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PERFORMANCE CHARACTERISTICS OF AUTOMOTIVE ENGINES IN THE UNITED STATES

Second Series - Report No. 6

1976 Nissan Diesel 198 CID (3.2 Liters), F.I.

D. E. Koehler
K. R. Stamper
W. F. Marshall

U.S. DEPARTMENT OF ENERGY
BARTLESVILLE ENERGY RESEARCH CENTER
P.O. Box 1398
Bartlesville OK 74003

MAY 1978

INTERIM REPORT

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Washington DC 20590

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16. Abstract

Experimental data were obtained in dynamometer tests of a 1976 Nissan diesel engine, Model SD-33 CN6-33, to determine fuel consumption and emissions (hydrocarbon, carbon monoxide, oxides of nitrogen) at steady-state engine-operating modes. The objective of the program is to obtain engine performance data for estimating emissions and fuel economy for varied engine service and duty. The intent of the work is to provide basic engine characteristic data required as input for engineering calculations involving ground transportation.

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PREFACE

This report, prepared by the U.S. Department of Energy, Bartlesville Energy Research Center, for the U.S. Department of Transportation, Transportation Systems Center, Energy Technology Branch, Cambridge MA, presents results of experimental work to obtain information on performance characteristics of an engine used in automobiles sold in the U.S. The engine used in this work is one of a series of 10 engines to be tested in the current program. This is the sixth of the reports to be published covering work with those engines.

This project is funded by the National Highway Traffic Safety Administration, Office of Research and Development, Office of Passenger Vehicle Research, Technology Assessment Division.

Ralph G. Colello and James A. Kidd, Jr., of the U.S. Department of Transportation, Transportation Systems Center, are the technical monitors.

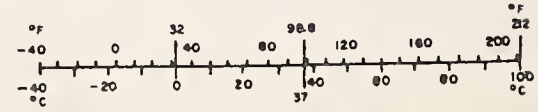
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



1. INTRODUCTION

The objective of this program is to obtain engine performance data for estimating fuel economy, smoke rate, and emissions for varied engine service and duty. The intent of this work is to provide basic engine characteristic data required as input for engineering calculations involving ground transportation.

This report presents the data acquired from tests of a 1976 Nissan diesel engine, Model SD-33 CN6-33. The engine is imported by Chrysler and is marketed as a Chrysler-Nissan Model SD-33 CN6-33.

The test results are sufficient to establish steady-state maps for fuel consumption, smoke rate, and emissions (carbon monoxide, unburned hydrocarbon, and oxides of nitrogen) over the entire operating range of the engine.

2. ENGINE TEST PROCEDURE

The engine test setup included a complete engine (SAE definition) with the exception of a fan and a cooling tower which were used in place of the radiator. The alternator was included but was not wired into the engine's electrical system. The new mean-tolerance engine was equipped with a positive crankcase ventilation system. General engine specifications are listed in table 1. A single batch of No. 2 diesel fuel was used throughout the breakin (table 2) and test; a detailed fuel analysis is given in table 3. The engine break in consisted of 24 hours of engine operation on the dynamometer. The engine was operated at various speeds and loads designed to simulate road/load conditions. Engine testing began on 22 July and ended on 31 August 1976, for a total engine operation time of about 95 hours. The engine was tested while operating at the following steady-state modes:

Idle speeds: 650; 750; 850 rpm

Idle loads: 1, 20, 40 bhp (repeated at 850 rpm)

Operating speeds: 1,000; 1,300; 1,600; 2,000; 2,300; 2,800; 3,300; 3,800 rpm

Operating loads: 0, 10, 25, 40, 60, 75, 90, 100 pct of full load (repeated at 0, 25, 60, 90 pct of full load for all speeds)

Total number of original test modes.....	73
Total number of repeats.....	35
Total number of tests.....	108

The following data were recorded at each test point:

Test number
Date
Barometric pressure, mm Hg
Dewpoint °F
Inlet air temperature, °F
Speed, rpm
Torque, lb-ft -- BLH strain gage; Daytronics indicator
Fuel rate, lb/hr -- FLO-TRON linear mass flowmeter
Throttle position -- deg.
CO, ppm -- Beckman NDIR
CO_2, pct -- Beckman NDIR
HC, ppmC -- Custom built heated FID
NO_x, ppm -- Thermo-Electron chemiluminescent detector

Oil temperature, °F
Oil pressure, psi
Coolant temperature, °F
Exhaust temperature, °F
Exhaust pressure, in. H_2O
Smoke, pct opacity -- PHS smokemeter
Air flow, lb/min -- Meriam laminar flow element.

The computed data include absolute humidity, power, exhaust flow rate, and emission rates of carbon monoxide (CO), unburned hydrocarbons (HC), and oxides of nitrogen (NO_x) in grams per hour. The following equations were applied in the computations:

$$H_2O \text{ (mm Hg)} = \exp\left[12.02\left(\frac{\text{Dew pt. (°F)} - 1.4}{\text{Dew pt. (°F)} + 212}\right)\right],$$

$$\text{Humidity (grains } H_2O\text{/lb dry air)} = \frac{4348\ (H_2O)}{\text{Baro} - H_2O},$$

$$\text{Power (bhp)} = \left(\frac{\text{Speed x Torque}}{5252}\right)\left(\frac{736.6}{\text{Baro} - H_2O}\right)\left(\frac{t_{air} + 460}{545}\right)^{0.7},$$

$$\text{Exhaust flow (lb/min)} = \text{Air flow (lb/min)} + \frac{\text{Fuel flow (lb/hr)}}{60},$$

$$\text{Mass CO} = \left(\frac{M_{EX}}{C_W}\right)\left(\frac{CO}{100}\right)\left(\frac{MW_{CO}}{MW_{EX}}\right)453.59237,$$

where MW_{CO} = molecular weight of CO (=28.01115)

MW_{EX} = molecular weight of exhaust gas (=28.967)

C_W = correction for water removal = $1 + \dfrac{\left(\frac{x}{2}\right)\left(CO+CO_2\right)-H_2}{100}$.

Mass HC = 0.0132 (exhaust rate) (ppmC HC)

$$\text{Mass } NO_x = 0.0432\ (\text{exhaust rate})\ (\text{ppm } NO_x)\left[\frac{1}{1 + 0.03\ CO_2\left(\frac{CO + CO_2}{CO + 3CO_2}\right)}\right]\left(K_H\right),$$

where K_H is the humidity correction factor (dimensionless):

$$K_H = \frac{1}{1 - 0.0047\ (H-75)}.$$

3. DISCUSSION OF RESULTS

Maximum corrected brake horsepower, maximum corrected torque, and brake specific fuel consumption (bsfc) are plotted as a function of engine speed at wide-open-throttle (WOT) in figure 1. The maximum power output of the engine was found at the specified speed but was lower than the value quoted in table 1. The maximum torque was found at a slightly higher rpm than that specified, but the value quoted in the table was reached. The fuel rate was found to be nearly linear with power for each engine speed as can be seen in the plots of fuel rate versus power for a given speed (figure 2). The NO_x emissions seem to show dependence on speed such that as the power is increased the NO_x concentration will increase; this is typical of diesel engines. However, the HC and CO emission patterns were highly irregular. See figures 3 to 5. The smoke rates for the given speeds seem to be scattered a small amount; this is due to a drift in calibration of the smoke meter used. This problem was resolved by running duplicate tests at the same modes to determine the smoke level. Plotting this value adequately defines the smoke level of the engine at a particular speed and load condition. Fuel rate increased with BHP. See figure 6.

4. CONCLUSIONS

The experimental work to obtain performance data for the Nissan diesel engine has been completed and is presented in the tables accompanying this report.

