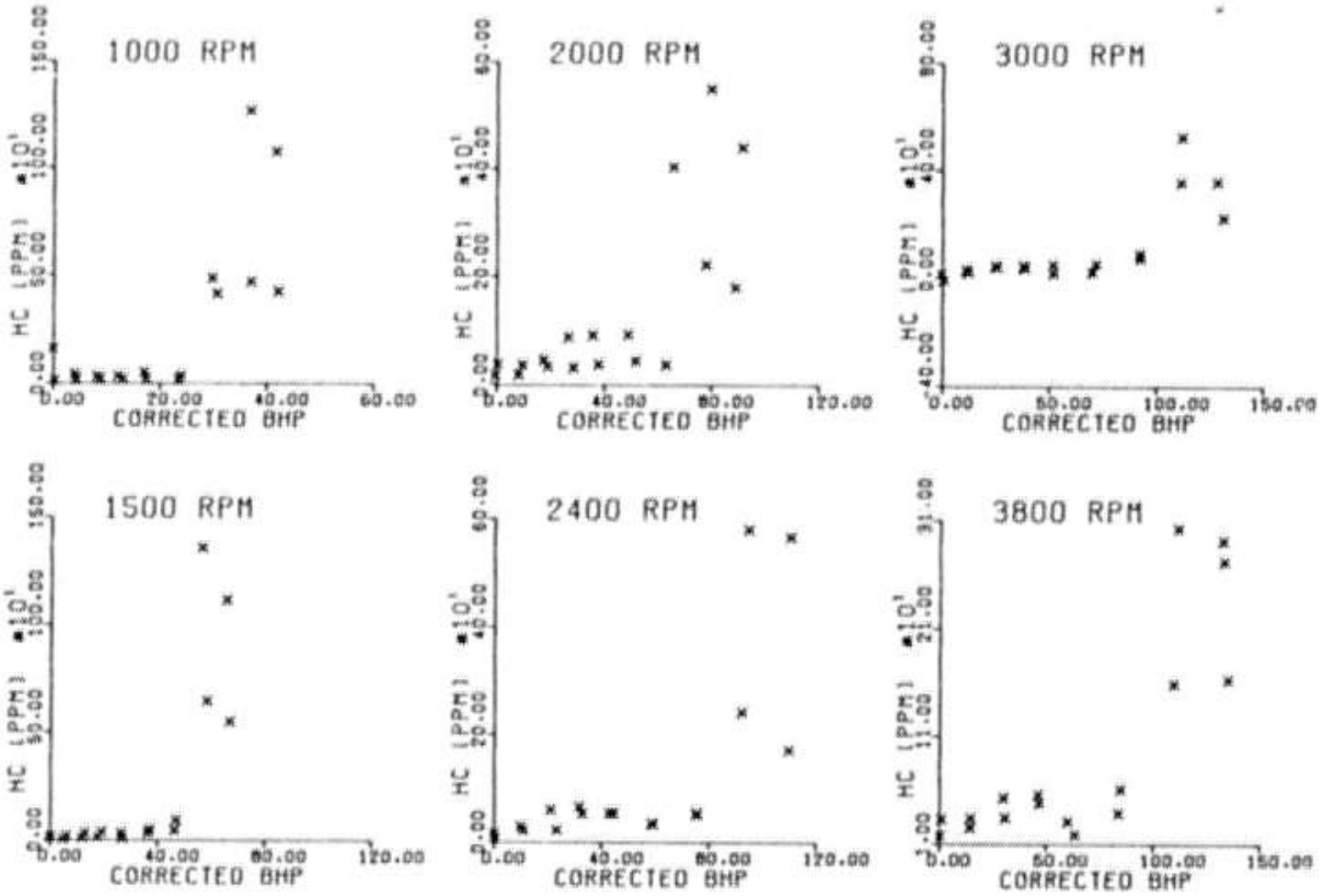

2000 RPM
O2 (%)
0.00
4.00
8.00
12.00
0.00
40.00
80.00
120.00
CORRECTED BHP


3000 RPM
O2 (%)
0.00
0.80
1.60
2.40
0.00
50.00
100.00
150.00
CORRECTED BHP


1500 RPM
O2 (%)
0.00
2.00
4.00
6.00
0.00
40.00
80.00
120.00
CORRECTED BHP


2400 RPM
O2 (%)
0.00
0.80
1.60
2.40
0.00
40.00
80.00
120.00
CORRECTED BHP


3200 RPM
O2 (%)
0.00
1.00
2.00
3.00
0.00
50.00
100.00
150.00
CORRECTED BHP


1000 RPM
2000 RPM
3000 RPM
1500 RPM
2400 RPM
3800 RPM
HC (PPM) *10'
CORRECTED BHP

3000 RPM
NOX (PPM)
CORRECTED BHP
2000 RPM
NOX (PPM)
CORRECTED BHP
1000 RPM
NOX (PPM)
CORRECTED BHP
3800 RPM
NOX (PPM)
CORRECTED BHP
2400 RPM
NOX (PPM)
CORRECTED BHP
1500 RPM
NOX (PPM)
CORRECTED BHP