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EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST

AT

WEST PENN POWER

REPORT PREPARED BY
UHI CORPORATION
PROVO, UTAH

April 1, 1991

CONTENTS

INTRODUCTION

FPC-1 is a complex combustion catalyst, which when added to liquid hydrocarbon fuels at a ratio of 1:5000 effectively improves the combustion reaction, resulting in increased engine efficiency and reduced fuel consumption.

Field and laboratory tests alike indicate a potential to reduce fuel consumption in diesel fleets in the range of 4% to 9%. This report summarizes the results of controlled back-to-back field tests conducted in cooperation with West Penn Power, with and without FPC-1 added to the fuel. The test procedures applied were the Carbon Balance Exhaust Emission Tests at a given load and speed.

ENGINES TESTED

The following engine makes were tested:

5 x 7.8 Ford Engines

TEST EQUIPMENT

The equipment and instruments involved in the carbon balance test program were:

Sun Electric SGA-9000 non-dispersive, infrared analyzer (NDIR) for measuring the exhaust gas constituents, HC (unburned hydrocarbons as hexane gas), CO, CO2, and O2.

A Fluke Model 51 type k thermometer and thermocouple for measuring exhaust gas and ambient temperature.

A Hewlett Packard Model 41C programmable calculator for the calculation of the engine performance factors.

TEST PROCEDURE

Carbon Balance

The carbon balance technique for determining changes in fuel consumption has been recognized by the US Environment Protection Agency (EPA) since 1973. The method relies upon the measurement of vehicle exhaust emissions to determine fuel consumption rather than direct measurement (volumetric or gravimetric) of fuel consumption.

The fuel consumption test method utilized in this study involves the measurement of exhaust gases of a stationary vehicle at a steady engine load and rpm. The method produces a value of engine fuel consumption with FPC-1 relative to a baseline value established with the same vehicle.

Engine speed and load are duplicated from test to test, and measurements of exhaust and ambient temperature are made. Under these conditions a minimum of five readings were taken for each parameter after stabilization of the exhaust temperature.
Five trucks were tested for both baseline and treated fuel segments. Each unit was tested under steady-state conditions at a specific engine speed (rpm) while the transmission was in neutral. Table 1 below summarizes the percent change in fuel consumption documented with the carbon balance on an individual unit basis.

Table 1: Summary of Carbon Balance Fuel Consumption Changes

Unit No.	Engine	RPM	% Change
270	7.8 Ford	2500	- 2.00
270	7.8 Ford	1750	- 5.40
227	7.8 Ford	2500	- 6.00
227	7.8 Ford	1750	- 12.10
163	7.8 Ford	2500	- 4.70
163	7.8 Ford	1750	- 6.70
161	7.8 Ford	2500	- 6.00
161	7.8 Ford	1750	- 9.60
156	7.8 Ford	2500	- 2.30
156	7.8 Ford	1750	- 14.60

The results indicate a reduction in fuel consumption for all units tested. The general trend of improved (reduced) fuel consumption is within the general parameters of reduced fuel consumption achievable by the use of FPC-1 Fuel Performance Catalyst.

CONCLUSIONS

The series of tests conducted on a number of 7.8 Ford powered trucks verify that the addition of FPC-1 to the fuel will reduce fuel consumption.

1) The reduction in fuel consumption for the fleet determined by the carbon balance method is 6.90%.

APPENDICES

CARBON BALANCE METHOD TECHNICAL APPROACH:

A fleet of diesel powered equipment owned and operated by West Penn Power was selected for the FPC-1 field test.

The SGA-9000 exhaust analyzer, and the thermometer instrumentation were calibrated prior to both baseline and treated fuel data collection. The SGA-9000 was calibrated using Scott Calibration Gases, and a leak test on the sampling hose and connections was performed.

Each engine was then brought up to stable operating temperature as indicated by the engine water temperature and exhaust temperature. No exhaust gas measurements were made until each engine had stabilized at the engine speed selected for the test. # 2 Diesel fuel was exclusively used throughout the evaluation.

The baseline fuel consumption test consisted of a minimum of five sets of measurements of CO_2, CO, unburned hydrocarbons (measured as CH_4), O_2, and exhaust temperature made at 90 second intervals. Each engine was tested in the same manner.

After the baseline test, on December 17, 1990, the fuel storage tank, from which the fleet is exclusively fueled, was treated with FPC-1 at the recommended level of 1 oz. of catalyst to 40 gallons of diesel fuel (1:5000 volume ratio). The equipment was then operated with the treated fuel as normal until March 27, 1991, when the treated fuel test was run. At this time, the test described above was repeated for each engine, only this time with FPC-1 treated fuel.

