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Trial Evaluation
of
Fuel Performance Catalyst - 1 (FPC-1)

by

U S Steel

October 10, 1988

Report Prepared
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and

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Abstract

This paper will discuss the effect of a fuel catalyst (FPC-1) upon the fuel economy and exhaust emissions of two diesel locomotive tractors owned and operated by U S Steel. It will be shown that the catalyst can provide significant cost savings to the diesel locomotive fleet operated by U S Steel. It will also be shown that a test method that measures changes in the carbon containing gases in the exhaust stream is an accurate means of determining changes in fuel flow to the engine.

Introduction

A combustion improver called Fuel Performance Catalyst - 1 (FPC-1) contains a catalyst that has undergone extensive testing in EPA recognized independent and university affiliated laboratories. These tests, in both gasoline and diesel powered passenger vehicles, have demonstrated that the catalyst can provide fuel savings of 2% to 10%, depending upon vehicle operating parameters, fuel quality, equipment condition, vehicle age and engine mileage.

Test procedures have included the EPA standardized Federal Test Procedures (FTP) and Highway Fuel Economy Test (HFET), the SAE J-1082 Suburban and Interstate Test Cycles, CRC cold start driveability test, and a computerized engine dynamometer test sequence.

Field testing, primarily in heavy duty diesel fleets, substantiates laboratory findings with even greater average improvements and also reveals the catalyst can be an effective means of further reducing operating costs by inhibiting the buildup of hard carbon deposits on critical engine components.

This report summarizes the results of the U S Steel test of the effect of FPC-1 on it's fleet of diesel powered locomotives.

The technique used to determine changes in fuel consumption for the U.S. Steel test is known as the carbon balance exhaust gas analysis. The method measures exhaust concentrations of carbon dioxide (CO2), carbon monoxide (CO), oxygen (O2), and unburned hydrocarbons (HC). Exhaust gas temperature is also measured and engine load is determined from engine tachometer readings.

Instrumentation

Instruments used to conduct the carbon balance include the following:

1) A Sun Electric non-dispersive infrared exhaust gas analyzer, which measures percent (%) CO, CO2, and O2, and HC in parts per million (ppm).

2) An IMC digital thermocouple and thermometer for measuring exhaust and air temperature.

3) A Hewlett-Packard programmable calculator to run the carbon balance calculations.

Methodology

Two diesel locomotives, owned and operated by U S Steel, were tested by UHI and U.S. Steel technicians.

After calibrating the SGA-9000 analyzer and the IMC thermocouple, and performing a leak test on the sampling hose and connections, each locomotive engine was brought up to stable operating temperature as verified with engine water temperature and exhaust temperature. No exhaust data were recorded until each engine had stabilized.

Each engine was tested at full rack (throttle) while stationary. Readings of CO2, CO, HC (measured as CH4), O2 and exhaust temperature were taken at approximately 60 second intervals.

After recording the first two readings, the SGA-9000 auto calibrating button was depressed and the instrument "checked itself" to prevent any drift. This self checking procedure was repeated after each set of two data points throughout the entire test. Several readings were taken on each engine at full rack. The raw data sheets are found in appendices.

After baseline testing, the fuel storage tank from which the U.S. Steel fleet is exclusively fueled, was treated with FPC-1 at the recommended 1 to 5000 ratio (1 oz. FPC-1 to 40 gallons diesel). This took place on Aug. 30, 1988.

On October 6, 1988, after approximately one month of FPC-1 treated fuel use, the above procedure was repeated and the data recorded.

All fuel used during the baseline and treated test segments was #2 diesel from the same bulk storage tank.

Note: A qualitative technique for determining reductions in smoke and particulate was performed during both baseline and treated fuel test segments. This was done by attaching a new 25 micron filter to the SGA-9000 sampling hose at the beginning of each exhaust gas test segment. The filter traps unburned fuel (soot or smoke) exhausted from the engine and sucked through the sampling hose during exhaust gas testing. A comparison of the filter traps revealed the fuel was burning much cleaner with FPC-1 as soot or particulate content was visibly reduced in the FPC-1 treated fuel filter. The control test filter was subjected to exhaust sampling for sixteen (16) minutes. The treated test filter was subjected to exhaust sampling twenty (20) minutes on the identical locomotives. A comparison photograph of the two filters is found in the appendices.

Equipment List

Unit #	Make
ET-4	EMD
ET-12	EMD

Summary

The data from the control and treated fuel test is summarized on Tables I and II.

