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EVALUATION OF FPC-1® FUEL PERFORMANCE CATALYST

at

A.T. MASSEY, SPROUSE CREEK MINE

Report Prepared by

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INTRODUCTION

FPC-1® is a 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. The products of incomplete combustion are also positively affected.

Field and laboratory tests alike indicate a potential to reduce fuel consumption in diesel fleets in the range of 5% to 10%. Smoke and carbon monoxide emissions are typically reduced 15 to 30%. This report summarizes the results of controlled back-to-back field tests conducted by UHI Corporation, FPC Unlimited, with and without FPC-1® added to the diesel fuel. The fuel consumption determination procedure applied was the Carbon Balance Exhaust Emission Test at a given engine load and speed. This same method also measures the exhaust concentrations of carbon monoxide and unburned hydrocarbons. Smoke testing was also conducted using the Bacharach Smokemeter method.

EQUIPMENT TESTED

2 x Caterpillar dozers powered by 3412 engines
1 x locomotive powered by an EMD 567 engine

TEST INSTRUMENTS:

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.

Scott Specialty BAR 90 calibration gases for SGA-9000 internal calibration of the SGA-9000.

A Fluke Model 51 type "k" thermometer and wet/dry probe for measuring exhaust, fuel, and ambient temperature.

A Dwyer magnehelic and pitot tube for exhaust pressure differential measurement and exhaust air flow determination (CFM).

A Monarch phototachometer to determine and control engine speed (rpm).

A Bacharach True-Spot smokespot meter to determine the density of exhaust smoke from diesel engines.

A hydrometer for fuel specific gravity (density) measurement.

A Hewlett Packard Model 42S programmable calculator for the calculation of the engine performance factors.

A Snap On throttle control for setting and holding engine speed at a fixed rpm.

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 (CO_2, CO, HC), oxygen (O_2), 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.

Smoke density was determined by drawing a fixed quantity of exhaust gases through a filter medium. The particulate's were collected onto the filter surface and the density determined by comparing the discoloration of the filter paper to a color calibrated scale.

Two dozers and one locomotive made up the final test fleet. The locomotive was tested at three throttle settings. Table 1 in the Appendices summarizes the percent change in fuel consumption based upon the change in carbon flow rate in the exhaust.

DISCUSSION

1. Fuel Density

Fuel specific gravity (density) was during the baseline carbon balance test only, and was not taken during the treated fuel test, therefore, there is no correction possible for any change in fuel density. However, many years experience has shown fuel density changes only slightly during the same season (in this case between April and July), and these changes have little impact upon fuel consumption.

2. The Effect of FPC-1 upon Smoke Density

Smoke density was determined using the Bacharach smoke spot method. The Bacharach True-Spot Smokemeter measures smoke density by drawing a specific volume of exhaust gas through a fine paper filter medium (5 micron) while the engine is operating at a fixed rpm and under

steady-state engine conditions. The smoke particles are trapped on the surface of the filter paper as the exhaust gases are drawn through it forming a darkened area called a "smoke spot". The filter paper is then removed from the smoke tester and the smoke spot visually compared to a precoded smoke scale. A smoke number is then assigned to the smoke spot according to the darkness of the spot. The smoke number scale ranges from 0 to 9. Higher smoke numbers correspond to darker smoke spots, which correspond to a greater smoke density in the exhaust. The baseline and treated fuel smoke spot numbers are found on Table 2 in the Appendices.

A reduction in smoke is prime evidence of improved combustion (Germane, SAE Technical Paper # 831204). Further, reduced exhaust smoking has been shown to be one of first evidences that engine carbon residue and soot blowby into the motor oil are also being reduced (ibid). The reductions in exhaust smoke are logical extensions of improved combustion created by FPC-1.

3. Volumetric Flowrate (Pitot Tube Readings)

The final calculation for determining the fuel flow rate or mass flow rate of the fuel into the engine takes into consideration the temperature and pressure velocity of all the gases in the exhaust. The exhaust gas temperature is recorded using a digital thermometer and thermocouple that is very accurate and easily fixed into place inside the exhaust stack. The pressure velocity readings are more difficult to measure because the pitot tube cannot be fixed inside the stack necessitating the use of a traversing method to locate the center velocity (the theoretical point of highest exhaust gas velocity). Therefore, the pitot tube readings are considered the least accurate and serve only as an indicator of engine speed or rpm.

The changes in the rate of fuel consumption shown are Table 1 are based upon carbon mass change in the exhaust alone, without correcting for exhaust volumetric flow rate (temperature and pressure). Since exhaust temperature and barometric pressure where virtually identical and engine speed was identical from test to test, exhaust pressure velocity is assumed to be constant from baseline to treated tests.

CONCLUSIONS

1) The fuel consumption change determined by the carbon balance method ranged from - 5.69 to - 12.89%. The fleet averaged a 9.34% reduction in fuel consumed after FPC-1 fuel treatment and engine preconditioning.

2) Smoke density was reduced approximately in the Cat engines 22%, while the EMD experienced a 57% average reduction. The fleet averaged a 43% reduction in smoke density after FPC-1 fuel treatment.

APPENDICES

CARBON BALANCE METHOD TECHNICAL APPROACH:

All test instruments were calibrated and zeroed prior to both baseline and treated fuel data collection. The SGA-9000 NDIR exhaust gas analyzer was internally calibrated using Scott Calibration Gases (BAR 90 Gases), and a leak test on the sampling hose and connections was performed. The same procedure was repeated after each test segment to determine any instrument drift.

Each vehicle's engine was brought up to operating temperature at a set rpm and allowed to stabilize as indicated by the engine water and exhaust temperature, and exhaust pressure. No exhaust gas measurements were made until each engine had stabilized at the rpm selected for the test. Engine rpm was set using the dash mounted tachometer (with the exception of shovel's #1 and #4) and checked periodically to prevent any change in engine speed during the data collection period. # 2 diesel was used exclusively throughout the evaluation. Fuel specific gravity (density) and temperature were also taken.

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. Engine rpm were also recorded at approximately 90 second intervals.

After the baseline test the fuel storage tanks were treated with FPC-1® at the recommended level of 1 oz. of catalyst to 40 gallons of fuel (1:5000 volume ratio). Each succeeding fuel shipment was also treated with FPC-1®. The equipment was operated on treated fuel until the final test was run.

During the two test segments, an internal self-calibration of the exhaust analyzer was performed after every two sets of measurements to correct instrument drift, if any.

From the exhaust gas concentrations of $C0_2$, CO, HC, and O_2 measured during the test, the average molecular weight of these gases, and the temperature and volumetric flow rate of the exhaust stream, the mass flow rate of the fuel to the engine (rate of fuel consumption) may be expressed as a engine "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.

COMPUTER PRINTOUTS

Company Name:	A.T. Massey	*Location*	Sprouse Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs*	18728		
Equipment Type:	Bull dozer	*ID #:*	2	*Baro*	30.12
Fuel Sp. Gravity(SG	0.8300	*Temp:*			
				Time:	1240

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
Full Throttle	467.8	2.8	0.03	8	3.25	15.5	
Full Throttle	468.8	2.8	0.03	8	3.25	15.4	
Full Throttle	468.8	2.8	0.03	8	3.24	15.4	
Full Throttle	469.2	2.8	0.03	8	3.23	15.4	
Full Throttle	469.8	2.8	0.03	8	3.25	16.1	
Full Throttle	469.2	2.8	0.03	8	3.25	16.1	
Full Throttle	469.4	2.8	0.03	8	3.25	16.2	
Full Throttle	470	2.8	0.03	8	3.23	16.3	
Full Throttle	470.4	2.8	0.03	8	3.23	16.3	
Full Throttle	469.8	2.8	0.03	8	3.23	16.3	
#DIV/0!	**469.320**	**2.800**	**.030**	**8.000**	**3.241**	**15.900**	Mean
#DIV/0!	**0.743564986**	**0**	**0**	**0**	**0.00994429**	**0.4163332**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1
8.00E-06	0.0003	0.03241	0.159	29.155024	189,152

Company Name:	A.T. Massey	*Location:*	Sprouse Creek	*Test Date:*	7/17/94
Test Portion:	Treated	*Stack Diam:*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs:*	19958		
Equipment Type	Bull dozer	*ID #:*	2	*Baro:*	30.01
Fuel Sp. Gravity:	0.83	*Temp:*	93		
SG Corr Factor	1			*Time:*	1830

