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EVALUATION OF FPC-1® FUEL PERFORMANCE CATALYST

AT

FMC Dry Valley Mine

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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 and is central to the EPA-Federal Test Procedures (FTP) and Highway Fuel Economy Test (HFET). 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 engine 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. A minimum of five readings are taken for each of the above parameters after engine stabilization has taken place (rpm, and exhaust, oil, and water temperature have stabilized). The technical approach to the carbon balance method is detailed in the Appendices.

Fuel specific gravity or density is measured enabling corrections to be made to the final engine performance factors based upon the energy content of the fuel reaching the injectors.

Exhaust smoke density was also measured to determine the effect of FPC-1® on this product of incomplete combustion. The change in smoke density is not used in the carbon balance calculation.

Three pieces of mining equipment were tested for both baseline and treated fuel segments. Table 1 below summarizes the percent change in fuel consumption based upon the change in carbon mass in the exhaust. Table 2 summarizes the change in fuel consumption corrected for ambient conditions.

Table 1:

Summary of Carbon Balance Fuel Consumption Changes
(Carbon Change Only)

Unit	Engine	RPM	% Change Fuel Consumption
204	CAT 3512	1800	-10.88
202	CAT 3512	1800	-13.18
201	CAT 3512	1800	-12.56

the engines was less profuse and lighter in color than observed during the baseline fuel test. Table 3 in the Appendices summarizes the changes in smoke density.

3. Fuel Density

Fuel specific gravity (density) for the baseline and treated tests are found on Table 4, along with the correction factors applied to the final engine performance factors (PF). Fuel being consumed by the FMC fleet during the FPC-1® treated test was less dense and, therefore, contained less energy.

4. Emissions Changes

Baseline CO and HC emissions were low, averaging .033% and 14.6 part per million (ppm), respectively. However, although produced in lower concentrations than those usually encountered in off-road heavy duty diesel engines, FPC-1® still had a significant impact upon these products of incomplete combustion. CO was reduced 15.15%; HC was reduced 40.4% after FPC-1® introduction in to the fuel. Table 5 summarizes the emissions data.

Also, exhaust odor created by unburned fuel in the exhaust was much less noticeable with FPC-1® treatment.

HC and CO emissions were basically unchanged in the shovel.

5. Effect of Ambient Conditions

Average air temperature was in the mid-60s for both tests. Barometric pressure for the two test segments did change dramatically averaging 29.58 " Hg for the baseline and 30.23 " Hg for the treated test segment. These data were used to correct engine parameters to standard conditions. Therefore, ambient conditions were corrected for and had little impact upon the fuel consumption changes. The mathematics for the carbon balance, including the corrections for ambient conditions are found on Figure 1 in the Appendices. A sample calculation is also found in the Appendices on Figure 2.

APPENDICES

Table 3:

Smoke Density Comparison

Unit	Base Smoke #	FPC-1® Treated Smoke #	% Change
201	9.00	7.00	-22.20
202	7.50	6.50	-13.30
204	7.50	6.50	-13.30

Table 4:

Fuel Density (specific gravity) Comparison

Base Fuel SG	Treated Fuel SG	Correction Factor
.833	.831	1.0024

Table 5:

Summary of Emissions Data

	Base Fuel				FPC-1® Fuel			
Unit #	**CO%**	**HC**	**CO2%**	**RPM**	**CO%**	**HC**	**CO2%**	**RPM**
204	.030	13.2	2.777	1800	.028	10.7	2.490	1800
202	.030	15.0	2.896	1800	.027	10.0	2.532	1800
201	.038	15.7	2.955	1800	.030	10.4	2.624	1800
FLEET AVE.	**.033**	**14.6**	**2.876**	**1800**	**.028**	**10.4**	**2.549**	**1800**

Table 6:

Summary of Ambient Conditions

	Ave. Air Temperature	Barometric Pressure
Baseline	60.00 deg F	29.58
Treated	66.20 deg F	30.20

Figure 1
CARBON MASS BALANCE FORMULA

ASSUMPTIONS: C_8H_{15} and SG = 0.78
Time is constant
Load is constant

DATA:

Mwt	= Molecular Weight
pf_1	= Calculated Performance Factor (Baseline)
pf_2	= Calculated Performance Factor (Treated)
PF_1	= Performance Factor (adjusted for Baseline exhaust mass)
PF_2	= Performance Factor (adjusted for Treated exhaust mass)
T	= Temperature (^OF)
F	= Flow (exhaust CFM)
SG	= Specific Gravity
VF	= Volume Fraction

$VFCO_2$ = "reading" ÷ 100
VFO_2 = "reading" ÷ 100
VFHC = "reading" ÷ 1,000,000
VFCO = "reading" ÷ 100

EQUATIONS:

$$Mwt = (VFHC)(86)+(VFCO)(28)+(VFCO_2)(44)+(VFO_2)(32)+[(1-VFHC-VFCO-VFO_2-VFCO_2)(28)]$$

$$pf_1 \text{ or } pf_2 = \frac{2952.3 \times Mwt}{89(VFHC)+13.89(VFCO)+13.89(VFCO_2)}$$

$$PF_1 \text{ or } PF_2 = \frac{pf \times (T+460)}{F}$$

FUEL ECONOMY:
PERCENT INCREASE (OR DECREASE)

$$\frac{PF_2 - PF_1}{PF_1} \times 100$$

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:

% Change4 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.