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NHTSA-
79-6

DOT-TSC-NHTSA-79-6

HS-803-835

PERFORMANCE CHARACTERISTICS OF AUTOMOTIVE ENGINES IN THE UNITED STATES

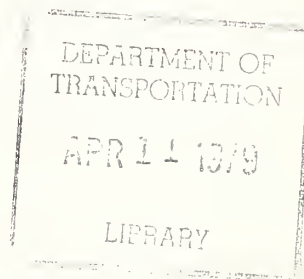
Third Series - Report No. 6
1978 Volkswagen Diesel, 90 CID (1.5 Liter), F.I.

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W.F. Marshall

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INTERIM REPORT



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Washington DC 20590

NOTICE

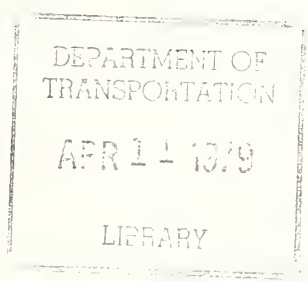
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16. Abstract Experimental data were obtained in dynamometer tests of a 1978 VW 90 CID engine to determine fuel consumption and emissions (hydrocarbon, carbon monoxide, oxides of nitrogen) at steady-state engine operating modes. The objective of the 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 Technology 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 United States. The VW 90 CID (diesel) engine used in this work is one of a series of 15 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.

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

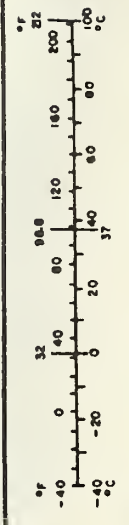
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	What 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				
m 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	0.9	tonnes	t
	(2000 lb)			
VOLUME				
tblsp	tablespoons	5	milliliters	ml
Tbsp	fluid ounces	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	What 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
km	kilometers	1.1	yards	yd
		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 the program is to obtain engine performance data for estimating fuel economy and emissions for varied engine service and duty. The intent of the work done at Bartlesville Energy Technology Center is to provide basic engine characteristic data required as input for engineering calculations of fuel consumption and emissions involving ground transportation.

The data acquired from tests of a 1978 VW 90 CID engine are presented in this report. Volkswagen uses the 90 CID diesel engine in the VW Rabbit weighing in the 2,250 lb weight class. The engine as equipped is intended for use in a forty-nine state (Federal) vehicle with manual transmission. The test results are sufficient to establish steady-state maps for fuel consumption and emissions (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) over the entire operating range of the engine.

2. ENGINE TEST REPORT

The engine test setup included a complete engine (SAE definition) coupled to an eddy-current dynamometer. A cooling tower was used in place of the fan and radiator. The alternator was included but was not wired into the engine's electrical system. The manufacturer's engine specifications are listed in Table 1.

Prior to testing, engine break-in consisted of approximately 1,500 miles with the engine installed in the vehicle. A single batch of No. 2 diesel fuel was used throughout the tests; a detailed fuel analysis is given in Table 2. Engine testing began on February 14, 1978 and ended on March 16, 1978.

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

Speeds: 1,000; 1,650; 2,000; 2,500; 3,000; 3,500; 4,500;
5,000 rpm

Loads: 0, 10, 25, 40, 60, 75, 90, 100 pct of full load
(0, 10, 25, 60, and 75 pct points were repeated at
all engine speeds)

Idle speed-load modes: 800 rpm -- 0, 7, 14 lb-ft
700 rpm -- 31 lb-ft

Over speed point: 5,200 rpm -- 47 lb-ft (WOT)

Total number of test modes.....	69
Total number of repeats.....	94
Total number of motoring modes.....	6
Total number of tests.....	<u>169</u>

At the conclusion of the tests, the engine was motored at 1,000; 1,500; and 2,000 rpm. At each of the speeds the engine was motored with the fuel on and with the fuel off.

The following data were recorded for each test point:

Test number
Date
Barometric pressure, mm Hg
Wet bulb temperature, °F
Dry bulb temperature, °F
Speed, rpm

Torque, lb-ft -- BLH Strain gauge; Daytronic indicator
 Fuel rate, lb/hr -- Fluidyne positive displacement fuel flow meter
 Rack position (throttle angle), degrees
 CO, pct -- Beckman NDIR
 CO₂, pct -- Beckman NDIR
 O₂, pct -- Beckman polarographic detector
 HC, ppmC -- Custom built heated flame ionization detector
 NO_x, ppm -- Thermo-Electron chemiluminescent detector
 Oil temperature, °F
 Oil pressure, psi
 Coolant temperature, °F
 Exhaust temperature, °F
 Exhaust pressure, in. H₂O
 Smoke, pct opacity -- Cellesco smoke meter
 Air flow, lb/min -- 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:

1. Partial pressure of water vapor in intake air (millimeters of mercury)

$$P_v = \exp \left[18.717 - \frac{7308.1}{393 + T_w} \right] + \frac{P_b}{2784.2} \left[1 + \frac{T_w}{1533.2} \right] \left[T_w - T_D \right]$$

T_w = Wet bulb temperature, °F
 T_D = Dry bulb temperature, °F
 P_b = Barometric pressure, mm Hg

2. Humidity (grains moisture per pound dry air)

$$H = \frac{4347.3 (P_v)}{P_b - P_v}$$

3. Corrected brake horsepower

$$HP_c = \left[\frac{(T)(N)}{5252.11} \right] \left\{ \frac{\left[\frac{T_D + 460}{545} \right]^{0.7}}{\left[\frac{P_b - P_v}{736.6} \right]} \right\}$$

T = Brake torque (lb ft)
 N = Engine speed (rpm)

4. Fuel mass flow rate (lbm/hr)

$$\dot{m}_f = (\dot{V}_f) (P_f) \left(\frac{3600}{453.59} \right) [1 + 0.0007(60 - T_f)]$$

\dot{V}_f = Volume flow rate (cc/sec)

P_f = Fuel specific gravity

T_f = Fuel temperature ($^{\circ}$ F)

5. Convert hydrocarbon concentration measurements from wet basis to dry basis

$$HC_D = HC_W \left[1 + \frac{x}{200} \left(\frac{3CO_2[CO + CO_2]}{CO + 3CO_2} \right) \right]$$

HC_W = Hydrocarbon concentration on wet basis (pct)

x = Fuel hydrogen/carbon atomic ratio

CO_2 = Carbon dioxide concentration on dry basis (pct)

CO = Carbon monoxide concentration on dry basis (pct)

6. Carbon monoxide mass emission rate (grams/hour)

$$\dot{m}_{CO} = \left[\frac{453.59 (\dot{m}_f)}{(M_F) (CO + CO_2 + HC_D)} \right] (CO) (M_{CO})$$

M_{CO} = Molecular weight of CO

M_F = Fuel molecular weight per carbon atom

7. Hydrocarbon mass emission rate (grams/hour)

$$\dot{m}_{HC} = \left[\frac{453.59 (\dot{m}_f)}{(M_F) (CO + CO_2 + HC_D)} \right] (HC_D) (M_{HC})$$

M_{HC} = Molecular weight of HC per carbon atom (assumed equal to M_F)

8. Oxides of nitrogen mass emission rate (grams/hour) (corrected for humidity)

$$\dot{m}_{NO_x} = \left[\frac{453.59 (\dot{m}_f)}{M_F + (CO + CO_2 + HC_D)} \right] (NO_x) (M_{NO_2}) \left[\frac{1}{1 - 0.0025 (H - 75)} \right]$$

M_{NO_2} = Molecular weight of NO_2

NO_x = Oxides of nitrogen concentration on dry basis (pct)

3. DISCUSSION OF TEST RESULTS

Maximum corrected brake horsepower, maximum corrected torque, and brake specific fuel consumption (bsfc) are plotted as a function of engine speed at full rack position in Figure 1. The maximum power output of the engine was produced at the specified speed and was similar to the value quoted in Table 1. The maximum torque produced by the engine was similar to the value quoted in Table 1 but was produced at a higher speed. The fuel rates were found to be nearly a linear function of power for all engine speeds and were repeatable for each speed.

Fuel rates were found to be nearly a linear function of power for most engine speeds (Figure 2).

Emissions of carbon monoxide (CO), hydrocarbon (HC), and oxides of nitrogen (NO_x) are plotted as a function of power for all engine speeds (Figures 3, 4, 5). The emissions of CO, HC, and NO_x were reasonably repeatable for all engine speeds. At particular speeds (1,000; 2,000; 2,500; 3,000 rpm), during light load and no load operation, some scatter in the CO and HC emissions was observed. The scatter at these modes is typical for light load operation. Exhaust stream opacity showed low levels of smoke for all engine speeds (Figure 6). The maximum opacity observed was 10 percent at 5,000 rpm (WOT).

4. CONCLUSIONS

The experimental work to obtain performance data for the Volkswagen 90 CID diesel engine has been completed, and these data are presented in the tables accompanying this report.