TABLE 1. MANUFACTURER'S ENGINE SPECIFICATIONS

Displacement, cu. in.....	198
Type.....	four-cycle water-cooled diesel with swirl chambers
Maximum horsepower, bhp @ 3,800 rpm.....	89
Maximum torque, lb-ft @ 1,600 rpm.....	133
Bore and stroke, in.....	3.27 x 3.94
Configuration.....	in-line 6-cylinder
Compression ratio.....	22:1
Firing order.....	1-4-2-6-3-5
Block material.....	cast iron
Head material.....	cast iron
Number of crankshaft main bearings.....	4
Number of compression rings/piston.....	3
Number of oil rings/piston.....	2
Cam drive type.....	gears
Valve lift:	
Intake, in.....	0.248
Exhaust, in.....	0.248
Valve timing:	
Intake opens, °BTDC.....	28
Intake closes, °ABDC.....	67
Exhaust opens, °BBDC.....	67
Exhaust closes, °ATDC.....	28
Engine weight, lb	662
Injection timing, advancing angle:*	
Starting °BTDC @ 1,000 rpm.....	20
High speed operation, °BTDC @3,600 rpm.....	35
Fuel injection pump.....	Bosch type A
Governor type.....	RSV
Engine family LD.....	SD-331
Engine model.....	SD-33 CN6-33

*Crankshaft deg.

TABLE 2. ENGINE BREAK-IN SCHEDULE

Mode	Engine Speed, rpm	Torque, ft-lb	Time in Mode, units
1	1,520	12	1 hr
2	1,900	12	"
3	1,900	25	2 hr
4	2,280	25	"
5	2,280	37	"
6	2,660	37	"
7	2,660	49	"
8	3,040	49	"
9	3,040	61	"
10	3,230	61	"
11	3,230	74	"
12	3,420	74	1 hr
13	3,420	86	"
14	3,610	86	"
15	3,800	99	"

TABLE 3. FUEL SPECIFICATIONS

Fuel No.	7621
Distillation, °F:	
10 pct evaporated	416
50 pct "	486
90 pct "	587
End point	630
API gravity, deg	35.4
Specific gravity, deg	0.8478
FIA analysis, pct:	
Aromatics	27
Olefins	4
Paraffins	64
Sulfur, pct	0.33

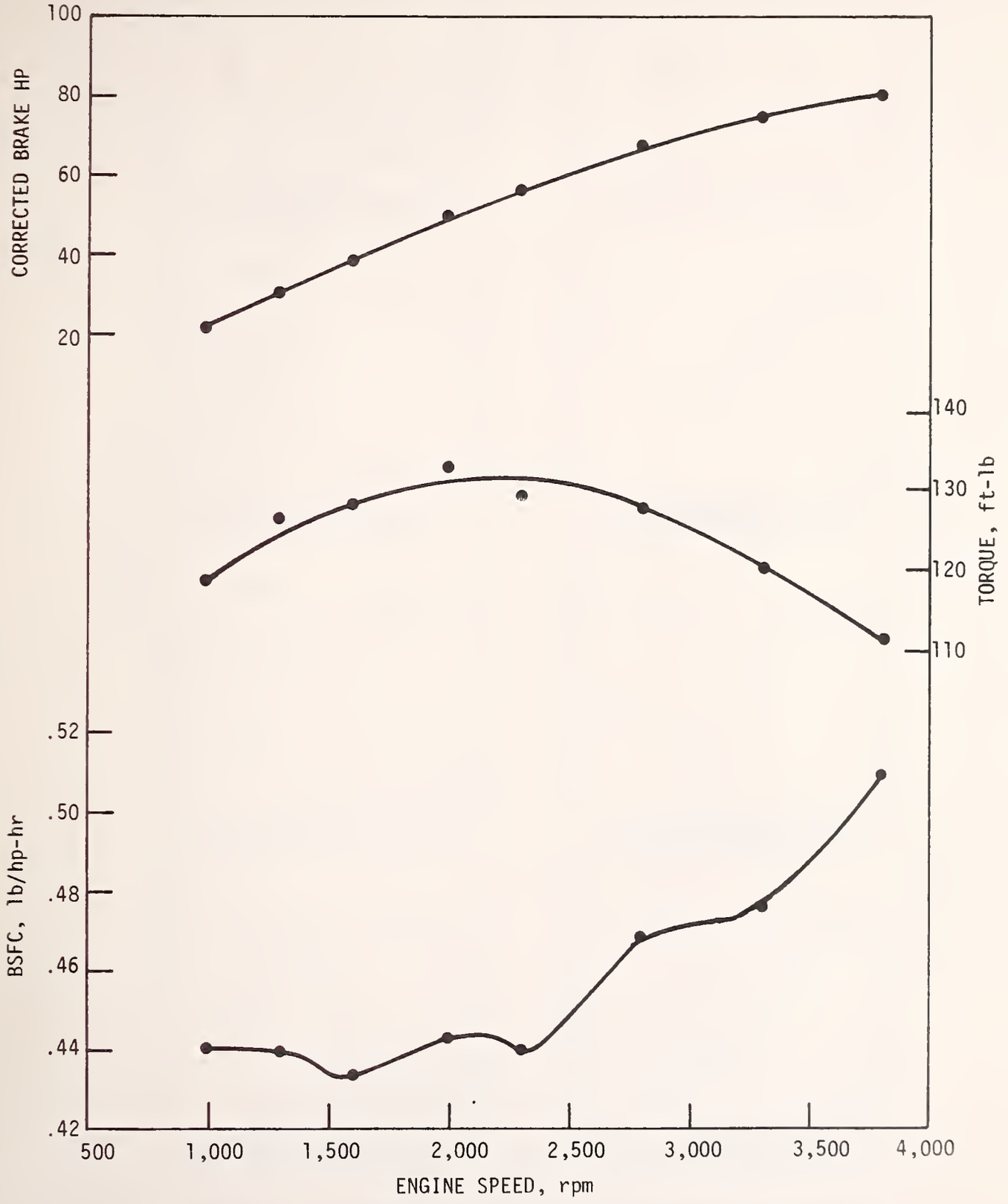


FIGURE 1. Brake Specific Fuel Consumption, Torque, and Brake Horsepower Versus Engine rpm at Wide-Open-Throttle--Chrysler-Nissan Diesel Engine.

