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ENGINE PERFORMANCE TEST OF THE
1975 CHRYSLER - NISSAN MODEL CN633
DIESEL ENGINE

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INTERIM REPORT

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N O T I C E

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16. Abstract An engine test of the Chrysler-Nissan Model CN633 diesel engine was performed to determine its steady-state fuel consumption and emissions (HC, CO, NO _x) maps. The data acquired are summarized in this report.		13. Type of Report and Period Covered Interim Report June 1975
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PREFACE

This report, prepared by the U.S. Energy Research and Development Administration, Bartlesville Energy Research Center for the U.S. Department of Transportation, Transportation Systems Center, Power and Propulsion Branch, Cambridge MA, presents results of an automobile engine test. This represents only the second of a series of 1975 engines to be tested.

Mr. Ralph G. Colello is the technical monitor on this project.

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1. INTRODUCTION

This report presents the data acquired from tests of a Nissan diesel engine, Model CN633. This engine is imported by Chrysler and is marketed as a Chrysler-Nissan Model CN633. The test results are sufficient to establish the steady-state maps for fuel consumption and emissions (CO, HC, NO_x) over the engine's entire operating range. This engine is one out of a series of engines tested or to be tested.

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

TABLE 3. ENGINE BREAK-IN SCHEDULE

Engine speed, rpm	Torque, lb/ft	Time in mode, hr
1,280	12	1
1,600	12	1
1,600	24	2
1,920	24	2
1,920	36	2
2,240	36	2
2,240	48	2
2,560	48	2
2,560	60	2
2,720	60	2
2,720	72	2
2,880	72	1
2,880	84	1
3,040	84	1
3,200	96	1

Throttle angle, degrees
 CO, ppm -- Beckman NDIR
 CO₂, 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. H₂O
 Smoke, pct opacity -- Celesco in-line smokemeter
 Air flow, lb/min -- Merrian 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). The following equations were applied in the computations:

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

$$\text{Humidity (grains H}_2\text{O/lb dry air)} = \frac{4348 (H_2O)}{\text{Baro} - H_2O}$$

$$\text{Power (bhp)} = \left(\frac{\text{Speed} \times \text{Torque}}{5252} \right) \left(\frac{736.6}{\text{Baro} - H_2O} \right) \left(\frac{t_{\text{air}} + 460}{545} \right)^{0.5}$$

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

$$\text{Mass CO} = (\text{exhaust flow rate}) \times (\text{concentration CO})$$

$$\times \left(\frac{\text{Mol. wt. CO}}{\text{Mol. wt. exhaust}} \right) \times (\text{correction for water removal})$$

$$\text{Mass CO} = .0263 (\text{exhaust rate}) (\text{ppm CO}) \left[\frac{1}{1 + .03 \text{CO}_2 \left(\frac{\text{CO} + \text{CO}_2}{\text{CO} + 3\text{CO}_2} \right)} \right]$$

$$\text{Mass HC} = .0132 (\text{exhaust rate}) (\text{ppmC HC})$$

$$\text{Mass NO}_x = .0432 (\text{exhaust rate}) (\text{ppm NO}_x) \left[\frac{1}{1 + .03 \text{CO}_2 \left(\frac{\text{CO} + \text{CO}_2}{\text{CO} + 3\text{CO}_2} \right)} \right]$$

