EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST

AT

STEIN DISTRIBUTING

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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 Stein Distributing, 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:

3 x Ford 7.8
1 x IH DT 466

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, CO_2, and O_2.

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.

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 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	IH DT 466	2000	- 8.36
170	Ford 8.2	2750	-10.60
174	Ford 8.2	2500	-11.00
176	Ford 8.2	3000	+ 0.19

DISCUSSION

Fuel specific gravity (density) at the time of the baseline test was 0.828 at 84.4 degrees F. Specific gravity measured during the FPC-1 treated test was 0.838 at 55.2 degrees F. The increase in fuel density was caused by the lower fuel temperature.

The relationship between fuel density (or energy content) and fuel consumption is inversely proportional. As fuel density increases, fuel consumption decreases (mpg improves). The relationship is 1:1.

Because of the significant change in fuel density during the FPC-1 treated test, the fuel consumption reductions listed in Table 1 must be corrected for the increase in fuel density. The correction factor is 0.988. The corrected reductions in fuel consumption are approximately 8.26%, 10.47%, and 10.86% for trucks 140, 170, and 174, respectively, while truck number 176 experienced a 0.187% increase in fuel consumption.

Harmful emissions were also effected by FPC-1 fuel treatment. Unburned hydrocarbons (HC, measured as hexane gas) showed a 33.46% reduction.

Smoke emissions, although not quantified, were also reduced as demonstrated by visual comparison of the particulate traps installed on the sampling train leading from the exhaust stack to the NDIR instrument.

Carbon monoxide (CO) increased approximately 18%. This is not surprising given the low mileage accumulation of the test fleet between baseline and FPC-1 treated fuel test segments, and the behavior of the FPC-1 active ingredient.

The increase in CO is likely due to insufficient running time on FPC-1, and the stop-and-go operation of the test fleet. These two factors combine to slow the engine conditioning effect of FPC-1.

FPC-1 appears to re-involve engine carbon residue in the combustion process gradually removing these deposits from critical combustion related areas. Until engine "cleanup" is complete, which may require 200 to 300 hours under ideal conditions, FPC-1 may cause initial increases in CO and smoke. However, once engine cleanup, and therefore, engine conditioning is complete, CO and smoke emissions will be lower than pre-FPC-1 levels. Further, FPC-1 will prevent future deposit formation. Engine performance will be sustained much longer. Emissions will remain lower than pre-FPC-1 levels.

CONCLUSIONS

1) The fuel consumption change, as determined by the carbon balance method and after being corrected for an increase in fuel density, range from +0.187% to -10.86%, with a fleet average reduction in fuel consumed of approximately 7.35%.

2) Smoke and unburned hydrocarbons emissions were reduced after FPC-1 fuel treatment.

3) Engines are still experiencing cleanup and conditioning, indicated by the increase in CO. Smoke and HC emissions, and fuel economy may improve even more with extended FPC-1 use.

RECOMMENDATION

Although a significant fuel savings has already been demonstrated, it is recommended an additional treated fuel test be conducted after the test fleet has accumulated more mileage running on FPC-1.

APPENDICES

CARBON BALANCE METHOD TECHNICAL APPROACH:

A fleet of diesel powered equipment owned and operated by Stein Distributing of Boise, Idaho was selected for the FPC-1 field test.
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.

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 June 10, 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 September 14, 1992, 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 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

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

$pf2 = 332{,}000$ (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 140/2000 RPM

Mwt1	29.0265	Mwt2	29.0434
pf1	281,275	pf2	263,214
PF1	372,630	PF2	403,775

% Change PF = [(403,775 - 372,630)/372,630](100)

% Change PF = + 8.36%

Table 2

Unit 170/2750 RPM

Mwt1	29.1054	Mwt2	29.1010
pf1	207,267	pf2	209,512
PF1	243,848	PF2	269,855

% Change PF = [(269,855 - 243,848)/243,848](100)

% Change PF = + 10.60%

Table 3

Unit 174/2500 RPM

Mwt1	29.0693	Mwt2	29.0640
pf1	225,657	pf2	226,871
PF1	286,227	PF2	318,361

% Change PF = [(318,361 - 286,227)/286,227](100)

% Change PF = + 11.00%

Table 4

Unit 176/3000 RPM

Mwt1	29.1493	Mwt2	29.1448
pf1	182,981	pf2	184,901
PF1	223,769	PF2	223.333

% Change PF = [(223,333 - 223,769)/223,769](100)

% Change PF = - 0.19%