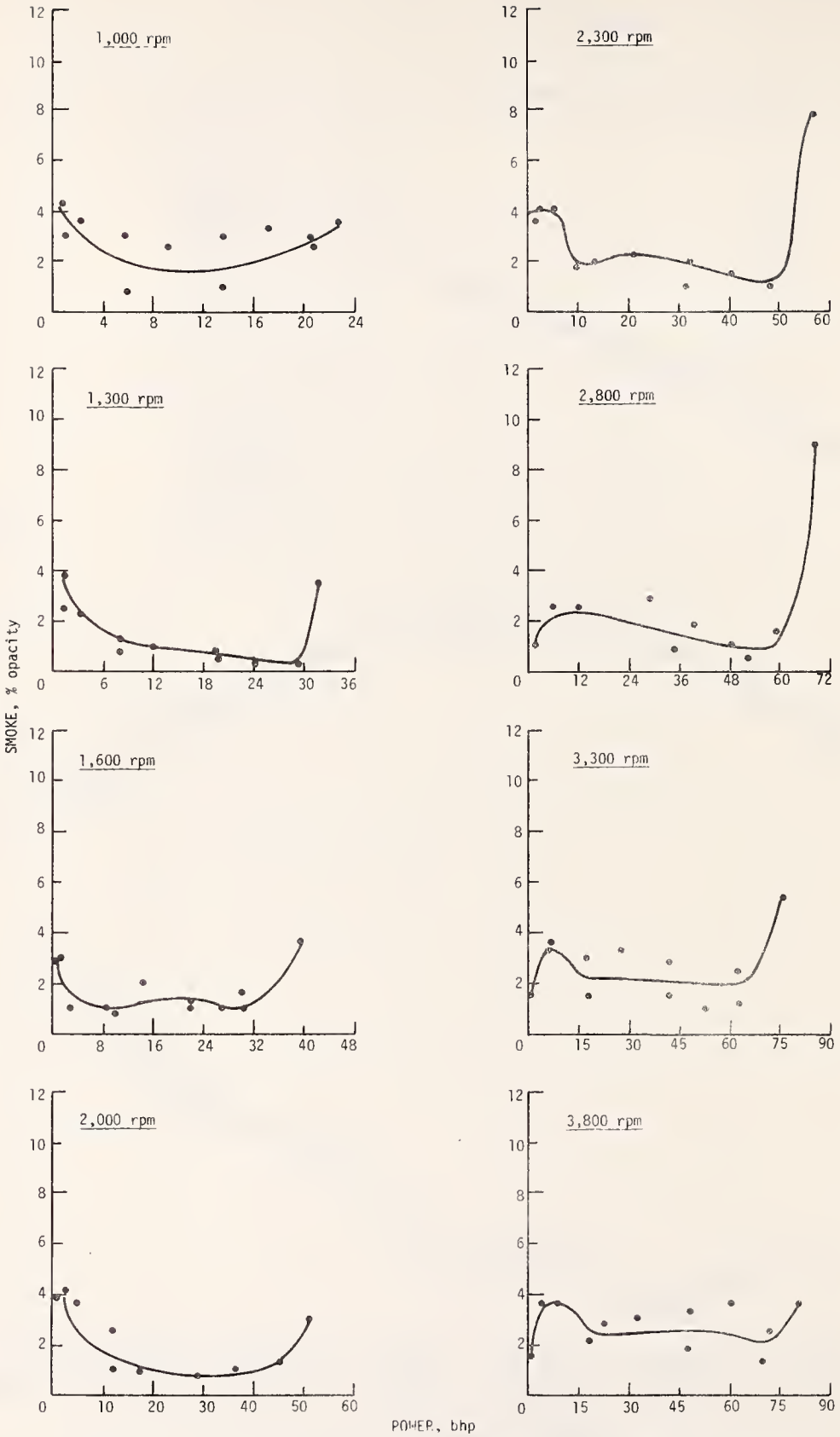


FIGURE 2. Emissions of Smoke Versus Power at Various Speed and Load Conditions--Chrysler-Nissan Diesel Engine.

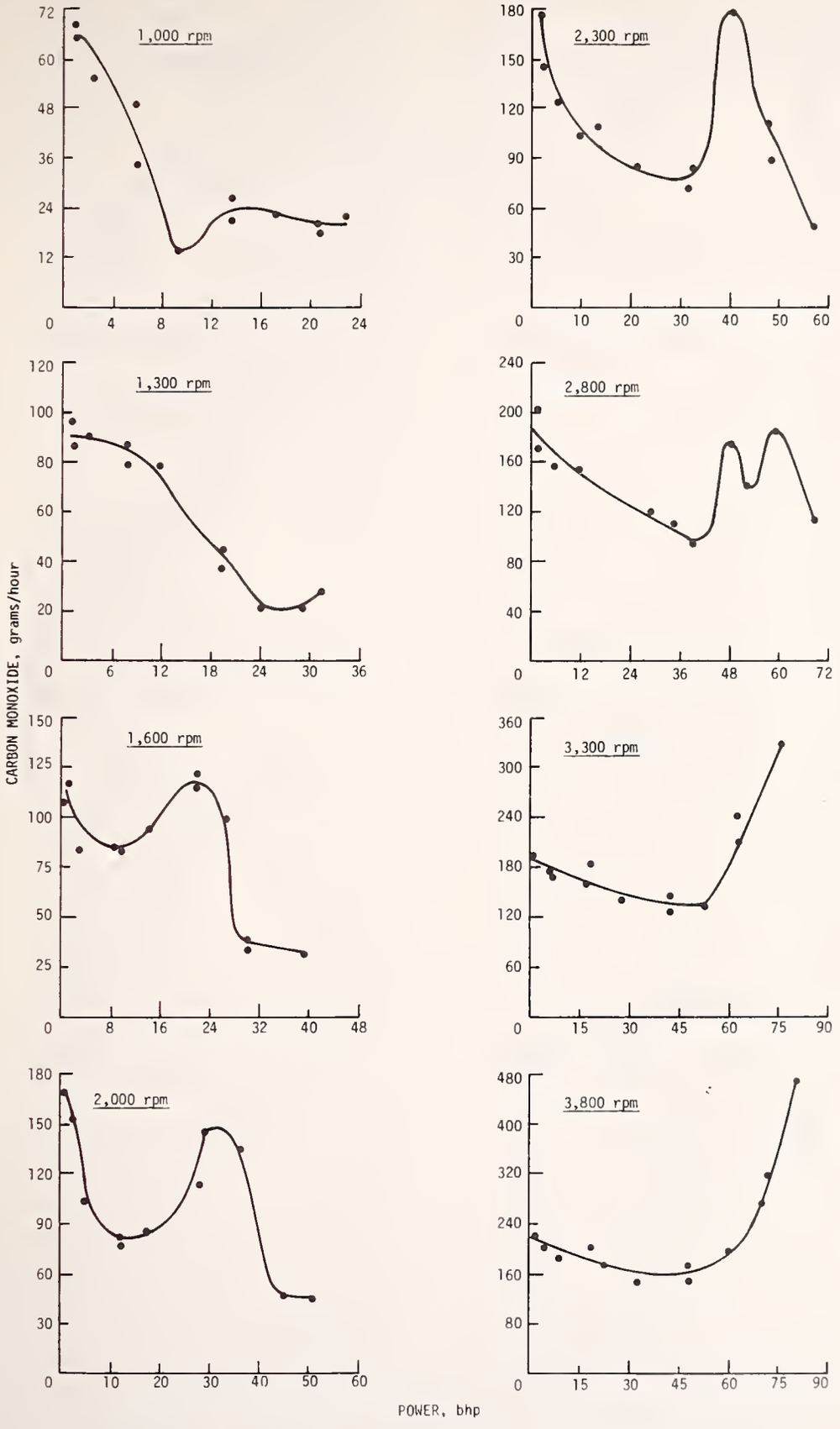


FIGURE 3. Carbon Monoxide Emissions Versus Power at Various Speed and Load Conditions--Chrysler-Nissan Diesel Engine.

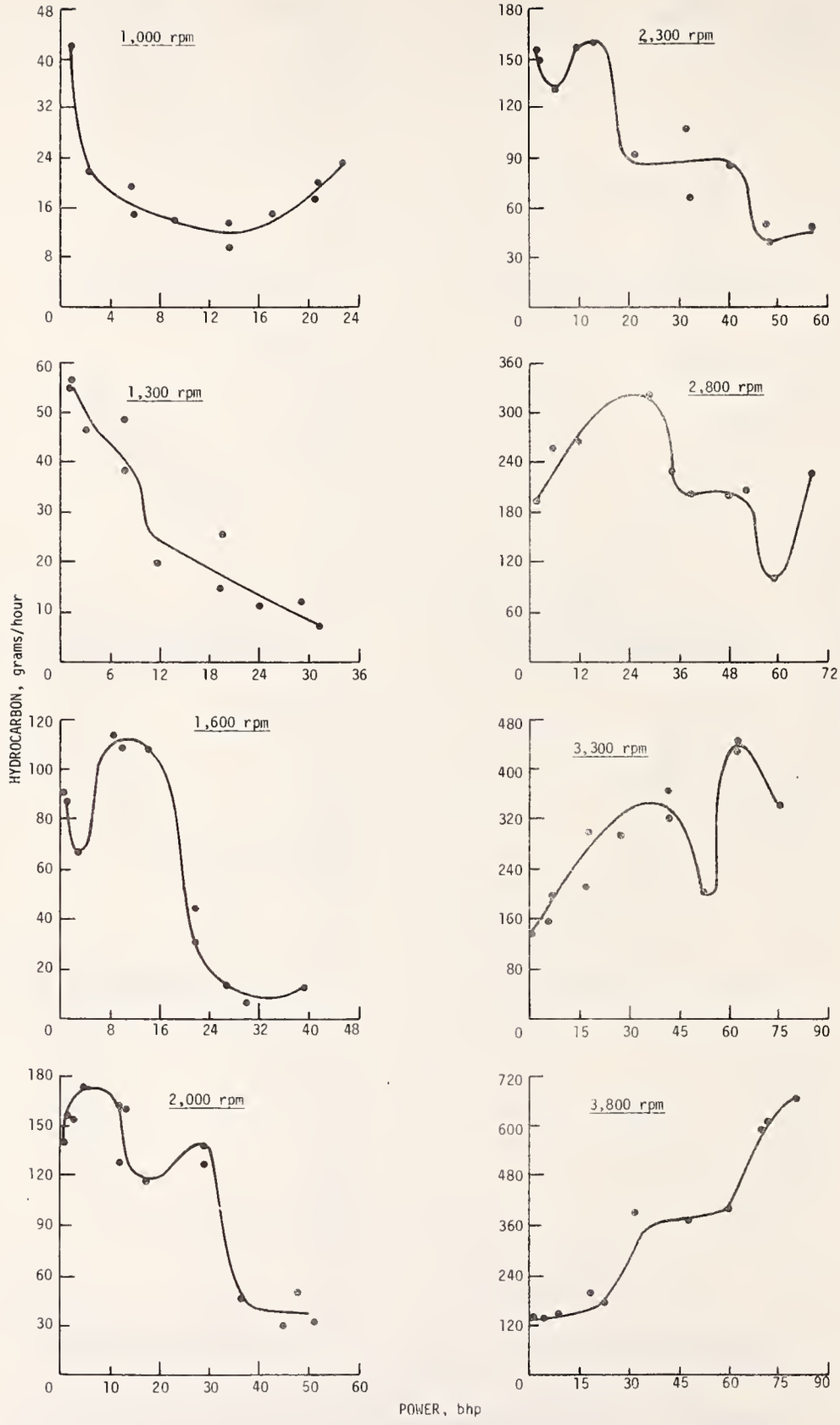


FIGURE 4. Hydrocarbon Emissions Versus Power at Various Speed and Load Conditions--Chrysler-Nissan Diesel Engine.

