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EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST

AT

ORE-IDA FOODS, INC.
PHASE II

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, 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 the Phase II controlled back-to-back field tests conducted in cooperation with Ore-Ida Foods, Inc., with and without FPC-1 added to the fuel. The Phase II test was conducted after initial testing with FPC-1 treated fuel indicated engine preconditioning was not complete. 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:
6 x KW T600 Trucks with CAT 3406 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 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.

DISCUSSION

Units 35, 36, and 38 experienced large reductions in exhaust pressure when tested with FPC-1 treated fuel. The remaining three trucks experienced little or no change in exhaust pressure at the time of the FPC-1 segment of the test.

An investigation into factors that might explain the large pressure change revealed all the units in question have curved exhaust stack openings. The curvature of the stacks increases the difficulty of taking accurate exhaust pressure readings. This is caused by the exhaust gases colliding with the stack walls at the curved stack opening. The disruption of the flow of the exhaust gases creates rolling turbulence and uneven air movement. Pitot tube placement in the exhaust stream becomes more critical, and the variability of pressure readings as the stack opening is traversed becomes more severe increasing the probability of significant reading error.

With the exception of Unit 37, all other trucks tested had straight exhaust stack openings. Air flow and, therefore, exhaust pressure is uniform through such openings with little variation as the stack opening is traversed. Pitot tube placement is less critical and the probability of error greatly reduced. Pressure readings are more reliable and more easily reproduced.

Further, exhaust temperature, which is directly related to exhaust pressure was unchanged, except for the effect of ambient temperatures, in all trucks. This too argues that FPC-1 treated fuel exhaust pressures should be virtually identical to the baseline pressure readings.

Given the above factors, the change in fuel consumption in Units 35, 36, and 38 has been calculated using the change in the mass of the carbon in the stack only.

Fuel specific gravity (density) at the time of the baseline test was 0.835 at 78.2 degrees F. Specific gravity measured during the FPC-1 treated test was 0.831 at 56.8 degrees F. Therefore, fuel density was .47% greater during the baseline test, as was fuel energy content. The correction factor for the change in fuel density is 1.0047.

Unburned hydrocarbons (HC, measured as hexane gas) showed a consistent reduction in virtually all trucks. Carbon monoxide (CO) emissions were also reduced. This indicates engine preconditioning has been completed, which was the purpose of the Phase II test. Extensive field and laboratory testing has shown that preconditioning requires from 250 to 300 hours of operation. The mileage accumulated before Phase II testing with FPC-1 agrees with the 250 to 300 hour preconditioning period.

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.

APPENDICES

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)

Table 1

Calculation of Fuel Consumption Changes

Unit 41/1600 RPM

Mwt1	28.9450	Mwt2	28.9586
pf1	466,272	pf2	462,678
PF1	378,003	PF2	387,814

% Change PF = [(387,814 - 378,003)/378,003](100)

% Change PF = + 2.59%

Table 2

Unit 35/1600 RPM

Mwt1	28.9780	Mwt2	28.9679
pf1	387,327	pf2	439,326

% Change PF = [(439,326 - 387,327)/387,327](100)

% Change PF = + 13.34%

Table 3

Unit 36/1600 RPM

Mwt1	28.9516	Mwt2	28.9486
pf1	464,708	pf2	506,644

% Change PF = [(506,644 - 464,708)/464,708](100)

% Change PF = + 8.94%

Comparison of a Baseline Fuel Consumption Rate to Four (4) FPC-1 Treated Fuel Consumption Rates in a Fleet of Kenworth T6000 Tractors over a Fourteen (14) Month Test Period.

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September 30, 1993

I. Introduction:

Beginning in June of 1992, UHI and FPC Technology, Inc. (FPCT), initiated a study of the effectiveness of FPC-1 Fuel Performance Catalyst in a fleet of T6000 Kenworth tractors owned and operated by Ore-Ida Foods, Inc., Ontario, Oregon. The original fleet was comprised of 10, Caterpillar 3406 TA powered tractors. The test procedure was the carbon mass balance calculation adapted for field use by UHI Corporation. The procedure measures the carbon mass in the exhaust while the vehicle is stationary and operating under steady-state engine conditions.

The study was originally intended to document fuel consumption reductions created by the addition of FPC-1 to standard # 2D fuel after an engine conditioning period of 8,000 to 10,000 miles. Later, the study was expanded to determine the effectiveness of the catalyst after approximately 20,000 miles of treated fuel use. Finally, after approximately one year of catalyst treatment, a third study was conducted comparing fuel consumption rate with FPC-1 fuel treatment to the fuel consumption after fuel treatment with the FPC-1 formulation in a new solvent carrier.

The several studies made it possible to determine the long term effectiveness of FPC-1, the accuracy of the test method, and the effectiveness of FPC-1 in the new carrier base.

II. Test Sequence # 1

The first test sequence was conducted using untreated #2D (PF1). Once completed, the test fleet was treated with FPC-1 at a 1:5000 mixing ratio, and put back into normal operation for approximately 90 days. The test procedure was repeated in September of 1992, this time with FPC-1 treated #2D (PF2). Table 1 compares the baseline and treated fuel engine performance factors (PF) and percent change in fuel consumption (PF2-PF1/PF1 x 100) after the 90 day period of FPC-1 use. Seven of the original ten units were available for testing with treated fuel.