x (humidity correction factor), K_H

$$K_H = \frac{1}{1 - .0047 (H-75)}$$

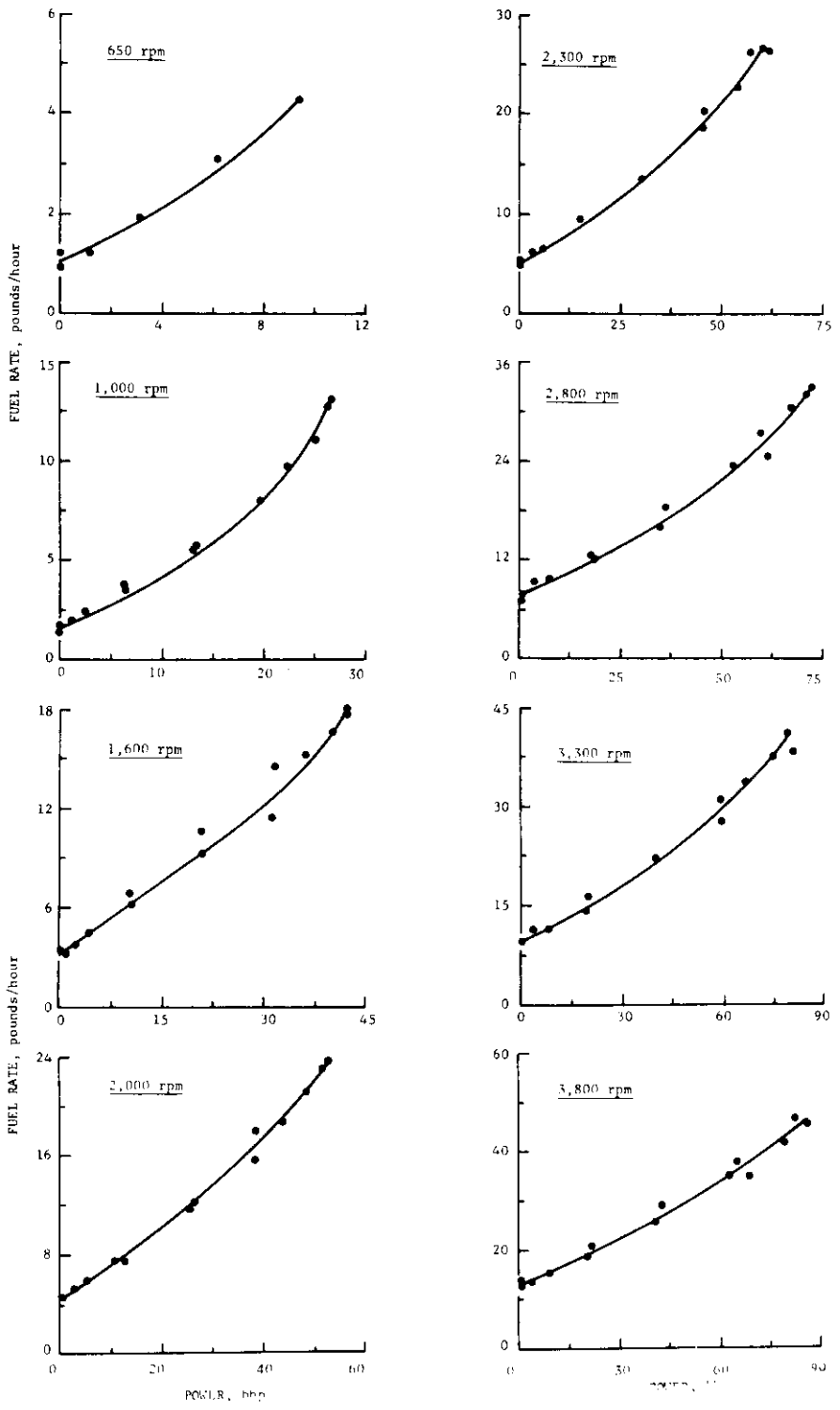


Figure 1. - Fuel Rate at Various Speed and Load Conditions--
Nissan CN633 Diesel Engine.