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
Full Throttle	467.6	2.6	0.03	6	2.97	15.8	
Full Throttle	467.4	2.6	0.03	6	2.97	15.8	
Full Throttle	467.4	2.6	0.03	6	2.95	15.7	
Full Throttle	467.6	2.6	0.03	6	2.95	15.7	
Full Throttle	467.8	2.6	0.03	7	2.94	15.7	
Full Throttle	467.8	2.6	0.03	6	2.94	15.7	
Full Throttle	468	2.6	0.03	6	2.92	15.8	
Full Throttle	468.4	2.6	0.03	6	2.92	16	
Full Throttle	468.4	2.6	0.03	6	2.92	16	
#DIV/0!	**467.822**	**2.600**	**.030**	**6.111**	**2.942**	**15.800**	Mean
#DIV/0!	**0.380058475**	**0**	**0**	**0.33333333**	**0.01986063**	**0.12247449**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2
6.11E-06	0.0003	0.02942222	0.158	29.10311	207,847

Performance factor adjusted for fuel density: 207,847

****% Change PF= 9.88 %**

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

Company Name:	A.T. Massey	*Location*	Sprouse Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs*	15690		
Equipment Type:	Bull dozer	*ID #:*	1	*Baro*	30.12
Fuel Sp. Gravity(SG	0.8300	*Temp:*			
				Time:	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
Full Throttle	468.8	2.9	0.03	9	3.25	15.6	
Full Throttle	473.6	2.9	0.03	10	3.23	15.7	
Full Throttle	474.4	2.9	0.03	8	3.23	16	
Full Throttle	475	2.9	0.03	7	3.9	16	
Full Throttle	475	2.9	0.03	8	3.2	15.9	
Full Throttle	475.2	2.9	0.03	7	3.19	15.9	
Full Throttle	474.8	2.9	0.03	8	3.18	15.9	
Full Throttle	474.8	2.9	0.03	9	3.18	16.1	
Full Throttle	475.4	2.9	0.03	9	3.17	16.1	
Full Throttle	475.2	2.9	0.03	9	3.17	16.1	
#DIV/0!	**474.220**	**2.900**	**.030**	**8.400**	**3.270**	**15.930**	Mean
#DIV/0!	**1.971913904**	**5.6196E-08**	**0**	**0.96609178**	**0.22310934**	**0.17029386**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1
8.40E-06	0.0003	0.0327	0.1593	29.1608872	187,516

Company Name:	A.T. Massey	*Location:*	Sprouse Creek	*Test Date:*	7/17/94
Test Portion:	Treated	*Stack Diam:*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs:*	16838		
Equipment Type	Bull dozer	*ID #:*	1	*Baro:*	30.01
Fuel Sp. Gravity:	0.83	*Temp:*	92.5		
SG Corr Factor:	1			*Time:*	18:45

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
Full Throttle	472.8	2.6	0.03	6	3.09	15.5	
Full Throttle	471.2	2.6	0.03	6	3.08	15.5	
Full Throttle	471.2	2.6	0.03	6	3.09	15.5	
Full Throttle	471	2.6	0.03	6	3.08	15.5	
Full Throttle	471	2.6	0.03	6	3.09	15.5	
Full Throttle	471.6	2.6	0.03	6	3.09	15.6	
Full Throttle	472.6	2.6	0.03	6	3.1	15.6	
Full Throttle	473	2.6	0.03	6	3.09	15.6	
#DIV/0!	**471.800**	**2.600**	**.030**	**6.000**	**3.089**	**15.538**	Mean
#DIV/0!	**0.855235974**	**0**	**0**	**0**	**0.0064087**	**0.05175492**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2
6.00E-06	0.0003	0.0308875	0.155375	29.116048	198,187

Performance factor adjusted for fuel density: 198,187

****% Change PF= 5.69 %**

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

Company Name:	A.T. Massey	*Location*	Sprouce Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs*			
Equipment Type:	Locomotive	*ID #:*	2598	*Baro*	30.12
Fuel Sp. Gravity(SG	0.8300	*Temp:*			
				Time:	1110

Notch	Exh Temp	Pv Inch	CO	HC	CO2	O2	
4	258.4	2.8	0.01	4	0.97	18.8	
4	258.8	2.8	0.01	4	0.97	18.8	
4	259.4	2.8	0.01	4	0.96	19	
4	259.6	2.8	0.01	3	0.96	19	
4	260.4	2.8	0.01	4	1.12	19	
4	262.4	2.7	0.01	4	0.95	19	
4	262.4	2.7	0.01	4	0.95	19	
4	262.6	2.8	0.01	3	0.95	19	
4.000	**260.500**	**2.775**	**.010**	**3.750**	**.979**	**18.950**	Mean
0	**1.730400449**	**0.046291**	**1.24453E-10**	**0.46291005**	**0.0576783**	**0.09258201**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1
3.75E-06	0.0001	0.0097875	0.1895	28.9148175	620,066

Company Name:	A.T. Massey	*Location:*	Sprouce Creek	*Test Date:*	7/17/94
Test Portion:	Treated	*Stack Diam:*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs:*			
Equipment Type	Locomotive	*ID #:*	2598	*Baro:*	30.04
Fuel Sp. Gravity:	0.83	*Temp:*	95.2		
SG Corr Factor:	1			*Time:*	1715

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
4	270	2.4	0.01	0	0.89	19.2	
4	270	2.4	0.01	0	0.89	19.1	
4	270	2.4	0.01	0	0.88	19.1	
4	270	2.4	0.01	0	0.88	19.1	
4	272.4	2.4	0.01	0	0.87	19	
4	273	2.4	0.01	0	0.87	19.1	
4.000	**270.900**	**2.400**	**.010**	**.000**	**.880**	**19.100**	Mean
0	**1.407124728**	**0**	**0**	**0**	**0.00894427**	**0.06324555**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2
0.00E+00	0.0001	0.0088	0.191	28.9048	690,301

Performance factor adjusted for fuel density: 690,301

****% Change PF= 11.33 %**

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

Company Name:	A.T. Massey	*Location*	Sprouce Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs*			
Equipment Type:	Locomotive	*ID #:*	2598	*Baro*	30.12
Fuel Sp. Gravity(SG	0.8300	*Temp:*			
				Time:	

Notch	Exh Temp	Pv Inch	CO	HC	CO2	O2	
6	293.8	5.3	0	2	1.24	18.8	
6	293.4	5.3	0.01	2	1.24	18.8	
6	294.8	5.3	0	2	1.24	18.8	
6	297.8	5.2	0.01	5	1.24	18.5	
6	298.6	5.2	0.01	6	1.24	18.4	
6	299.6	5.2	0.01	6	1.23	18.3	
6	300.8	5.2	0.01	6	1.24	18.2	
6.000	**296.971**	**5.243**	**.007**	**4.143**	**1.239**	**18.543**	Mean
0	**2.956188022**	**0.05345225**	**0.0048795**	**2.03540098**	**0.00377964**	**0.2572751**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1
4.14E-06	7.14286E-05	0.01238571	0.185428571	28.940126	492,738

Company Name:	A.T. Massey	*Location:*	Sprouce Creek	*Test Date:*	7/17/94
Test Portion:	Treated	*Stack Diam:*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs:*			
Equipment Typ:	Locomotive	*ID #:*	2598	*Baro:*	30.04
Fuel Sp. Gravity:	0.83	*Temp:*	95.2		
SG Corr Factor:	1			*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
6	316.8	4.9	0	0	1.18	18.6	
6	319	4.9	0.01	0	1.18	18.6	
6	317.6	4.9	0.01	0	1.18	18.6	
6	315.6	4.9	0.01	0	1.16	18.7	
6	315	4.9	0.01	0	1.15	18.7	
6	315.4	4.9	0.01	0	1.15	18.7	
6	315.2	4.9	0.01	1	1.15	18.7	
6	316.2	4.9	0	1	1.15	18.7	
6	321.6	4.9	0.01	0	1.14	18.6	
6	322.8	4.9	0.01	0	1.15	18.6	
6.000	**317.520**	**4.900**	**.008**	**.200**	**1.159**	**18.650**	Mean
0	**2.766787146**	**1.1239E-07**	**0.00421637**	**0.42163702**	**0.01523884**	**0.05270463**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2
2.00E-07	0.00008	0.01159	0.1865	28.9314516	526,878

Performance factor adjusted for fuel density: 526,878

****% Change PF= 6.93 %**

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

Company Name:	A.T. Massey	*Location*	Sprouce Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs*			
Equipment Type:	Locomotive	*ID #:*	2598	*Baro*	30.12
Fuel Sp. Gravity(SG	0.8300	*Temp:*			
				Time:	

Notch	Exh Temp	Pv Inch	CO	HC	CO2	O2	
8	334.6	8.1	0.01	5	1.67	18	
8	331	8.1	0.01	5	1.67	18	
8	334	8.1	0.01	8	1.68	17.9	
8	334.8	8.1	0.01	5	1.66	17.9	
8	335	8.1	0.01	5	1.68	17.9	
8	335.4	8	0.01	5	1.69	17.9	
8	338	8	0.01	6	1.69	17.8	
8	337	8	0.01	6	1.68	17.8	
8.000	**334.975**	**8.063**	**.010**	**5.625**	**1.678**	**17.900**	Mean
0	**2.082409319**	**0.05175492**	**1.24453E-10**	**1.06066017**	**0.01035098**	**0.07559289**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1
5.63E-06	0.0001	0.016775	0.179	28.9847263	364,298