TABLE 1. - MANUFACTURER'S ENGINE SPECIFICATIONS

Displacement, cubic inches.....	90
Maximum horsepower, bhp @ 5,000 rpm.....	48
Maximum torque, lb-ft @ 2,500 rpm.....	58
Bore and stroke, inches.....	3.012 x 3.15
Compression ratio.....	23:1
Configuration.....	in-line, 4-cyl.
Firing order.....	1-3-4-2
Block material.....	cast iron
Head material.....	cast aluminum
Number of crankshaft main bearings.....	5
Number of compression rings/piston.....	2
Number of oil rings/piston.....	1
Cam drive type.....	belt
Valve lift:	
Intake, inches.....	0.32
Exhaust, inches.....	0.35
Valve timing:	
Intake opens, °BTC.....	5
Intake closes, °ABC.....	14
Exhaust opens, °BBC.....	27
Exhaust closes, °ATC.....	5
Engine weight, lbs.....	305
Carburetor type.....	fuel injection
Injection pressure, psi.....	1,778
Injection timing, inch stroke @ TDC.....	0.033
Fuel pump type.....	Bosch mechanical injection pump
Combustion system.....	swirl chamber

TABLE 2. - FUEL ANALYSIS

Fuel No. (No. 2 diesel).....	7807
Distillation, °F:	
10 pct evaporated.....	396
50 pct "	478
95 pct "	596
End point "	614
API gravity, degrees.....	36.55
Specific gravity, degrees.....	0.842
FIA analysis, pct:	
Aromatics.....	27
Olefins.....	3
Paraffins.....	70
Sulfur, pct.....	0.218
Hydrogen/carbon atomic ratio.....	1.79

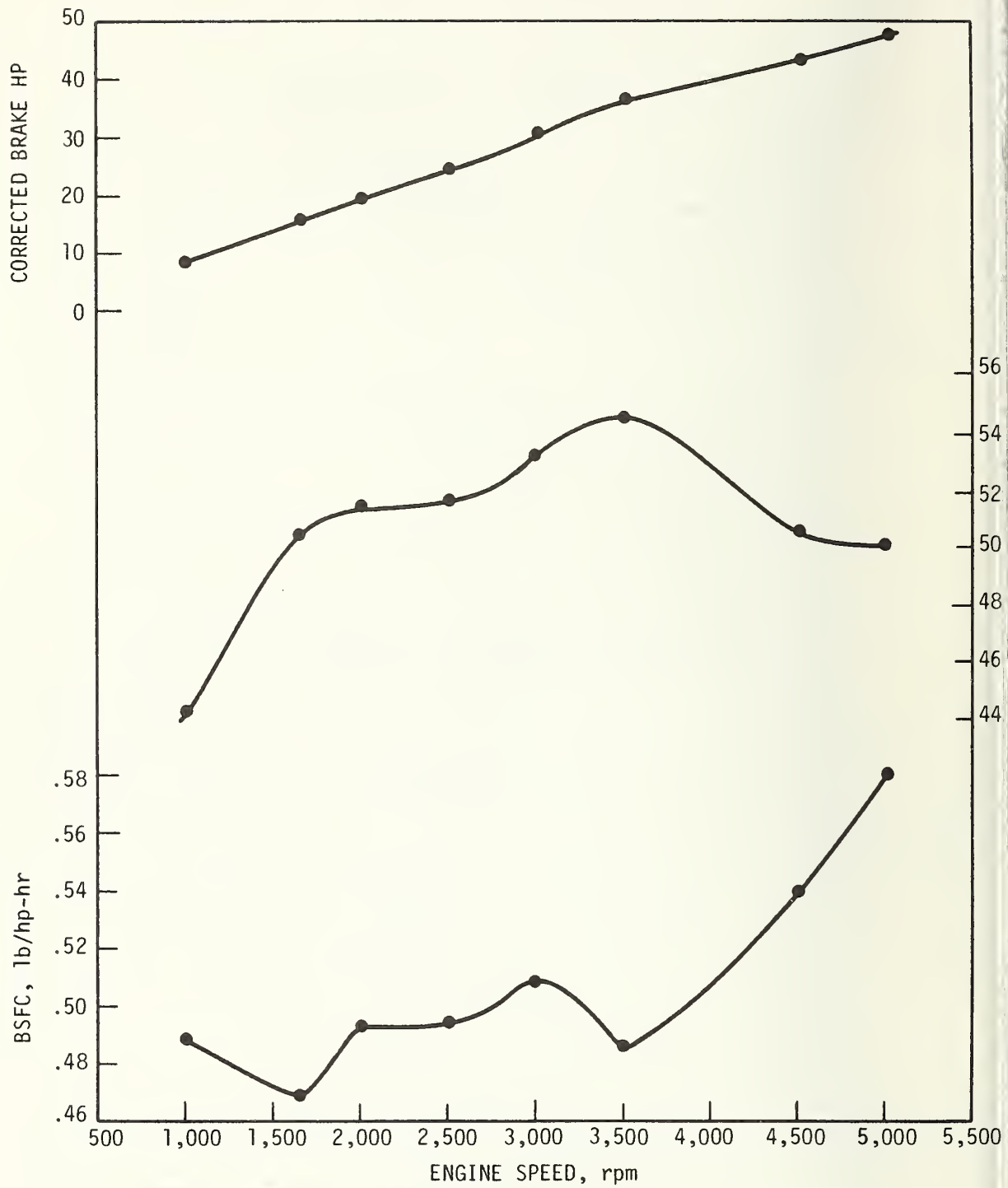


FIGURE 1. Brake Specific Fuel Consumption, Torque, and Brake Horsepower Versus Engine rpm at Wide-Open-Throttle--Volkswagen 90-CID Diesel Engine.

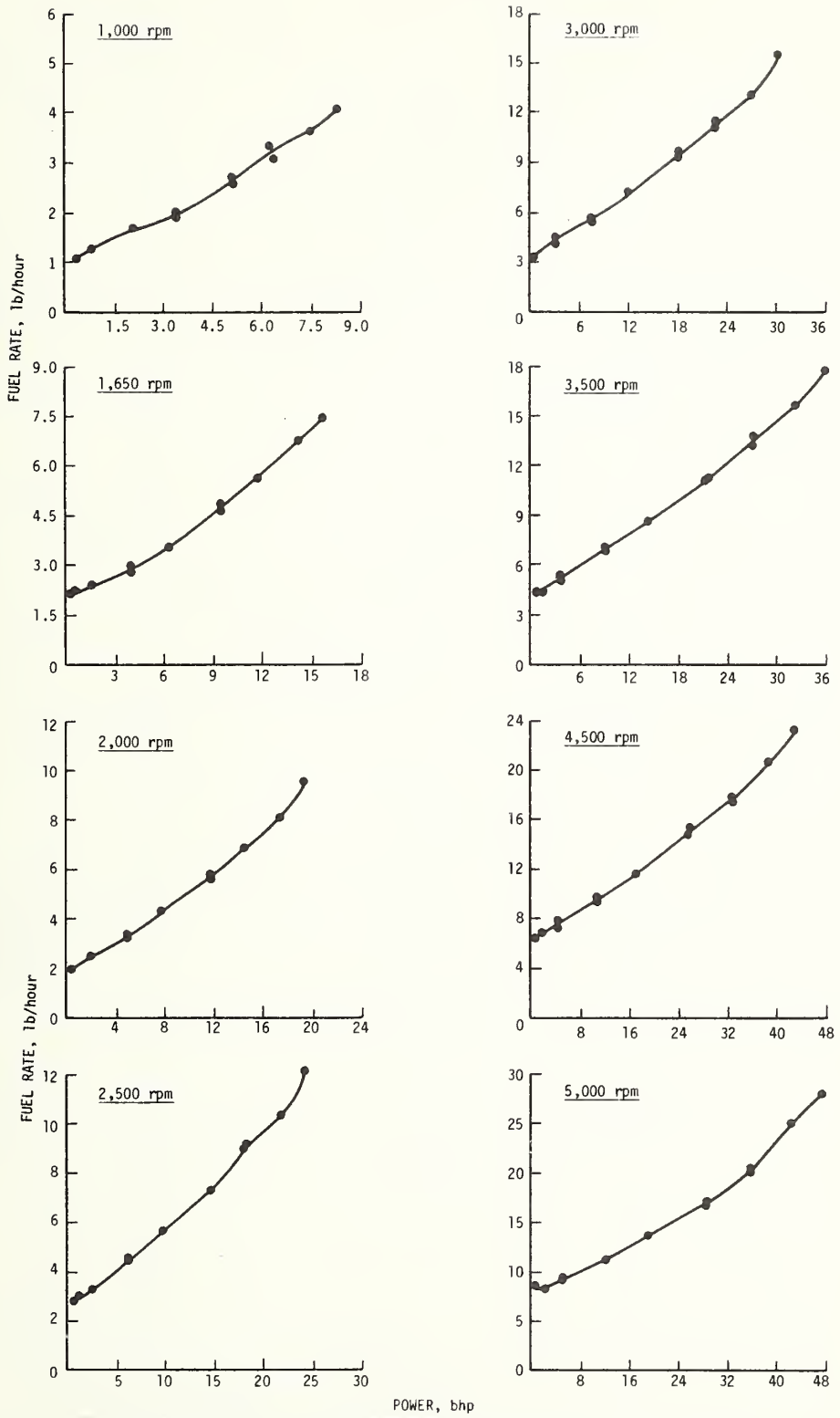


FIGURE 2. Fuel Rate Versus Power at Various Speed and Load Conditions-- Volkswagen 90 CID Diesel Engine.