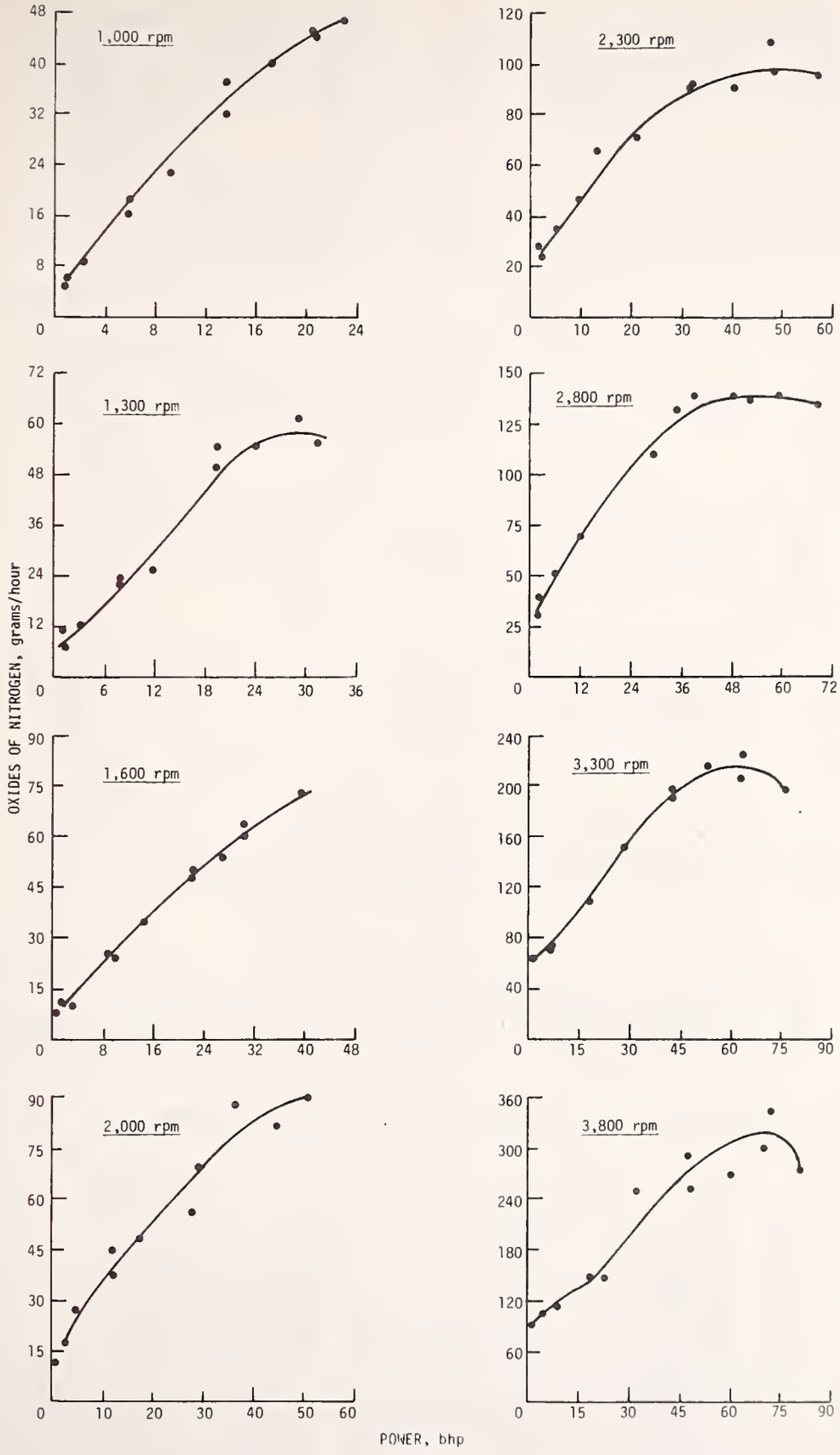


FIGURE 5. Oxides of Nitrogen Emissions Versus Power at Various Speed and Load Conditions--Chrysler-Nissan Diesel Engine.

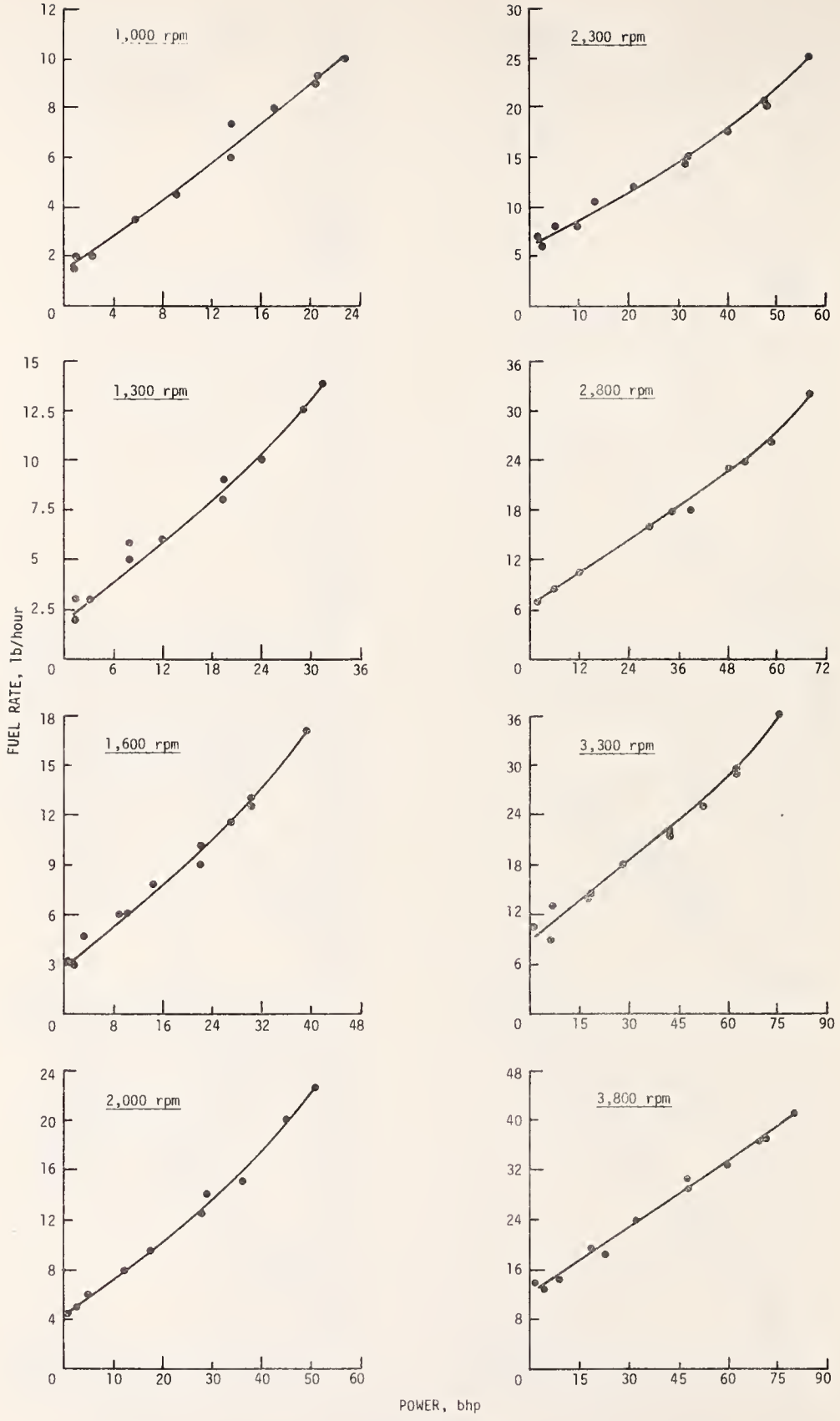


FIGURE 6. Fuel Rate Versus Power at Various Speed and Load Conditions--Chrysler-Nissan Diesel Engine.