Company Name:	A.T. Massey	*Location:*	Sprouce Creek	*Test Date:*	7/17/94
Test Portion:	Treated	*Stack Diam:*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs:*			
Equipment Type	Locomotive	*ID #:*	2598	*Baro:*	30.04
Fuel Sp. Gravity:	0.83	*Temp:*	95.2		
SG Corr Factor:	1			*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
8	328.6	7.9	0.01	1	1.48	17.9	
8	332.8	7.9	0.01	1.2	1.5	17.9	
8	340.8	7.9	0.01	1.2	1.48	17.9	
8	345.8	7.9	0.01	1.2	1.58	17.7	
8	351.6	7.9	0.01	1.2	1.47	17.8	
8	352.4	7.9	0.01	1.2	1.48	17.8	
8	354.8	7.9	0.01	1.2	1.47	17.8	
8	356.2	7.9	0.01	1.2	1.46	17.8	
8	359	7.9	0.01	1.2	1.45	17.8	
8.000	**346.889**	**7.900**	**.010**	**1.178**	**1.486**	**17.822**	Mean
0	**10.72245826**	**1.1921E-07**	**1.64636E-10**	**0.06666667**	**0.03811532**	**0.06666667**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2
1.18E-06	0.0001	0.01485556	0.178222222	28.9506461	411,240

Performance factor adjusted for fuel density: 411,240

****% Change PF= 12.89 %**

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

Table 1:
Summary of Carbon Balance Fuel Consumption Changes

Unit	Engine	THROTTLE	% Change Fuel Consumption
1	CAT 3412	Full	- 5.69
2	CAT 3412	Full	- 9.88
2598	EMD 567	4	- 11.33
2598	EMD 567	6	- 6.93
2598	EMD 567	8	- 12.89
Average:			**- 9.34**

Table 2:
Comparison of Smoke Spot Numbers

Unit No.	Base SS#	Treated SS#	% Change
1	9.0	7.0	22
2	9.0	7.0	22
2598 (4)	3.0	1.0	66
2598 (6)	3.5	1.5	57
2598 (8)	7.0	3.5	50
Average:			**43**

Figure 1
CARBON MASS BALANCE FORMULAE

ASSUMPTIONS: $C_{12}H_{26}$ and SG = 0.82
Time is constant
Load is constant

DATA:

Mwt = Molecular Weight
pf1 = Calculated Performance Factor (Baseline)
pf2 = Calculated Performance Factor (Treated)
PF1 = Performance Factor (adjusted for Baseline exhaust mass)
PF2 = Performance Factor (adjusted for Treated exhaust mass)
CFM = Volumetric Flow Rate of the Exhaust
SG = Specific Gravity of the Fuel
VF = Volume Fraction
d = Exhaust stack diameter in inches
Pv = Velocity pressure in inches of H_20
P_B = Barometric pressure in inches of mercury
Te = Exhaust temperature ^{O}F

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

EQUATIONS:

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

$$pf1 \text{ or } pf2 = \frac{3099.6 \times Mwt}{86(VFHC)+13.89(VFCO)+13.89(VFCO_2)}$$

$$CFM = \frac{(d/2)^2\pi}{144} \bullet 1096.2 \sqrt{\frac{Pv}{1.325\,(P_B/ET + 460)}}$$

$$PF1 \text{ or } PF2 = \frac{pf \times (Te+460)}{CFM}$$

FUEL ECONOMY:
PERCENT INCREASE (OR DECREASE) $\frac{PF2 - PF1}{PF1} \times 100$

Figure 2.

SAMPLE CALCULATION FOR THE CARBON MASS BALANCE

BASELINE:

Equation 1 (Volume Fractions)

VFHC = 13.20/1,000,000
= 0.0000132

VFCO = 0.017/100
= 0.00017

$VFCO_2$ = 1.937/100
= 0.01937

VFO_2 = 17.10/100
= 0.171

Equation 2 (Molecular Weight)

$$Mwt1 = (0.0000132)(86)+(0.00017)(28)+(0.01937)(44)+(0.171)(32) + [(1-0.0000132-0.00017-0.01937-0.171)(28)]$$

$$Mwt1 = 28.995$$

Equation 3 (Calculated Performance Factor)

$$pf1 = \frac{3099.6 \times 28.995}{86(0.0000132)+13.89(0.00017)+13.89(0.01937)}$$

$$pf1 = 329{,}809$$

Equation 4 (CFM Calculations)

$$CFM = \frac{(d/2)^2\pi \bullet 1096.2}{144}\sqrt{\frac{Pv}{1.325\ \{P_B/(Te + 460)\}}}$$

d = Exhaust stack diameter in inches
Pv = Velocity pressure in inches of H_20
P_B = Barometric pressure in inches of mercury
Te = Exhaust temperature ^OF

$$CFM = \frac{(10/2)^2\pi \bullet 1096.2}{144}\sqrt{\frac{.80}{1.325\{30.00/(313.100 + 460)\}}}$$

CFM = 2358.37

Equation 5 (Corrected Performance Factor)

$$PF1 = \frac{329{,}809(313.1 \text{ deg F} + 460)}{2358.37 \text{ CFM}}$$

PF1 = 108,115

TREATED:

Equation 1 (Volume Fractions)

VFHC = 14.6/1,000,000
= 0.0000146

VFCO = .013/100
= 0.00013

$VFCO_2$ = 1.826/100
= 0.01826

VFO_2 = 17.17/100
= 0.1717

Equation 2 (Molecular Weight)

$$Mwt2 = (0.0000146)(86)+(0.00013)(28)+(0.01826)(44)+(0.1717)(32) + [(1-0.0000146-0.00013-0.01826-0.1717)(28)]$$

$$Mwt2 = 28.980$$

Equation 3 (Calculated Performance Factor)

$$pf2 = \frac{3099.6 \times 28.980}{86(0.0000146)+13.89(0.00013)+13.89(0.01826)}$$

$$pf2 = 349{,}927$$

Equation 4 (CFM Calculations)

$$CFM = \frac{(d/2)^2\pi}{144} \bullet 1096.2 \frac{Pv}{1.325\{P_B/(Te + 460)\}}$$

d = Exhaust stack diameter in inches
Pv = Velocity pressure in inches of H_20
P_B = Barometric pressure in inches of mercury
Te = Exhaust temperature ^oF

$$CFM = \frac{(10/2)^2\pi}{144} \bullet 1096.2 \sqrt{\frac{.775}{1.325\{29.86/(309.02 + 460)\}}}$$

$$CFM = 2320.51$$

Equation 5 (Corrected Performance Factor)

$$PF2 = \frac{349{,}927(309.02 \text{ deg F} + 460)}{2320.51 \text{ CFM}}$$

$$= 115{,}966$$

Fuel Specific Gravity Correction Factor

Baseline Fuel Specific Gravity - Treated Fuel Specific Gravity/Baseline Fuel Specific Gravity +1

.840-.837/.840+1=1.0036

PF2 = 115,966 x Specific Gravity Correction

PF2 = 115,966 x 1.0036

PF2 = 116,384

Equation 6 (Percent Change in Engine Performance Factor:)

$$\% \text{ Change PF} = \frac{PF2 - PF1}{PF1} \times 100$$

% Change PF = [(116,384 - 108,115)/108,115](100)

= +7.65

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

****

Item: 2 Code: CWV

1PM Sun 17 April WEST VIRGINIA this hour TODAY'S DATA

TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Wheeling	mstly cldy	62	W 11G23	54	20	35%	30.02s			
Morgantown	mstly cldy	63	NW 20G24	51	25	28%	30.00s	63	40	
Clarksburg	ptly cldy	62	W 21G29	49	25	26%	30.04f	62	44	
Parkersburg	ptly cldy	64	NW 11G29	57	20	25%	30.10r	64	38	
Elkins	ptly cldy	62	NW 21G31	49	25	24%	30.06s	62	38	
Martinsburg	mstly cldy	64	W 17G37	54	25	26%	29.94s	64	39	
Huntington	clear	67	NW 14G26	59	20	31%	30.12s	67	51	Trace
Charleston	clear	66	W 11G30	60	20	24%	30.10s	66	45	0.03
Beckly	clear	62	NW 22G30	49	40	21%	30.12s	62	41	
Lewisburg	clear	63	W 14G28	54	20	37%	30.06f	63	41	
White SulfSpg	.....									
Bluefield	clear	64	W 18G26	53	20	22%	30.11s	64	46	

