EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST

AT

UTAH POWER AND LIGHT COMPANY
OGDEN, UTAH

REPORT PREPARED BY
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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 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 the Utah Power and Light (UP&L) Transportation Department, Ogden, Utah, under the direction of Mr. Scott Hassett, UP&L Project Engineer, 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 engine speed.

ENGINES TESTED

The following engine makes were tested:

7 x 3208 Cats
2 x 8.2L Detroits

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 Dwyer Magnehelic and pitot tube for measuring exhaust pressure and velocity.

A Monarch Contact/Noncontact hand held tachometer to measure engine speed where a tach was not already available.

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

TEST PROCEDURE

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 and pressure change are made to perform appropriate corrections. Under these conditions a minimum of six readings were taken for each parameter after stabilization of the exhaust temperature.

Nine trucks were tested for both baseline and treated fuel segments. Also, units 3796, 4557, and 4503 were tested again several days later for data verification. Each truck was tested under steady-state conditions at either 2,200, 2,300, 2,400, 2,500 or 3,000 rpm while the transmission was in neutral. Table 1 below summarizes the percent change in fuel consumption on an individual unit basis.

Table 1

Unit No.	Engine	RPM	% Change
3738	3208 Cat	2200	-12.9
**3796	8.2L Detroit	3000	- 4.4
4557	3208 Cat	2500	-10.6
*4557	"	2500	- 7.1
4076	3208 Cat	2500	- 6.1
4487	3208 Cat	2500	-10.7
4503	3208 Cat	2500	- 9.4
*4503	"	2500	-11.5
3777	8.2L Detroit	3000	- 7.5
3386	3208 Cat	2400	- 8.6
4917	3208 Cat	2300	- 9.0

* Fuel consumption reduction from second set of data.

** The second set of data on this unit was thrown out because of an apparent injector problem which caused excessive smoke and erratic exhaust gas readings.

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.

CONCLUSION

The series of tests conducted on a number of Cat and Detroit powered trucks confirm that the addition of FPC-1 to the fuel will reduce fuel consumption.

The reduction in fuel consumption in the fleet is in the range of 4.4% to 12.9%, with a fleet average reduction of 8.9%.

Carbon monoxide (CO) was reduced an average 36.4% and was reduced in all but one engine (see Appendices, Table 10). Unburned hydrocarbons (HC) emissions decreased by an average 2.8% (see Appendices, Table 11).

APPENDICES

CARBON BALANCE METHOD TECHNICAL APPROACH:

A fleet of diesel powered trucks owned and operated by Utah Power and Light Company was selected for the FPC-1 evaluation.

The SGA-9000 exhaust analyzer, the pressure/velocity gauge, the hand held tach, 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 truck 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 truck engine had stabilized at the engine speed selected for the test. Diesel fuel blended at a 50/50 ratio was exclusively used throughout the evaluation.

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

After the baseline test, on January 26, 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 trucks were then operated with the treated fuel as normal until April 20, 1990, when the treated fuel test was run. At this time, the test described above was repeated for each truck engine, only this time with FPC-1 treated fuel.

On May 3, 1990, units 3796, 4557, and 4503 were tested again for data verification. Also, units 3386 and 4917 were tested, having not been available during the April 20th treated test segment.

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, the exhaust pressure 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 the fuel characteristics, engine operating conditions and test conditions are essentially the same throughout the test.

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

Note: In spite of the overall average increase in exhaust temperature, the treated fuel exhaust pressure readings were lower in all but one truck engine. This is contrary to gas laws, which state that pressure increases as temperature increases. Further, it has been our experience that, for the most part, as exhaust temperature increases so does exhaust pressure. The device used to measure the pressure differences in the exhaust is the least precise of the test instruments used, in part because of the scale the device uses and in part because of the even more critical placement of the pitot tube in the exhaust stack. Further, the original magnehelic used during the baseline test was destroyed during another test and a replacement device was used during the treated test segments.

