EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST

AT

THE CITY OF OGDEN

REPORT PREPARED BY
UHI CORPORATION
PROVO, UTAH

December 1, 1992

Report No. SOTR 105R

CONTENTS

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 application of the carbon balance test method utilized in this study involves the measurement of exhaust gases of a stationary vehicle under steady-state conditions. 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 carbon containing exhaust gases (CO2, CO, HC), oxygen (O2), exhaust and ambient temperature, and exhaust and ambient pressure are made. Under these conditions a minimum of five readings are taken for each of the above parameters after stabilization of the exhaust, oil, and water 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 Fuel Consumed
140	Cummins L10	2000	-12.09
142	Cummins L10	2300	- 7.42
143	Cummins L10	2300	+ 2.04
144	Cummins L10	2400	- 6.18
141	Cummins L10	2400	-10.00

DISCUSSION

Fuel specific gravity (density) at the time of the baseline test was 0.822 at 94.4 degrees F. Specific gravity measured during the FPC-1 treated test was 0.811 at 70.0 degrees F. Therefore, fuel density was 1.34% greater during the baseline test, as was fuel energy content. The correction factor for the change in fuel density is 1.0134.

Unburned hydrocarbons (HC, measured as hexane gas) showed a consistent reduction in virtually all trucks (24.32 ppm Base vs 16.74 ppm Treated). Carbon monoxide (CO) emissions were also reduced although CO readings were extremely low even during the baseline test (0.0180% Base vs 0.0157% Treated).

CONCLUSIONS

1) The fuel consumption change, as determined by the carbon balance method, ranged from + 2.04% to -12.09%, with a fleet average reduction in fuel consumed of approximately 6.73%. When corrected for the change in fuel density and energy content, the average increases to 6.82% (6.73 x 1.0134).

2) Unburned hydrocarbons and carbon monoxide were reduced. The HC reduction was approximately 31%. The CO reduction was approximately 12.8%.

INTRODUCTION

FPC-1 is a complex combustion catalyst which, when added to liquid hydrocarbon fuels at a ratio of 1:5000, 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 8%. This report summarizes the results of controlled back-to-back field tests conducted in cooperation with the City of Ogden, with and without FPC-1 added to the fuel. The test procedure applied was the Carbon Balance Exhaust Emission Tests at a given engine load and speed.

ENGINES TESTED

The following engine makes were tested:

5 x Cummins L10

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 wet/dry probe for measuring exhaust gas, fuel, and ambient temperature.

A Dwyer magnehelic and pitot tube for exhaust pressure differential measurement.

A hand held photo tachometer for engine speed (rpm) determination where dash mounted tachometers are not available (dash mounted tachometers were used in place of the hand held tachometer).

A hydrometer for fuel specific gravity (density) measurement.

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

APPENDICES

CARBON BALANCE METHOD TECHNICAL APPROACH:

A fleet of five diesel powered trucks owned and operated by the City of Ogden, Ogden, Utah, was selected for a field test to determine the effect of FPC-1 on fuel consumption and harmful emissions.

All instruments were calibrated prior to both baseline and treated fuel data collection. The SGA-9000 was calibrated using Scott Calibration Gases (I/M Protocol 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, oil, and exhaust temperature. No exhaust gas measurements were made until each engine had stabilized at the rpm selected for the test. # 2 Diesel fuel was exclusively used throughout the evaluation. Fuel specific gravity and temperature were taken before testing.

The baseline fuel consumption test consisted of a minimum of five sets of measurements of CO_2, CO, HC, O_2, and exhaust temperature and pressure made at 90 second intervals. Each engine was tested in the same manner.

After the baseline test on August 31, 1992, 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 November 24, 1992, when the trucks were retested. 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 molecular weight of each constituent, and the temperature of the exhaust stream, the 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 engine operating conditions are essentially the same throughout the test. Engines with known mechanical problems or having undergone repairs affecting fuel consumption are removed from the sample.

A sample calculation is found in Figure 2. All performance factors are rounded off to the nearest meaningful place in the sample.

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

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

$$pf2 = 332{,}000 \text{ (rounded)}$$

Equation 4 Percent Change in Engine Performance Factor:

$$\%\ \text{Change PF} = [(332{,}000 - 316{,}000)/316{,}000](100)$$

$$= +\ 4.8\%$$

A + 4.8% change in the calculated engine performance factor equates to a 4.8% reduction in fuel consumption.

Table 1

Calculation of Fuel Consumption Changes

Unit 140/2000 RPM

Mwt1	29.0820	Mwt2	29.0647
pf1	230,619	pf2	246,182
PF1	268,523	PF2	301,109

% Change PF = [(301,109 - 268,523)/268,523](100)

% Change PF = + 12.09%

Table 2

Unit 141/2400 RPM

Mwt1	29.1208	Mwt2	29.1064
pf1	202,059	pf2	210,966
PF1	185,842	PF2	204,433

% Change PF = [(204,433 - 185,842)/185,842](100)

% Change PF = + 10.00%

Table 3

Unit 144/2400 RPM

Mwt1	29.1264	Mwt2	29.1093
pf1	198,546	pf2	207,761
PF2	169,711	PF2	180,197

% Change PF = [(180,197 - 169,711)/169,711](100)

% Change PF = + 6.18%

Table 4

Unit 143/2300 RPM

Mwt1	29.1101	Mwt2	29.1205
pf1	211,954	pf2	203,894
PF1	199,749	PF2	195,676

% Change PF = [(195,676 - 199,749)/199,749](100)

% Change PF = - 2.04%

Table 5

Unit 142/2300 RPM

Mwt1	29.1261	Mwt2	29.0997
pf1	196,624	pf2	216,031
PF2	188,080	PF2	202,045

% Change PF = [(202,045 - 188,080)/188,080](100)

% Change PF = + 7.42%

Note: A positive change in engine performance (PF) indicates a reduction in fuel consumption.