DOT-TSC-RSPA-82-2

Fuel Economy and Exhaust Emissions Characteristics of a Diesel Vehicle: Results of the Prototype Volkswagen 1.5-Liter Turbocharged Rabbit Tests

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16. Abstract

Tests were performed on a prototype Volkswagen (VW) Turbocharged (TC) Rabbit diesel vehicle on a chassis dynamometer. The vehicle was tested for fuel economy and emissions on the Urban Federal Test Procedure (FTP), Highway Fuel Economy Test (HFET), Congested Urban Expressway (CUE), and New York City Cycle (NYCC). Steady state measurements were performed at three speeds. Particulate measurements were completed at all test conditions. Approximately 250 grams of particulate matter were collected over the HFET cycle for inclusion in the Environmental Protection Agency Diesel Health Effects Research Program. During the urban cycle the vehicle obtained 45.7 mpg, with emission rates of 0.14, 0.89 and 1.07 grams per mile of HC, CO, and NO_x, respectively. The Rabbit obtained 56.5 mpg during the HFET cycle.

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PREFACE

This project was performed in cooperation with the U.S. Environmental Protection Agency (USEPA) under Interagency Agreement EPA79-D-X0546 by the U.S. Department of Transportation, Transportation Systems Center (DOT/TSC). The authors wish to acknowledge Ronald L. Bradow, Chief Mobile Source Emissions Research Branch, ESRL, EPA/RTP, North Carolina, for his technical assistance. Special acknowledgement is due to Automotive Research Laboratory staff who performed the testing: Alfred C. Dahlgren, Michael M. Davis, Maurice W. Dumais, and Charles R. Hoppen. The test vehicle was on loan to TSC from Volkswagenwerk A.G. through contract DOT-TSC-1193.

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SYMBOLS AND ABBREVIATIONS

AA	Ann Arbor Certification Test Facility
ASTM	American Society for Testing Materials
BHP	Brake Horsepower
BTU	British Thermal Units
CFO	Critical Flow Orifice
CVS	Constant Volume Sampling
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CUE	Congested Urban Expressway
DOD	Department of Defense
DFM-2	Diesel Fuel Marine #2
ESRL	Environmental Sciences Research Laboratory
FID	Flame Ionization Detector
FTP	Federal Test Procedure
gpm	Grams/Mile
HC	Hydrocarbon
H/C	Hydrogen/Carbon
HFET	Highway Fuel Economy Test
HFID	Hot Flame Ionization Detector
hp	Horsepower
kW	Kilowatt
mpg	Miles/Gallon
NA	Naturally Aspirated
NDIR	Non-dispersive Infrared
Nm	Newton-Meter
NO_x	Oxides of Nitrogen
NYCC	New York City Cycle
psig	Pounds/Sq In. Gauge Pressure
rpm	Revolutions/Minute
RTP	Research Triangle Park
TC	Turbocharged
USEPA	United States Environmental Protection Agency
VW	Volkswagen

1. INTRODUCTION

The objectives of this project were twofold:

- To characterize the gaseous and particulate exhaust emissions and the fuel economy of a prototype VW-TC diesel Rabbit vehicle under various test conditions, and
- To provide adequate particulate samples for chemical and biological characterization as part of the EPA Diesel Health Effects Research Program.

Under contract DOT-TSC-1193, Volkswagenwerk A.G. provided an extensive data base on lightweight automotive diesel power plants in the 50-hp to 100-hp range used in vehicles of inertia weights from 2,000 pounds to 3,000 pounds. This data base considered diesel engine technology, fuel economy, emissions, performance, and advanced vehicle concepts.

The vehicle loaned to DOT/TSC was a prototype TC diesel (70 hp at 4800 rpm) in a 2250-lb inertia weight configuration (Figure 1-1) and was equipped with a 1.5-liter indirect-injection engine and four-speed manual transmission. The vehicle was tested on the DOT/TSC large-roll chassis dynamometer (Figure 1-2) over various test cycles and steady-state conditions. The test cycles included the EPA/FTP urban cycle, the HFET cycle, the CUE cycle, and the NYCC. Steady-state measurements were performed at three speeds. Approximately 250 grams of particulate matter was collected and sent to EPA/ RTP for inclusion in the EPA Diesel Health Effects Research Program.[1]