Throughout the entire fuel consumption test, an internal self-calibration of the exhaust analyzer was performed after every two sets of measurements to correct instrument drift, if any. A new analyzer exhaust gas filter was installed before both the baseline and treated fuel test series.

From the exhaust gas concentrations measured during the test, the average molecular weight of these gases, and the temperature of the exhaust stream, the rate of fuel consumption may be expressed as a "performance factor" which relates the fuel consumption of the treated fuel to the baseline. The calculations are based on the assumption that the fuel characteristics, engine operating conditions and test conditions are essentially the same throughout the test. All of these factors are controlled as much a possible.

All performance factors are rounded off to the nearest meaningful place, as shown in the sample calculation in Figure 2.

Figure 2.

SAMPLE CALCULATION FOR THE CARBON MASS BALANCE

Baseline:

Equation 1 Volume Fractions

$VFCO2 = 1.932/100$
$= 0.01932$

$VFO2 = 18.95/100$
$= 0.1895$

$VFHC = 9.75/1,000,000$
$= 0.00000975$

$VFCO = 0.02/100$
$= 0.0002$

Equation 2 Molecular Weight

$$Mwt1 = (0.00000975)(86)+(0.0002)(28)+(0.01932)(44)+(0.1895)(32) + [(1-0.00000975-0.0002-0.1895-0.01932)(28)]$$

$Mwt1 = 29.0677$

Equation 3 Calculated Performance Factor

$$pf1 = \frac{2952.3 \times 29.0677}{86(0.00000975)+13.89(0.0002)+13.89(0.01932)}$$

pf1 = 316,000 (rounded to nearest meaningful place)

Treated:

Equation 1 Volume Fractions

$VFCO2 = 1.832/100$
$= 0.01832$

$VFO2 = 18.16/100$
$= 0.1816$

$VFHC = 10.2/1,000,000$
$= 0.0000102$

VFCO = .02/100
= 0.0002

Equation 2 Molecular Weight

Mwt2 = (0.0000102)(86)+(0.0002)(28)+(0.01832)(44)+(0.1816)(32)
+[(1-0.0000102-0.0002-0.1816-0.01832)(28)]

Mwt2 = 29.0201

Equation 3 Calculated Performance Factor

$$pf2 = \frac{2952.3 \times 29.0201}{86(0.0000102)+13.89(0.0002)+13.89(0.01832)}$$

pf2 = 332,000 (rounded)

Equation 4 Percent Change in Fuel Consumption:

% Change F.C. = [(332,000 - 316,000)/316,000](100)

= - 4.8%

Calculation of Fuel Consumption Changes/Carbon Balance

Table 1

Unit 270/2500 RPM

Mwt1	29.1188	Mwt2	29.1137
pf1	201,000	pf2	205,000

% Change F.C. = [(205,000 - 201,000)/201,000](100)

% Change F.C. = - 2.00%

Table 2

Unit 270/1750 RPM

Mwt1	29.0177	Mwt2	29.0044
pf1	294,000	pf2	310,000

% Change F.C. = [(310,000 - 294,000)/294,000](100)

% Change F.C. = - 5.40%

Table 3

Unit 227/2500 RPM

Mwt1	29.0564	Mwt2	29.0397
pf1	251,000	pf2	266,000

% Change F.C. = [(266,000 - 251,000)/251,000](100)

% Change F.C. = - 6.00%

Table 4

Unit 227/1750 RPM

Mwt1	28.9938	Mwt2	28.9689
pf1	340,000	pf2	381,000

% Change F.C. = [(381,000 - 340,000)/340,000](100)

% Change F.C. = - 12.10%

Table 5

Unit 163/2500 RPM

Mwt1	29.1045	Mwt2	29.0874
pf1	212,000	pf2	222,000

% Change F.C. = [(222,000 - 212,000)/212,000](100)

% Change F.C. = - 4.70%

Table 6

Unit 163/1750 RPM

Mwt1	29.0006	Mwt2	28.9829
pf1	327,000	pf2	349,000

% Change F.C. = [(349,000 - 327,000)/327,000](100)

% Change F.C. = - 6.70%

Table 7

Unit 161/2500 RPM

Mwt1	29.0966	Mwt2	29.0813
pf1	215,000	pf2	228,000

% Change F.C. = [(228,000 - 215,000)/215,000](100)

% Change F.C. = - 6.00%

Table 8

Unit 161/1750 RPM

Mwt1	29.0085	Mwt2	28.9839
pf1	313,000	pf2	343,000

% Change F.C. = [(343,000 - 313,000)/313,000](100)