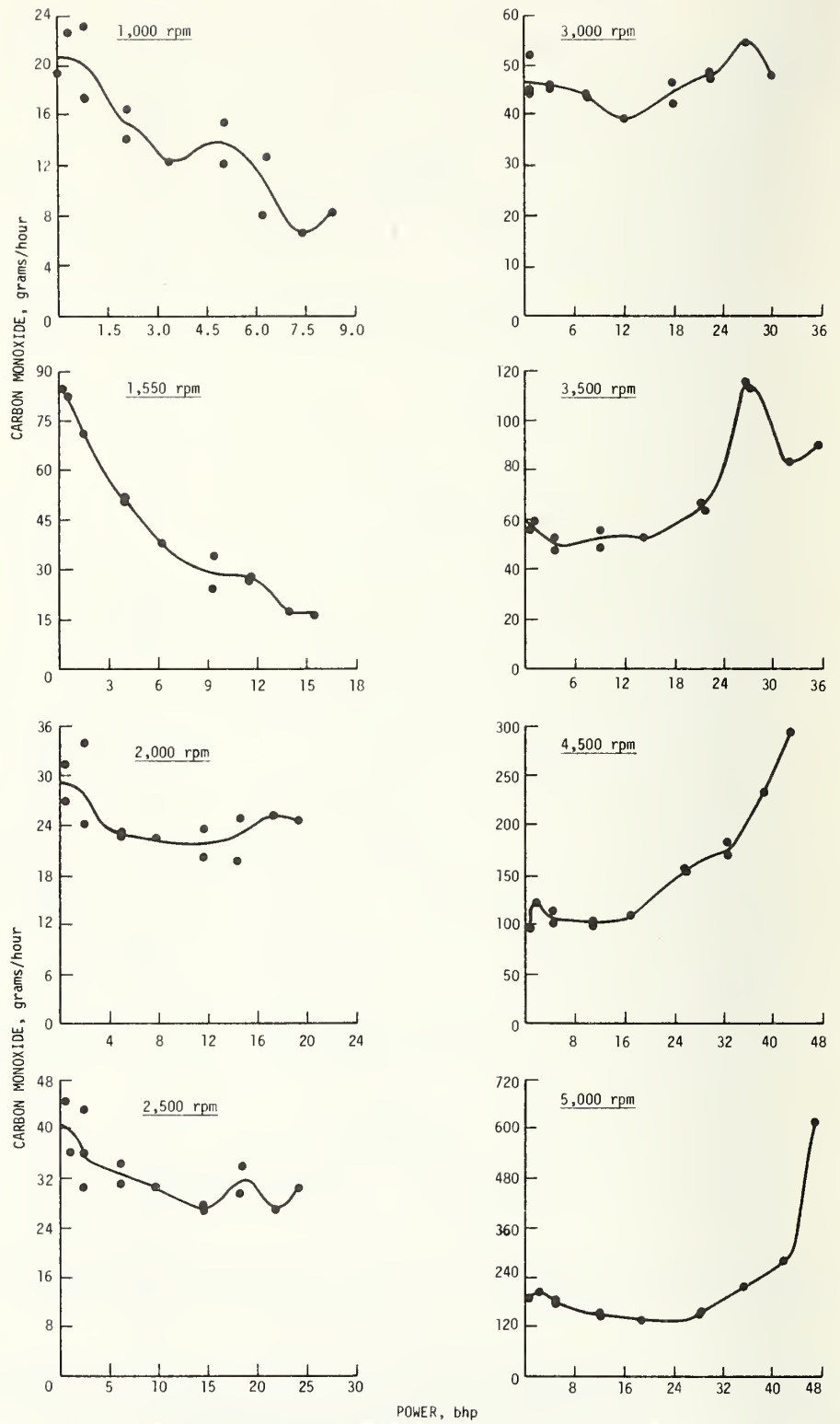


FIGURE 3. Carbon Monoxide Emissions Versus Power at Various Speed and Load Conditions-- Volkswagen 90 CID Diesel Engine.

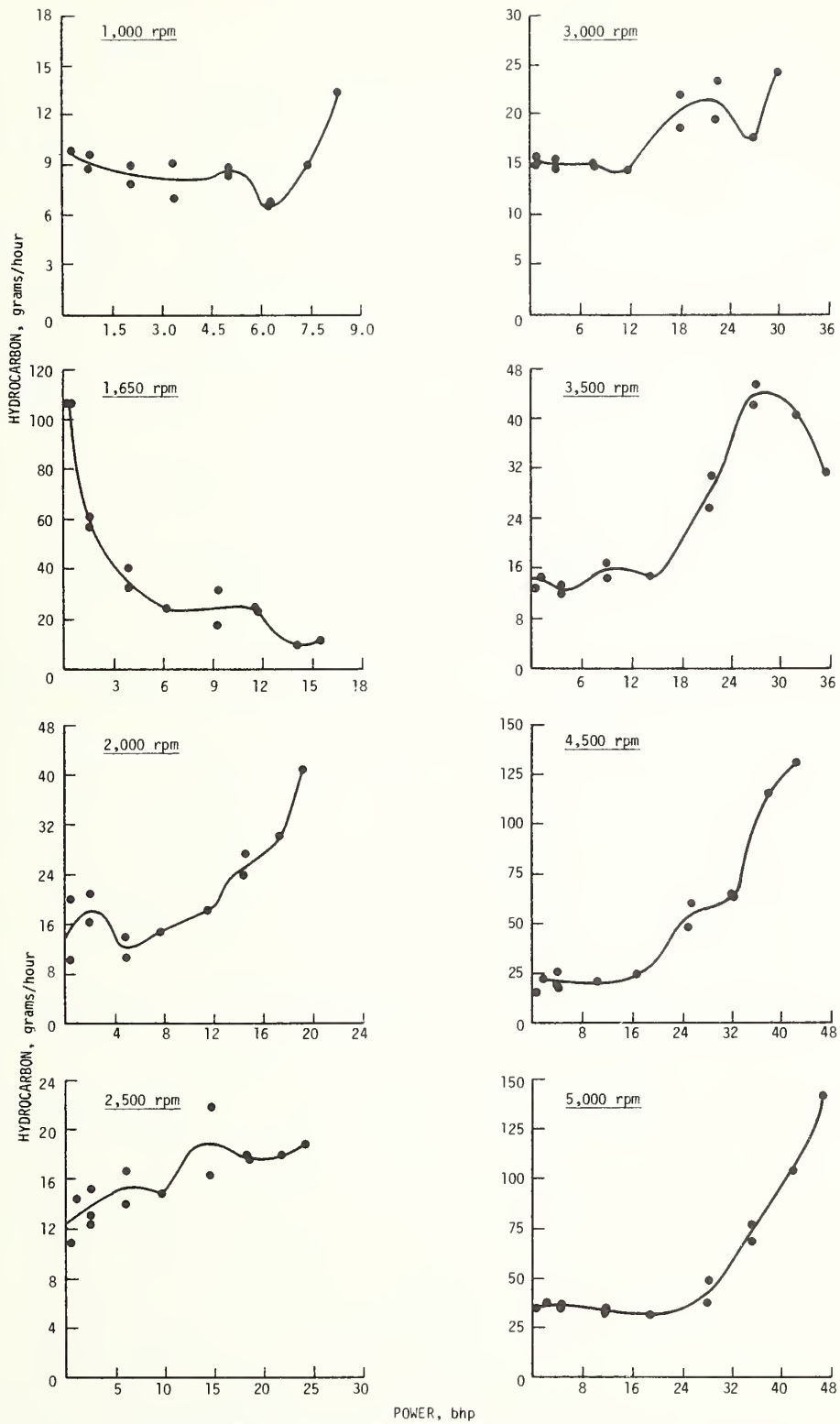


FIGURE 4. Hydrocarbon Emissions Versus Power at Various Speed and Load Conditions-- Volkswagen 90 CID Diesel Engine.