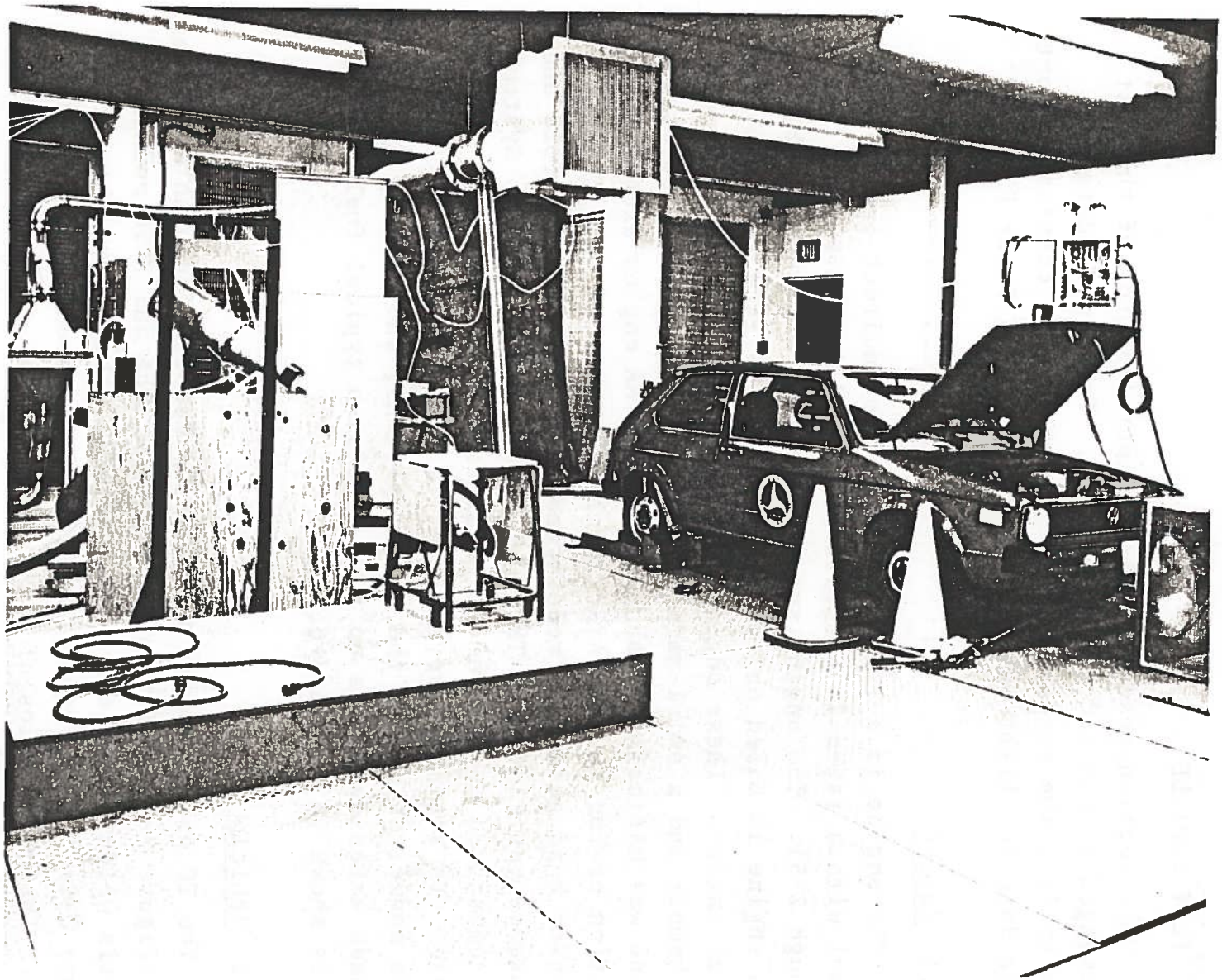


FIGURE 1-2. VW RABBIT ON DOT/TSC LARGE - ROLL CHASSIS DYNAMOMETER

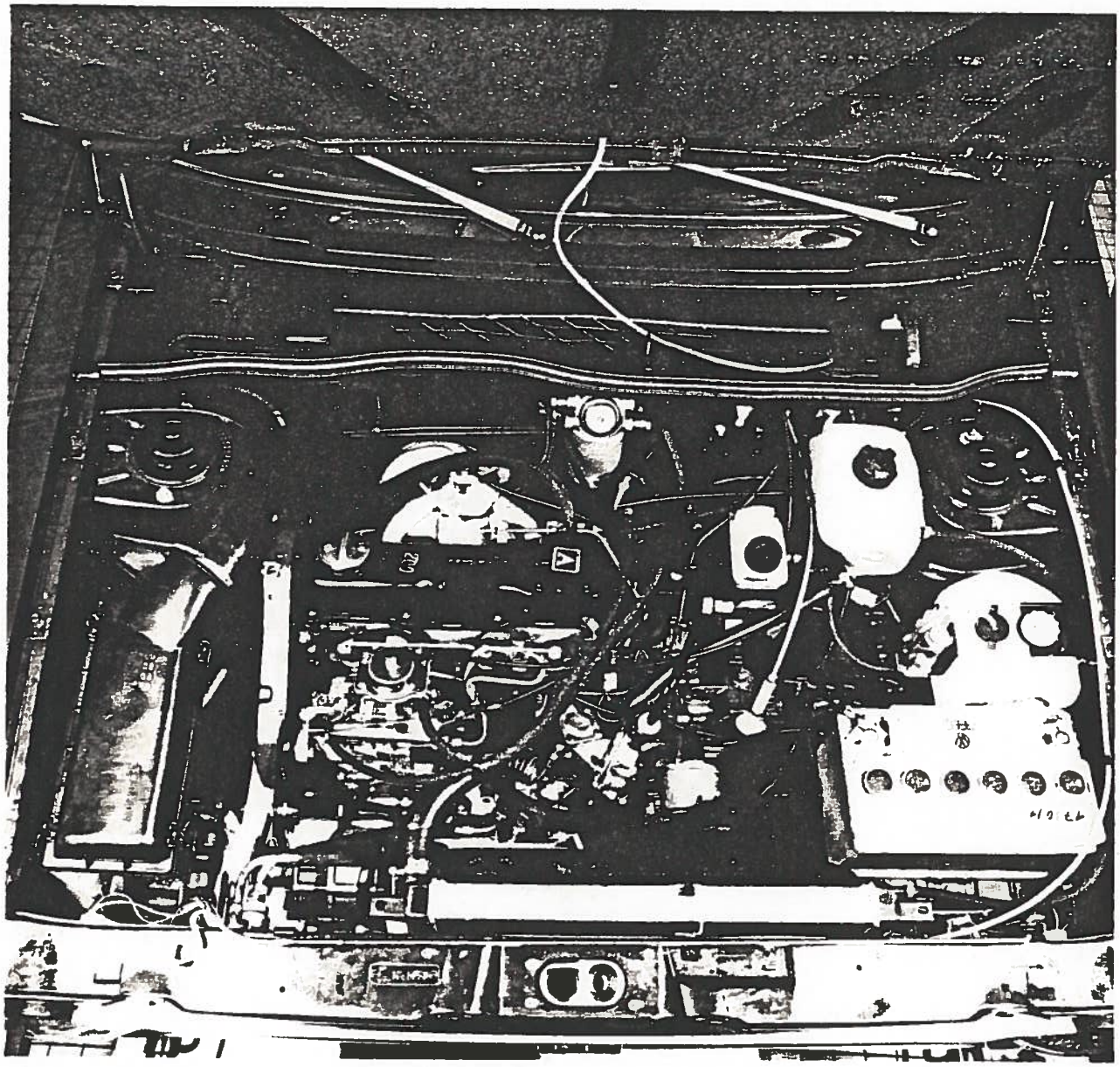


FIGURE 2-1. VW 1.5-LITER DIESEL ENGINE IN RABBIT

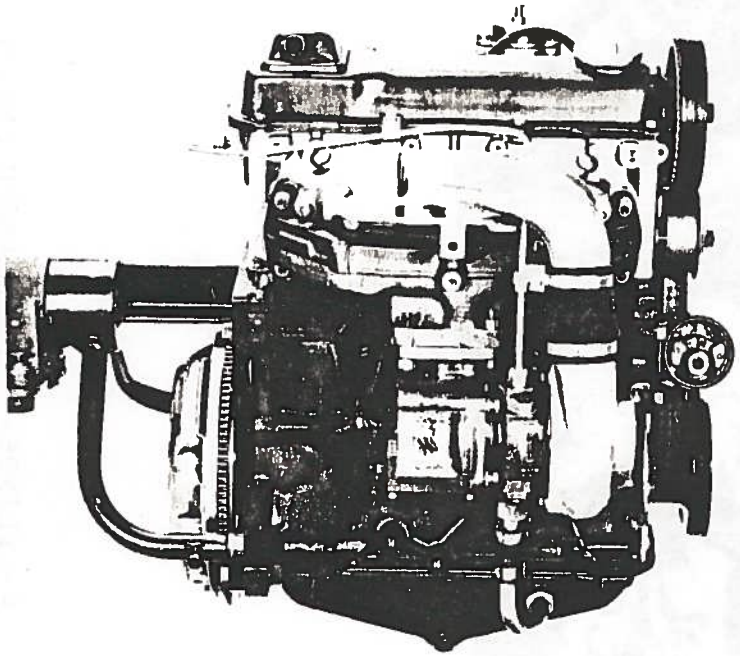


FIGURE 2-3. 4-CYLINDER TURBOCHARGED ENGINE-SIDE VIEW-INLET MANIFOLD

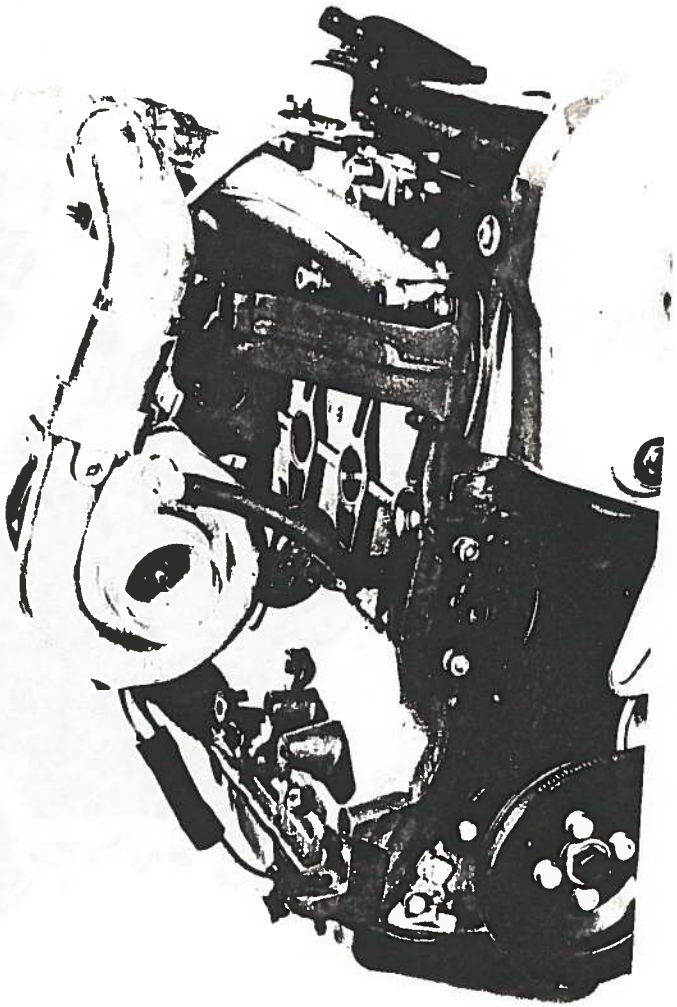


FIGURE 2-4. 4-CYLINDER TURBHCHARGED ENGINE-FRONT VIEW-COMPRESSOR INLET

TABLE 2-1. 4-CYLINDER TC IN-LINE ENGINE SPECIFICATIONS

Swept Volume	1.471 L
Bore	76.5 mm
Stroke	80 mm
Stroke/Bore	1.05
Cylinder Volume	367.7 cm^3
Compression	23.5
Maximum Boost Pressure	0.6 bar
Firing Sequence	1 - 3 - 4 - 2
Power	51.4 kW (70 BHP)
Rated Speed	4,800 rpm
Specific Power Output	35 kW/L (47.6 BHP/1)
Maximum Torque	118 Nm (87.1 lb ft) at 3,000 rpm
Maximum Mean Effective Pressure	10.3 bar
Mean Piston Velocity at Rated Speed	12.8 m/s
Weight*	132 kg
Weight-to-Power Ratio	2.56 kg/kW
Length, Width, Height	514 x 572x645 mm
Power-to-Volume Ratio	272 kW/m^3 (369 BHP/m^3)
Oil Capacity	3.5 L

*Including clutch, intake and exhaust manifolds, air filter, oil, generator; excluding cooling system, coolant, starter motor.