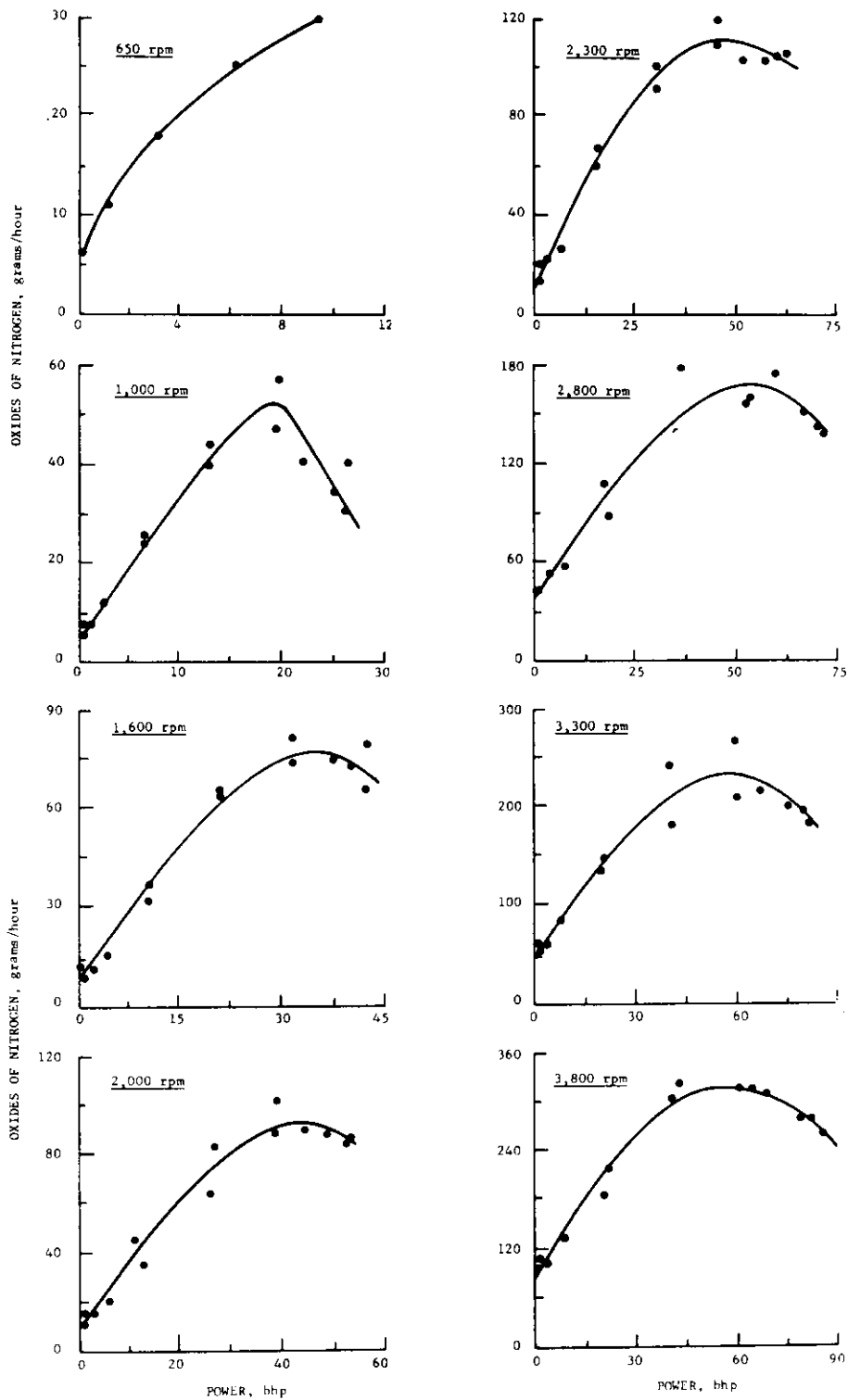


Figure 3. - Oxides of Nitrogen Emissions at Various Speed and Load Conditions--Nissan CN633 Diesel Engine.