ENGINE CHRYSLER·NISSAN
FUEL NO.2-D

TEST NUMBER	1	2	3	4	5	6	7
TEST DATE	7/22/76	7/22/76	7/22/76	7/22/76	7/22/76	7/22/76	7/22/76
BAROMETER, MM HG	745.5	745.5	745.5	745.5	745.5	745.5	745.5
HUMIDITY, GRAINS/LB	75	75	75	75	75	75	75
TEMPERATURE, F	81	82	83	84	85	85	86
ENGINE SPEED, RPM	650	650	650	750	750	750	850
TORQUE, LB-FT	1.2	19.9	43.0	1.2	23.5	40.6	2.0
POWER, BHP*	.1	2.5	5.3	.2	3.4	5.8	.3
FUEL RATE, LB/HR	1.1	2.0	3.0	1.2	2.2	3.2	1.7
THROTTLE ANGLE, DEG	1.0	3.5	7.9	3.0	7.2	9.9	6.5
CONCENTRATIONS, DRY BASIS:							
CO, %	.0401	.0286	.0240	.0424	.0332	.0286	.0561
CO2, %	2.25	3.37	5.21	2.20	3.65	4.63	2.20
HC, PPMC	143	93	74	128	98	103	389
NOX, PPM	95	165	238	80	150	200	62
EMISSION RATES, G/HR:							
CO	23.1	16.4	13.6	25.6	21.4	17.0	40.8
HC	4.1	2.7	2.1	3.9	3.2	3.1	14.2
NOX**	9.0	15.5	22.1	7.9	15.9	19.6	7.4
OIL TEMPERATURE, F	156	158	174	170	172	174	175
OIL PRESSURE, PSIG	40	37	32	38	42	36	42
COOLANT TEMPERATURE, F	168	170	168	171	173	175	171
EXHAUST TEMPERATURE, F	161	196	250	176	222	261	180
EXHAUST PRESSURE, IN H2O	2.8	2.8	2.8	2.8	2.8	2.8	2.8
EXHAUST FLOW, LB/MIN	2.24	2.25	2.26	2.35	2.54	2.37	2.83
SMOKE, % OPACITY	2.0	2.3	3.0	2.3	2.0	2.0	2.2

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	8	9	10	11	12	13	14
TEST DATE	7/22/76	7/22/76	7/27/76	7/27/76	7/27/76	7/27/76	7/27/76
BAROMETER, MM HG	745.5	745.5	739.0	739.0	739.0	739.0	739.0
HUMIDITY, GRAINS/LB	75	75	69	69	69	69	69
TEMPERATURE, F	86	86	88	87	87	86	86
ENGINE SPEED, RPM	850	850	1000	1000	1000	1000	1000
TORQUE, LB-FT	20.8	41.6	117.0	105.0	87.8	70.0	46.8
POWER, BHP*	3.4	6.8	22.7	20.4	17.0	13.5	9.1
FUEL RATE, LB/HR	3.1	3.9	10.0	9.0	8.0	6.0	4.5
THROTTLE ANGLE, DEG	8.5	11.0	35.0	29.0	26.0	24.0	18.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0424	.0355	.0263	.0240	.0263	.0309	.0470
CO2, %	3.46	4.80	11.22	10.09	8.55	7.15	3.56
HC, PPMC	259	210	545	407	347	311	311
NOX, PPM	120	185	345	330	290	230	160
EMISSION RATES, G/HR:							
CO	30.7	25.5	21.9	20.1	22.3	26.3	41.2
HC	9.4	7.6	22.8	17.2	14.8	13.3	13.7
NOX**	14.3	21.8	46.5	44.8	39.8	31.8	22.7
OIL TEMPERATURE, F	175	177	197	198	197	197	195
OIL PRESSURE, PSIG	42	40	43	40	40	40	40
COOLANT TEMPERATURE, F	172	175	188	190	187	186	186
EXHAUST TEMPERATURE, F	218	280	579	537	472	403	322
EXHAUST PRESSURE, IN H20	2.8	2.8	5.0	3.0	3.0	3.0	3.0
EXHAUST FLOW, LB/MIN	2.85	2.86	3.52	3.51	3.50	3.47	3.45
SMOKE, % OPACITY	1.8	1.5	3.6	3.0	3.3	3.0	2.6

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H20/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	15	16	17	18	19	20	21
TEST DATE	7/27/76	7/27/76	7/27/76	8/12/76	7/23/76	7/23/76	7/23/76
BAROMETER, MM HG	739.0	739.0	739.0	742.0	747.0	747.0	747.0
HUMIDITY, GRAINS/LB	69	69	69	71	64	64	64
TEMPERATURE, F	87	87	86	84	82	82	82
ENGINE SPEED, RPM	1000	1000	1000	1600	1600	1600	1600
TORQUE, LB-FT	29.3	11.7	4.0	127.5	99.0	88.0	71.8
POWER, BHP*	5.7	2.3	.8	39.2	30.1	26.8	21.9
FUEL RATE, LB/HR	3.5	2.0	1.5	17.0	12.5	11.5	10.1
THROTTLE ANGLE, DEG	15.0	12.0	11.5	35.0	29.0	28.0	25.5
CONCENTRATIONS, DRY BASIS:							
CO, %	.0561	.0630	.0772	.0240	.0286	.0738	.0844
CO2, %	3.82	2.64	2.20	12.50	8.74	7.84	6.31
HC, PPMC	436	493	951	197	120	205	457
NOX, PPM	115	60	35	340	280	250	220
EMISSION RATES, G/HR:							
CO	48.6	54.8	67.5	31.3	38.1	98.7	114.0
HC	19.0	21.5	41.7	12.9	8.0	13.8	31.0
NOX**	16.1	8.5	4.9	72.2	59.5	53.4	47.5
OIL TEMPERATURE, F	195	193	226	205	201	192	197
OIL PRESSURE, PSIG	40	40	30	48	47	49	49
COOLANT TEMPERATURE, F	187	186	186	190	180	181	178
EXHAUST TEMPERATURE, F	267	222	230	751	570	517	443
EXHAUST PRESSURE, IN H2O	2.0	2.0	0.0	10.0	3.0	3.0	3.0
EXHAUST FLOW, LB/MIN	3.42	3.40	3.40	5.58	5.50	5.49	5.46
SMOKE, % OPACITY	3.0	3.6	4.3	3.6	1.0	1.0	1.3

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	22	23	24	25	26	27	28
TEST DATE	7/23/76	8/31/76	7/23/76	7/23/76	8/12/76	7/28/76	7/28/76
BAROMETER, MM HG	747.0	743.4	747.0	747.0	742.0	740.6	740.6
HUMIDITY, GRAINS/LB	64	64	64	64	71	68	68
TEMPERATURE, F	83	77	93	81	87	81	81
ENGINE SPEED, RPM	1600	1600	1600	1600	1300	1300	1300
TORQUE, LB-FT	47.0	28.5	9.6	4.4	125.0	117.0	97.0
POWER, BHP*	14.3	8.7	3.0	1.3	31.4	29.1	24.1
FUEL RATE, LB/HR	7.8	6.0	4.7	3.0	13.8	12.5	10.0
THROTTLE ANGLE, DEG	23.0	20.5	18.0	17.0	35.0	28.0	27.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0653	.0607	.0561	.0796	.0286	.0193	.0193
CO2, %	4.74	3.69	2.67	2.20	12.38	11.55	9.40
HC, PPMC	1493	1608	894	1186	146	223	208
NOX, PPM	150	113	43	48	350	350	310
EMISSION RATES, G/HR:							
CO	93.7	84.9	83.3	116.2	27.8	20.8	21.0
HC	107.5	112.9	66.6	86.9	7.1	12.1	11.3
NOX**	34.4	25.2	10.2	11.2	55.3	60.8	54.4
OIL TEMPERATURE, F	195	197	176	186	205	174	192
OIL PRESSURE, PSIG	50	47	50	50	47	49	47
COOLANT TEMPERATURE, F	177	184	172	183	188	186	187
EXHAUST TEMPERATURE, F	345	292	232	214	695	662	582
EXHAUST PRESSURE, IN H2O	3.0	6.0	2.0	2.0	6.0	7.0	5.0
EXHAUST FLOW, LB/MIN	5.72	5.52	5.80	5.67	4.15	4.57	4.52
SMOKE, % OPACITY	2.0	1.0	1.0	3.0	3.5	.3	.3