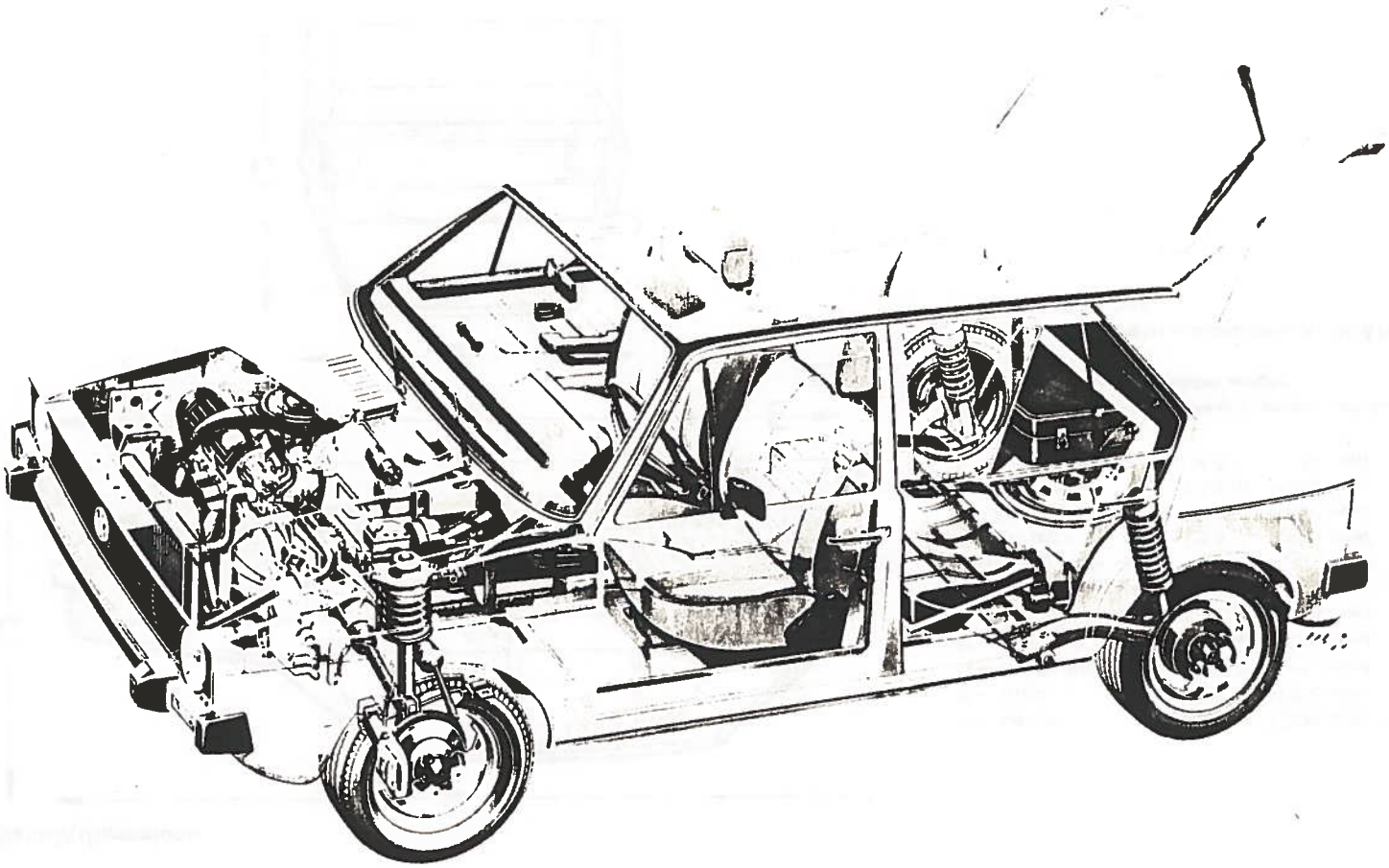


FIGURE 2-7. VW GOLF (RABBIT)

respectively. VW measured the fuel economy as 42.0 mpg urban and 56.0 mpg highway, a composite of 47.3 mpg.

2.1.3 Fuel

The primary fuel used for these vehicle tests was provided by the USEPA and is referred to as the EPA/ESRL fuel. This fuel is from a common lot that has been used in other vehicles to generate particulate samples for the EPA Diesel Particulate Health Effects Research Program. The fuel was analyzed by DOT/TSC and the results are given in Table 2-2. In addition, some preliminary vehicle tests were performed using a shale-derived distillate. This fuel was provided by the DOD/U.S. Navy Paraho-shale project. The analysis of this fuel is also shown in Table 2-2. The EPA/ESRL test fuel has a high specific gravity and relatively low cetane index which tends to increase slightly the specific fuel consumption (g/hp-hr). EPA/RTP reports that the fuel has a mid-range aromatic content which will slightly increase smoke emissions and lower the cetane index. The sulfur content of the EPA fuel (0.25 percent) is typical of an ASTM Grade 1-D fuel. In contrast, the Navy shale-derived fuel has a lower density and a higher cetane index and should give slightly better specific fuel consumption. The sulfur content was determined to be 0.20 percent. Although not measured here, the fuel-bound nitrogen content of shale oil is generally higher and could contribute to higher NO_x emissions.

2.2 TEST EQUIPMENT

This section briefly describes the test equipment including the DOT/TSC large-roll chassis dynamometer, and the gaseous and particulate measurement techniques.

2.2.1 Dynamometer

The DOT/TSC chassis dynamometer is a fully programmable direct-current machine with a single 50-inch diameter roll. The features of this dynamometer are given in Table 2-3. This

TABLE 2-3. DIRECT-CURRENT CHASSIS DYNAMOMETER

SINGLE AXIS, LARGE (50-Inch Diameter) ROLL (400 Revolutions/mile)

MAXIMUM TORQUE, SPEED: 6400 LB-FT, 0-39 MPH

MAXIMUM POWER, SPEED: 315 HP, 39-105 MPH

TORQUE SENSITIVITY: ± 1.3 LB-FT (0.02% Full Scale)