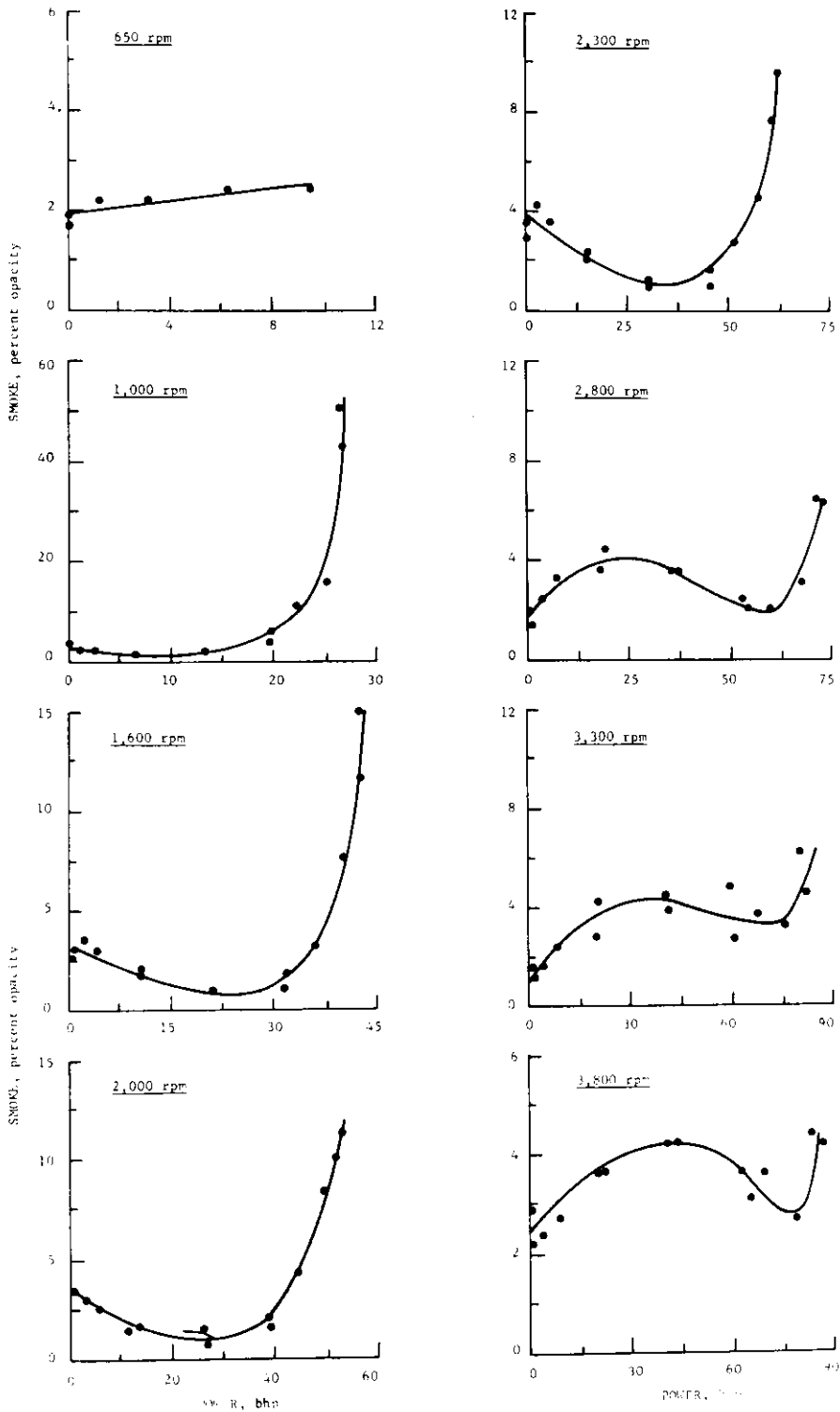


Figure 5. - Smoke Level at Various Speed and Load Conditions--
Nissan CN633 Diesel Engine.

4. CONCLUSIONS

Repeatability of emission rate and fuel consumption data were satisfactory for purposes of this test.

Highway diesel, 193-CID
7557

	104 5/15/75	103 5/15/75	111 5/ 9/75	100 5/15/75	10 5/ 9/75	9 5/ 9/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	743.8	743.8	745.5	743.8	740.2	740.2
Humidity, grains/lb.....	81	81	81	81	64	64
Temperature, F.....	78	78	80	78	81	77
Engine speed, rpm.....	650	650	1000	1000	1000	1000
Torque, lb-ft.....	50.0	76.0	1.2	.8	6.8	13.6
Power, bhp*.....	6.2	9.4	.2	.2	1.3	2.6
Fuel rate, lb/hr.....	3.1	4.3	1.7	1.4	2.0	2.4
Ignition timing, deg BTC.....						
Manifold vacuum, in Hg.....	8.5	12.0	11.0	11.5	11.0	12.0
Throttle angle, deg.....						
Concentrations, dry basis:						
CO, %.....	.0159	.0116	.0594	.0532	.0496	.0375
CO2, %.....	5.17	7.18	2.00	1.91	2.43	2.74
O2, %.....						
HC, ppmC.....	163	172	827	567	597	294
NOx, ppm.....	240	290	39	45	55	89
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	9.8	7.0	56.7	51.0	44.4	34.0
HC.....	5.0	5.2	39.6	27.3	26.9	13.4
NOx**.....	24.9	29.7	6.3	7.3	7.7	12.6
Oil temperature, F.....	167	166	172	170	181	170
Oil pressure, psi.....	28	28	37	40	34	38
Coolant temperature, F.....	167	170	165	167	168	167
Exhaust temperature, F.....	227	199	213	156	258	250
Exhaust pressure, in H2O.....	1.0	1.0	2.6	1.0	2.5	2.9
Exhaust flow, lb/min.....	2.45	2.47	3.71	3.72	3.49	3.54
Smoke, % opacity.....	2.4	2.4	3.6	2.4	2.7	2.4

* Corrected - SAE J3169.
** Corrected for humidity.