****

Item: 4 Code: CWV

(1pm) ~~3PM~~ Sun 17 July WEST VIRGINIA this hour TODAY'S DATA

TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Wheeling	haze	83	SW 5	96	6	59%	30.08f	84	76	
Morgantown	haze	83	S 6	96	6	59%	30.08f	84	63	
Clarksburg	ptly cldy	80	W 8	93	7	65%	30.09f	80	64	
Parkersburg	.....									
Elkins	hvy rain	75	CALM	89	7	79%	30.16f	75	60	0.63
Martinsburg	.....									
Huntington	haze	85	S 7	99	5	57%	30.04s	85	70	
Charleston	ptly cldy	83	NE 6	99	10	65%	30.06r	83	67	0.02
Beckly	lgt rain	75	S 7	89	10	79%	30.16s	76	64	0.04
Lewisburg	light fog	70	CALM	85	3	97%	30.15f	75	61	
White SulfSpg	.....									
Bluefield	mstly cldy	77	W 9	89	7	69%	30.17r	82	65	Trace

Interim Report
A.T. Massey Field Trial of FPC-1 Fuel Performance Catalyst

Prepared by UHI Corporation
Provo, Utah

May 3, 1994

I. Introduction

FPC-1 Fuel Performance Catalyst is a burn rate modifier proven to reduce fuel consumption and increase engine horsepower in several recognized, independent laboratory tests, and dozens of independent field trials. The catalyst also has a positive impact upon the products of incomplete combustion, primarily soot (smoke) and carbon monoxide.

The intent of the current trial at A.T. Massey is to determine the degree of fuel consumption, smoke and carbon monoxide reduction resulting from the addition of the FPC-1 catalyst to the # 2 diesel fuelling a select fleet of haul trucks. The test methodology for determining fuel consumption is the carbon mass balance (CMB). The CMB method measures the carbon containing products of the combustion process (CO2, CO, HC) found in the exhaust, rather than directly measuring fuel flow into the engine.

This report summarizes the baseline fuel emissions data and computes the engine performance factors (mass flow rates) for the same.

II. Discussion of Carbon Mass Balance Method

The data collected during the baseline fuel carbon balance test are summarized on the attached computer printouts. The data provides the volume fraction (VF) of each gas is determined and the average molecular weight (Mwt) of the exhaust gases computed. Next, the engine performance factor (pf) based upon the carbon mass in the exhaust is computed. The pf is finally corrected for intake air temperature and pressure, and total exhaust mass yielding a corrected engine performance factor (PF). The baseline PFs are tabulated on Table 1 below. The baseline PFs will be compared to FPC-1 treated fuel PFs and a percent change in mass carbon flow rate (fuel consumption) computed. This percent change equates to the fuel consumption change created by the addition of FPC-1.

Also, the treated fuel PF must be corrected for any change in fuel density (measured as specific gravity), and therefore, energy content. The baseline fuel density is used as the reference. No correction factor is shown in the attached printouts. These will be tabulated and shown in the final report.

The CMB procedure is conducted while the engine is operated under steady-state conditions at a high idle. No load is placed on the engine. Consequently, the engine is tested while operating under conditions conducive to high efficiency and low emissions of the products of incomplete combustion. The CMB results, therefore, represent minimum improvements, and FPC-1 created engine efficiency should be higher under high load/transient operation.

Table 1. Comparison of Baseline PFs

Unit No.	Engine Type	Baseline PF
2	CAT 3412	56,921
1	CAT 3412	55,593
2598 (Notch 4)	EMD 567 D3	73,350
2598 (Notch 6)	EMD 567 D3	43,466
2598 (Notch 8)	EMD 567 D3	26,557

III. Discussion of Bacharach Smoke Spot Method

Smoke density was determined using the Bacharach Smoke Spot method. The Bacharach method draws a constant volume of exhaust gas through a filter medium. The particulate in the exhaust gas sample collects on the surface of the filter medium. The surface is darkened by the particulate according to the density of the particulate in the exhaust sample. The greater the particulate density, the darker the color. The Bacharach smoke scale ranges from 0 to 9, with 0 being a white, particulate free filter, and 9 being a completely black filter.

The smoke spot (density) numbers for each engine tested are shown on Table 2 below. The FPC-1 treated smoke spot numbers will be compared to the baseline smoke numbers.

Table 2: Smoke Numbers

Unit No.	Smoke No.
2	9.0
1	9.0
2598 (Notch 4)	3.0
2598 (Notch 6)	3.5
2598 (Notch 8)	7.0
Fleet Average:	**6.3**

IV. Summary

The baseline CMB and Bacharach Smoke Spot procedures have been completed at A.T. Massey. The Bacharach Smoke Spot test has also been done. Carbon monoxide emissions are a part of the CMB, and therefore, are also available for comparison to the treated fuel concentrations.

The A.T. Massey fuel system is treated with FPC-1. The engine preconditioning period will be completed after approximately 500 hours of engine operation.

Company Name:	A.T. Massey	*Location*	Sprouse Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs*	18728		
Equipment Type:	Bull dozer	*ID #:*	2	*Baro*	30.12
Fuel Sp. Gravity(SG		*Temp:*			
				Time:	1240

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
Full Throttle	467.8	2.8	0.03	8	3.25	15.5	
Full Throttle	468.8	2.8	0.03	8	3.25	15.4	
Full Throttle	468.8	2.8	0.03	8	3.24	15.4	
Full Throttle	469.2	2.8	0.03	8	3.23	15.4	
Full Throttle	469.8	2.8	0.03	8	3.25	16.1	
Full Throttle	469.2	2.8	0.03	8	3.25	16.1	
Full Throttle	469.4	2.8	0.03	8	3.25	16.2	
Full Throttle	470	2.8	0.03	8	3.23	16.3	
Full Throttle	470.4	2.8	0.03	8	3.23	16.3	
Full Throttle	469.8	2.8	0.03	8	3.23	16.3	
#DIV/0!	**469.320**	**2.800**	**.030**	**8.000**	**3.241**	**15.900**	Mean
#DIV/0!	**0.743564986**	**0**	**0**	**0**	**0.00994429**	**0.4163332**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
8.00E-06	0.0003	0.03241	0.159	29.155024	189,152	56,921

Company Name:	A.T. Massey	*Location:*	Sprouse Creek	*Test Date:*	
Test Portion:	Treated	*Stack Diam:*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs:*			
Equipment Type	Bull dozer	*ID #:*	2	*Baro:*	
Fuel Sp. Gravity:		*Temp:*			
SG Corr Factor:				*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Mean
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Performance factor adjusted for fuel density: #DIV/0!

****% Change PF= ##### %**

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

Company Name:	A.T. Massey	*Location*	Sprouse Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs*	15690		
Equipment Type:	Bull dozer	*ID #:*	1	*Baro*	30.12
Fuel Sp. Gravity(SG		*Temp:*			
				Time:	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
Full Throttle	468.8	2.9	0.03	9	3.25	15.6	
Full Throttle	473.6	2.9	0.03	10	3.23	15.7	
Full Throttle	474.4	2.9	0.03	8	3.23	16	
Full Throttle	475	2.9	0.03	7	3.9	16	
Full Throttle	475	2.9	0.03	8	3.2	15.9	
Full Throttle	475.2	2.9	0.03	7	3.19	15.9	
Full Throttle	474.8	2.9	0.03	8	3.18	15.9	
Full Throttle	474.8	2.9	0.03	9	3.18	16.1	
Full Throttle	475.4	2.9	0.03	9	3.17	16.1	
Full Throttle	475.2	2.9	0.03	9	3.17	16.1	
#DIV/0!	**474.220**	**2.900**	**.030**	**8.400**	**3.270**	**15.930**	Mean
#DIV/0!	**1.971913904**	**5.6196E-08**	**0**	**0.96609178**	**0.22310934**	**0.17029386**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
8.40E-06	0.0003	0.0327	0.1593	29.1608872	187,516	55,593

Company Name:	A.T. Massey	*Location:*	Sprouse Creek	*Test Date:*	
Test Portion:	Treated	*Stack Diam:*	8 Inches		
Engine Type:	CAT 3412	*Mile/Hrs:*			
Equipment Type	Bull dozer	*ID #:*	1	*Baro:*	
Fuel Sp. Gravity:		*Temp:*			
SG Corr Factor:				*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Mean
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Performance factor adjusted for fuel density: #DIV/0!