CORRESPONDING TRACTIVE FORCE AT WHEELS: ± 0.61 LB

DUAL TORQUE LOAD CELLS, 150% and 15% of FULL SCALE

SIMULATED ROAD-SPEED AIR FLOW: 0-72 MPH

MAXIMUM DRIVE-AXLE LOAD CAPACITY: 5000 LB

MECHANICAL INERTIA OF SYSTEM EQUIVALENT TO VEHICLE WEIGHT OF 1800 LB

ELECTRICAL SIMULATION OF VEHICLE WEIGHT FROM 1200 LB to 7000 LB

MECHANICAL SIMULATION OF VEHICLE WEIGHT FROM 1800 LB to 8750 LB

DIGITAL TORQUE CONTROL SYSTEM, PROGRAMMABLE TO SIMULATE -

- ROLLING AND AERODYNAMIC LOSSES
- VEHICLE INERTIA
- POSITIVE AND NEGATIVE GRADES
- HEAD AND TAIL WINDS

ADJUSTABLE CONSTANT-SPEED CONTROL

FULL DRIVE-CYCLE CAPABILITY

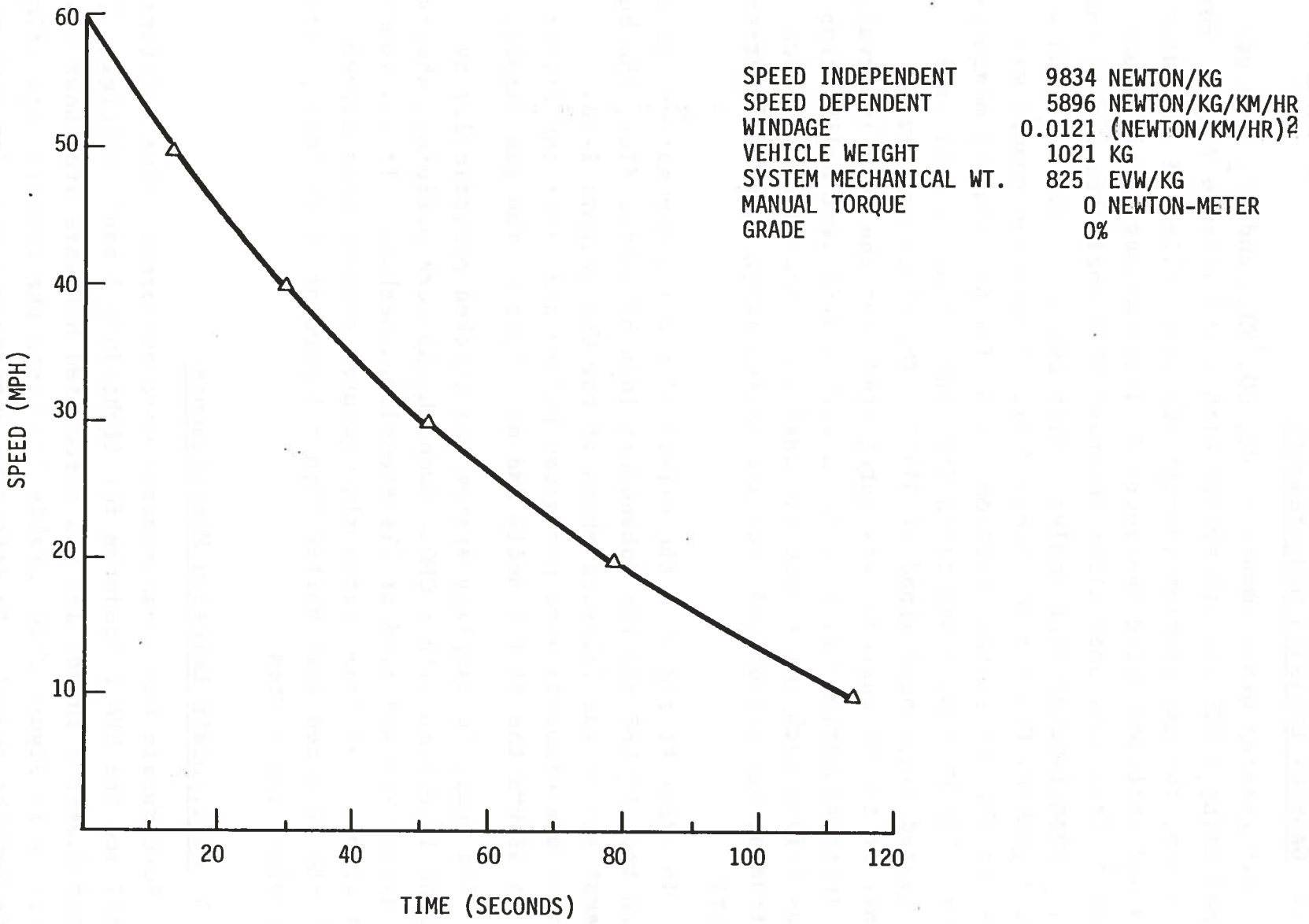


FIGURE 2-9. COAST-DOWN CHARACTERISTICS OF VW TURBO RABBIT

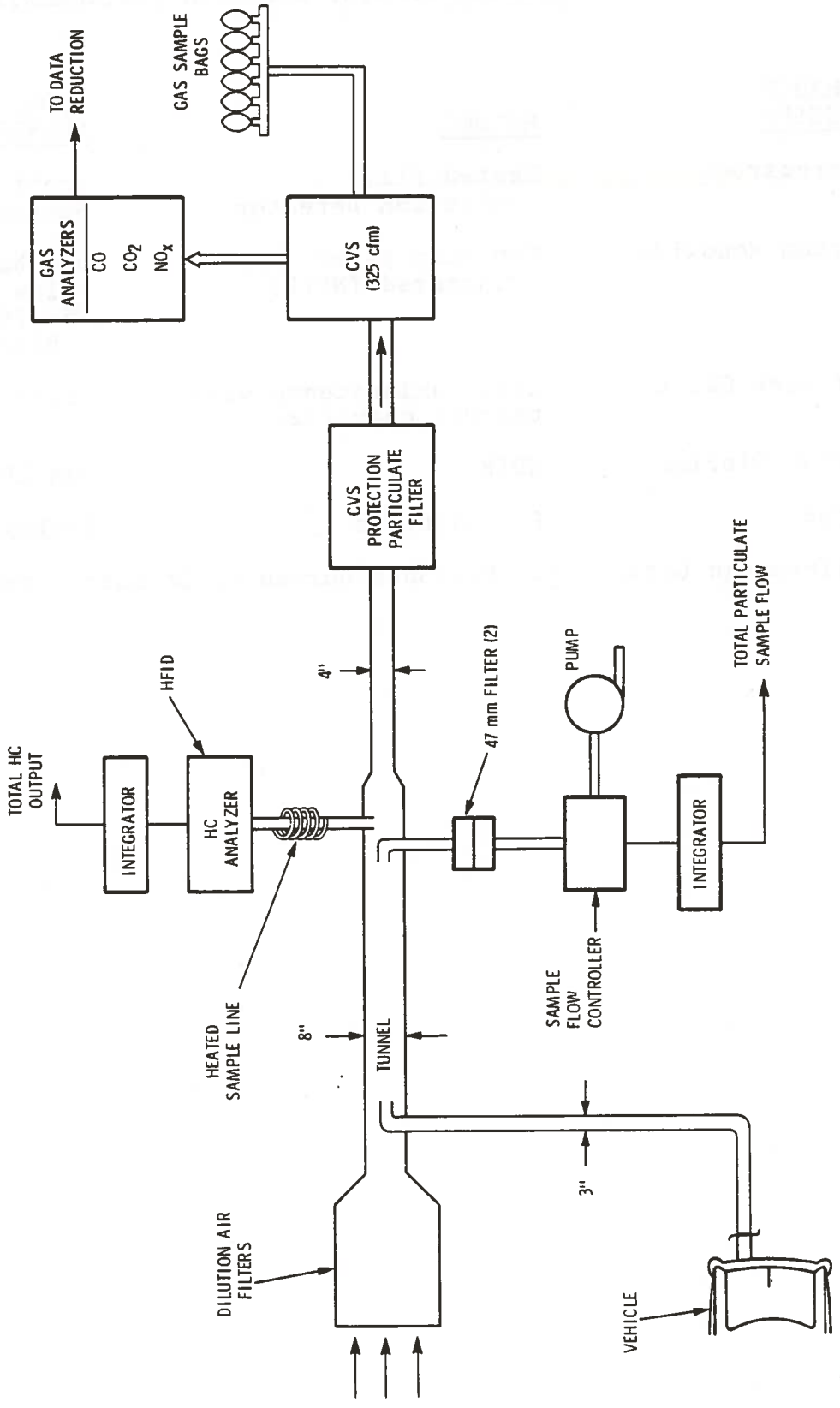


FIGURE 2-10. AUTOMOTIVE RESEARCH LABORATORY PARTICULATE/GAS SAMPLING SYSTEM (CHARACTERIZATION)

TABLE 2-5. EXHAUST DILUTION TUNNEL SPECIFICATIONS

Diameter	8 inch
Minimum Active Length*	75 inches
Minimum Residence Time	0.42 sec. @325 cfm
Material	Stainless Steel
Air Filters	
Prefilter	Cambridge Model 3CP60
Hydrocarbon Filter	Cambridge Activated Carbon Model 5FB45
Absolute Filter	Cambridge Model 1B-1000-1
Connecting Tubing	3-inch and 4-inch dia. stainless steel straight wall and flexible tubing
Connectors	Marmon

*Distance from vehicle exhaust exit to nearest sampling port.

TABLE 2-6. EXHAUST PARTICULATE SAMPLING AND MEASUREMENT

CHARACTERIZATION	
Sample Probes	1-in diameter stainless steel
Filter Holder	Millipore 47 mm
Filter Media	Pallflex T60A20 Fluoropore
Sample Flow Control	Tylan Mass Flow Controller Model FC202 and FMT-3 electronics unit
Scale	Cahn electrobalance
Large Volume Collection	
Filter Media	Pallflex T60A20 20in x 20in
Sample Flow Control	Filtration of full tunnel flow
Scale	Mettler P1200 (modified)