% Change F.C. = - 9.60%

Table 9

Unit 156/2500 RPM

Mwt1	29.0928	Mwt2	29.0763
pf1	221,000	pf2	226,000

% Change F.C. = [(226,000 - 221,000)/221,000](100)

% Change F.C. = - 2.30%

Table 10

Unit 156/1750 RPM

Mwt1	29.0055	Mwt2	28.9725
pf1	316,000	pf2	362,000

% Change F.C. = [(362,000 - 316,000)/316,000](100)

% Change F.C. = - 14.60%

terprises
d Consulting
(412) 538-8842
P.O. Box 156 Evans City, PA 16033

EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: West Penn Power

DATE OF TEST: Dec 17 90

ENGINE TYPE AND SPECS: 7.8 Ford

I.D. NUMBER: 378156 MILEAGE (OR HOURS): 2431

TYPE OF TEST:

AMBIENT AIR TEMPERATURE:

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.04	17	2.75	16.3	428	2500
2.	.04	17	2.73	16.2	430	2500
3.	.04	17	2.74	16.3	433	2500
4.	.04	17	2.74	16.3	434	2500
5.	.04	17	2.72	16.4	437	2500
6.	.02	17	1.91	17.4	359	1750
7.	.02	17	1.91	17.4	357	1750
8.	.02	17	1.92	17.5	349	1750
9.	.02	17	1.92	17.4	347	1750
10.	.02	15	1.92	17.5	341	1750

O = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 4:49 END TIME: 4:56 LENGTH OF TEST: 7

Signature of technician(s):

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EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: West Penn Power

DATE OF TEST: Dec 17, 90

ENGINE TYPE AND SPECS: 7.8 Ford

I.D. NUMBER: 378161 MILEAGE (OR HOURS): 1838

TYPE OF TEST:

AMBIENT AIR TEMPERATURE:

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.04	15	2.84	16.1	427	2500
2.	.04	15	2.82	16.1	429	2500
3.	.04	15	2.82	16.1	436	2500
4.	.04	15	2.83	16.0	437	2500
5.	.04	17	2.82	16.1	442	2500
6.	.02	17	1.92	17.5	354	1750
7.	.02	17	1.92	17.4	352	1750
8.	.02	15	1.93	17.4	345	1750
9.	.02	15	1.95	17.3	345	1750
10.	.02	17	1.98	17.5	343	1750

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 4:36 END TIME: 4:46 LENGTH OF TEST: 10

Signature of technician(s):

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EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: WEST PENN POWER

DATE OF TEST: DEC 17, 1990

ENGINE TYPE AND SPECS: 7.8 Ford 6cy.

I.D. NUMBER: 37-8163 MILEAGE (OR HOURS): 1553

TYPE OF TEST:

AMBIENT AIR TEMPERATURE: 45

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.04	13	2.87	16.1	434	2500
2.	.04	14	2.87	16.1	436	2500
3.	.04	15	2.87	16.2	440	2500
4.	.04	14	2.86	16.1	441	2500
5.	.04	15	2.86	16.1	444	2500
6.	.02	15	1.84	17.5	354	1750
7.	.02	15	1.86	17.5	361	1750
8.	.02	15	1.86	17.7	343	1750
9.	.02	14	1.86	17.6	341	1750
10.	.02	14	1.86	17.5	334	1750

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 4:24 END TIME: 4:32 LENGTH OF TEST: 8

Signature of technician(s):

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NO THROTTLE LOCK

EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: WEST PENN POWER

DATE OF TEST: DEC 17,90

ENGINE TYPE AND SPECS: 7.8 Ford

I.D. NUMBER: 408227 MILEAGE (OR HOURS): 34,194

TYPE OF TEST:

AMBIENT AIR TEMPERATURE:

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.02	10	2.45	16.5	427	2500
2.	.02	10	2.44	16.6	427	2500
3.	.02	10	2.44	16.6	428	2500
4.	.02	10	2.44	16.6	428	2500
5.	.02	10	2.41	16.7	429	2500
6.	.02	10	1.78	17.8	352	1750
7.	.02	10	1.79	17.7	351	1750
8.	.02	11	1.80	17.6	345	1750
9.	.02	10	1.74	17.7	343	1750
10.	.02	11	1.78	17.2	340	1750

FAN ON 1.96

O = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 5:22 END TIME: 5:30 LENGTH OF TEST: 8

Signature of technician(s): W. Beer

B.L.