Table 1. Fuel Consumption Reduction PF2-PF1/PF1

Unit No.	PF1 (Base)	PF2 (FPC-1)
30	354,022	*399,491
28	365,054	389,190
25	358,950	375,600
37	375,389	420,347
41	378,003	384,917
40	355,245	397,044
42	393,891	401,804
Average:	368,651	395,484
% Change: 7.28%		

* A positive change in the PF equates to a reduction in fuel consumption

III. Test Sequence # 2

Laboratory data indicates a definite engine preconditioning period before maximum fuel consumption reduction can be realized after FPC-1 fuel treatment. The test fleet had accumulated only 8,000 miles of FPC-1 use during the 90 day test period. Engineers wanted to determine if an additional 8,000 to 10,000 miles would effect a greater reduction in fuel consumption. Accordingly, since the test fleet was using FPC-1 on a regular basis, a second carbon mass balance was conducted after the fleet had accumulated an additional 10,000 miles. Table 2 compares the baseline to the second treated fuel (PF3) and presents the fuel consumption reduction. Three of the units tested during the baseline were available for the second treated fuel test segment.

Table 2. Fuel Consumption Reduction PF3-PF1/PF1

Unit No.		PF1 (Base)	PF3 (FPC-1)
25		358,950	*396,212
37		375,389	407,908
41		378,003	387,814
Average:		370,780	397,311
% Change:	7.16%		

* A positive change in PF equates to a reduction in fuel consumption.

The study appeared to demonstrate maximum FPC-1 benefit can be obtained in an 8,000 mile road test. Further, the study confirmed the accuracy of the data and results obtained from the first test sequence. Note the engine performance factors (PF1, PF2, and PF3) show good repeatability.

IV. Test Sequence # 3

During the summer of 1993, UHI, as part of it's continuous program to develop and improve FPC-1, produced a high flash point solvent carrier for FPC-1. Due to the consistency of the data collected in the previous tests of the Kenworth fleet, this fleet was selected for a trial evaluation of FPC-1 and the new carrier.

Although the purpose of this test was to establish a new baseline with FPC-1 treated fuel and compare any change from the baseline after the addition of FPC-1 in the new carrier, the study allowed for an additional comparison of the effectiveness of FPC-1, and the accuracy of the carbon mass balance field adaptation.

The FPC-1 baseline was conducted in August of 1993 (PF4). Table 4 makes the comparison of the August '93 FPC-1 baseline to the June '92 untreated baseline (PF1). Four of the trucks baselined on untreated fuel were available for comparison.

Table 3. Fuel Consumption Reduction PF4-PF1/PF1

Unit No.		PF1 (Base)	PF4 (FPC-1)
37		375,389	*420,902
41		378,003	401,001
40		355,245	418,195
42		393,891	414,174
Average:		375,632	413,568
% Change:	10.10%		

* A positive change in PF euates to a reduction in fuel consumption.

The data indicate greater improvement in fuel consumption after long term FPC-1 use. An examination of truck maintenance showed none of the trucks in the test sample had undergone major repairs.

V. Test Sequence # 4

The 4th and final test sequence was conducted after 8,000 miles of FPC-1 and the new carrier. Although designed to compare FPC-1 baseline fuel consumption to FPC-1 new carrier fuel consumption, the data can be used to determine the continued effectiveness and the accuracy of the carbon mass balance. Table 4 compares the FPC-1 new carrier data (PF5) to the original baseline (PF1).

Table 4. Fuel Consumption Reduction PF5-PF1/PF1

Unit No.		PF1 (Base)	**PF5 (FPC-1)
37		375,389	*418,451
41		378,003	391,059
40		355,245	417,964
Average:		369,546	409,159
% Change:	10.72%		

* A positive change in PF equates to a reduction in fuel consumption.
** New carrier

VI. Appendices

A description of the carbon mass balance technical approach is attached as Appendix 1. A bar graph of the results is attached as Appendix 2.

VII. Conclusion

The following conclusions can be made from an analysis of the data from the several test sequences shown above.

1) FPC-1 new carrier is at least as effective as baseline FPC-1.

2) Fuel consumption reductions may not be maximized in the Cat 3406 engine in a short term test.

3) Fuel consumption reductions averaged approximately 10% in the Cat 3406 engines after nearly 14 months of FPC-1 fuel treatment.

4) The carbon mass balance procedure adapted for field use by UHI is an accurate method of determining changes in fuel consumption. The data indicate the method is accurate to less than 1%.

Appendices

CARBON BALANCE METHOD TECHNICAL APPROACH:

A fleet of Cat 3406 TA powered trucks owned and operated by Ore-Ida Foods, Inc. of Ontario, Oregon, was selected for a FPC-1 field test to determine the effect of FPC-1 on engine performance.

All test 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, 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 put back into operation with the treated fuel until 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 and mass flow rate 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.