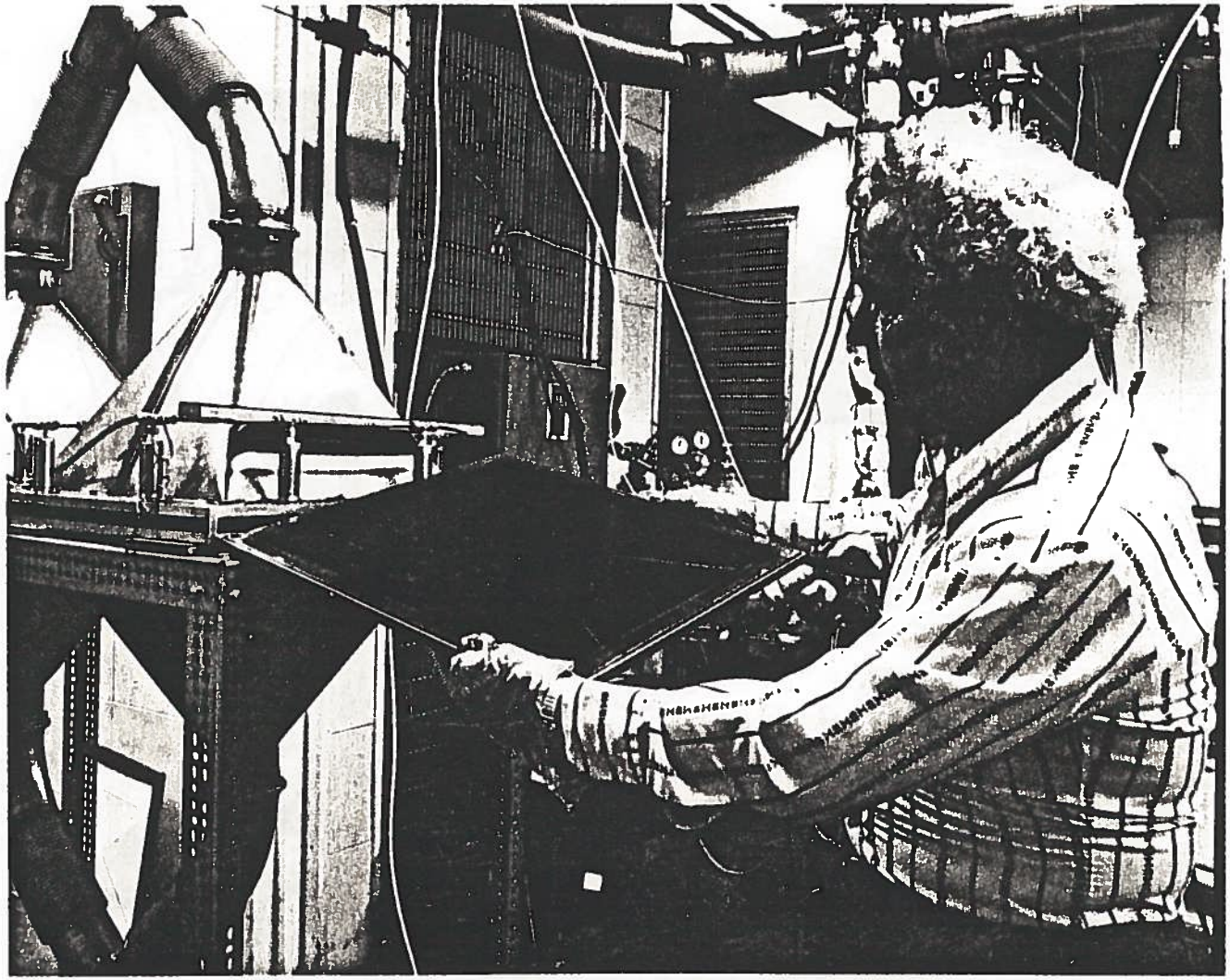


FIGURE 2-12. REMOVING PARTICULATE LOADED 20in x 20in FILTER FROM COLLECTION HOLDER

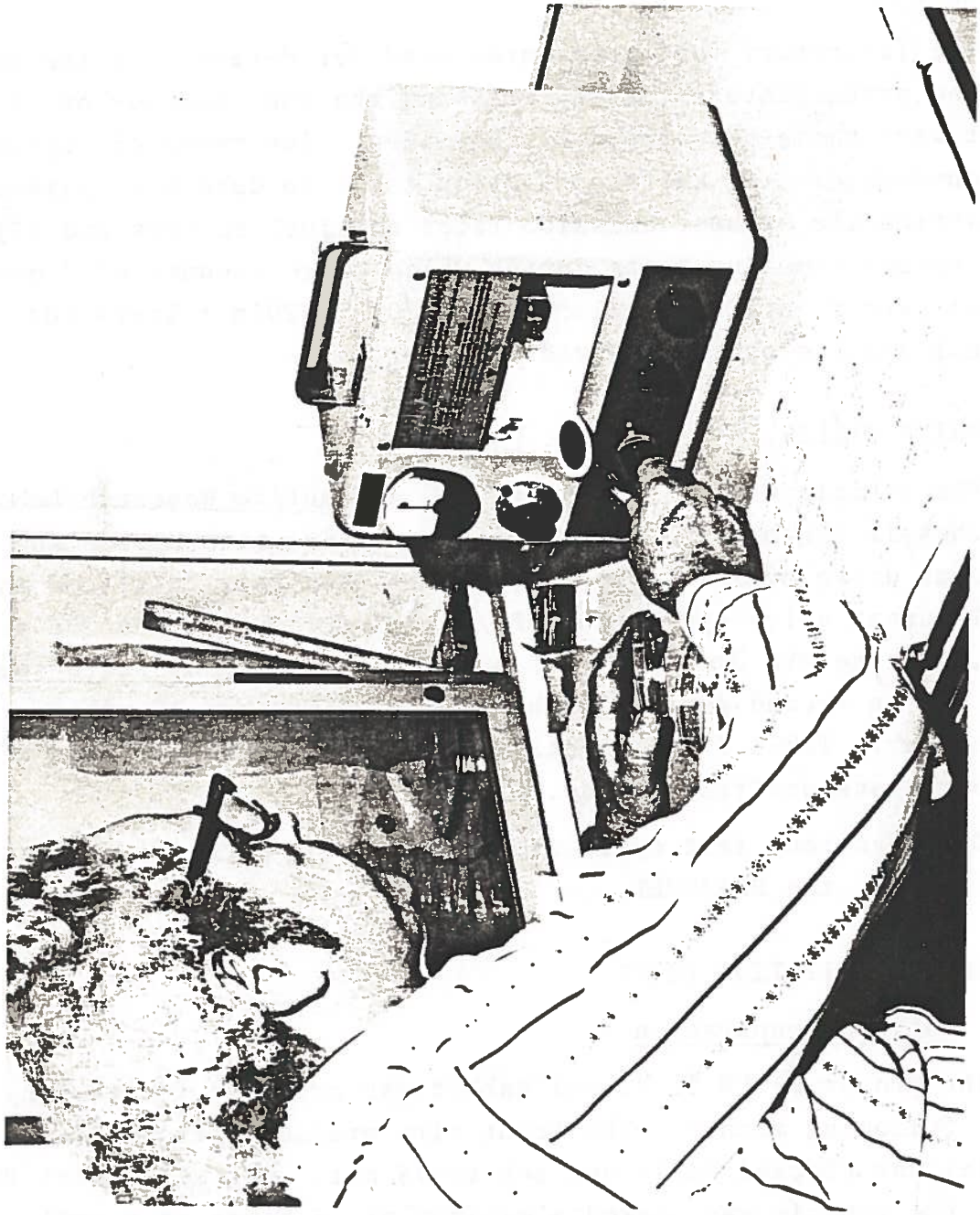


FIGURE 2-14. WEIGHING LOADED 47mm FILTER

TABLE 3-1. TEST CYCLE CHARACTERISTICS

Cycle	Distance (mile)	Avg. Speed (mph)	Time (sec)	Remarks
Federal Test Procedure (FTP)	11.1	21.6	1877	Composite
Bag 1	3.6	25.6	505	Cold Start
Bag 2	3.9	16.2	867	Stablized
Bag 3	3.6	25.6	505	Hot Start
Highway Fuel Economy Test (HFET)	10.2	48.2	765	Hot Start
Congested Urban Expressway - Sulfate (CUE)	13.3	34.2	1398	Hot Start
New York City Cycle (NYCC)	1.1	6.6	598	Hot Start

TABLE 3-2. VW TURBO RABBIT SUMMARY BY LABORATORY EMISSIONS GRAMS/MILE*

LABORATORY	CYCLE	HC	CO	NO_x	PART	FE (MPG)	NOTES
			grams/mile				
VW	FTP	.11	.8	.9	.24	45	
TSC	FTP	.14	.89	1.07	.17	45.7	Averages
		.11-.18	.68-.93	1.02-1.19	.13-.22	44.9-47.3	Range of 7 Tests
	HWY	.06	.50	1.02	.24	56.5	
	NYCC	.41	1.93	1.60	.27	27.9	
	CUE	.11	.51	.99	.19	54.5	
EPA RTP	FTP	.29	.97	1.03	.18	42.5	
EPA AA	FTP	.41	.99	1.16	-	44.5	
	HWY	.30	.68	1.16	-	55.8	

*The fuel, particulate filter media, and filter face velocity may have differed among the laboratories.

TEST-DATE: 378779 VEH MAKE&MODEL: VW TURBORAB VEH ID: DOT 131 VEH TYPE: D DRIVER: AD

	PB	PD	RH	VMIX	KM	DF	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	757.9	20.1	24.	2751	5.76	21.1	28.0	3.0	29.0 .0	37.0 1.5	.63 .04	.22	.99	.98	236.11	42.72
	PARTIC MGS IN= 2.87				FLOWRATE(LPM)=14.8				BAG-TIME (SEC)= 506		CORR PARTIC GMS.=1.29			PGPM= .36		
BAG 2	757.8	20.4	24.	4673	6.26	33.2	11.0	3.5	19.5 .0	23.0 2.0	.40 .04	.15	1.84	.84	225.24	44.82
	PARTIC MGS IN= .89				FLOWRATE(LPM)=14.8				BAG-TIME (SEC)= 862		CORR PARTIC GMS.= .55			PGPM= .14		
BAG 3	757.8	20.4	24.	2741	5.74	23.8	12.0	3.0.	29.0 .0	28.0 1.5	.56 .04	.11	.99	.67	287.85	48.62
	PARTIC MGS IN= 1.51				FLOWRATE(LPM)=14.8				BAG-TIME (SEC)= 506		CORR.PARTIC GMS.= .94			PGPM= .26		