Nissan diesel, 198-CID
7557

	5/ 8/75	4/ 8/75	3/ 8/75	96/ 5/15/75	20/ 5/ 9/75	95/ 5/15/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	740.2	740.2	740.2	743.8	745.5	743.8
Humidity, grains/lb.....	64	64	64	81	81	81
Temperature, F.....	86	85	84	77	88	76
Engine speed, rpm.....	1000	1000	1000	1000	1600	1600
Torque, lb-ft.....	115.4	129.2	136.2	139.0	1.8	.8
Power, bhp*.....	22.2	24.9	26.2	26.5	.6	.2
Fuel rate, lb/hr.....	9.7	11.1	12.7	13.1	3.1	3.3
Ignition timing, deg BTC.....						
Manifold vacuum, in Hg.....	26.0	29.0	36.0	36.5	17.0	16.5
Throttle angle, deg.....						
Concentrations, dry basis:						
CO, %.....	.0987	.1854	1.3445	.9816	.0730	.0680
CO2, %.....	11.25	13.09	13.89	13.62	2.05	2.00
O2, %.....						
HC, ppmC.....	357	485	1843	2202	1764	1245
NOx, ppm.....	370	320	245	275	42	50
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	68.5	127.9	1066.1	845.0	101.8	106.6
HC.....	12.4	16.8	73.3	95.1	123.5	98.0
NOx**.....	40.1	34.5	30.3	40.0	9.9	13.2
Oil temperature, F.....	178	174	172	174	181	179
Oil pressure, psi.....	37	37	37	37	46	47
Coolant temperature, F.....	165	174	174	165	168	169
Exhaust temperature, F.....	752	866	912	532	244	181
Exhaust pressure, in H2O.....	6.1	7.1	7.9	8.5	5.0	6.0
Exhaust flow, lb/min.....	2.94	2.97	3.46	3.74	5.42	6.09
Smoke, % opacity.....	11.2	15.7	50.7	43.0	3.1	2.7

* Corrected - SAE J816b.
** Corrected for humidity.

Nissan diesel, 19G-CID
7557

Engine.....
Fuel.....

	15 5/ 9/75	92 5/15/75	14 5/ 9/75	13 5/ 9/75	12 5/ 9/75	91 5/15/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	745.5	743.8	745.5	745.5	745.5	743.8
Humidity, grains/lb.....	81	81	81	81	81	81
Temperature, F.....	89	77	88	85	83	78
Engine speed, rpm.....	1600	1600	1600	1600	1600	1600
Torque, lb-ft.....	101.8	102.2	116.0	130.0	137.0	138.4
Power, bhp*.....	31.5	31.2	35.8	40.0	42.0	42.3
Fuel rate, lb/hr.....	14.5	11.4	15.2	16.7	18.0	17.8
Ignition timing, deg BTC.....						
Manifold vacuum, in HG.....	30.5	29.0	33.9	35.5	36.5	36.5
Throttle angle, deg.....						
Concentrations, dry basis:						
CO, %.....	.0394	.0375	.0413	.0328	.3380	.2002
CO2, %.....	9.42	8.74	10.68	12.57	13.35	13.35
O2, %.....						
HC, ppmC.....	260	268	239	583	920	1069
NOx, ppm.....	330	350	330	320	300	340
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	52.1	52.1	56.0	44.3	436.1	279.0
HC.....	17.3	18.6	16.3	39.6	59.6	74.8
NOx**.....	73.6	82.0	75.4	72.9	65.3	80.0
Oil temperature, F.....	189	136	190	185	188	187
Oil pressure, psi.....	47	45	47	47	47	46
Coolant temperature, F.....	172	171	173	171	165	170
Exhaust temperature, F.....	779	468	905	1049	1095	628
Exhaust pressure, in H2O.....	10.0	10.0	12.0	12.5	15.2	14.0
Exhaust flow, lb/min.....	5.50	5.74	5.71	5.79	5.57	6.01
Smoke, % opacity.....	1.7	1.0	3.1	7.6	14.7	11.6

* Corrected - SAE J816b.
** Corrected for humidity.