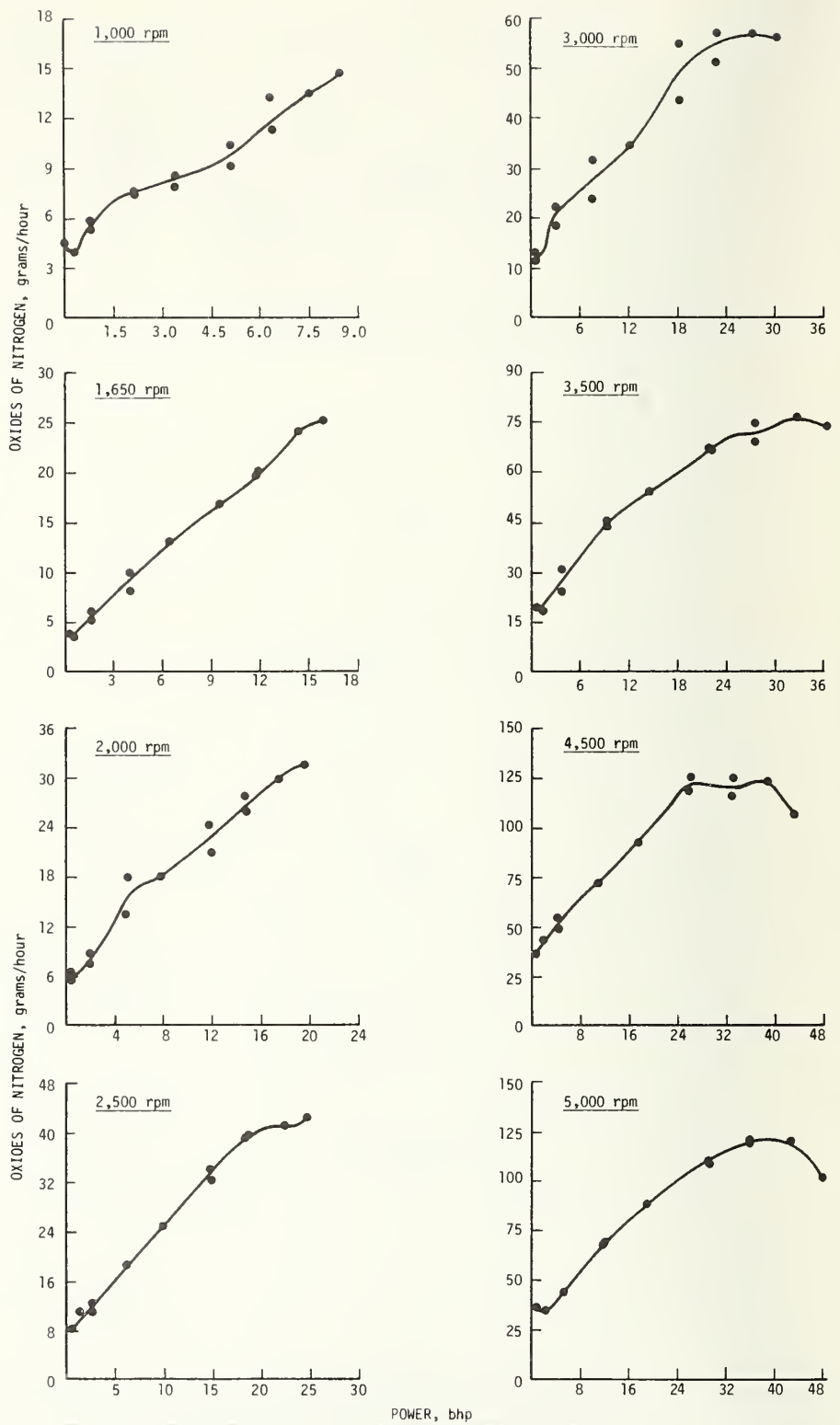


FIGURE 5. Oxides of Nitrogen Emissions Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

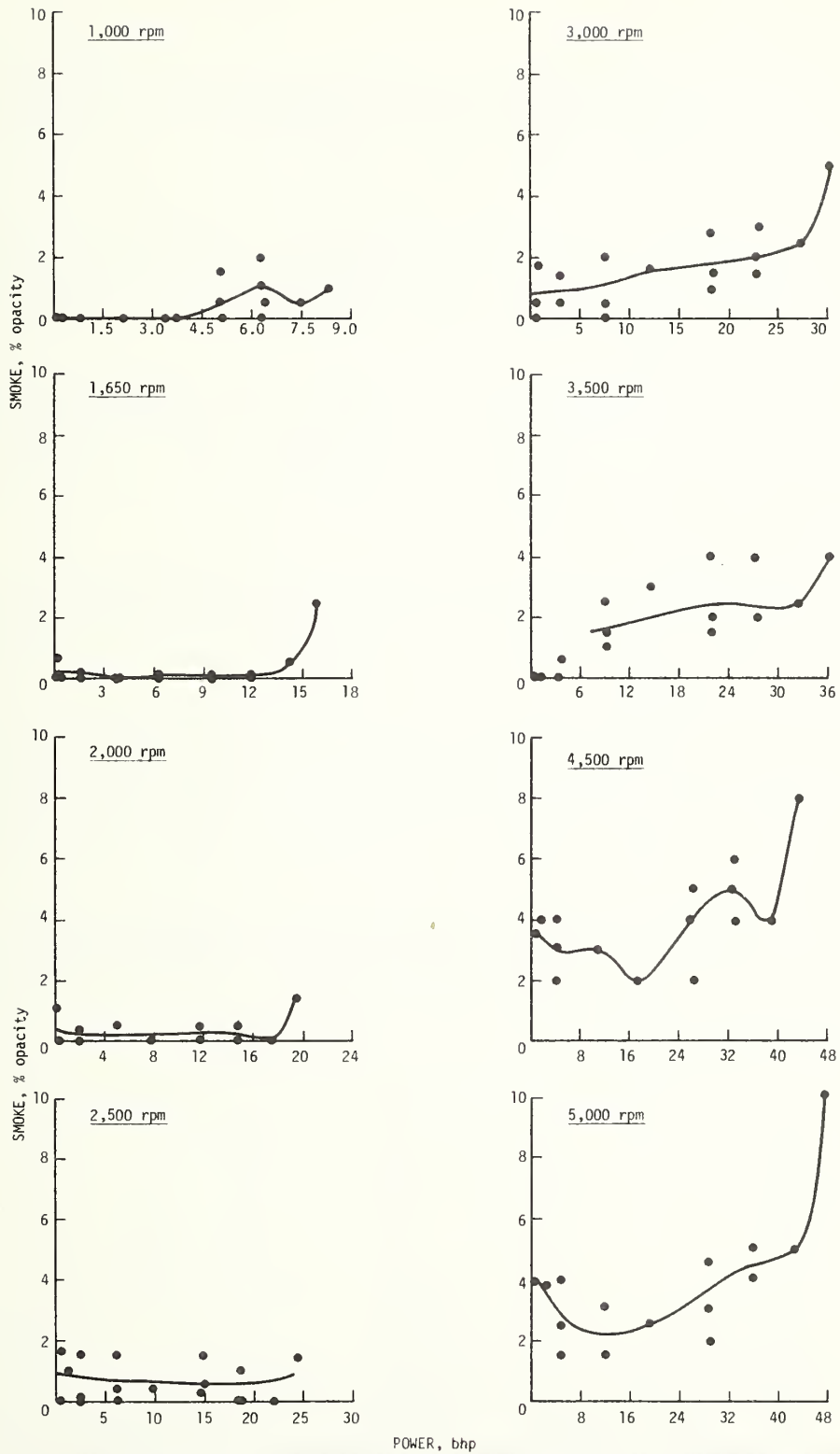


FIGURE 6. Smoke Versus Power at Various Speed and Load Conditions--Volkswagen 90 CID Diesel Engine.

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO₂, %

O₂, %

HC, PPMC

NOX, PPM

SMOKE, % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H₂O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

	1.01	2.01	3.01	4.01	5.01	6.01
	1	1	1	1	1	1
TEST DATE	2/14/78	2/14/78	2/14/78	2/14/78	2/14/78	2/14/78
BAROMETER, MMHG	749.0	749.0	749.0	749.0	749.5	749.5
HUMIDITY, GRAINS/LB	33	33	33	33	33	33
TEMPERATURE, F	73	73	73	72	72	73
ENGINE SPEED, RPM	825	820	800	700	1000	1000
TORQUE, FT-LB	3.4	6.5	13.0	30.6	45.1	40.6
POWER, BHP*	.5	1.0	1.9	4.0	8.4	7.5
FUEL RATE, LB/HR	1.2	1.2	1.5	2.5	4.1	3.6
THROTTLE ANGLE, DEG	.0	.2	.2	1.1	39.5	12.6
CONCENTRATIONS, DRY BASIS						
CO, %	.0499	.0503	.0444	.0343	.0202	.0170
CO ₂ , %	2.66	2.95	3.91	8.03	9.16	8.49
O ₂ , %	17.12	16.63	15.34	9.69	7.62	9.04
HC, PPMC	730	854	1247	605	661	473
NOX, PPM	89	91	99	132	241	235
SMOKE, % OPACITY	1.0	2.5	5.0	2.0	1.0	.5
EMISSION RATES, G/HR						
CO	19.9	17.9	15.3	9.6	8.3	6.6
HC	14.4	14.9	21.1	8.3	13.4	9.0
NOX+	5.3	4.8	5.1	5.5	14.7	13.5
OIL TEMPERATURE, F	155	159	163	139	177	184
OIL PRESSURE, PSI	39	37	33	47	40	35
COOLANT TEMPERATURE, F	161	167	173	145	182	181
EXHAUST PRESSURE, IN. H ₂ O	2.0	2.0	2.0	2.0	2.0	2.0
EXHAUST TEMPERATURE, F	206	220	272	386	590	575
EXHAUST FLOW RATE, LB/HR	77.6	77.5	74.0	75.0	88.2	86.4