WEIGHTED 3-BAG VALUES: WHCGPM= .15 WNOGPM= 1.02 WCOGPM= .88 WC2GPM=222.7 WMPG=45.33

WPGPM= .22

FIGURE 3-1. DOT/TSC CHASSIS-DYNO HWY-BAG EMISSIONS REPORT

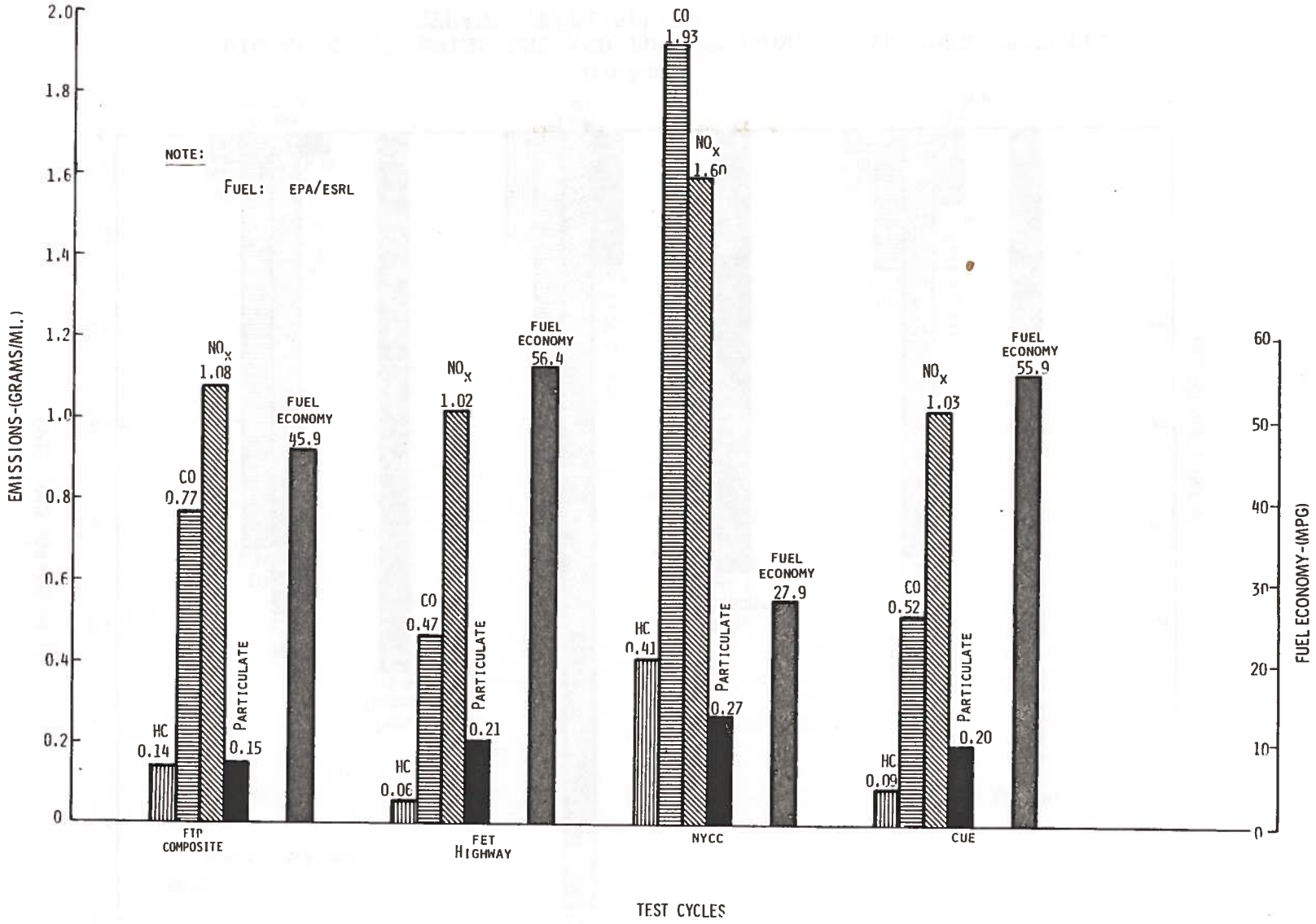
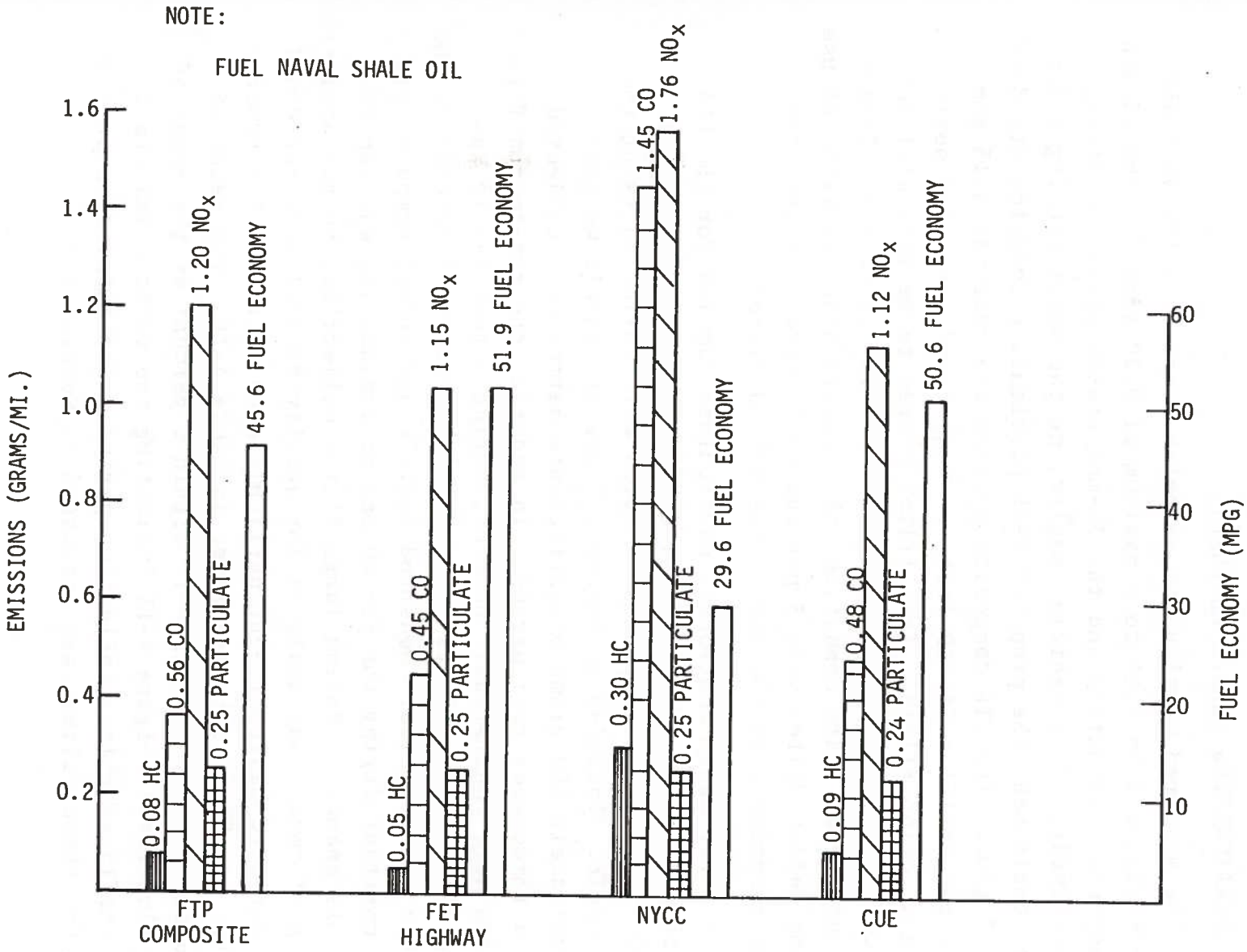


FIGURE 4-1. EMISSIONS AND FUEL ECONOMY OF VW TURBO RABBIT: VARIOUS DRIVE CYCLES



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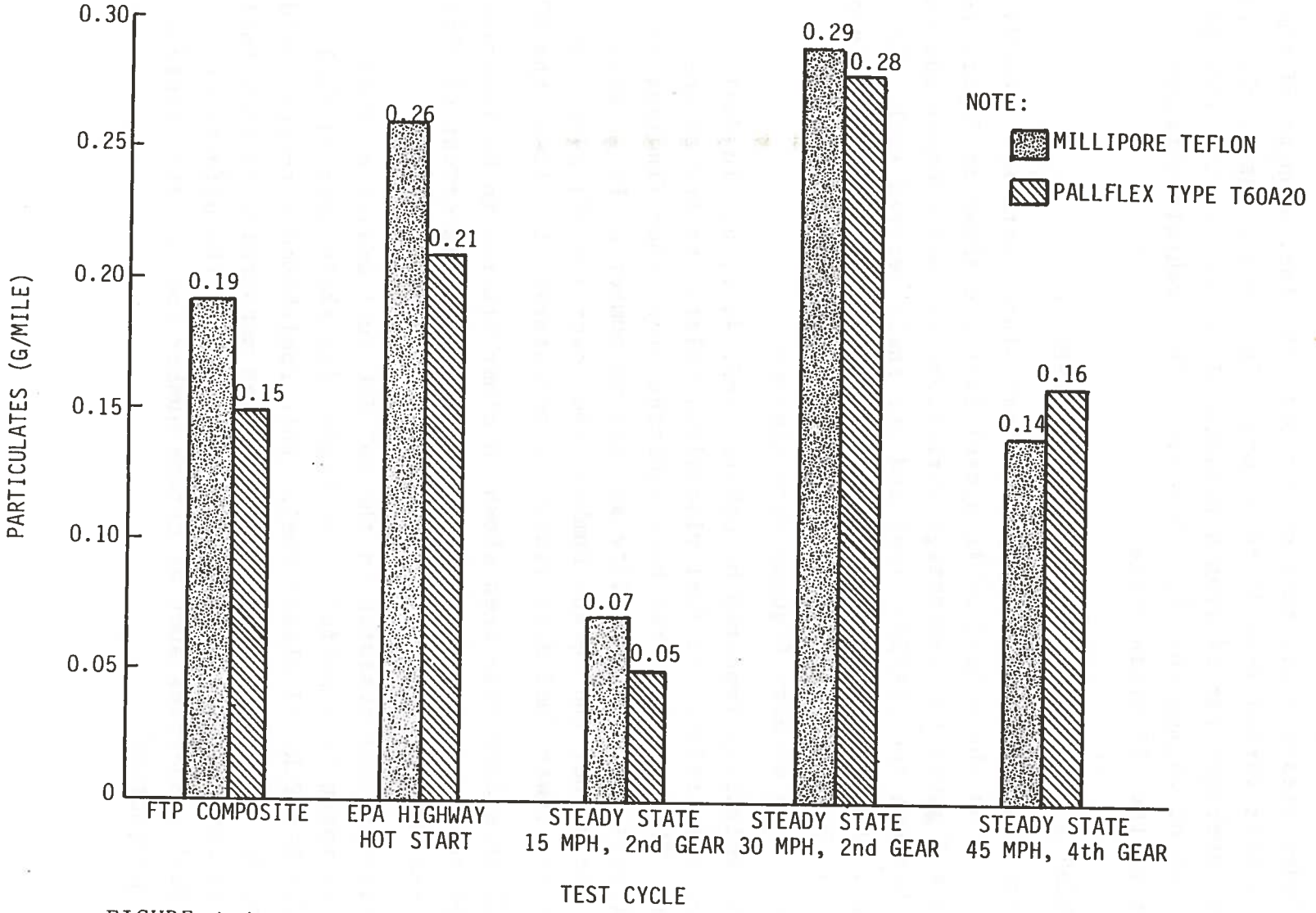