Nissan diesel, 193-CID
7557

	25 5/ 9/75	88 5/15/75	24 5/ 9/75	87 5/15/75	23 5/ 9/75	22 5/ 9/75
Test Number.....	745.5	743.8	745.5	743.8	745.5	745.5
Test Date.....	71 79	81 76	71 79	81 77	71 79	71 81
Barometer, mm Hg.....	2000	2000	2000	2000	2000	2000
Humidity, grains/lb.....	67.2	69.2	101.0	101.2	114.2	126.6
Temperature, F.....	25.6	26.4	38.5	38.7	43.5	48.4
Engine speed, rpm.....	11.5	12.2	15.6	17.8	18.6	21.0
Torque, lb-ft.....						
Power, bhp*.....						
Fuel rate, lb/hr.....						
Ignition timing, deg BTC...						
Manifold vacuum, in Hg.....	24.5	24.5	29.5	29.0	32.0	34.0
Throttle angle, deg.....						
Concentrations, dry basis:						
CO, %.....	.0702	.0828	.0418	.0511	.0347	.0691
CO2, %.....	6.11	6.45	9.02	9.42	10.68	12.32
O2, %.....						
HC, ppmC.....	1214	992	294	351	227	388
NOx, ppm.....	220	275	320	350	350	330
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	126.5	148.2	72.2	88.7	58.7	113.5
HC.....	109.8	89.1	25.5	50.6	19.3	32.0
NOx**.....	63.9	83.1	89.1	102.5	90.0	87.5
Oil temperature, F.....	193	196	196	198	199	200
Oil pressure, psi.....	49	49	48	49	48	48
Coolant temperature, F.....	171	171	171	173	172	172
Exhaust temperature, F.....	589	475	812	603	945	1073
Exhaust pressure, in H2O...	10.5	12.0	12.3	16.0	14.2	15.2
Exhaust flow, lb/min.....	7.27	7.25	7.16	7.22	7.12	7.02
Smoke, % opacity.....	1.4	.8	2.0	1.5	4.2	8.3

* Corrected - SAE J816b.
** Corrected for humidity.

Nissan Diesel, 19C-CID
7557

Engine.....
Fuel.....

	35 5/ 9/75	84 5/14/75	34 5/ 9/75	83 5/14/75	33 5/ 9/75	82 5/14/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	745.5	742.0	745.5	742.0	745.5	742.0
Humidity, grains/lb.....	71	71	71	71	71	71
Temperature, F.....	79	78	81	81	81	81
Engine speed, rpm.....	2300	2300	2300	2300	2300	2300
Torque, lb-ft.....	34.2	34.4	68.4	68.0	102.8	102.8
Power, bhp*.....	15.0	15.2	30.1	30.0	45.3	45.5
Fuel rate, lb/hr.....	9.5	9.5	13.3	13.6	18.8	20.2
Ignition timing, deg BTC.....						
Manifold vacuum, in Hg.....						
Throttle angle, deg.....	21.0	21.5	25.9	24.5	29.0	29.5
Concentrations, dry basis:						
CO, %.....	.0594	.0647	.0491	.0522	.0691	.0724
CO2, %.....	4.25	4.33	6.42	6.42	9.32	9.93
O2, %.....						
HC, ppmC.....	1418	1839	1265	1444	413	521
NOx, ppa.....	175	195	270	300	345	380
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	124.7	137.1	101.1	107.5	134.1	139.5
HC.....	149.4	195.6	130.7	149.2	40.3	50.4
NOx**.....	59.3	66.8	89.7	99.8	108.0	118.3
Oil temperature, F.....	198	200	201	202	205	207
Coolant temperature, psi.....	49	49	50	49	50	49
Coolant temperature, F.....	172	172	172	171	173	173
Exhaust temperature, F.....	423	355	622	471	884	661
Exhaust pressure, in H2O.....	12.5	13.0	19.0	15.0	18.0	19.5
Exhaust flow, lb/min.....	8.32	8.41	8.33	8.33	8.07	8.05
Smoke, % opacity.....	2.0	2.4	1.2	1.0	1.7	1.0

* Corrected - SAE J816b.
** Corrected for humidity.