****% Change PF= ##### %**

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

Company Name:	A.T. Massey	*Location*	Sprouce Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs*			
Equipment Type:	Locomotive	*ID #:*	2598	*Baro*	30.12
Fuel Sp. Gravity(SG		*Temp:*			
				Time:	1110

Notch	Exh Temp	Pv Inch	CO	HC	CO2	O2	
4	258.4	2.8	0.01	4	0.97	18.8	
4	258.8	2.8	0.01	4	0.97	18.8	
4	259.4	2.8	0.01	4	0.96	19	
4	259.6	2.8	0.01	3	0.96	19	
4	260.4	2.8	0.01	4	1.12	19	
4	262.4	2.7	0.01	4	0.95	19	
4	262.4	2.7	0.01	4	0.95	19	
4	262.6	2.8	0.01	3	0.95	19	
4.000	**260.500**	**2.775**	**.010**	**3.750**	**.979**	**18.950**	Mean
0	**1.730400449**	**0.046291**	**1.24453E-10**	**0.46291005**	**0.0576783**	**0.09258201**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
3.75E-06	0.0001	0.0097875	0.1895	28.9148175	620,066	73,350

Company Name:	A.T. Massey	*Location:*	Sprouce Creek	*Test Date:*	
Test Portion:	Treated	*Stack Diam:*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs:*			
Equipment Type	Locomotive	*ID #:*	2598	*Baro:*	
Fuel Sp. Gravity:		*Temp:*			
SG Corr Factor:				*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Mean
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Performance factor adjusted for fuel density: #DIV/0!

****% Change PF= ##### %**

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

Company Name:	A.T. Massey	*Location*	Sprouce Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs*			
Equipment Type:	Locomotive	*ID #:*	2598	*Baro*	30.12
Fuel Sp. Gravity(SG		*Temp:*			
				Time:	

Notch	Exh Temp	Pv Inch	CO	HC	CO2	O2	
6	293.8	5.3	0	2	1.24	18.8	
6	293.4	5.3	0.01	2	1.24	18.8	
6	294.8	5.3	0	2	1.24	18.8	
6	297.8	5.2	0.01	5	1.24	18.5	
6	298.6	5.2	0.01	6	1.24	18.4	
6	299.6	5.2	0.01	6	1.23	18.3	
6	300.8	5.2	0.01	6	1.24	18.2	
6.000	**296.971**	**5.243**	**.007**	**4.143**	**1.239**	**18.543**	Mean
0	**2.956188022**	**0.05345225**	**0.0048795**	**2.03540098**	**0.00377964**	**0.2572751**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
4.14E-06	7.14286E-05	0.01238571	0.185428571	28.940126	492,738	43,466

Company Name:	A.T. Massey	*Location:*	Sprouce Creek	*Test Date:*	
Test Portion:	Treated	*Stack Diam:*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs:*			
Equipment Type	Locomotive	*ID #:*	2598	*Baro:*	
Fuel Sp. Gravity:		*Temp:*			
SG Corr Factor:				*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Mean
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Performance factor adjusted for fuel density: #DIV/0!

****% Change PF= ##### %**

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

Company Name:	A.T. Massey	*Location*	Sprouce Creek	*Date:*	4/17/94
Test Portion:	Baseline	*Stack Diam.*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs*			
Equipment Type:	Locomotive	*ID #:*	2598	*Baro*	30.12
Fuel Sp. Gravity(SG		*Temp:*			
				Time:	

Notch	Exh Temp	Pv Inch	CO	HC	CO2	O2	
8	334.6	8.1	0.01	5	1.67	18	
8	331	8.1	0.01	5	1.67	18	
8	334	8.1	0.01	8	1.68	17.9	
8	334.8	8.1	0.01	5	1.66	17.9	
8	335	8.1	0.01	5	1.68	17.9	
8	335.4	8	0.01	5	1.69	17.9	
8	338	8	0.01	6	1.69	17.8	
8	337	8	0.01	6	1.68	17.8	
8.000	**334.975**	**8.063**	**.010**	**5.625**	**1.678**	**17.900**	Mean
0	**2.082409319**	**0.05175492**	**1.24453E-10**	**1.06066017**	**0.01035098**	**0.07559289**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
5.63E-06	0.0001	0.016775	0.179	28.9847263	364,298	26,557

Company Name:	A.T. Massey	*Location:*	Sprouce Creek	*Test Date:*	
Test Portion:	Treated	*Stack Diam:*	12 Inches		
Engine Type:	EMD 567 D3	*Mile/Hrs:*			
Equipment Type	Locomotive	*ID #:*	2598	*Baro:*	
Fuel Sp. Gravity:		*Temp:*			
SG Corr Factor:				*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Mean
#DIV/0!	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Performance factor adjusted for fuel density: #DIV/0!

****% Change PF= ##### %**

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

Carbon Mass Balance Field Data Form

Company: AT MASSEY Location: SPROUSE Test Date: 4/17/94
Test Portion: Baseline: ✓ Treated: _____ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 Miles/Hours: 5690 I.D.#: 1
Type of Equipment: DOZER

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 1:05 PM

7 minutes to stabilize

RPM (Fast Idle)	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
	468.8	2.9	.03	9	3.25	15.6	
	473.6	2.9	.03	10	3.23	15.7	
	474.4	2.9	.03	8	3.23	16.0	
	475.0	2.9	.03	7	3.19	16.0	
	475.0	2.9	.03	8	3.20	15.9	
	475.2	2.9	.03	7	3.19	15.9	
	474.8	2.9	.03	8	3.18	15.9	
	474.8	2.9	.03	9	3.18	16.1	
	475.4	2.9	.03	9	3.17	16.1	
	475.2	2.9	.03	9	3.17	16.2	

Cal

Cal

Names of Customer Personnel Participating in Test:

Exh Temps = 1800
Smoke
Chip = 9

_____ _____

Baseline

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: AT MASSEY Location: SPRUCE CREEK Test Date: 4/17/94
Test Portion: Baseline: ✓ Treated: _____ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 ~~Miles~~/Hours: 18,728 I.D.#: 2
Type of Equipment: BULL DOZER

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 12:45 PM

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
full throttle	467.8	2.8	.03	8	3.25	15.5	
	468.8	2.8	.03	8	3.25	15.4	
	468.8	2.8	.03	8	3.24	15.4	
	469.2	2.8	.03	8	3.23	15.4	auto cal
	469.8	2.8	.03	8	3.25	16.1	
	469.2	2.8	.03	8	3.25	16.1	
	469.4	2.8	.03	8	3.25	16.2	
	470.0	2.8	.03	8	3.23	16.3	
	470.4	2.8	.03	8	3.23	16.3	
	469.8	2.8	.03	8	3.23	16.3	

Engine temp 190°

Names of Customer Personnel Participating in Test:

_____ _____

Smoke #9

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: A-MASS/EJ Location: ~~GROVE CREEK~~ Test Date: 4/17/94
Test Portion: Baseline: ✓ Treated: _____ Exhaust Stack Diameter: ~~12~~ 24 Inches

Engine Make/Model: EMD 567D3 Miles/Hours: NA I.D.#: 2598 (LOCO #)
Type of Equipment: LOCOMOTIVE

Fuel Specfic Gravity: * .832 @: _____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 11:10

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO~~ oil pres	
4	258.4	2.8	.01	4	.97	18.8	36#	175°F 170°
4	258.8	2.8	.01	4	.97	18.8		
4	259.4	2.8	.01	4	.96	19.0		
4	259.6	2.8	.01	3 ~~4~~	.96	19.0	35#	175° 180
4	260.4	2.8	.01	4	a/c hitch on 9.12	19.0		
4	262.4	2.7	.01	4 Calib.	.95	19.0	34#	180° 183
4	262.4	2.7	.01	4	.95	19.0		* .832
4	262.6	2.8	.01	4	.95	19.0	33#	
4								
4								

Names of Customer Personnel Participating in Test:

_____ _____

Smoke #3

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company:_____ Location:_____ Test Date:_____
Test Portion: Baseline:_____ Treated:_____ Exhaust Stack Diameter: ___Inches

Engine Make/Model: _____ Miles/Hours:_____ I.D.#: 2598
Type of Equipment: ~~Locomotive~~

Fuel Specfic Gravity: _____ @:_____ (°F)

Barometric Pressure: 20.12 inches of Mercury Start Time:_____

Reload

~~RPM~~ Notch #	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO~~ (ppm)	oil temp °F	water temp °F
6	293.8	5.3	0.00	2	1.24	18.8	32#	180	170
6	293.4	5.3	0.0	3	1.24	18.8		185	175
6	294.8	5.3	0.00	2	1.24	18.8			
6	297.8	5.2	0.01	5	1.24	18.5		188	180
6	298.6	5.2	.01	6	1.24	18.4		190	185
6	299.6	5.2	.01	6	1.23	18.3	32#		
6	300.8	5.2	.01	6	1.24	18.2		195	190
6									
6									
6									

Closed

Normal

Names of Customer Personnel Participating in Test: Smoke # 3-5

_____ _____

Signature of Technicians:

_____ _____

Page 2 of 3

Page 6 3.5

Carbon Mass Balance Field Data Form

Company:_____ Location:_____ Test Date:_____
Test Portion: Baseline:_____ Treated:_____ Exhaust Stack Diameter: __Inches

Engine Make/Model: _____ Miles/Hours:_____ I.D.#:2598
Type of Equipment: Locomotive

Fuel Specfic Gravity: _____ @:_____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time:_____

Reload

~~RPM~~ N1 T4	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ alpha	
8	334.6	8.1 ~~8.2~~	.01	5	1.67	18.0		190 170
8	331.0	8.1	.01	5	1.67	18.0	32#	
8	334.0	8.1	.01	8	1.68	17.9		
8	334.8	8.1	.01	5	1.66 ~~1.79~~	17.9		190 175
8	335	8.1	.01	5	1.68 ~~1.79~~	17.9		
8	335.4	8.0	.01	5	1.69	17.9		190 175
8	335.0	8.0	.01	6	1.69	17.8		
8	337	8.0	.01	6	1.68	17.8		190 177
8								
8								

Eng 3 off

Names of Customer Personnel Participating in Test:

_____ _____

Smoke #7

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: A T MASSEY Location: ~~PROUSE CREEK~~ Test Date: 7/17/94 Pg 1 of 1
Test Portion: Baseline:_____ Treated: ✓ Exhaust Stack Diameter: ~~8~~ Inches

Engine Make/Model: CAT 3412 ~~Miles~~/Hours: 16838 I.D.#: 1
Type of Equipment: DOZER

Fuel Specfic Gravity: .830 @: 92.5 (°F)

Barometric Pressure: 29.01 inches of Mercury Start Time: 18:45 Eastern

~~PPM~~ full	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
Throttle	472.8	~~3.0~~ 2.6	~~.04~~ .03	~~3.09~~ 6	~~15.5~~ 3.09	15.5	
	471.2	2.6	.03	6	3.08	15.5	
	471.2	2.6	.03	6	3.09	15.5	
	471.0	2.6	.03	6	3.08	15.5	
	471.0	2.6	.03	6	3.09	15.5	
	471.6	2.6	.03 auto cal	6	3.09	15.6	
	472.6	2.6	.03 auto cal	6	3.10	15.6	
	473.0	2.6	.03	6	3.09	15.6	

Names of Customer Personnel Participating in Test:

_____ _____

Engine Temp = 180

Smoke Chip = 7

Signature of Technicians:

_____ _____

7/17/94

Carbon Mass Balance Field Data Form

Company: AT MASSEY Location: SPROUSE CREEK Test Date: 7/17/94
Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 Miles/Hours: 19958 I.D.#: 2
Type of Equipment: BULLDOZER

Fuel Specfic Gravity: .820 @: 93 (°F)

Barometric Pressure: 30.04 inches of Mercury Start Time: 1830 Eastern

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
	467.6	2.6	.03	6	2.97	15.8	
	467.4	2.6	.03	6	2.97	15.8	
full throttle	467.4	2.6	.03	6	2.93	15.7	
	467.6	2.6	.03	6	2.95	15.7	
	467.8	2.6	.03	7	2.94	15.7	
	467.8	2.6	.03	6	2.94	15.7	
		Auto Calibrate					
	468.0	2.6	.03	6	2.92	15.8	
	468.4	2.6	.03	6	2.92	16.0	
	468.4	2.6	.03	6	2.92	16.0	

Names of Customer Personnel Participating in Test:

_____ _____

Org # 2
7/17/94

Signature of Technicians:

_____ _____

Eng temp = 190
Smoke = 7

Carbon Mass Balance Field Data Form

Pg 1 of 3

Company: AT MASSEY Location: SPRUCE CREEK Test Date: 7/12/94
Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 12x24 Inches

Engine Make/Model: EMD 567 D3 Miles/Hours: NA I.D.#: 2598
Type of Equipment: LOCOMOTIVE

Fuel Specific Gravity: .830 @: 95.2 (°F)

Barometric Pressure: 30.04 inches of Mercury Start Time: ~~1650~~ 1715 Eastern

RPM NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO$_x$~~ OIL PRESSURE	water temp	oil temp
4	270	2.4	.01	0	.89	19.2	33	175	179
4			.01	0	.89	19.1	33	178	182
4			.01	0	.88	19.1	32	181	184
4			.01	0	.88	19.1	31	182	185
4	272.4	2.4	.01	0	.87	19.0	29	186	188
4	273		.01	0	.87	19.1	28	188	190
4									
4									
4									
4									

all four readings almost

Names of Customer Personnel Participating in Test:

_____ _____

Treated

Signature of Technicians:

_____ _____

Smoke = #1

Carbon Mass Balance Field Data Form

Pg 2 of 3

Company: A T M A S S E Y Location: S P R U C E C R E E K Test Date: 7/17/94
Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: ___ Inches

Engine Make/Model: E M D 5 6 7 0 3 Miles/Hours: N/A I.D.#: 2598
Type of Equipment: L O C O M O T I V E

Fuel Specfic Gravity: .830 @: 95.2 (°F)

Barometric Pressure: 30.04 inches of Mercury Start Time: _____

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ OIL PRESSURE	Oil Temp	H_2O Temp
6	316.8		0.00	0	1.18	18.6	28	192	181
6	319.0		.01	0	1.18	18.6	28	192	
6	317.6		.01	0	1.18	18.6			
6	315.6		0	0	1.16	18.7	28	195	186
6	315.0		.01	0	1.15	18.7	28	198	192
6	315.4		.01	0	1.15	18.7	28	200	195
6	315.2		.01	1	1.15	18.7	28	202	193
6	316.2		.00	1	1.15	18.7	28	205	201
6	321.6	Auto Calibrate	.01	0	1.14	18.6	28	208	204
6	322.8	4.9	.01	0	1.15	18.6	28	210	209

1 fan used 40 hp

1 fan on

all fans

Names of Customer Personnel Participating in Test:

_____ _____

$\alpha_{ho} = 1.5$

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Pg 3 of 3

Company: ATMASSEY Location: SARDIS CREEK Test Date: 7/12/94
Test Portion: Baseline:_____ Treated: ✓ Exhaust Stack Diameter: ___Inches

Engine Make/Model: EMD 567 B3 Miles/Hours: NA I.D.#: 2598
Type of Equipment: LOCOMOTIVE

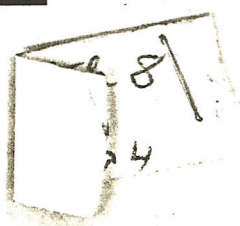
Fuel Specfic Gravity: .830 @: 95.2 (°F)

Barometric Pressure: 29.04 inches of Mercury Start Time:_____

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ OIL PRESSURE	oil Temp	Wate Temp
8	328.6	7.9	.01	1.0	14.8	17.9		190	
8	332.8		.01	1.2	15.0	17.9			
8	340.8		.01	1.2	14.8	17.9	27	193	191
8	345.8		.01	1.2	15.8	17.7	27	202	191
8	351.6		.01	1.2	14.7	17.8			
8	352.4		.01	1.2	14.8	17.8	27	209	203
8	354.8		.01	1.2	14.7	17.8			
8	356.2		.01	1.2	14.6	17.8	27	213	213
8	359.0	7.9	.01	1.2	14.5	17.8			
8									

Names of Customer Personnel Participating in Test:

_____ _____



Smoke = 3.5

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: AT MASSEY Location: GROUSE CREEK Test Date: 4/17/94

Test Portion: Baseline: ✓ Treated: ______ Exhaust Stack Diameter: 12 x 24 Inches

Engine Make/Model: EMD 567 D3 Miles/Hours: NA I.D.#: 2598 (LOCO #)

Type of Equipment: LOCOMOTIVE

Fuel Specfic Gravity: ______________ @: ________ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 11:10

Exhaust filter used Pg 1 of 3

29.85

RELAY 1	2	3	~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO~~ oil press	Oil temp / Water temp
0	0	0	4	258.4	2.8	.01	4	.97	18.8	36#	175°F 170°
0	0	0	4	258.8	2.8	.01	4	.97	18.8		
0	0	0	4	259.4	2.8	.01	4	.96	19.0		
0	0	0	4	259.6	2.8	.01	3	.96	19.0	35#	175° 180
0	0	0	4	260.4	2.5	.01	4	a/c kicked on 1.12	19.0		
0	0	0	4	262.4	2.7	.01	4	Calib. .95	19.0	34#	180° 183
0	0	0	4	262.4	2.7	.01	4	.95	19.0		
0	0	0	4	262.6	2.8	.01	3	.95	19.0	33#	
0	0	0	4								
0	0	0	4								

Names of Customer Personnel Participating in Test:

______________________ ______________________

Smokett 3

Signature of Technicians:

______________________ ______________________

Carbon Mass Balance Field Data Form

Company:_____ Location:_____ Test Date:_____ Ps 3 of 3

Test Portion: Baseline:_____ Treated:_____ Exhaust Stack Diameter: __Inches

Engine Make/Model: _____ Miles/Hours:_____ I.D.#:2598

Type of Equipment: Locomotive

Fuel Specfic Gravity: _____ @:_____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time:_____

Reload

~~RPM~~ N1 T4	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ adjust	
8	334.6	8.1	.01	5	1.67	18.0		190 170
8	331.0	8.1	.01	5	1.67	18.0	32#	
8	334.0	8.1	.01	8	1.68	17.9		
8	334.8	8.1	.01	5	1.66	~~1.79~~ 17.9		190 175
8	335	8.1	.01	5	1.68	~~1.79~~ 17.9		
8	335.4	8.0	.01	5	1.69	17.9		190 175
8	335.0	8.0	.01	6	1.69	17.8		
8	337	8.0	.01	6	1.68	17.8		190 177
8								
8								

Eng 3 off

Names of Customer Personnel Participating in Test:

_____ _____ Smoke #7

Signature of Technicians:

_____ _____

Rack 8
7.0

Carbon Mass Balance Field Data Form

Company:_____ Location:_____ Test Date:_____
Test Portion: Baseline:_____ Treated:_____ Exhaust Stack Diameter: __Inches

Engine Make/Model: _____ Miles/Hours:_____ I.D.#: 2598
Type of Equipment: Locomotive

By 2 of 3

Fuel Specific Gravity: _____ @:_____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time:_____

Reloop

~~Rpm~~ Notch	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO~~ oil pres	oil temp	water temp
6	293.8	5.3	0.00	2	1.24	18.8	32#	180	170
6	293.4	5.3	0.00	3	1.24	18.8		185	175
6	294.8	5.3	0.00	2	1.24	18.8			
6	297.8	5.2	0.01	5	1.24	18.5		188	180
6	298.6	5.2	.01	6	1.24	18.4		190	185
6	299.6	5.2	.01	6	1.23	18.3	32#		
6	300.8	5.2	.01	6	1.24	18.2		195	190
6									
6									
6									

Notch 6 Closed

Names of Customer Personnel Participating in Test:

Smoke #
3-5

_____ _____

Signature of Technicians:

_____ _____

Page 3 of 3

Carbon Mass Balance Field Data Form

Company: A.T. Massey Location: Sprouse Creek Test Date: 04/17/94

Test Portion: Baseline: XXXX Treated: _____ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: Cat 3412 XXXX Miles/Hours: 18,728 I.D.#: 2

Type of Equipment: Bull Dozer

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 12:40 PM

Smoke chip for test = 9; Engine Temperature for test = 190° F

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
UNIT RUN AT	467.8	2.8	.03	8	3.25	15.5	
FULL THROT-TLE	468.8	2.8	.03	8	3.25	15.4	
ENTIRE TEST	468.8	2.8	.03	8	3.24	15.4	
	469.2	2.8	.03	8	3.23	15.4	
	CALIBRATION - 2 MINUTE DELAY						
	469.8	2.8	.03	8	3.25	16.1	
	469.2	2.8	.03	8	3.25	16.1	
	469.4	2.8	.03	8	3.25	16.2	
	470.0	2.8	.03	8	3.23	16.3	
	470.4	2.8	.03	8	3.23	16.3	
	469.8	2.8	.03	8	3.23	16.3	

Names of ~~Customer Personnel~~ Participating in Test:

~~XXXXXXXXXXXXXXXX~~

Independent Observers

E. M. (Ernie) Rogers Richard L. (pete) Runyon

Signature of Technicians:

Craig Flinders Kim LeBaron

Carbon Mass Balance Field Data Form

CAT

Company: A.T. Massey Location: SPROUSE CREEK Test Date: 04/17/94
Test Portion: Baseline: XXX Treated: _____ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 Miles/Hours: 15690 I.D.#: 1
Type of Equipment: BULLDOZER

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 1:05 PM
Smoke Chip for test = 9 ; Engine Temperature for test = 180°F

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
UNIT RUN AT	468.8	2.9	.03	9	3.25	15.6	
FULL THRO-ttle	There was a seven minute pause between reading 1 & 2						
	473.6	2.9	.03	10	3.23	15.7	
ENTIRE TEST	474.4	2.9	.03	8	3.23	16.0	
	CALIBRATION - 2 MINUTE DELAY						
	475.0	2.9	.03	7	3.19	16.0	
	475.0	2.9	.03	8	3.20	15.9	
	475.2	2.9	.03	7	3.19	15.9	
	474.8	2.9	.03	8	3.18	15.9	
	CALIBRATION - 2 MINUTE DELAY						
	474.8	2.9	.03	9	3.18	16.1	
	475.4	2.9	.03	9	3.17	16.1	
	475.2	2.9	.03	9	3.17	16.1	

Names of ~~Customer Personnel~~ Participating in Test:
Independent Observers

E. M. (Ernie) Rogers Richard L. (Pete) Runyon

Signature of Technicians:

Craig Flinders Kim LeBaron

Carbon Mass Balance Field Data Form

CAT #1

Company: A.T. Massey Location: SPROUSE CREEK Test Date: 04/17/94
Test Portion: Baseline: XXX Treated: _____ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 Miles/Hours: 15690 I.D.#: 1
Type of Equipment: BULLDOZER

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 1:05 PM
Smoke Chip for test = 9 ; Engine Temperature for test = 180°F

~~RPM~~	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
UNIT RUN AT	468.8	2.9	.03	9	3.25	15.6	
FULL THRO-ttle	There was a seven minute pause between reading 1 & 2						
	473.6	2.9	.03	10	3.23	15.7	
ENTIRE TEST	474.4	2.9	.03	8	3.23	16.0	
	CALIBRATION - 2 MINUTE DELAY						
	475.0	2.9	.03	7	3.19	16.0	
	475.0	2.9	.03	8	3.20	15.9	
	475.2	2.9	.03	7	3.19	15.9	
	474.8	2.9	.03	8	3.18	15.9	
	CALIBRATION - 2 MINUTE DELAY						
	474.8	2.9	.03	9	3.18	16.1	
	475.4	2.9	.03	9	3.17	16.1	
	475.2	2.9	.03	9	3.17	16.1	

Names of ~~Customer Personnel~~ Participating in Test:
Independent Observers

E. M. (Ernie) Rogers Richard L. (Pete) Runyon

Signature of Technicians:

Craig Flinders Kim LeBaron

Carbon Mass Balance Field Data Form

CAT #2

Company: A.T. Massey Location: Sprouse Creek Test Date: 04/17/94
Test Portion: Baseline: XXXX Treated: _____ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: Cat 3412 XXXX Miles/Hours: 18,728 I.D.#: 2
Type of Equipment: Bull Dozer

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 12:40 PM
Smoke chip for test = 9; Engine Temperature for test = 190° F

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
UNIT RUN AT	467.8	2.8	.03	8	3.25	15.5	
FULL THROT-TLE	468.8	2.8	.03	8	3.25	15.4	
ENTIRE TEST	468.8	2.8	.03	8	3.24	15.4	
	469.2	2.8	.03	8	3.23	15.4	
	CALIBRATION - 2 MINUTE DELAY						
	469.8	2.8	.03	8	3.25	16.1	
	469.2	2.8	.03	8	3.25	16.1	
	469.4	2.8	.03	8	3.25	16.2	
	470.0	2.8	.03	8	3.23	16.3	
	470.4	2.8	.03	8	3.23	16.3	
	469.8	2.8	.03	8	3.23	16.3	

Names of ~~Customer Personnel~~ Participating in Test: XXXXXXXXXXXXXXXX
Independent Observers

E. M. (Ernie) Rogers Richard L. (pete) Runyon

Signature of Technicians:

Craig Flinders Kim LeBaron

Carbon Mass Balance Field Data Form

Company:_____ Location:_____ Test Date:_____

*Test Portion: Baseline:*_____ *Treated:*_____ *Exhaust Stack Diameter:* __Inches

Engine Make/Model: _____ Miles/Hours:_____ I.D.#: 2598

Type of Equipment: ~~Locomotive~~

Fuel Specfic Gravity: _____ @:_____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time:_____

Relay

~~RPM~~ Notch	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO$_x$~~ oil pres	oil temp	water temp
6	293.8	5.3	0.00	2	1.24	18.8	32#	160	170
6	293.4	5.3	0.00	2	1.24	18.8		185	175
6	294.8	5.3	0.00	2	1.24	18.8			
6	297.8	5.2	0.01	5	1.24	18.5		188	180
6	298.6	5.2	.01	6	1.24	18.4		190	185
6	299.6	5.2	.01	6	1.23	18.3	32#		
6	300.8	5.2	.01	6	1.24	18.2		195	190
6									
6									
6									