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FANON

EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: WEST PENN POWER

DATE OF TEST: DEC 17 90

ENGINE TYPE AND SPECS: 2.8 Ford

I.D. NUMBER: 439270 MILEAGE (OR HOURS): 17 888

TYPE OF TEST:

AMBIENT AIR TEMPERATURE:

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.02	13	3.09	15.8	439	2500
2.	.02	13	3.08	15.7	442	2500
3.	.02	13	3.04	15.7	451	2500
4.	.02	12	3.04	15.7	453	2500
5.	.02	13	3.03	15.7	455	2500
6.	.02	17	2.04	17.2	371	1750
7.	.02	15	2.04	17.2	368	1750
8.	.02	17	2.08	17.1	362	1750
9.	.02	15	2.08	17.1	361	1750
10.	.02	17	2.07	17.2	356	1750

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 5:02 END TIME: 5:14 LENGTH OF TEST: 12

Signature of technician(s):

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EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: West Penn Power

DATE OF TEST: March 27, 1991

ENGINE TYPE AND SPECS: 2.8 Ford

I.D. NUMBER: 378156 MILEAGE (OR HOURS): 4645

TYPE OF TEST:

AMBIENT AIR TEMPERATURE: 75

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.05	26	2.67	16.3	416	2500
2.	.05	26	2.66	16.2	419	2500
3.	.05	24	2.68	16.3	429	2500
4.	.05	25	2.65	16.1	433	2500
5.	.05	24	2.66	16.1	438	2500
6.	.03	23	1.67	17.5	355	1750
7.	.03	23	1.65	17.6	351	1750
8.	.03	21	1.63	17.8	342	1750
9.	.03	20	1.65	17.7	346	1750
10.	.03	21	1.66	17.7	344	1750

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 4:33 END TIME: 4:45 LENGTH OF TEST: 12

Signature of technician(s):

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EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: West Penn Power

DATE OF TEST: MARCH 27, 1991

ENGINE TYPE AND SPECS: _____

I.D. NUMBER: 378161 MILEAGE (OR HOURS): 46977

TYPE OF TEST: _____

AMBIENT AIR TEMPERATURE: _____

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.05	24	2.66	16.3	439	2500
2.	.05	24	2.66	16.3	441	2500
3.	.05	24	2.64	16.4	446	2500
4.	.05	23	2.64	16.5	447	2600
5.	.04	23	2.63	16.5	453	2500
6.	.02	23	1.75	17.6	361	1750
7.	.02	23	1.75	17.6	358	1750
8.	.02	22	1.71	17.7	350	1750
9.	.02	22	1.72	17.6	348	1750
10.	.02	22	1.71	17.7	343	1750

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 5:17 END TIME: 5:27 LENGTH OF TEST: 10

Signature of technician(s): _____

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EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: WEST PENN POWER

DATE OF TEST: MARCH 27, 1991

ENGINE TYPE AND SPECS:

I.D. NUMBER: 328163 MILEAGE (OR HOURS): 4878

TYPE OF TEST:

AMBIENT AIR TEMPERATURE:

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.05	26	2.73	16.3	445	2500
2.	.05	26	2.71	16.3	447	2500
3.	.05	28	2.71	16.3	453	2500
4.	.05	28	2.71	16.2	454	2500
5.	.05	28	2.70	16.3	458	2500
6.	.02	24	1.72	17.6	371	1750
7.	.02	24	1.72	17.6	368	1750
8.	.02	23	1.74	17.6	354	1750
9.	.02	22	1.73	17.6	352	1750
10.	.02	23	1.72	17.7	345	1750

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 5:04 END TIME: 5:15 LENGTH OF TEST: 11

Signature of technician(s): WSB

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EXHAUST GAS ANALYSIS DATA SHEET

NAME OF COMPANY: West Penn Power

DATE OF TEST: March 27, 1991

ENGINE TYPE AND SPECS: _____

I.D. NUMBER: 408227 MILEAGE (OR HOURS): 38159

TYPE OF TEST: _____

AMBIENT AIR TEMPERATURE: 73

EXHAUST READINGS

	CO	HC	CO2	O2	EX. TEMP.	RPM
1.	.03	22	2.28	16.8	422	2500
2.	.03	22	2.28	16.9	424	2500
3.	.03	22	2.27	16.9	428	2500
4.	.03	22	2.26	16.8	429	2500
5.	.02	20	2.27	16.9	433	2500
6.	.02	22	1.58	17.8	361	1250
7.	.02	22	1.57	17.9	357	1250
8.	.02	20	1.60	17.9	347	1250
9.	.02	20	1.59	17.8	346	1250
10.	.02	20	1.60	17.9	340	1250

CO = Carbon Monoxide; HC = Hydrocarbons; CO2 = Carbon Dioxide; O2 = Oxygen

START TIME: 5:45 END TIME: 5:55 LENGTH OF TEST: 10

Signature of technician(s): _____