Engine..... Nissan diesel, 190-CID
 Fuel..... 7557

	46 5/ 9/75	45 5/ 9/75	44 5/ 9/75	79 5/14/75	43 5/ 9/75	78 5/14/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	745.5	745.5	745.5	742.0	745.5	742.0
Humidity, grains/lb.....	81	81	81	71	81	71
Temperature, F.....	77	77	78	77	79	77
Engine speed, rpm.....	2800	2900	2900	2900	2800	2800
Torque, lb-ft.....	7.0	14.0	34.8	33.4	65.0	66.8
Power, bhp*.....	3.8	7.5	19.7	17.9	34.9	35.9
Fuel rate, lb/hr.....	9.4	9.7	12.0	12.3	16.0	18.4
Ignition timing, deg BTC.....						
Manifold vacuum, in Hg.....						
Throttle angle, deg.....	20.0	20.0	23.0	22.0	26.5	26.0
Concentrations, dry basis:						
CO, %.....	.0669	.0702	.0713	.0900	.0542	.0764
CO2, %.....	3.00	3.29	4.62	4.51	6.27	6.91
O2, %.....						
HC, ppmC.....	1691	1897	1786	2056	1722	1837
NOx, ppm.....	110	130	210	245	330	430
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	188.5	184.0	176.5	243.5	132.6	195.3
HC.....	239.1	249.6	221.9	279.2	211.5	235.7
NOx**.....	52.3	57.5	87.7	107.1	136.1	177.6
Oil temperature, F.....	206	207	208	203	212	201
Oil pressure, psi.....	52	50	50	52	50	52
Coolant temperature, F.....	172	172	172	172	173	171
Exhaust temperature, F.....	381	378	495	404	651	493
Exhaust pressure, in H2O.....	22.0	19.5	19.0	20.0	22.0	23.0
Exhaust flow, lb/min.....	11.04	10.30	9.85	10.76	9.89	10.40
Smoke, % opacity.....	2.4	3.3	4.4	3.5	3.5	3.5

* Corrected - SAE J616.
 ** Corrected for humidity.

Hiscaan diesel, 193-CID
7557

Engine.....
Fuel.....

	56 5/13/75	70 5/13/75	55 5/13/75	54 5/13/75	53 5/13/75	69 5/13/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	742.0	742.0	742.0	742.0	742.0	742.0
Humidity, grains/lb.....	69	69	69	69	69	69
Temperature, F.....	77	77	78	78	77	75
Engine speed, rpm.....	3300	3300	3300	3300	3300	3300
Torque, lb-ft.....	2.4	1.0	6.0	12.8	31.0	32.4
Power, bhp*.....	1.5	.6	3.8	8.1	19.7	20.5
Fuel rate, lb/hr.....	9.4	9.5	11.3	11.6	14.1	16.3
Ignition timing, deg BTC.....						
Manifold vacuum, in Hg.....	18.5	19.0	19.9	20.5	22.0	23.0
Throttle angle, deg.....						
Concentrations, dry basis:						
CO, %.....	.0702	.0913	.0747	.0781	.0793	.1129
CO2, %.....	3.00	3.00	3.29	3.72	4.98	4.98
O2, %.....						
HC, ppmC.....	1499	1639	1604	1932	2322	1936
NOx, ppm.....	110	120	125	175	285	300
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	222.3	280.7	229.0	238.3	235.4	346.1
HC.....	238.3	252.8	246.8	295.9	346.0	297.9
NOx**.....	55.6	58.9	61.2	85.3	135.1	146.9
Oil temperature, F.....	213	214	213	215	218	217
Oil pressure, psi.....	52	51	51	51	51	51
Coolant temperature, F.....	170	171	170	170	173	172
Exhaust temperature, F.....	393	415	413	449	540	557
Exhaust pressure, in H2O.....	23.0	25.0	27.5	28.0	29.0	30.0
Exhaust flow, lb/min.....	12.41	12.05	12.05	12.04	11.86	12.25
Smoke, % opacity.....	1.2	1.5	1.7	2.4	2.7	4.2

* Corrected - SAE J816b.
** Corrected for humidity.