FIGURE 4-4. FILTER COMPARISON: PARTICULATE EMISSIONS OF VW TURBO RABBIT

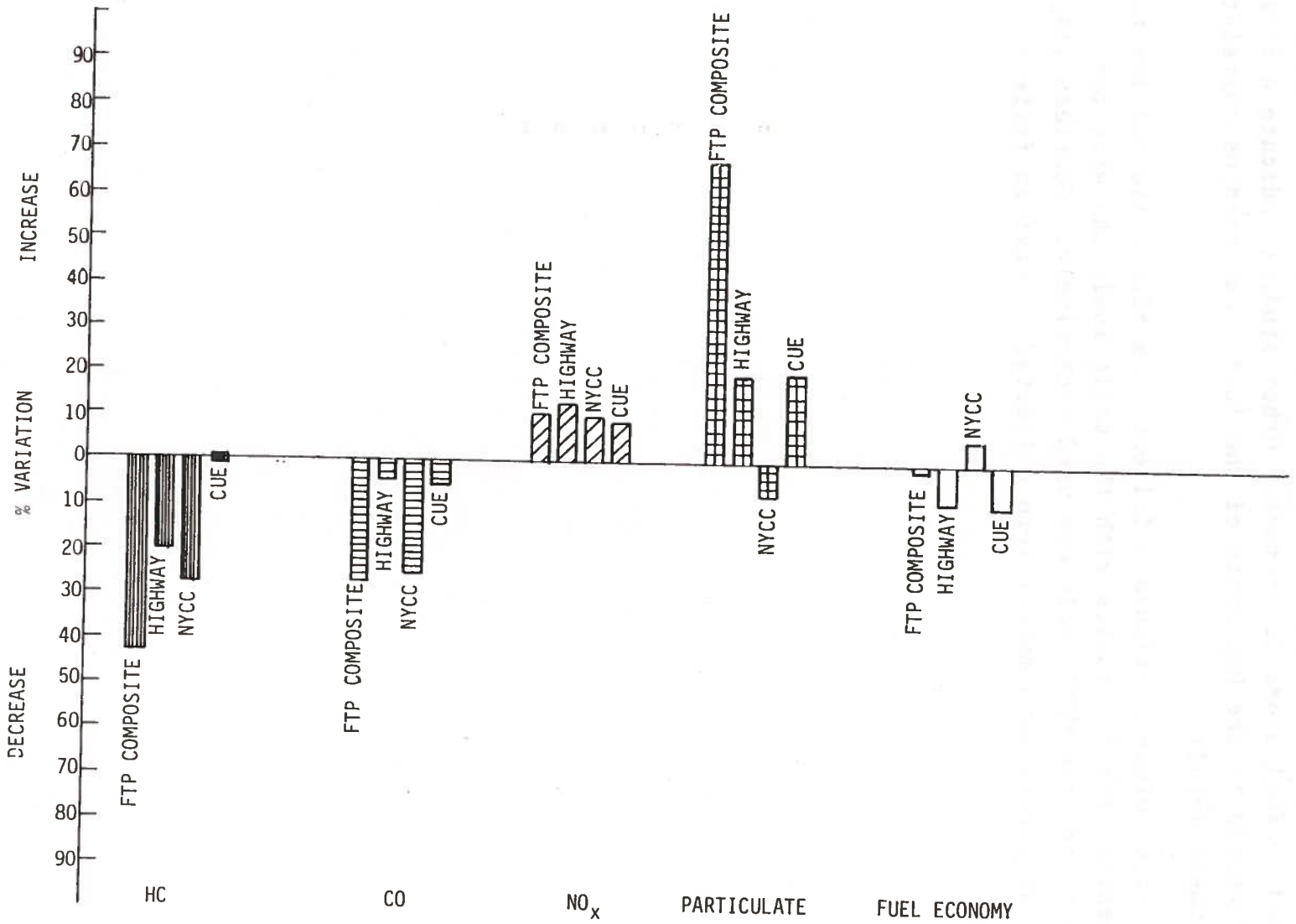

FIGURE 4-5. PERCENT VARIATION IN EMISSIONS AND FUEL ECONOMY BETWEEN EPA FUEL AND SHALE FUEL

5. LARGE-VOLUME PARTICULATE FILTERS

The net weights of the large-volume particulate samples are given in Appendix B. These samples were sent to the Environmental Research Laboratory, Research Triangle Park, North Carolina, for organic solvent extraction

5.1 ORGANIC EXTRACTION PROCEDURES

The EPA fuel-particulate matter was extracted in 12-15 gram amounts (net particulate weight) in 2.2-liter side-chamber Soxhlet extractors. The shale fuel samples were extracted by the same methods in 2-2.5 gram amounts. The solvent used was methylene chloride. The extractions were run for 48 hours and then distilled to approximately 1 liter. The extract was filtered through a 0.2 micron filter and concentrated to 250 ml in an evaporator. The percentages of extractables were determined using a 2-ml aliquot and evaporating to dryness in a tared vial. In total, 19 filter groups were extracted. The results are shown in Appendixes C and D. For the VW run on EPA fuel, the percent extractable for each filter group varied from 15.9 to 21.9 percent, with an average of 17.75 percent. The extracts from the shale oil varied from 19.2 percent to 23.7 percent for the 7 groups tested, with an average of 21.25 percent.

APPENDIX A

VEHICLE LOG AND TEST RESULTS

VEHICLE LOG
TABLE A-1

Vehicle Type: Volkswagen Rabbit, 2-door

Vehicle Identification Number: 1773229865

Vehicle Engine: 1.5 liter, prototype IDI, Turbocharged Diesel

Transmission: 4-speed Manual

Date	Remarks
October 4, 1978	Vehicle received at TSC
Oct. 13-23, 1978	Dynamometer Matching
Nov. 11, 1978 - March 20, 1979	Measurement System Fabrication and Calibration Characterization Tests.
March 22, 1979	Vehicle Mileage: 11,350
March 23-27, 1979	Installation and Checkout of Large Volume Sampling System
March 28, 1979	Engine Lubrication and Filter Change -- Oil: Valvoline SAE W30-CC
March 29, 1979 - April 12, 1979	Large-Volume Sample Collection
March 30, 1979	Vehicle Mileage: 11,534
April 6, 1979	Vehicle Mileage: 12,340
April 12, 1979	Vehicle Mileage: 13,264
May 5-17, 1979	DFM-2 fuel derived from oil shale
May 17, 1979	Vehicle Mileage: 13,466
June 22, 1979	Large-Volume Sample Collection for Lovelace ITRI
June 22, 1979	All Tests Completed. Vehicle Mileage: 13,575

TABLE A-3. EMISSIONS AND FUEL ECONOMY OF VW TURBO-RABBIT: EPA HIGHWAY CYCLE

HC g/mile	CO g/mile	NO_x g/mile	Part. g/mile	CO_2 g/mile	Fuel Economy (MPG)	Notes
0.07	0.50	0.96	0.30	177.5	57.0	Millipore
0.05	0.51	1.00	0.25	178.1	56.8	Teflon
0.05	0.45	0.99	0.23	175.7	57.6	Filters
			$\bar{x}$ = 0.26			
0.07	0.48	1.10	0.02	183.3	55.2	Pallflex
0.06	0.46	1.06	0.21	183.3	55.3	Filters
0.05	0.47	1.04	0.21	177.5	57.0	T60A20
			$\bar{x}$ = 0.21			
$\bar{x}$ = 0.06	0.47	1.02		180.0	56.4	
σ = 0.01	0.02	0.05		3.23	1.0	

TABLE A-5. EMISSIONS AND FUEL ECONOMY OF VW TURBO-RABBIT: CONGESTED URBAN EXPRESSWAY (SULFATE CYCLE)

HC g/mile	CO g/mile	NO_x g/mile	Part. g/mile	CO_2 g/mile	Fuel Economy (MPG)	Notes
0.08	0.54	1.16	0.21	169.6	59.6	Pallflex Filters T60A20
0.06	0.51	0.99	0.17	186.8	54.2	
0.11	0.52	0.99	0.23	183.3	55.2	
0.14	0.51	1.00	0.18	086.2	54.3	
$\bar{x}$ = 0.09	0.52	1.03	0.20	181.4	55.9	

TABLE A-6. EMISSIONS AND FUEL ECONOMY OF VW TURBO-RABBIT: STEADY STATE (CONT.)