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	29	30	31	32	33	34	35
TEST DATE	7/28/76	8/ 6/76	7/28/76	7/28/76	7/28/76	8/22/76	7/23/76
BAROMETER, MM HG	740.6	745.0	740.6	740.6	740.6	743.4	747.0
HUMIDITY, GRAINS/LB	68	66	68	68	68	63	64
TEMPERATURE, F	81	85	81	82	81	81	111
ENGINE SPEED, RPM	1300	1300	1300	1300	1300	2000	2000
TORQUE, LB-FT	78.0	48.0	32.0	13.0	4.8	133.0	114.0
POWER, BHP*	19.4	11.9	8.0	3.2	1.2	50.8	45.0
FUEL RATE, LB/HR	8.0	6.0	5.0	3.0	2.0	22.5	20.0
THROTTLE ANGLE, DEG	25.0	19.0	17.0	15.0	14.5	35.0	32.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0309	.0724	.0653	.0700	.0700	.0263	.0286
CO2, %	7.06	5.16	4.08	2.64	2.20	13.67	11.11
HC, PPMC	252	368	635	719	798	369	361
NOX, PPM	260	147	120	60	50	330	310
EMISSION RATES, G/HR:							
CO	36.4	77.5	78.3	89.7	95.5	44.5	46.5
HC	14.9	19.8	38.2	46.2	54.6	31.3	29.5
NOX**	49.4	25.2	23.2	12.4	11.0	88.9	80.5
OIL TEMPERATURE, F	192	191	166	180	186	195	214
OIL PRESSURE, PSIG	47	47	49	47	47	50	50
COOLANT TEMPERATURE, F	187	184	174	186	186	187	182
EXHAUST TEMPERATURE, F	507	315	254	232	217	832	775
EXHAUST PRESSURE, IN H2O	5.0	4.0	4.0	3.0	3.0	16.0	4.0
EXHAUST FLOW, LB/MIN	4.80	4.28	4.74	5.00	5.31	7.31	6.87
SMOKE, % OPACITY	.8	1.0	1.3	2.3	2.5	3.0	1.3

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	36	37	38	39	40	41	42
TEST DATE	7/26/76	8/31/76	8/27/76	7/26/76	7/26/76	8/27/76	8/22/76
BAROMETER, MM HG	744.0	743.2	742.7	744.0	744.0	742.8	743.2
HUMIDITY, GRAINS/LB	69	64	68	69	69	68	62
TEMPERATURE, F	82	78	77	82	82	78	82
ENGINE SPEED, RPM	2000	2000	2000	2000	2000	2000	2300
TORQUE, LB-FT	95.0	76.0	46.0	31.6	12.7	2.0	129.0
POWER, BHP*	36.3	29.0	17.5	12.1	4.8	.8	56.8
FUEL RATE, LB/HR	15.0	12.2	9.4	8.0	6.0	4.5	25.0
THROTTLE ANGLE, DEG	29.0	26.0	24.0	22.0	20.0	18.0	35.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0748	.0700	.0447	.0447	.0561	.0868	.0263
CO2, %	8.37	7.15	5.16	4.33	3.07	2.42	13.01
HC, PPMC	510	1447	1210	1748	1856	1435	509
NOX, PPM	300	210	155	150	90	37	320
EMISSION RATES, G/HR:							
CO	133.8	121.3	85.2	81.7	103.3	167.6	49.0
HC	45.7	125.8	115.8	160.4	171.5	139.0	47.5
NOX**	86.8	58.2	47.7	44.3	26.8	11.5	94.7
OIL TEMPERATURE, F	198	206	202	202	202	207	221
OIL PRESSURE, PSIG	50	50	50	50	50	48	50
COOLANT TEMPERATURE, F	182	185	185	178	176	187	185
EXHAUST TEMPERATURE, F	615	487	376	358	286	252	863
EXHAUST PRESSURE, IN H2O	10.0	11.0	8.0	8.0	6.0	6.0	17.0
EXHAUST FLOW, LB/MIN	7.37	7.06	7.63	7.25	7.22	7.52	8.00
SMOKE, % OPACITY	1.0	.7	.9	2.5	3.6	3.8	7.8

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	43	44	45	46	47	48	49
TEST DATE	7/26/76	7/26/76	7/26/76	7/26/76	8/31/76	7/26/76	7/26/76
BAROMETER, MM HG	744.0	744.0	744.0	744.0	743.6	744.0	744.0
HUMIDITY, GRAINS/LB	64	64	64	64	62	64	64
TEMPERATURE, F	88	87	87	87	78	86	86
ENGINE SPEED, RPM	2300	2300	2300	2300	2300	2300	2300
TORQUE, LB-FT	109.0	91.0	73.0	48.0	22.4	12.0	5.4
POWER, BHP*	48.3	40.3	32.3	21.2	9.8	5.3	2.4
FUEL RATE, LB/HR	20.0	17.5	15.0	12.0	8.0	8.0	6.0
THROTTLE ANGLE, DEG	32.0	30.0	28.0	25.0	21.5	20.0	18.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0470	.0892	.0401	.0401	.0493	.0600	.0677
CO2, %	10.30	8.74	7.15	5.16	3.82	3.30	2.85
HC, PPMC	408	849	627	863	1480	1266	1389
NOX, PPM	320	285	275	210	140	105	70
EMISSION RATES, G/HR:							
CO	88.7	176.7	83.2	84.3	103.2	123.1	144.1
HC	38.7	84.4	65.3	91.0	155.5	130.3	148.4
NOX**	96.5	90.2	91.2	70.5	46.6	34.4	23.8
OIL TEMPERATURE, F	218	216	214	212	211	207	201
OIL PRESSURE, PSIG	50	50	50	50	50	50	50
COOLANT TEMPERATURE, F	187	182	181	181	185	177	174
EXHAUST TEMPERATURE, F	768	653	562	437	321	297	280
EXHAUST PRESSURE, IN H20	14.0	12.0	13.0	11.0	11.0	9.0	9.0
EXHAUST FLOW, LB/MIN	7.92	8.20	8.46	8.41	8.27	8.06	8.33
SMOKE, % OPACITY	1.0	1.5	2.0	2.3	1.8	4.1	4.1

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H20/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	50	51	52	53	54	55	56
TEST DATE	8/22/76	8/31/76	7/26/76	8/31/76	7/26/76	7/26/76	7/26/76
BAROMETER, MM HG	742.8	743.5	744.0	743.4	744.0	744.0	744.0
HUMIDITY, GRAINS/LB	62	66	64	66	64	64	64
TEMPERATURE, F	83	77	93	77	88	88	87
ENGINE SPEED, RPM	2800	2800	2800	2800	2800	2800	2800
TORQUE, LB-FT	127.0	98.0	89.3	65.4	54.0	22.0	11.0
POWER, BHP*	68.3	52.3	48.5	34.9	29.1	11.9	5.9
FUEL RATE, LB/HR	32.0	23.8	23.0	17.8	16.0	10.5	8.5
THROTTLE ANGLE, DEG	35.0	32.0	30.0	28.0	25.0	21.5	21.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0470	.0561	.0700	.0424	.0470	.0561	.0584
CO2, %	13.01	9.60	8.92	6.89	6.00	3.95	3.24
HC, PPMC	1865	1645	1607	1743	2492	1924	1911
NOX, PPM	350	340	350	315	270	160	120
EMISSION RATES, G/HR:							
CO	112.9	139.7	172.5	109.6	119.4	152.5	155.4
HC	224.8	205.6	198.8	226.1	317.8	262.5	255.1
NOX**	133.6	136.0	137.8	130.8	109.6	69.5	51.0
OIL TEMPERATURE, F	226	225	231	216	222	223	221
OIL PRESSURE, PSIG	50	51	50	52	50	50	50
COOLANT TEMPERATURE, F	188	187	183	186	187	187	186
EXHAUST TEMPERATURE, F	932	685	704	492	462	360	316
EXHAUST PRESSURE, IN H20	24.0	24.0	10.0	20.0	16.0	17.5	12.0
EXHAUST FLOW, LB/MIN	10.32	10.38	10.21	10.51	10.24	10.75	10.45
SMOKE, % OPACITY	8.9	.5	1.0	.8	2.8	2.5	2.5