Missan diesel, 100-CID
7557

	43 5/ 9/75	86 5/13/75	65 5/13/75	75 5/13/75	64 5/13/75	63 5/13/75
Test Number.....						
Test Date.....						
Barometer, mm Hg.....	745.5	742.0	742.0	742.0	742.0	742.0
Humidity, grains/lb.....	81	69	69	69	69	69
Temperature, F.....	81	77	79	75	78	79
Engine speed, rpm.....	3300	3300	3800	3800	3800	3800
Torque, lb-ft.....	124.6	128.0	1.0	1.2	5.2	12.2
Power, bhp*.....	79.3	81.2	.7	.9	3.8	9.0
Fuel rate, lb/hr.....	41.0	38.5	12.8	14.0	13.4	15.3
Ignition timing, deg BTC....						
Manifold vacuum, in Hg.....						
Throttle angle, deg.....	36.5	36.5	21.0	20.5	20.1	22.0
Concentrations, dry basis:						
CO, %.....	2352	2453	.0852	.1367	.1058	.1129
CO ₂ , %.....	13.09	13.62	3.60	3.70	3.67	4.21
O ₂ , %.....						
HC, ppmC.....	3033	2649	1106	1369	1610	1699
NOx, ppm.....	400	410	175	160	180	240
Air-fuel ratio.....						
Emission rates, g/hr:						
CO.....	681.6	685.1	307.9	506.4	374.0	396.4
HC.....	441.1	371.3	200.6	254.5	285.6	299.4
NOx**.....	195.5	182.9	101.0	94.7	101.6	134.6
Oil temperature, F.....	234	222	224	228	225	225
Oil pressure, psi.....	52	51	52	51	52	52
Coolant temperature, F.....	175	174	171	172	171	171
Exhaust temperature, F.....	1330	1273	454	495	481	720
Exhaust pressure, in H ₂ O....	51.0	42.0	35.0	37.0	34.0	37.0
Exhaust flow, lb/min.....	12.48	12.08	14.24	14.62	13.94	13.92
Smoke, % opacity.....	6.2	4.5	2.2	2.9	2.4	2.7

* Corrected - SAE J816b.
** Corrected for humidity.

7557
 Hissna diesel, 199-CID

	59 5/13/75	58 5/13/75	57 5/13/75	71 5/13/75
Test Number.....	59	58	57	71
Test Date.....	5/13/75	5/13/75	5/13/75	5/13/75
Barometer, mm Hg.....	742.0	742.0	742.0	742.0
Humidity, grains/lb.....	69	69	69	69
Temperature, F.....	81	91	79	76
Engine speed, rpm.....	3800	3800	3800	3800
Torque, lb-ft.....	93.2	105.8	111.4	117.0
Power, bhp*.....	68.6	79.0	82.0	85.7
Fuel rate, lb/hr.....	34.8	41.5	46.6	45.5
Ignition timing, deg BTC....				
Manifold vacuum, in Hg.....	32.0	34.5	36.5	36.5
Throttle angle, deg.....				
Concentrations, dry basis:				
CO, %.....	.1200	.1731	.2504	.2707
CO2, %.....	10.36	11.84	13.22	13.62
O2, %.....	3642	3258	4399	3664
HC, ppmC.....	570	540	510	490
NOx, ppm.....				
Air-fuel ratio.....				
Emission rates, g/hr:				
CO.....	402.6	552.2	839.1	894.6
HC.....	613.4	521.6	739.9	607.8
NOx**.....	305.4	275.1	272.9	258.6
Oil temperature, F.....	241	242	234	235
Oil pressure, psi.....	52	52	52	52
Coolant temperature, F.....	174	175	175	175
Exhaust temperature, F.....	1064	1220	1282	1342
Exhaust pressure, in H2O....	52.0	55.0	67.0	64.0
Exhaust flow, lb/min.....	14.09	13.58	14.45	14.30
Smoke, % opacity.....	3.6	2.7	4.4	4.2

* Corrected - SAE J816b.
 ** Corrected for humidity.

