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EVALUATION OF FPC-1® FUEL PERFORMANCE CATALYST

AT

THE CITY OF BOISE

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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 Boise, at the West Boise Waste-water Treatment Plant, 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:

1 x Cummins 330
1 x Cummins 270
1 x Mack 300

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.

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 (CO_2, CO, HC), oxygen (O_2), 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.

Four trucks were tested for the baseline. Three of those same trucks were available for the FPC-1® treated fuel test. 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
91TOY8	Cummins 330	2000	-11.24
353SE	Cummins 270	2000	- 8.44
366SE	Mack 300	1600	- 7.89

DISCUSSION

Unit 363SE was baseline tested but was unavailable for the FPC-1® treated fuel segment of the fuel economy test.

Fuel specific gravity (density) at the time of the baseline test was 0.830 at 59.2 degrees F. Specific gravity measured during the FPC-1® treated test was 0.836 at 47.8 degrees F. Therefore, fuel density was .72% greater during the treated test, as was fuel energy content. The correction factor for the change in fuel density is .9928.

Unburned hydrocarbons (HC, measured as hexane gas) showed a consistent reduction in virtually all trucks. Carbon monoxide (CO) emissions were slightly higher than the baseline which may be caused by insufficient hours of FPC-1® use, (incomplete engine preconditioning), by the colder, more humid weather conditions, or the two factors in tandem.

Extensive field and laboratory testing has shown that preconditioning requires from 250 to 300 hours of operation. The mileage accumulated before testing with FPC-1® would also indicate full engine preconditioning may not be complete.

Smoke emissions could not be quantified, however, comparison of the particulate traps attached to the exhaust gas sampling train show soot or particulate (smoke) has been greatly reduced since FPC-1® treatment. Exhaust odor (due to unburned fuel) was much less noticeable with FPC-1® treatment which also indicates a more complete combustion of the fuel after FPC-1® treatment.

CONCLUSIONS

1) The fuel consumption change, as determined by the carbon balance method, ranged from -7.89% to -11.24%, with a fleet average reduction in fuel consumed of approximately 9.19%. When corrected for the change in fuel density and energy content, the average is 9.12% (9.19 x .9928).

2) Smoke and unburned hydrocarbons were reduced. The HC reduction was 24.34%. Smoke reductions could not be quantified, but appear to be significant.

3) Diesel exhaust odor was noticeably reduced.

Note:
Since completing the carbon balance test, Boise City managers have reviewed actual mileage, fuel consumption, and load records and have determined the fleet has consumed 10%+ less fuel since treating with FPC-1®, when compared to the same six week period in 1991.

APPENDICES

CARBON BALANCE METHOD TECHNICAL APPROACH:

A fleet of four diesel powered trucks owned and operated by the City of Boise, Boise, Idaho, 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 September 16, 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 17, 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.

Calculation of Fuel Consumption Changes

Table 1

Unit 91/2000 RPM

Mwt1	29.0360	Mwt2	29.0226
pf1	309,384	pf2	319,239
PF1	233,622	PF2	259,899

% Change PF = [(259,899 - 233,622)/233,622](100)

% Change PF = + 11.24%

Table 2

Unit 366/1600 RPM

Mwt1	28.9563	Mwt2	28.2962
pf1	407,378	pf2	395,022
PF1	359,381	PF2	387,731

% Change PF = [(387,731 - 359,381)/359,381](100)

% Change PF = + 7.89%

Table 3

Unit 353/2000 RPM

Mwt1	29.1704	Mwt2	29.0031
pf1	328,820	pf2	340,758
PF2	296,392	PF2	321,425

% Change PF = [(321,425 - 296,392)/296,392](100)

% Change PF = + 8.44%

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