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H20/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	57	58	59	60	61	62	63
TEST DATE	8/25/76	8/22/76	8/31/76	7/27/76	7/27/76	7/27/76	7/27/76
BAROMETER, MM HG	742.7	742.4	743.3	741.0	741.0	741.0	741.0
HUMIDITY, GRAINS/LB	60	62	59	64	64	64	64
TEMPERATURE, F	79	84	81	94	94	87	84
ENGINE SPEED, RPM	2800	3300	3300	3300	3300	3300	3300
TORQUE, LB-FT	3.0	119.0	99.0	81.8	65.4	43.6	27.3
POWER, BHP*	1.6	75.6	62.6	52.6	42.1	27.8	17.3
FUEL RATE, LB/HR	6.9	36.0	29.5	25.0	22.0	18.0	14.0
THROTTLE ANGLE, DEG	19.5	35.0	32.5	29.5	28.5	24.0	23.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0607	.1132	.0700	.0424	.0401	.0447	.0493
CO2, %	2.96	12.75	10.30	8.19	8.02	6.55	4.33
HC, PPMC	1365	2369	2952	1299	2053	1865	1315
NOX, PPM	90	425	470	430	380	300	210
EMISSION RATES, G/HR:							
CO	169.4	325.9	209.4	132.1	124.6	139.8	158.2
HC	191.2	342.3	443.1	203.1	320.3	292.9	211.7
NOX**	39.8	194.5	222.2	214.3	188.9	150.1	107.7
OIL TEMPERATURE, F	211	237	232	218	231	231	231
OIL PRESSURE, PSIG	50	50	52	53	52	52	52
COOLANT TEMPERATURE, F	186	187	187	188	188	188	187
EXHAUST TEMPERATURE, F	282	940	747	630	607	564	447
EXHAUST PRESSURE, IN H20	12.0	31.0	33.0	26.0	25.0	24.0	21.0
EXHAUST FLOW, LB/MIN	10.93	12.35	12.55	12.82	12.77	12.68	12.73
SMOKE, % OPACITY	1.0	5.4	1.2	1.0	2.8	3.3	3.0

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H20/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	64	65	66	67	68	69	70
TEST DATE	7/27/76	7/27/76	8/22/76	8/31/76	7/27/76	7/27/76	7/27/76
BAROMETER, MM HG	741.0	741.0	742.7	743.1	741.0	741.0	741.0
HUMIDITY, GRAINS/LB	64	64	62	59	64	64	64
TEMPERATURE, F	84	84	83	81	88	87	87
ENGINE SPEED, RPM	3300	3300	3800	3800	3800	3800	3800
TORQUE, LB-FT	10.9	9.6	110.0	96.0	82.0	66.0	44.0
POWER, BHP*	6.9	6.1	80.5	70.0	60.3	48.5	32.4
FUEL RATE, LB/HR	13.0	9.0	41.0	36.5	32.7	29.0	24.0
THROTTLE ANGLE, DEG	21.0	20.0	35.0	32.5	30.5	29.5	27.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0515	.0538	.1373	.0772	.0561	.0424	.0424
CO2, %	3.43	3.30	12.75	10.90	9.40	8.37	8.37
HC, PPMC	1216	971	3893	3329	2298	2168	2276
NOX, PPM	140	135	510	540	485	460	460
EMISSION RATES, G/HR:							
CO	166.4	173.1	463.2	270.2	193.7	144.4	143.6
HC	197.2	156.9	659.2	584.7	398.2	370.6	386.8
NOX**	72.3	69.5	273.5	298.8	267.8	250.6	249.1
OIL TEMPERATURE, F	232	232	237	245	251	246	247
OIL PRESSURE, PSIG	52	52	50	53	50	52	50
COOLANT TEMPERATURE, F	186	188	187	187	188	188	187
EXHAUST TEMPERATURE, F	386	350	927	827	822	716	684
EXHAUST PRESSURE, IN H2O	20.0	18.0	40.0	44.0	36.0	34.0	32.0
EXHAUST FLOW, LB/MIN	12.71	12.64	14.48	14.77	14.37	14.04	13.95
SMOKE, % OPACITY	3.6	3.3	3.6	1.3	3.6	3.3	3.0

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	71	72	73	80	81	82
TEST DATE	7/27/76	7/27/76	7/27/76	7/28/76	7/28/76	7/28/76
BAROMETER, MM HG	741.0	741.0	741.0	740.6	740.6	740.6
HUMIDITY, GRAINS/LB	69	69	69	69	69	69
TEMPERATURE, F	87	85	86	81	79	81
ENGINE SPEED, RPM	3800	3800	3800	850	850	850
TORQUE, LB-FT	30.8	12.0	6.0	3.2	20.0	40.0
POWER, BHP*	22.7	8.8	4.4	.5	3.2	6.5
FUEL RATE, LB/HR	18.5	14.5	13.0	1.3	1.9	3.3
THROTTLE ANGLE, DEG	24.5	22.0	21.0	6.5	9.5	12.0
CONCENTRATIONS, DRY BASIS:						
CO, %	.0470	.0493	.0538	.0538	.0493	.0401
CO2, %	5.30	4.08	2.69	1.80	3.30	4.60
HC, PPMC	948	802	739	433	341	262
NOX, PPM	250	190	175	50	100	155
EMISSION RATES, G/HR:						
CO	169.8	180.5	198.6	39.5	36.0	32.1
HC	171.9	147.3	135.1	15.9	12.5	10.5
NOX**	146.2	112.6	104.5	5.9	11.8	20.0
OIL TEMPERATURE, F	236	237	243	185	181	182
OIL PRESSURE, PSIG	50	50	50	35	38	40
COOLANT TEMPERATURE, F	187	187	187	182	182	186
EXHAUST TEMPERATURE, F	483	420	412	177	187	254
EXHAUST PRESSURE, IN H2O	30.0	26.0	26.0	1.0	1.0	2.0
EXHAUST FLOW, LB/MIN	14.47	14.49	14.42	2.84	2.87	3.18
SMOKE, % OPACITY	2.8	3.6	3.6	3.3	3.0	2.5

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	83	84	85	86	88	89	90
TEST DATE	8/27/76	7/29/76	8/11/76	7/29/76	7/29/76	9/ 1/76	7/29/76
BAROMETER, MM HG	742.6	741.2	744.0	741.2	741.2	742.5	741.2
HUMIDITY, GRAINS/LB	68	85	73	85	85	58	85
TEMPERATURE, F	79	81	78	82	84	77	86
ENGINE SPEED, RPM	1000	1000	1000	1000	1300	1300	1300
TORQUE, LB-FT	108.0	70.0	31.0	5.2	78.0	32.0	5.4
POWER, BHP*	20.6	13.5	5.9	1.0	19.6	7.9	1.4
FUEL RATE, LB/HR	9.3	7.4	3.5	2.0	9.0	5.8	3.0
THROTTLE ANGLE, DEG	29.0	24.0	15.0	12.0	25.5	17.0	14.5
CONCENTRATIONS, DRY BASIS:							
CO, %	.0216	.0240	.0424	.0724	.0355	.0748	.0772
CO2, %	10.90	6.89	4.20	2.20	7.68	4.60	2.53
HC, PPMC	477	214	365	930	409	837	1005
NOX, PPM	330	250	140	40	260	120	40
EMISSION RATES, G/HR:							
CO	17.3	21.0	34.0	64.4	44.0	86.4	85.9
HC	19.8	9.4	14.7	41.6	25.5	48.5	56.2
NOX**	44.0	36.9	18.3	6.0	54.2	21.8	7.5
OIL TEMPERATURE, F	198	182	185	186	198	195	192
OIL PRESSURE, PSIG	38	45	44	45	47	46	50
COOLANT TEMPERATURE, F	177	187	182	176	187	182	185
EXHAUST TEMPERATURE, F	553	412	302	192	494	302	214
EXHAUST PRESSURE, IN H2O	4.0	4.0	2.0	2.0	6.0	4.0	4.0
EXHAUST FLOW, LB/MIN	3.49	3.56	3.18	3.46	5.07	4.59	4.34
SMOKE, % OPACITY	2.6	1.0	.8	3.0	.5	.8	3.8