UHI and UP&L engineers feel the across the board reduction in exhaust pressure difference when exhaust temperature had increased may be due in part the above factors.
Therefore, the engine performance factors and subsequent fuel consumption changes shown in this report are calculated from changes in the carbon mass of the exhaust stream only.

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

Table 1

Unit No. 3738

Mwt1	29.0407	Mwt2	28.9867
pf1	272,000	pf2	307,000

% Change F.C. = [(307,000 - 272,000)/272,000](100)

% Change F.C. = -12.9%

Table 2

Unit No. 3796

Mwt1	29.0374	Mwt2	28.9932
pf1	270,000	pf2	282,000

% Change F.C. = [(282,000 - 270,000)/272,000](100)

% Change F.C. = - 4.4%

Table 3

Unit No. 4557

Mwt1	29.0379	Mwt2	28.9909
pf1	282,000	pf2	312,000

% Change F.C. = [(312,000 - 282,000)/282,000](100)

% Change F.C. = -10.6%

Table 3a

Unit No. 4557

Mwt1	29.0379	Mwt2	28.9932
pf1	282,000	pf2	302,000

% Change F.C. = [(302,000 - 282,000)/282,000](100)

% Change F.C. = - 7.1%

Table 4

Unit No. 4487

Mwt1	29.0603	Mwt2	29.0050
pf1	262,000	pf2	290,000

% Change F.C. = [(290,000 - 262,000)/262,000](100)

% Change F.C. = -10.7%

Table 5

Unit No. 4076

Mwt1	29.0355	Mwt2	28.9895
pf1	295,000	pf2	313,000

% Change F.C. = [(313,000 - 295,000)/295,000](100)

% Change F.C. = - 6.1%

Table 6

Unit No. 4503

Mwt1	29.0442	Mwt2	28.9834
pf1	286,000	pf2	313,000

% Change F.C. = [(313,000 - 286,000)/286,000](100)

% Change F.C. = - 9.4%

Table 6a

Unit No. 4503

Mwt1	29.0442	Mwt2	28.9811
pf1	286,000	pf2	327,000

% Change F.C. = [(327,000 - 286,000)/286,000](100)

% Change F.C. = -11.5%

Table 7

Unit No. 3777

Mwt1	29.0265	Mwt2	28.9827
pf1	292,000	pf2	314,000

% Change F.C. = [(314,000 - 292,000)/292,000](100)

% Change F.C. = - 7.5%

Table 8

Unit No. 3386

Mwt1	29.0673	Mwt2	29.0070
pf1	257,000	pf2	279,000

% Change F.C. = [(279,000 - 257,000)/257,000](100)

% Change F.C. = - 8.6%

Table 9

Unit No. 4917

Mwt1	29.0540	Mwt2	28.9934
pf1	268,000	pf2	292,000

% Change F.C. = [(292,000 - 268,000)/268,000](100)

% Change F.C. = - 9.0%

Table 10

Changes in Carbon Monoxide

Unit Number	Baseline CO%	Treated CO%
3738	.110	.060
3796	.053	.030
*4557	.048	.030
4487	.030	.020
4076	.042	.030
*4503	.030	.020
3777	.043	.040
3386	.013	.010
4917	.030	.030
Fleet Average:	.044	.028

Average Reduction on CO = 36.4%

* Treated CO reading was identical in both treated tests

Table 11

Changes in Unburned Hydrocarbons

Unit Number	Baseline HCppm	Treated HCppm
3738	27.8	23.0
3796	11.6	9.3
4557	13.7	15.5
4557		14.3
4487	12.7	11.7
4076	12.8	13.0
4503	12.5	12.2
4503		13.8
3777	11.3	13.5
3386	6.0	7.5
4917	19.0	21.3
Fleet Average:	14.5	14.1

Unburned hydrocarbons decrease = 2.8%

Unburned hydrocarbons are measured as hexane gas.