* CORRECTED SAE J8168

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPMC

NOX, PPM

SMOKE: % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

7.01	10.01	11.01	12.01	13.01	14.01
1	1	1	1	1	1
2/14/78	2/16/78	2/16/78	3/16/78	2/16/78	2/16/78
749.5	750.0	750.0	750.0	749.6	749.6
33	35	35	35	40	40
73	74	75	75	74	75
1000	1000	1000	1000	1650	1650
33.8	11.3	4.5	1.5	51.5	46.4
6.3	2.1	.8	.3	15.8	14.3
3.3	1.7	1.3	1.1	7.4	6.7
10.8	7.5	6.6	5.6	38.0	20.7
.0192	.0346	.0409	.0540	.0244	.0252
7.06	3.63	2.69	2.22	10.15	8.92
11.05	16.33	17.58	18.26	7.05	8.78
317	445	417	471	324	273
210	124	91	62	248	233
.0	.0	.0	.0	2.5	.5
8.1	14.2	17.5	22.8	16.3	17.2
6.6	9.0	8.8	9.8	10.7	9.2
13.2	7.6	5.8	3.9	25.1	24.1
185	168	172	173	185	205
33	44	39	40	59	46
180	167	173	172	177	182
2.0	2.0	2.0	2.0	11.0	13.0
500	267	234	207	780	760
87.3	95.6	93.9	100.0	248.9	156.9

* CORRECTED SAE J8168

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPMC

NOX, PPM

SMOKE, % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

16.01	17.01	18.01	19.01	20.01	21.01
1	1	1	1	1	1
2/16/78	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78
749.5	749.5	749.5	749.5	749.5	749.5
41	41	41	41	41	33
72	72	72	73	72	76
1650	1650	1650	1650	1650	2000
30.9	20.6	12.9	5.2	.6	52.6
9.5	6.3	4.0	1.6	.2	19.5
4.6	3.5	2.8	2.4	2.1	9.6
17.0	15.0	14.1	13.2	13.0	39.4
.0348	.0528	.0707	.0987	.1130	.0297
6.03	4.39	3.50	2.77	2.13	10.59
12.83	15.09	16.24	16.52	17.27	6.03
490	665	913	1600	2873	994
158	119	92	57	33	257
.2	.0	.0	.2	.6	1.4
24.2	37.9	50.1	70.7	84.5	24.5
16.9	23.6	31.9	56.5	105.9	40.5
16.7	12.9	9.9	6.1	3.7	31.6
181	193	193	190	187	203
61	53	54	56	59	59
183	178	176	175	174	183
5.0	5.0	4.0	4.0	3.0	12.0
517	408	350	301	259	917
155.2	156.4	158.1	157.7	159.7	195.4

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER	22.01	23.01	24.01	25.01	26.01	27.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/16/78	2/16/78	2/16/78	3/16/78	2/16/78	2/16/78
BAROMETER, MMHG	749.5	749.5	749.5	749.5	749.5	749.5
HUMIDITY, GRAINS/LB	33	33	29	29	33	29
TEMPERATURE, F	75	75	75	75	74	74
ENGINE SPEED, RPM	2000	2000	2000	2000	2000	2000
TORQUE, FT-LB	47.3	39.5	31.6	21.0	13.2	5.3
POWER, BHP*	17.5	14.6	11.7	7.8	4.9	2.0
FUEL RATE, LB/HR	8.1	6.9	5.8	4.3	3.4	2.5
THROTTLE ANGLE, DEG	21.1	19.9	18.1	16.1	14.8	13.6
CONCENTRATIONS, DRY BASIS						
CO, %	.0302	.0240	.0239	.0269	.0265	.0373
CO2, %	8.78	7.64	6.27	4.74	3.61	2.50
O2, %	8.00	9.91	11.74	13.82	15.23	16.48
HC, PPMC	724	578	434	354	325	365
NOX, PPM	241	228	196	147	106	55
SMOKE, % OPACITY	.0	.0	.0	.0	.5	.4
EMISSION RATES, G/HR						
CO	25.2	19.8	20.1	22.4	22.6	33.9
HC	29.9	23.6	18.0	14.5	13.7	16.4
NOX+	30.0	27.9	24.4	18.1	13.5	7.4
OIL TEMPERATURE, F	208	210	208	205	202	199
OIL PRESSURE, PSI	55	54	57	59	61	63
COOLANT TEMPERATURE, F	184	182	180	178	178	176
EXHAUST PRESSURE, IN. H2O	10.0	9.0	9.0	8.0	7.0	6.0
EXHAUST TEMPERATURE, F	787	707	598	463	391	306
EXHAUST FLOW RATE, LB/HR	189.2	189.2	192.6	191.1	193.8	192.8

* CORRECTED SAE J8168

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER	29.01	30.01	31.01	32.01	33.01	34.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78	2/16/78
BAROMETER, MMHG	749.5	749.5	749.5	749.5	749.5	749.5
HUMIDITY, GRAINS/LB	35	35	35	35	35	35
TEMPERATURE, F	77	76	76	76	75	75
ENGINE SPEED, RPM	2500	2500	2500	2500	2500	2500
TORQUE, FT-LB	52.8	47.5	39.6	31.7	21.1	13.2
POWER, BHP*	24.5	22.1	18.4	14.7	9.8	6.1
FUEL RATE, LB/HR	12.1	10.3	9.0	7.2	5.6	4.5
THROTTLE ANGLE, DEG	39.5	22.4	20.5	19.0	16.8	15.5
CONCENTRATIONS, DRY BASIS						
CO, %	.0288	.0254	.0271	.0253	.0284	.0285
CO2, %	10.58	8.96	7.61	6.31	4.72	3.73
O2, %	6.33	8.47	10.21	12.18	14.26	15.50
HC, PPMC	367	348	337	315	281	260
NOX, PPM	271	259	242	206	153	112
SMOKE, % OPACITY	1.4	.0	.0	.2	.4	.4
EMISSION RATES, G/HR						
CO	30.1	26.7	29.3	26.5	30.6	31.3
HC	18.9	18.0	18.0	16.3	14.9	14.0
NOX+	42.3	40.7	39.2	32.3	24.6	18.3
OIL TEMPERATURE, F	217	219	220	218	215	211
OIL PRESSURE, PSI	64	63	64	66	60	71
COOLANT TEMPERATURE, F	185	185	183	181	180	178
EXHAUST PRESSURE, IN. H2O	16.0	14.0	13.0	12.0	11.0	11.0
EXHAUST TEMPERATURE, F	996	857	758	640	508	411
EXHAUST FLOW RATE, LB/HR	246.5	245.7	246.6	245.9	246.5	249.7

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

	35.01	36.01	37.01	38.01	39.01	40.01
TEST NUMBER	1	1	1	1	1	1
DATA SOURCE CODE	2/16/78	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78
TEST DATE	749.5	750.8	750.8	750.8	750.8	750.8
BAROMETER, MMHG	35	32	32	32	32	32
HUMIDITY, GRAINS/LB	75	73	75	75	76	75
TEMPERATURE, F	2500	2500	3000	3000	3000	3000
ENGINE SPEED, RPM	5.3	1.0	54.5	49.1	40.9	32.7
TORQUE, FT-LB	2.5	.5	30.3	27.3	22.7	18.2
POWER, BHP*	3.2	2.8	15.4	13.0	11.0	9.2
FUEL RATE, LB/HR	13.4	12.2	39.5	24.3	22.6	21.0
THROTTLE ANGLE, DEG						
CONCENTRATIONS, DRY BASIS						
CO, %	.0286	.0375	.0360	.0402	.0362	.0311
CO2, %	2.74	2.12	10.57	8.79	7.42	6.19
O2, %	16.88	18.03	6.01	8.28	10.61	12.09
HC, PPMC	235	187	369	263	291	277
NOX, PPM	69	47	285	284	256	216
SMOKE, % OPACITY	2	1.6	5.0	2.5	2.0	2.8
EMISSION RATES, G/HR						
CO	30.6	44.4	47.9	54.3	48.9	42.2
HC	12.4	10.9	24.2	17.5	19.4	18.6
NOX+	11.1	8.2	56.3	57.0	51.3	43.5
OIL TEMPERATURE, F	209	202	229	227	229	226
OIL PRESSURE, PSI	73	79	69	72	72	75
COOLANT TEMPERATURE, F	178	181	187	185	184	183
EXHAUST PRESSURE, IN. H2O	10.0	9.0	25.0	23.0	21.0	19.0
EXHAUST TEMPERATURE, F	334	275	1089	920	785	670
EXHAUST FLOW RATE, LB/HR	250.6	253.5	301.9	303.5	304.6	305.9