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	91	92	93	94	96	97	98
TEST DATE	8/26/76	7/29/76	8/26/76	8/26/76	7/26/76	8/31/76	7/29/76
BAROMETER, MM HG	741.8	741.2	741.9	742.5	744.0	743.3	741.2
HUMIDITY, GRAINS/LB	68	85	68	68	69	64	85
TEMPERATURE, F	80	84	77	77	82	77	84
ENGINE SPEED, RPM	1600	1600	1600	1600	2000	2000	2000
TORQUE, LB-FT	98.0	71.0	32.5	1.6	76.0	32.0	6.8
POWER, BHP*	30.0	21.9	9.9	.5	29.0	12.2	2.6
FUEL RATE, LB/HR	12.9	9.0	6.1	3.2	14.0	7.8	5.0
THROTTLE ANGLE, DEG	29.0	25.5	22.0	17.0	26.0	22.0	18.0
CONCENTRATIONS, DRY BASIS:							
CO, %	.0240	.0820	.0561	.0700	.0796	.0424	.0772
CO2, %	9.11	6.47	4.01	2.20	7.33	4.14	3.07
HC, PPMC	98	597	1457	1176	1503	1393	1547
NOX, PPM	279	200	100	33	235	128	52
EMISSION RATES, G/HR:							
CO	33.5	121.1	82.7	106.7	143.4	77.0	152.2
HC	6.9	44.2	107.8	89.9	135.9	127.0	153.1
NOX**	63.0	49.7	23.8	8.1	68.5	37.0	17.3
OIL TEMPERATURE, F	202	196	196	200	204	201	202
OIL PRESSURE, PSIG	47	47	48	48	50	50	50
COOLANT TEMPERATURE, F	187	186	187	187	182	187	184
EXHAUST TEMPERATURE, F	588	446	292	212	542	317	277
EXHAUST PRESSURE, IN H20	10.0	8.0	5.0	4.0	10.0	8.0	8.0
EXHAUST FLOW, LB/MIN	5.80	5.98	5.83	5.92	7.36	7.19	7.73
SMOKE, % OPACITY	1.6	1.0	.8	2.9	.8	1.0	4.1

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H20/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	99	100	101	102	103	104	106
TEST DATE	8/31/76	8/31/76	7/29/76	7/29/76	8/25/76	8/25/76	7/29/76
BAROMETER, MM HG	743.6	743.6	741.2	741.2	742.4	742.4	741.2
HUMIDITY, GRAINS/LB	62	62	85	85	60	60	85
TEMPERATURE, F	78	78	84	84	82	81	84
ENGINE SPEED, RPM	2300	2300	2300	2300	2800	2800	2800
TORQUE, LB-FT	109.0	72.0	30.0	4.0	109.8	73.2	3.2
POWER, BHP*	47.7	31.5	13.3	1.8	59.0	39.3	1.7
FUEL RATE, LB/HR	20.5	14.2	10.5	7.0	26.0	18.0	7.0
THROTTLE ANGLE, DEG	32.0	28.0	22.5	18.0	33.0	29.0	19.5
CONCENTRATIONS, DRY BASIS:							
CO, %	.0561	.0355	.0515	.0796	.0724	.0355	.0772
CO2, %	10.50	7.15	5.16	3.07	11.11	7.68	2.85
HC, PPMC	497	1045	1499	1392	789	1508	1466
NOX, PPM	345	280	185	75	345	330	70
EMISSION RATES, G/HR:							
CO	110.1	71.7	108.5	176.0	183.2	93.8	200.8
HC	49.0	106.0	158.5	154.5	100.2	199.9	191.4
NOX**	107.6	89.9	65.6	27.9	138.2	138.0	30.7
OIL TEMPERATURE, F	215	217	214	210	224	227	216
OIL PRESSURE, PSIG	49	49	50	50	50	50	51
COOLANT TEMPERATURE, F	187	186	186	186	187	187	186
EXHAUST TEMPERATURE, F	731	530	411	374	752	576	311
EXHAUST PRESSURE, IN H2O	18.0	14.0	10.0	10.0	21.0	18.0	14.0
EXHAUST FLOW, LB/MIN	8.25	8.24	8.43	8.67	10.69	10.82	10.18
SMOKE, % OPACITY	1.0	1.0	2.0	3.6	1.5	1.8	1.0

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	107	108	109	110	111	112	113
TEST DATE	7/29/76	8/31/76	9/ 1/76	8/31/76	7/30/76	8/31/76	8/27/76
BAROMETER, MM HG	741.2	743.2	743.1	743.1	741.2	742.9	742.8
HUMIDITY, GRAINS/LB	85	59	58	59	73	59	76
TEMPERATURE, F	82	81	77	78	77	81	82
ENGINE SPEED, RPM	3300	3300	3300	3300	3800	3800	3800
TORQUE, LB-FT	98.0	66.6	29.0	1.2	99.0	66.0	25.3
POWER, BHP*	62.5	42.1	18.2	.8	72.0	48.1	18.5
FUEL RATE, LB/HR	29.0	21.5	14.5	10.5	37.0	30.5	19.5
THROTTLE ANGLE, DEG	32.5	28.5	23.0	20.0	32.5	29.5	24.5
CONCENTRATIONS, DRY BASIS:							
CO, %	.0772	.0470	.0561	.0584	.0868	.0470	.0538
CO2, %	10.50	7.50	4.81	3.43	10.90	8.19	5.30
HC, PPMC	2736	2366	1830	828	3329	2029	1053
NOX, PPM	390	400	210	120	580	505	242
EMISSION RATES, G/HR:							
CO	239.5	144.2	182.3	192.7	313.4	170.5	199.2
HC	426.1	364.4	298.3	137.1	603.3	369.5	195.8
NOX**	203.7	194.1	107.6	62.6	342.1	289.7	147.6
OIL TEMPERATURE, F	220	235	222	232	176	246	241
OIL PRESSURE, PSIG	53	52	52	51	55	52	51
COOLANT TEMPERATURE, F	188	186	186	185	177	186	186
EXHAUST TEMPERATURE, F	691	601	412	342	727	640	453
EXHAUST PRESSURE, IN H2O	30.0	30.0	25.0	22.0	40.0	38.0	29.0
EXHAUST FLOW, LB/MIN	13.04	12.55	12.95	12.98	15.23	14.93	14.83
SMOKE, % OPACITY	2.5	1.5	1.5	1.5	2.5	1.8	2.1

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

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ENGINE CHRYSLER NISSAN
FUEL NO.2-D

TEST NUMBER	114
TEST DATE	8/31/76
BAROMETER, MM HG	743.1
HUMIDITY, GRAINS/LB	59
TEMPERATURE, F	81
ENGINE SPEED, RPM	3800
TORQUE, LB-FT	1.8
POWER, BHP*	1.3
FUEL RATE, LB/HR	14.0
THROTTLE ANGLE, DEG	21.0
CONCENTRATIONS, DRY BASIS:	
CO, %	.0561
CO2, %	3.82
HC, PPMC	727
NOX, PPM	150
EMISSION RATES, G/HR:	
CO	216.5
HC	140.8
NOX**	91.5
OIL TEMPERATURE, F	237
OIL PRESSURE, PSIG	52
COOLANT TEMPERATURE, F	186
EXHAUST TEMPERATURE, F	396
EXHAUST PRESSURE, IN H2O	28.0
EXHAUST FLOW, LB/MIN	15.24
SMOKE, % OPACITY	1.5

* CORRECTED - SAE J186B
** CORRECTED TO 75 GR. H2O/ LB. DRY AIR

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