Closed

Notch

Names of Customer Personnel Participating in Test:

Smoke # 3-5

_____ _____

Signature of Technicians:

_____ _____

Race 6 3.5

Carbon Mass Balance Field Data Form

Pg 3 of 3

Company:_____ Location:_____ Test Date:_____
Test Portion: Baseline:_____ Treated:_____ Exhaust Stack Diameter: __Inches

Engine Make/Model: _____ Miles/Hours:_____ I.D.#:2598
Type of Equipment: Locomotive

Fuel Specfic Gravity: _____ @:_____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time:_____

Reading

~~RPM~~ N7 T4	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ adjust	
8	334.6	8.1 ~~8.1~~	.01	5	1.67	18.0		190 170
8	331.0	8.1	.01	5	1.67	18.0	32#	
8	334.0	8.1	.01	8	1.68	17.9		
8	334.8	8.1	.01	5	1.66 ~~1.79~~	17.9		190 175
8	335	8.1	.01	5	1.68 ~~1.79~~	17.9		
8	335.4	8.0	.01	5	1.69	17.9		190 175
8	335.0	8.0	.01	6	1.69	17.8		
8	337	8.0	.01	6	1.68	17.8		190 177
8								
8								

Exit temp 335

Names of Customer Personnel Participating in Test:

_____ _____

Smoke #7

Signature of Technicians:

_____ _____

Rack 2
7.0

Carbon Mass Balance Field Data Form

Company: AT-MASS (V) Location: BRUSH CREEK Test Date: 4/17/94
Test Portion: Baseline: √ Treated: _____ Exhaust Stack Diameter: ~~12~~ 24 Inches

Engine Make/Model: EMD 567D3 Miles/Hours: N/A I.D.#: 2598 (LOCO #)
Type of Equipment: LOCOMOTIVE

Fuel Specfic Gravity: _____ @: _____ (°F)

Barometric Pressure: 30.12 inches of Mercury Start Time: 11:10

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO~~ oil press	
4	258.4	2.8	.01	4	.97	18.8	36#	175°F 170°F
4	258.8	2.8	.01	4	.97	18.8		
4	259.4	2.8	.01	4	.96	19.0		
4	259.6	2.8	.01	3	.96	19.0	35#	175° 180°
4	260.4	2.8	.01	4	a/c kicked on .92	19.0		
4	262.4	2.7	.01	4 Calib.	.95	19.0	34#	180° 183°
4	262.4	2.7	.01	4	.95	19.0		
4	262.6	2.8	.01	3	.95	19.0	33#	
4								
4								

Names of Customer Personnel Participating in Test:

_____ _____

Smoke #3

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Pg 3 of 3

Company: ATMASSEY Location: SPRUCE CREEK Test Date: 7/17/94
Test Portion: Baseline:_____ Treated: ✓ Exhaust Stack Diameter: __Inches

Engine Make/Model: EMD 567 B3 Miles/Hours: NA I.D.#: 2598
Type of Equipment: LOCOMOTIVE

Fuel Specfic Gravity: .830 @: 95.2 (°F)

Barometric Pressure: 30.04 inches of Mercury Start Time:_____

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ OIL PRESSURE	oil Temp	Water Temp
8	328.6	7.9	.01	1.0	14.8	17.9		190	
8	332.8		.01	1.2	15.0	17.9			
8	340.8		.01	1.2	14.8	17.9	27	193	191
8	345.8		.01	1.2	15.8	17.7	27	202	191
8	357.6		.01	1.2	14.7	17.8			
8	352.4		.01	1.2	14.8	17.8	27	209	203
8	354.8		.01	1.2	14.7	17.8			
8	356.2		.01	1.2	14.6	17.8	27	213	213
8	359.0	7.9	.01	1.2	14.5	17.8			
8									

Names of Customer Personnel Participating in Test:

_____ _____

Signature of Technicians:

Smoke = 3.5

_____ _____

Carbon Mass Balance Field Data Form

Pg 2 of 3

Company: A TM ASSEY Location: SPRUCE CREEK Test Date: 7/17/94
Test Portion: Baseline:_____ Treated: ✓ Exhaust Stack Diameter: ___Inches

Engine Make/Model: EMD 567 D3 Miles/Hours: N/A I.D.#: 2598
Type of Equipment: LOCOMOTIVE

Fuel Specfic Gravity: .830 @: 95.2 (°F)

Barometric Pressure: 30.04 inches of Mercury Start Time:_____

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ OIL PRESSURE	Oil Temp	H_2O Temp
~~6~~	316.8		0.00	0	1.18	18.6	28	~~192~~ 191	181
~~6~~	319.0		.01	0	1.18	18.6	28	192	
~~6~~	317.6		.01	0	1.18	18.6			
~~6~~	315.6		0	0	1.16	18.7	28	195	185
~~6~~	315.0		.01	0	1.15	18.7	28	198	192
~~6~~	315.4		.01	0	1.15	18.7	28	200	195
~~6~~	315.2		.01	1	1.15	18.7	28	~~202~~ 200	193
6	316.2		.00	1	1.15	18.7	28	205	201
6	321.6	Auto Calibrate .01		0	1.14	18.6	28	208	204
6	322.8	~~4.9~~	.01	0	1.15	18.6	28	210	209

1 fan used 40 hp on

All four

Names of Customer Personnel Participating in Test:

_____ _____

Smoke = 1.5

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Pg 1 of 3

Company: AT MASSEY Location: SPRAUSS CREEK Test Date: 7/12/94 12x24
Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: ~~4~~ Inches

Engine Make/Model: EMD 567 D3 Miles/Hours: NA I.D.#: 2598
Type of Equipment: LOCOMOTIVE

Fuel Specfic Gravity: .830 @: 95.2 (°F)

Barometric Pressure: 30.04 inches of Mercury Start Time: ~~1650~~ 1715 Eastern

~~RPM~~ NOTCH	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	~~NO_x~~ OIL PRESSURE	water temp	oil temp
4	270	2.4	.01	0	.89	19.2	33	175	179
4			.01	0	.89	19.1	33	178	182
4			.01	0	.88	19.1	32	181	184
4			.01	0	.88	19.1	31	182	185
4	272.4	2.4	.01	0	.87	19.0	29	186	188
4	273		.01	0	.87	19.1	28	188	190 ✓
4									
4									
4									
4									

all for relays closed

Names of Customer Personnel Participating in Test:

_____ _____

Treated

Signature of Technicians:

Smoke = #1

_____ _____

Carbon Mass Balance Field Data Form

Company: ATMASSEY Location: SPROUSE CAT Test Date: 7/12/94
Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 ~~Miles~~/Hours: 19958 I.D.#: 2
Type of Equipment: BULLDOZER

Fuel Specfic Gravity: .820 @: 93 (°F)

Barometric Pressure: 30.10 inches of Mercury Start Time: 1830 Eastern

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
	467.6	2.6	.03	6	2.97	15.8	
full throttle	467.4	2.6	.03	6	2.97	15.8	
	467.4	2.6	.03	6	2.95	15.7	
	467.6	2.6	.03	6	2.95	15.7	
	467.8	2.6	.03	7	2.94	15.7	
	467.8	2.6	.03	6	2.94	15.7	
	468.0	Auto Calibrate 2.6	.03	6	2.92	15.8	
	468.4	2.6	.03	6	2.92	16.0	
	468.4	2.6	.03	6	2.92	16.0	

Names of Customer Personnel Participating in Test:

_____ _____ Dozer #2 7/12/94

Eng temp = 190
Smoke = 7

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Pg 1 of 1

Company: A T MASSEY Location: PROUSE CREEK Test Date: 7/17/94

Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 8 Inches

Engine Make/Model: CAT 3412 Miles/Hours: 16838 I.D.#: 1

Type of Equipment: DOZER

Fuel Specfic Gravity: .830 @: 92.5 (°F)

Barometric Pressure: 29.01 inches of Mercury Start Time: 18:45 Eastern

~~RPM~~ full	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
Throttle	472.8	2.6 ~~3.0~~	.03 ~~.6~~	6 ~~3.09~~	3.09 ~~15.5~~	15.5	
	471.2	2.6	.03	6	3.08	15.5	
	471.2	2.6	.03	6	3.09	15.5	
	471.0	2.6	.03	6	3.08	15.5	
	471.0	2.6	.03	6	3.09	15.5	
	471.6	2.6	Auto cal .03	6 ~~5~~	3.09	15.6	
	472.6	2.6	Auto cal .03	6	3.10	15.6	
	473.0	2.6	.03	6	3.09	15.6	

X1

Names of Customer Personnel Participating in Test:

Engine Temp = 180

_____ _____

Smoke Chip = 7

Signature of Technicians:

_____ _____