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807									
TEST NUMBER	41.01	42.01	44.01	45.01	46.01	47.01			
DATA SOURCE CODE	1	1	1	1	1	1			
TEST DATE	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78			
BAROMETER, MMHG	752.8	752.8	751.5	751.5	752.8	751.5			
HUMIDITY, GRAINS/LB	32	32	32	32	32	32			
TEMPERATURE, F	74	74	73	74	75	75			
ENGINE SPEED, RPM	3000	3000	3000	3500	3500	3500			
TORQUE, FT-LB	21.8	13.6	1.5	56.0	50.4	42.0			
POWER, BHP*	12.1	7.5	.8	36.2	32.6	27.2			
FUEL RATE, LB/HR	7.2	5.7	3.4	17.6	15.5	13.2			
THROTTLE ANGLE, DEG	18.3	16.5	13.0	39.5	27.5	25.2			
CONCENTRATIONS, DRY BASIS									
CO, %	.0278	.0315	.0348	.0600	.0549	.0749			
CO2, %	4.66	3.72	2.36	10.67	9.23	7.79			
O2, %	14.88	15.93	18.02	6.33	8.35	10.54			
HC, PPMC	204	219	151	424	541	557			
NOX, PPM	164	115	59	330	337	303			
SMOKE: % OPACITY	1.6	2.0	1.7	4.0	2.5	4.0			
EMISSION RATES, G/HR									
CO	39.2	44.1	45.2	90.3	83.7	114.9			
HC	14.2	15.1	9.7	31.4	40.6	42.2			
NOX+	34.4	23.9	11.4	73.9	76.2	69.1			
OIL TEMPERATURE, F	221	219	202	237	235	233			
OIL PRESSURE, PSI	78	81	89	79	79	82			
COOLANT TEMPERATURE, F	184	182	173	185	185	184			
EXHAUST PRESSURE, IN. H2O	19.0	16.0	14.0	32.0	32.0	30.0			
EXHAUST TEMPERATURE, F	528	430	290	900	880	790			
EXHAUST FLOW RATE, LB/HR	312.7	310.3	311.4	362.6	362.9	360.1			

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7907

TEST NUMBER

DATA SOURCE CODE

TEST DATE

SPIROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPM

NOX, PPM

SMOKE, % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

48.01	49.01	51.01	52.01	53.01	54.01
1	1	1	1	1	1
2/17/78	2/17/78	2/17/78	2/17/78	2/17/78	2/17/78
751.5	751.5	752.8	752.8	752.8	752.8
32	32	32	32	32	32
75	74	75	76	80	77
3500	3500	3500	3500	4500	4500
33.6	22.4	5.6	2.2	52.0	46.8
21.7	14.5	3.6	1.4	43.2	38.9
11.1	8.6	5.1	4.3	23.3	20.7
22.5	19.4	14.6	13.3	39.6	28.1
.0425	.0341	.0343	.0390	.1618	.1220
6.39	5.01	2.99	2.56	11.52	9.75
12.44	14.45	16.79	17.33	5.38	7.96
329	191	177	193	1471	1238
287	233	105	82	400	434
4.0	3.0	.0	.0	8.0	4.0
67.0	53.4	52.6	59.3	293.3	232.2
25.6	14.7	13.4	14.4	131.5	116.3
67.2	54.0	24.0	18.5	107.7	122.8
237	234	198	219	262	260
80	83	95	88	78	80
183	181	170	181	188	186
28.0	25.0	18.0	18.0	60.0	53.0
675	540	349	333	1215	1035
359.8	363.0	364.7	364.9	452.7	453.3

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THRUSTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO₂, %

O₂, %

HC, PPMC

NOX, PPM

SMOKE: % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H₂O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

56.01	57.01	58.01	59.01	60.01	61.01
1	1	1	1	1	1
2/17/78	2/17/78	2/17/78	2/17/78	2/17/78	2/21/78
752.8	752.8	752.8	752.8	752.8	745.0
32	32	32	32	32	31
76	75	74	74	74	77
4500	4500	4500	4500	4500	5000
31.0	20.8	13.0	5.2	2.2	51.0
25.7	17.3	10.8	4.3	1.8	47.6
14.8	11.6	9.4	7.3	6.9	27.6
22.3	18.6	15.7	13.6	12.6	39.4
.0820	.0566	.0500	.0520	.0592	.3212
6.95	5.48	4.43	3.38	3.05	12.88
11.53	13.71	15.17	16.57	16.99	3.27
509	256	217	204	219	1505
415	323	250	171	144	360
4.0	2.0	3.0	3.0	4.0	10.0
157.3	108.5	96.0	100.9	119.2	610.0
48.2	24.2	20.5	19.6	21.7	141.0
118.4	91.9	71.5	49.4	43.0	101.2
257	254	251	249	246	264
82	84	85	86	87	82
183	182	183	181	181	187
45.0	40.0	37.0	34.0	33.0	69.0
740	601	506	436	416	1337
450.7	449.1	450.1	449.6	449.9	470.8

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1979 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER	62.01	63.01	64.01	65.01	66.01	67.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78
BAROMETER, MMHG	749.8	745.0	745.0	745.0	745.0	745.0
HUMIDITY, GRAINS/LB	31	31	31	31	31	31
TEMPERATURE, F	76	76	76	76	75	75
ENGINE SPEED, RPM	5000	5000	5000	5000	5000	5000
TORQUE, FT-LB	45.9	38.3	30.6	20.4	12.8	5.1
POWER, BHP*	42.6	35.8	28.6	19.0	11.9	4.8
FUEL RATE, LB/HR	24.7	19.9	16.6	13.6	11.2	9.2
THROTTLE ANGLE, DEG	.0	.0	.0	.0	.0	.0

CONCENTRATIONS, DRY BASIS

CO, %	1388	1057	0737	0672	0764	0898
CO2, %	11.10	8.88	7.56	6.08	4.95	3.97
O2, %	5.65	8.55	10.40	12.38	13.84	15.07
HC, PPMC	1048	765	378	313	323	362
NOX, PPM	401	400	373	298	228	143
SMOKE % OPACITY	5.0	4.0	3.0	2.5	3.0	4.0

EMISSION RATES, G/HR

CO	278.2	213.3	146.8	135.9	155.3	185.2
HC	103.5	76.1	37.1	31.2	32.3	36.8
NOX+	119.0	119.6	110.0	89.3	68.7	43.7
OIL TEMPERATURE, F	252	262	265	260	256	255
OIL PRESSURE, PSI	86	83	83	85	85	87
COOLANT TEMPERATURE, F	188	185	183	182	181	180
EXHAUST PRESSURE, IN. H2O	61.0	53.0	50.0	46.0	43.0	40.0
EXHAUST TEMPERATURE, F	1143	936	820	685	597	515
EXHAUST FLOW RATE, LB/HR	474.7	467.0	465.2	466.0	466.6	465.3

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO₂, %

O₂, %

HC, PPM

NOX, PPM

SMOKE % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H₂O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

68.01	69.01	70.01	71.01	72.01	74.01
1	1	1	1	1	1
2/21/78	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78
745.0	745.0	745.0	745.0	745.0	745.0
31	33	33	33	33	33
75	75	74	74	74	74
5000	800	800	800	700	1000
2.5	1.8	6.5	13.0	22.0	27.1
2.3	3	1.0	1.9	2.9	5.1
8.5	1.0	1.2	1.5	2.1	2.6
0	0	2	1.7	0	10.7
0.974	0.507	0.466	0.409	0.340	0.306
3.64	2.54	3.13	4.05	6.84	5.93
15.43	17.66	16.71	15.43	11.62	12.83
367	387	436	450	448	424
115	88	111	134	134	175
3.8	0	0	5	2.0	1.5
202.0	18.0	15.8	13.9	9.4	12.3
37.5	6.8	7.3	7.5	6.1	8.4
35.4	4.6	5.6	6.8	5.5	10.4
254	176	168	166	165	175
87	29	32	33	28	37
180	168	166	167	170	178
39.0	0	0	0	0	1.0
501	208	210	236	303	326
466.2	74.4	73.3	72.4	60.1	93.7

* CORRECTED SAE J8168

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

SAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THRUSTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPM

NOX, PPM

SMOKE, % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

75.01	76.01	78.01	79.01	80.01	81.01
1	1	1	1	1	1
2/21/78	2/21/78	2/21/78	2/21/78	2/21/78	2/21/78
745.0	745.0	745.0	745.0	745.0	745.0
33	33	33	33	33	31
74	74	74	74	74	74
1000	1000	1650	1650	1650	1650
11.3	4.5	38.6	30.9	12.9	5.2
2.1	.8	11.9	9.5	4.0	1.6
1.7	1.3	5.6	4.8	3.0	2.4
7.5	5.7	38.6	16.4	13.6	12.8
.0393	.0519	.0406	.0463	.0683	.0912
3.51	2.53	7.31	5.87	3.37	2.60
15.91	17.09	10.75	12.62	15.74	16.64
377	437	665	857	1049	1587
118	79	193	154	72	44
.0	.0	.1	.0	.0	.0
16.6	23.2	28.3	34.0	52.4	71.1
7.9	9.6	22.9	31.1	39.7	61.1
7.4	5.3	20.0	16.8	8.2	5.1
177	171	183	188	187	186
37	40	56	55	58	59
175	168	182	179	175	173
.0	.0	4.0	4.0	4.0	3.0
266	195	634	519	355	305
96.5	94.9	154.1	156.8	158.5	159.8