30/MPH/2nd GEAR

HC g/mile	CO g/mile	NO_x g/mile	Part. g/mile	CO_2 g/mile	Fuel Economy (MPG)	Notes
0.15	0.86	1.61	0.30	238.3	42.4	Millipore Teflon Filters
0.21	0.93	1.60	0.31	234.1	43.1	
0.20	0.80	1.54	0.25	223.0	45.2	
			$\bar{x}$ = 0.29			
0.19	0.97	1.57	0.29	220.9	45.6	Pallflex Filters T60A20
0.31	1.02	1.58	0.32	214.1	47.0	
0.27	1.14	1.48	0.24	212.2	47.4	
			$\bar{x}$ = 0.28			
$\bar{x}$ 0.22	0.95	1.6		223.8	45.1	
σ = 0.06	0.12	0.05		10.5	2.0	

TABLE A-7. EMISSIONS AND FUEL ECONOMY OF VW TURBO-RABBIT: SHALE DERIVED NAVY DIESEL FUEL (DFM-2)

Cycle	HC g/mile	CO g/mile	NO_x g/mile	Part. g/mile	CO_2 g/mile	Fuel Economy (MPG)	Notes
FTP Urban	0.06	0.55	1.22	0.25	216.4	46.8	
FTP Urban	0.11	0.58	1.18	0.26	228.2	44.4	
	$\bar{x}$ = 0.08	0.56	1.20	0.25	222.3	45.6	
Highway	0.04	0.44	1.16	0.27	191.9	52.8	
Highway	0.07	0.46	1.14	0.24	198.2	51.1	
	$\bar{x}$ = 0.05	0.45	1.15	0.25	195.0	51.9	
NYCC	0.28	1.48	1.68	0.25	321.0	31.4	CO_2 Background
NYCC	0.32	1.42	1.83	0.25	361.7	27.9	Varied
	$\bar{x}$ = 0.3	1.45	1.76	0.25	341.4	29.6	
CUE	0.09	0.48	1.12	0.24	200.1	50.6	
CUE	0.07	0.46	1.08	0.19	188.1	53.8	
	$\bar{x}$ = 0.08	0.47	1.10	0.22	194.1	52.2	

APPENDIX B

LARGE-VOLUME PARTICULATE FILTERS COLLECTED FOR EPA'S DIESEL HEALTH EFFECTS RESEARCH PROGRAM

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA 02142

April 3, 1979

REPLY TO ATTENTION OF: DTS-321

Dr. Roy Zweidinger
Research Chemist
USEPA - MD 59
Research Triangle Park, NC 27711

Dear Roy:

Enclosed are the initial diesel particulate samples obtained by TSC from the VW-Turbocharged Rabbit under EPA#TSC Interagency Agreement.

Please note that Samples 1 through 4 tunnel gas temperatures exceeded the maximum recommended by EPA by approximately 15°C. These samples are included; you may wish to discard them.

Sincerely,

Joseph C. Sturm

2 Enclosures:
List of Filters
Filters

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA 02142

Joe Sturm

April 27, 1979

REPLY TO ATTENTION OF: DTS-331

Dr. Roy Zwerdinger
Research Chemist
US EPA - MD 59
Research Triangle Park, NC 2711

Dear Roy:

Enclosed are the remainder of the 20 x 20 filters from the VW Rabbit. Also enclosed is a list of the filter #s and weights. This information is also on each envelope.

Sincerely,

R. A. Walter

Enclosures

Filter Number	Run Number	Net Weight Grams
37a	4-3-9	0.97
37b	4-3-9	0.93
38a	4-3-10	1.00
38b	4-3-10	1.04
39a	4-3-10	1.08
39b	4-3-10	1.11
40a	4-3-12	1.00
40b	4-3-12	0.96
41a	4-3-14	0.92
41b	4-3-14	0.92
42a	4-3-13	1.04
42b	4-3-13	1.00
43a	4-4-1	0.80
43b	4-4-1	0.76
44a	4-4-2	0.79
44b	4-4-2	0.79
45a	4-4-3	0.90
45b	4-4-3	0.87
46a	4-4-4	0.87
46b	4-4-4	0.90
47a	4-4-5	0.89
47b	4-4-5	0.84
48a	4-4-6	0.86
48b	4-4-6	0.85
49a	4-4-7	0.98
49b	4-4-7	0.92
50a	4-4-8	0.94
50b	4-4-8	0.88
51a	4-4-9	0.88
51b	4-4-9	0.87

Filter Number	Run Number	Net Weight Grams
128a	4-11-13	0.87
128b	4-11-13	0.79
129a	4-12-1	0.88
129b	4-12-1	0.87
130a	4-12-2	0.84
130b	4-12-2	0.83
131a	4-12-3	0.86
131b	4-12-3	0.86
132a	4-12-4	0.84
132b	4-12-4	0.88
133a	4-12-5	0.72
133b	4-12-5	0.60
134a	4-12-6	0.54
134b	4-12-6	0.57
135a	4-12-7	0.65
135b	4-12-7	0.66
136a	4-12-8	0.77
136b	4-12-8	0.80
137a	4-12-9	1.02
137b	4-12-9	0.99
138a	4-12-10	1.20
138b	4-12-10	1.19
139a	4-12-11	1.12
139b	4-12-11	1.15
140a	4-12-12	1.10
140b	4-12-12	1.12
141a	4-12-13	1.02
141b	4-12-13	1.02
142a	4-12-14	1.06
142b	4-12-14	1.08

Filter Number	Run Number	Net Weight Grams
67a	4-5-10	0.90
67b	4-5-10	0.88
68a	4-5-11	1.00
68b	4-5-11	1.03
69a	4-5-12	1.04
69b	4-5-12	0.98
70a	4-5-13	0.98
70b	4-5-13	0.99
71a	4-5-14	0.90
71b	4-5-14	0.88
72a	4-6-1	0.89
72b	4-6-1	0.88
73a	4-6-2	0.82
73b	4-6-2	0.85
75a	4-6-4	1.00
75b	4-6-4	0.99
76a	4-6-5	0.89
76b	4-6-5	0.91
77a	4-6-6	0.93
77b	4-6-6	0.97
78a	4-6-7	1.01
78b	4-6-7	1.02
79a	4-6-8	1.03
79b	4-6-8	0.99
80a	4-6-9	0.94
80b	4-6-9	0.92
81a	4-6-10	1.00
81b	4-6-10	0.93
82a	4-6-11	0.96
82b	4-6-11	0.93

Filter Number	Run Number	Net Weight Grams
113a	4-10-13	0.86
113b	4-10-13	0.87
114a	4-10-14	0.81
114b	4-10-14	0.87
115a	4-10-15	0.92
115b	4-10-15	0.93
116a	4-11-1	0.70
116b	4-11-1	0.75
117a	4-11-2	0.73
117b	4-11-2	0.72
118a	4-11-3	0.79
118b	4-11-3	0.78
119a	4-11-4	0.81
119b	4-11-4	0.85
120a	4-11-5	0.82
120b	4-11-5	0.85
121a	4-11-6	0.85
121b	4-11-6	0.91
122a	4-11-7	0.92
122b	4-11-7	0.98
123a	4-11-8	0.85
123b	4-11-8	0.84
124a	4-11-9	0.77
124b	4-11-9	0.79
125a	4-11-10	0.84
125b	4-11-10	0.87
126a	4-11-11	0.87
126b	4-11-11	0.89
127a	4-11-12	0.86
127b	4-11-12	0.85

APPENDIX C

SOLVENT EXTRACTION OF LARGE-VOLUME PARTICULATE FILTERS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

May 23, 1979

Mr. Joeseph Sturm, DTS-321
Dept. of Transportation
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Dear Joe:

Enclosed is the extraction data for the VW Turbocharged Rabbit diesel particulate samples. Most of the extractions were carried out in groups of 16 filters using 2.2 liter side-chamber soxhlet extractors (Corning 3885). All extractions were done with Burdick and Jackson Methylenechloride.

Extractions were run for 48 hours with a cycle rate of approximately one per hour. The extracts were then distilled down to about one liter, filtered using a Millipore 0.2 micron filter and concentrated to 250 ml on an all glass rotary evaporator. The percentage extractables were then determined by taking a 2 ml aliquot and evaporating to dryness under nitrogen in a tared vial.

All the individual extracts were then pooled and concentrated to about one liter. Aliquots of this stock composite will be taken to prepare bioassay and skin painting samples. Because of sample backlog, the earliest Ames Test data will not be available until about the middle of June.

Call me if you need additional information.

Sincerely,

Roy Zweidinger

Roy Zweidinger
Research Chemist

Enclosure

APPENDIX D

LARGE-VOLUME PARTICULATE FILTERS FROM NAVAL DFM-2 OIL SHALE-DERIVED FUEL

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA 02142

June 4, 1979

REPLY TO ATTENTION OF: DTS-321

Dr. Ronald L. Bradow
EPA-ESRL
Mail Drop 46
Research Triangle Park, N.C. 27711

Dear Ron,

Subject: Diesel Particulate Samples - Oil Shale - VV917

Attached are sixteen (16) filter samples (Pallflex T60A20 20 inch X 20 inch) of diesel particulate collected from the VW Turbo-Rabbit operated on a diesel fuel derived from oil shale and supplied by the U.S. Navy.

These samples were collected with the vehicle operated on the Highway FET driving schedule.

Sincerely,

Joseph C. Sturm

Attachment