Table I

Summary of Locomotive Exhaust Gas Data for ET - 4

	CO	**HC**	**CO2**	**O2**	**Exh. Temp.**
Baseline	0.010%	8.2ppm	1.21%	19.0%	264.0 *F
Treated	0.010%	4.8ppm	1.12%	18.3%	271.4 *F

Table II

Summary of Locomotive Exhaust Gas Data for ET - 12

	CO	**HC**	**CO2**	**O2**	**Exh. Temp.**
Baseline	0.026%	8.0ppm	0.76%	19.76%	226.2 *F
Treated	0.028%	4.7ppm	0.72%	19.82%	226.2 *F

From the above data, volume fractions can be calculated. These are then weighed using the known molecular weight of each gas. The average molecular weight and engine performance factors can then be calculated from which fuel consumption changes are determined. The volume fractions, average molecular weight and engine performance factors for the baseline fuel exhaust readings are calculated on Table III. The treated fuel calculations are found on Table IV. The carbon balance calculations and a sample calculation are found in the appendices.

Table III Calculations for ET - 12

Volume Fractions

	Baseline	Treated
VfCO	0.00026	0.00028
VfHC	0.000008	0.0000047
VfCO2	0.00076	0.00072
VfO2	0.1976	0.1982

Total Molecular Weight and Performance Factors

Mwt1	28.9127	Mwt2	28.9084
pf1	776,949	pf2	822,653

Percent Change in Fuel Flow

833,653 - 776,949 = 56,704

$$\frac{56{,}704}{776{,}949}(100) = +5.9\%$$

Table IV Calculations for ET - 42

Volume Fractions

	Baseline	**Treated**
VfCO	0.0001	0.0001
VfHC	0.0000082	0.0000048
VfCO2	0.00121	0.00112
VfO2	0.1900	0.1830

Total Molecular Weight and Performance Factors

Mwt1	28.9543	**Mwt2**	28.9116
pf1	502,348	**pf2**	542,387

Percent Change in Fuel Flow

$$542{,}387 - 502{,}348 = 40{,}039$$

$$\frac{40{,}039}{502{,}348}(100) = +8.0\%$$

Conclusion

Based upon the data gathered during exhaust gas testing with and without FPC-1 Fuel Performance Catalyst, the addition of FPC-1 to the fuel used by the U.S. Steel test fleet created an average 6.95% reduction in fuel consumption at full rack. The fuel consumption reduction reflects measured reductions in the carbon content of the engine exhaust gases while at identical rack settings with the addition of FPC-1.

The qualitative filter trap analysis shows that the FPC-1 treated fuel burned cleaner as manifested by a marked reduction in particulate accumulation in the filter trap.

Appendices


WELCOME to the
LOCO SHOP
"WE KEEP THINGS MOVING"
USS MON VALLEY WORKS
ET-3
APEX


U S STEEL LOCOMOTIVE OCT-1988

EMD

UNIT #	PF_{BL}	PF_{T}	% Δ	MEAN	STDEV	RANGE
12	776,949	822,653	5.88	6.93	1.48	2.09
4	502,348	542,387	7.97			

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EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY U.S. STEEL

DATE OF TEST AUG 30, 1988

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS EMD

I.D. NUMBER ET-~~B~~ 4 MILEAGE (OR HOURS) —

TYPE OF TEST

AMBIENT AIR TEMPERATURE

BACK STACK

EXHAUST READINGS

	CO	HC	CO_2	O_2	EX. TEMP.	RPM FULL
1.	.01	8	1.21	19.0	260	
2.	.01	9	1.21	19.1	261	
3.	.01	8	1.21	19.0	266	
4.	.01	8	1.21	18.9	266	
5.	.01	8	1.21	19.0	267	
6.	.01	8.2	1.21	19.0	264	
7.						
8.	PF_B = 502,347.8 ...					
9.						
10.						

START TIME: 12:29 END TIME: 12:37 LENGTH OF TEST:

Signature of technicians

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EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY U. S. STEEL

DATE OF TEST OCT 6 1988

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS EMD

I.D. NUMBER ET-4 MILEAGE (OR HOURS)

TYPE OF TEST

AMBIENT AIR TEMPERATURE

EXHAUST READINGS

	CO	HC	CO_2	O_2	EX. TEMP.	RPM
1.	.01	5	1.12	18.3	268	FULL
2.	.01	5	1.12	18.2	269	
3.	.01	5	1.13	18.4	271	
4.	.01	5	1.13	18.2	272	
5.	.01	4	1.10	18.4	277	
	.01	4.8	1.12	18.3	271.4	
6.	Cal J Ross					
7.						
8.						
9.				PF = 542,1381,1523		
10.						