* CORRECTED SAE J816B
+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPMC

NOX, PPM

SMOKE % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

82.01	1	86.01	1	87.01	1	89.01	1	90.01	1	91.01	1
2/21/78		2/22/78		2/22/78		2/22/78		2/22/78		2/22/78	
745.0	35	745.5	35	745.5	35	745.5	35	745.5	35	745.5	39
	74		76		76		77		76		76
1650		2000		2000		2500		2500		2500	
1.6		5.3		1.1		31.7		13.2		5.3	
.5		2.0		.4		14.8		6.2		2.5	
2.2		2.5		2.0		7.3		4.4		3.3	
12.4		13.4		12.6		18.8		15.7		13.9	
.0976		.0276		.0360		.0255		.0312		.0336	
2.08		2.53		2.07		6.17		3.58		2.79	
17.17		17.17		17.71		12.34		15.43		16.76	
2553		479		457		409		306		288	
28		66		43		210		113		77	
.0		.0		.0		1.5		1.5		1.5	
82.3		24.2		31.3		27.7		34.3		35.8	
106.2		20.7		19.6		21.8		16.6		15.1	
3.5		8.6		5.5		34.0		18.5		12.4	
184		200		197		217		210		209	
60		63		66		65		72		71	
173		177		176		183		181		181	
3.0		8.0		8.0		13.0		12.0		9.0	
260		290		249		616		385		321	
158.4		195.7		195.3		248.0		250.4		252.5	

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPMC

NOX, PPM

SMOKE: % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

92.01	93.01	94.01	96.01	97.01	98.01
1	1	1	1	1	1
2/22/78	2/22/78	2/22/78	2/22/78	3/22/78	2/22/78
745.5	745.5	745.5	745.5	745.5	745.5
39	39	39	39	39	39
76	76	77	76	76	79
2500	3000	3000	3000	3000	3500
2.6	40.9	32.7	5.5	1.2	42.0
1.2	22.9	18.3	3.1	.7	27.5
3.1	11.4	9.5	4.6	3.4	13.7
13.5	23.0	21.3	14.7	13.0	25.3
.0339	.0357	.0348	.0332	.0324	.0745
2.56	7.86	6.48	3.02	2.25	8.22
16.99	9.86	11.57	16.14	16.99	9.83
273	359	335	217	222	611
67	288	274	107	65	328
1.0	1.5	1.0	.5	.5	2.0
36.3	47.1	46.3	45.3	44.3	112.3
14.4	23.3	22.0	14.6	15.0	45.4
10.8	57.4	55.0	22.0	13.3	74.6
207	221	228	217	215	229
73	76	74	83	83	82
179	184	184	180	180	185
9.0	20.0	20.0	15.0	13.0	31.0
302	755	663	344	286	817
246.9	305.0	304.1	306.1	307.0	356.6

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VM 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO₂, %

O₂, %

HC, PPM

NO_x, PPM

SMOKE % OPACITY

EMISSION RATES, G/HR

CO

HC

NO_x†

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H₂O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

	99.01	100.01	101.01	102.01	103.01	104.01
	1	1	1	1	1	1
2/22/78	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78
745.5	745.5	745.5	745.5	745.5	745.5	745.5
38	38	38	38	43	43	43
79	77	76	76	78	78	78
3500	3500	3500	3500	4500	4500	4500
33.6	14.0	5.6	.8	39.0	31.0	31.0
22.0	9.2	3.7	.5	32.8	26.1	26.1
11.3	7.2	5.5	4.3	17.9	15.3	15.3
22.6	17.2	15.0	13.3	25.2	22.8	22.8
.0428	.0315	.0310	.0362	.0999	.0823	.0823
6.91	4.21	3.18	2.49	8.87	7.48	7.48
11.56	15.11	16.34	17.13	9.06	10.58	10.58
417	185	155	164	723	658	658
299	197	130	84	418	443	443
1.5	1.0	.0	.0	6.0	5.0	5.0
63.7	49.3	48.3	56.4	182.1	152.2	152.2
30.6	14.3	11.9	12.6	65.0	60.0	60.0
66.9	46.3	30.6	19.6	116.1	124.8	124.8
238	231	228	226	236	255	255
76	83	85	85	89	82	82
186	186	180	180	188	186	186
29.0	22.0	21.0	20.0	48.0	45.0	45.0
718	457	374	319	896	791	791
354.1	353.7	357.4	358.1	447.3	445.6	445.6

* CORRECTED SAE J8168

† CORRECTED FOR HUMIDITY

ENGINE: 1378 VW 90-CID DIESEL
 FUEL CODE: 7807

TEST NUMBER	105.01	106.01	107.01	108.01	112.01	113.01
DATA SOURCE CODE	1	1	1	1	1	1
TEST DATE	2/22/78	2/22/78	2/22/78	2/22/78	2/22/78	3/9/78
BAROMETER, MMHG	745.5	745.5	745.5	745.5	745.5	744.0
HUMIDITY, GRAINS/LB	43	43	43	43	43	34
TEMPERATURE, F	77	76	76	77	77	75
ENGINE SPEED, RPM	4500	4500	4500	5000	5000	5200
TORQUE, FT-LB	13.0	5.2	.8	38.3	.5	47.0
POWER, BHP*	10.9	4.4	.7	35.8	.5	45.8
FUEL RATE, LB/HR	9.9	8.2	6.5	20.3	8.4	28.7
THROTTLE ANGLE, DEG	15.2	13.4	12.0	28.3	12.6	38.0
CONCENTRATIONS, DRY BASIS						
CO, %	.0551	.0511	.0503	.1094	.0947	.0050
CO2, %	4.72	3.83	3.10	9.42	3.68	12.95
O2, %	14.24	15.33	16.18	7.78	15.26	3.03
HC, PPM	218	185	161	709	349	212
NOX, PPM	251	190	129	408	119	458
SMOKE % OPACITY	3.0	4.0	3.5	5.0	4.0	.0
EMISSION RATES, G/HR						
CO	104.2	98.2	95.2	213.0	190.8	10.1
HC	20.3	17.5	15.0	68.0	34.7	21.2
NOX+	72.2	55.5	37.1	121.0	36.5	138.6
OIL TEMPERATURE, F	248	247	245	256	257	260
OIL PRESSURE, PSI	85	86	87	84	86	84
COOLANT TEMPERATURE, F	184	182	180	186	181	.187
EXHAUST PRESSURE, IN. H2O	36.0	34.0	32.0	56.0	40.0	21.0
EXHAUST TEMPERATURE, F	546	469	409	959	513	1280
EXHAUST FLOW RATE, LB/HR	443.3	443.1	443.1	470.0	463.3	485.6

* CORRECTED SAE J816B
 + CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAMS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THRUSTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPMC

NOX, PPM

SMOKE % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX†

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

118.01	119.01	123.01	124.01	125.01	127.01
1	1	1	1	1	1
2/23/78	2/23/78	2/23/78	2/23/78	2/24/78	2/24/78
748.7	749.9	748.7	748.7	739.5	739.5
41	43	43	43	51	51
77	77	76	77	81	76
1000	1650	2000	2000	2000	2000
.2	38.6	39.5	31.6	13.2	1.1
.0	11.8	14.7	11.8	5.0	.4
1.1	5.6	6.9	5.6	3.3	2.0
4.4	17.5	18.2	16.5	13.6	11.6
.0460	.0404	.0299	.0291	.0260	.0298
2.23	7.64	7.56	6.31	3.37	2.01
17.57	10.79	10.56	12.08	15.86	17.53
301	716	662	459	237	224
69	192	205	169	128	49
.0	.0	.5	.0	.5	.0
19.5	27.0	24.8	23.6	23.3	26.9
6.3	23.6	27.0	18.3	10.5	10.0
4.4	19.5	25.9	20.9	17.8	6.9
179	171	203	205	203	197
36	71	59	56	60	64
170	173	180	182	179	175
.0	6.0	9.0	8.0	7.0	6.0
225	633	686	586	355	241
95.7	158.1	196.4	195.1	195.5	194.2

* CORRECTED SAE J816B

† CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO₂, %

O₂, %

HC, PPMC

NOX, PPM

SMOKE, % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H₂O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

128.01	131.01	135.01	136.01	137.01	140.01
1	1	1	1	1	1
2/24/78	2/24/78	2/24/78	2/24/78	2/24/78	2/24/78
739.5	739.5	739.5	739.5	739.5	739.5
51	46	46	46	46	46
77	76	77	77	76	77
2500	2500	3000	3000	3000	3500
39.6	5.3	13.6	5.5	1.2	14.0
18.7	2.5	7.7	3.1	.7	9.2
9.1	3.2	5.4	4.1	3.3	6.9
19.4	12.6	15.0	13.1	12.0	16.1
.0297	.0396	.0335	.0344	.0408	.0362
7.30	2.66	3.72	2.72	2.30	4.07
10.37	17.15	15.60	16.77	17.33	14.90
315	244	230	237	252	220
224	64	157	89	67	186
.0	.0	.0	.5	.0	1.5
33.6	43.1	43.8	46.2	52.2	55.9
17.6	13.1	14.9	15.7	15.9	16.8
39.5	10.7	31.4	18.4	13.0	44.0
214	210	225	221	218	235
66	70	75	78	80	82
184	179	180	179	179	180
14.0	12.0	17.0	16.0	15.0	5.0
726	326	421	340	297	460
248.1	250.2	304.5	306.2	306.4	357.5