START TIME: 1:12 END TIME: 1:23 LENGTH OF TEST: 9

Signature of technicians

7.

8. PF = 822,653,3210

9.

10.

START TIME: 12:38 END TIME: 12:49 LENGTH OF TEST: 11

Signature of technicians

RONNING

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EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY U.S. STEEL

DATE OF TEST AUG 30, 1988

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS EMD

I.D. NUMBER ET-12 MILEAGE (OR HOURS) ——

TYPE OF TEST

AMBIENT AIR TEMPERATURE 79

BACK STACK

EXHAUST READINGS

	CO	HC	CO_2	O_2	EX. TEMP.	RPM
1.	.03	8	.77	19.8	225	FULL
2.	.03	7	.76	19.7	225	
3.	.02	8	.76	19.8	226	
4.	.02	8	.76	19.7	227	
5.	.03	9	.76	19.8	228	
	.026	8	.76	19.76	226.2	
6.						
7.	PF = 776,949.07 PZ					
8.						
9.						
10.						

START TIME: 12:16 END TIME: 12:24 LENGTH OF TEST:

Signature of technicians

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EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY U.S. STEEL

DATE OF TEST OCT. 6, 1988

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS EMD

I.D. NUMBER ET-12 MILEAGE (OR HOURS)

TYPE OF TEST

AMBIENT AIR TEMPERATURE 52

BACK STACK

EXHAUST READINGS

	CO	HC	CO_2	O_2	EX. TEMP.	RPM
1.	.03	4	.72	19.8	225	FULL
2.	.02	5	.71	19.7	225	
3.	.03	4	.72	19.9	226	
4.	.03	5	.72	19.8	227	
5.	.03	5	.71	19.9	228	
	.028	4.66	.716	19.82	226.2	
6.	R. Dennis					
7.						
8.	PF = 822,653.3210					
9.						
10.						

START TIME: 12:38 END TIME: 12:49 LENGTH OF TEST: 11

Signature of technicians

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EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY U. S. STEEL

DATE OF TEST OCT 6, 1988

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS EMD

I.D. NUMBER ET-4 MILEAGE (OR HOURS)

TYPE OF TEST

AMBIENT AIR TEMPERATURE

BACK STACK

EXHAUST READINGS

	CO	HC	CO_2	O_2	EX. TEMP.	RPM
1.	.01	5	1.12	18.3	268	FULL
2.	.01	5	1.12	18.2	269	
3.	.01	5	1.13	18.4	271	
4.	.01	5	1.13	18.2	272	
5.	.01	4	1.10	18.4	277	
6.	Carl J Ross					
7.						
8.						
9.						
10.						

START TIME: 1:12 END TIME: 1:23 LENGTH OF TEST: 9

Signature of technicians

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EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY U.S. STEEL

DATE OF TEST OCT. 6, 1988

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS EMD

I.D. NUMBER ET-12 MILEAGE (OR HOURS)

TYPE OF TEST

AMBIENT AIR TEMPERATURE 52

BACK STACK

EXHAUST READINGS

	CO	HC	CO_2	O_2	EX. TEMP.	RPM
1.	.03	4	.72	19.8	225	FULL
2.	.02	5	.871	19.7	225	
3.	.03	4	.72	19.9	226	
4.	.03	5	.72	19.8	227	
5.	.03	5	.71	19.9	228	
6.	R. Dennis					
7.						
8.						
9.						
10.						

START TIME: 12:38 END TIME: 12:49 LENGTH OF TEST: 11

Signature of technicians

U. S. STEEL   OCT 6, 1988

TREATED

AMB Temp. 52°

I.D.# ET-4   9 minutes   BACK STACK

	CO	HC	CO_2	O_2	Temp	RPM
1	.01	5	1.12	18.3	268	FULL
2	↓	5	1.12	18.2	269	↓
3		5	1.13	18.4	271	
4		5	1.13	18.2	272	
5		4	1.10	18.4	277	

I.D. ET-12   11 minutes   BACK STACK

	CO	HC	CO_2	O_2	Temp	RPM
1	.03	4	.72	19.8	225	FULL
2	.02	5	.71	19.7	225	↓
3	.03	4	.72	19.9	226	
4	.03	5	.72	19.8	227	
5	.03	5	.71	19.9	228	

Good FILTER picture!

CRAIG, CALL me when you GET BACK.

Ed