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER 1

DATA SOURCE CODE 1

TEST DATE 2/24/78

BAROMETER, MMHG 739.5

HUMIDITY, GRAINS/LB 46

TEMPERATURE, F 77

ENGINE SPEED, RPM 4500

TORQUE, FT-LB 39.0

POWER, BHP* 33.1

FUEL RATE, LB/HR 17.5

THROTTLE ANGLE, DEG 23.0

CONCENTRATIONS, DRY BASIS

CO, % .0895

CO2, % 8.36

O2, % 9.33

HC, PPMC 686

NOX, PPM 431

SMOKE, % OPACITY 4.0

EMISSION RATES, G/HR

CO 169.1

HC 63.9

NOX+ 124.6

OIL TEMPERATURE, F 240

OIL PRESSURE, PSI 87

COOLANT TEMPERATURE, F 187

EXHAUST PRESSURE, IN. H2O 48.0

EXHAUST TEMPERATURE, F 877

EXHAUST FLOW RATE, LB/HR 445.7

142.01	144.01	145.01	146.01	147.01	148.01
1	1	1	1	1	1
2/24/78	2/24/78	2/24/78	2/24/78	2/24/78	2/27/78
739.5	739.5	739.5	739.5	739.5	741.0
46	46	46	46	46	61
77	77	77	77	77	76
4500	4500	5000	5000	5000	1000
39.0	5.2	30.6	12.8	5.1	33.8
33.1	4.4	28.8	12.1	4.8	6.4
17.5	7.9	17.1	11.0	9.0	3.1
23.0	12.7	26.2	21.5	20.6	10.8
.0895	.0580	.0767	.0741	.0866	.0313
8.36	3.68	7.80	4.96	3.95	7.00
9.33	15.71	10.15	13.91	15.15	11.21
686	270	495	366	347	340
431	183	358	228	143	177
4.0	2.0	2.0	1.5	1.5	.5
169.1	112.3	151.9	147.6	176.0	12.6
63.9	25.8	48.3	36.0	34.8	6.8
124.6	54.3	108.6	69.7	44.6	11.3
240	249	261	262	258	181
87	85	83	83	85	35
187	181	187	182	182	181
48.0	.0	51.0	45.0	43.0	2.0
877	488	851	629	543	480
445.7	440.8	465.3	461.5	461.8	93.4

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL

FUEL CODE: 7807

TEST NUMBER

DATA SOURCE CODE

TEST DATE

BAROMETER, MMHG

HUMIDITY, GRAINS/LB

TEMPERATURE, F

ENGINE SPEED, RPM

TORQUE, FT-LB

POWER, BHP*

FUEL RATE, LB/HR

THROTTLE ANGLE, DEG

CONCENTRATIONS, DRY BASIS

CO, %

CO2, %

O2, %

HC, PPM

NOX, PPM

SMOKE % OPACITY

EMISSION RATES, G/HR

CO

HC

NOX+

OIL TEMPERATURE, F

OIL PRESSURE, PSI

COOLANT TEMPERATURE, F

EXHAUST PRESSURE, IN. H2O

EXHAUST TEMPERATURE, F

EXHAUST FLOW RATE, LB/HR

149.01	156.01	157.01	159.01
2/27/78	2/27/78	2/27/78	3/ 6/78
741.0	740.0	740.0	745.0
46	46	42	33
76	76	76	74
1000	1000	1000	1650
27.1	18.2	18.0	30.9
5.1	3.4	3.4	9.5
2.7	2.0	1.9	4.8
10.0	7.7	8.0	16.4
.0363	.0301	.0334	.0463
5.80	4.56	4.62	5.87
12.81	15.34	15.48	12.62
429	349	505	857
141	138	143	154
.0	.0	.0	.0
15.4	12.2	12.3	34.0
9.0	7.0	9.2	31.1
9.1	8.6	8.0	16.8
181	182	177	188
36	34	38	55
176	177	173	179
2.0	3.0	3.0	4.0
418	336	348	519
95.8	96.2	95.5	156.8

* CORRECTED SAE J8168

+ CORRECTED FOR HUMIDITY

ENGINE: 1978 VW 90-CID DIESEL MOTORING DATA

	164.01	165.01	166.01	167.01	168.01	169.01
FUEL CODE: 7807	1	1	1	1	1	1
TEST NUMBER	3/16/78	3/16/78	3/16/78	3/16/78	3/16/78	3/16/78
DATA SOURCE CODE	753.8	753.8	753.8	753.2	753.2	753.2
BAROMETER, MMHG	39	67	39	39	39	39
HUMIDITY, GRAINS/LB	74	74	74	74	74	74
TEMPERATURE, F	1000	1500	2000	1000	1500	2000
ENGINE SPEED, RPM	-20.0	-22.4	-23.4	-20.2	-21.4	-23.8
TORQUE, FT-LB	3.7	6.1	8.6	3.7	5.9	8.8
POWER BHP*	2	0	0	0	0	1
FUEL RATE, LB/HR	5	5	5	5	5	5
THROTTLE ANGLE, DEG						
CONCENTRATIONS, DRY BASIS						
CO, %	0305	0032	0152	0000	0000	0000
CO2, %	17	08	14	01	01	01
O2, %	20.61	20.78	20.70	21.00	21.00	21.00
HC, PPMC	1128	469	705	1	1	1
NOX, PPM	6	3	3	1	1	1
SMOKE % OPACITY	0	0	0	0	0	0
EMISSION RATES, G/HR						
CO	18.9	0	4	0	0	0
HC	34.6	0	8	0	0	4
NOX+	5	0	0	0	0	1.2
OIL TEMPERATURE, F	174	171	176	180	184	184
OIL PRESSURE, PSI	39	66	85	36	55	75
COOLANT TEMPERATURE, F	165	165	167	173	173	172
EXHAUST PRESSURE, IN. H2O	1.0	1.0	1.0	1.0	1.0	1.0
EXHAUST TEMPERATURE, F	173	100	94	80	82	89
EXHAUST FLOW RATE, LB/HR	57.5	0	202.2	0	0	202.2

* CORRECTED SAE J816B

+ CORRECTED FOR HUMIDITY

HE 18.5

.A34

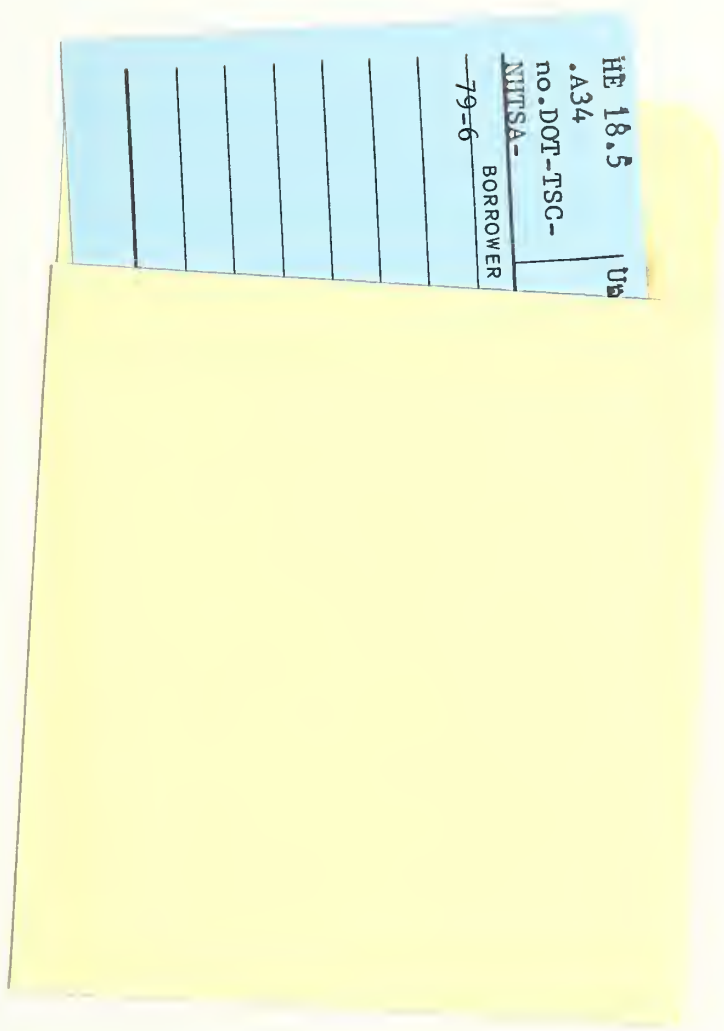
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Aug 17, 2015

