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EVALUATION OF FPC-1® FUEL PERFORMANCE CATALYST

at

BFI HOLDING
Oosterbeek, Netherlands

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 Limited, and BFI Holding, 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 DAF 75S 240 Trucks
1 x DAF 75 Truck
1 x DAF 2500 Truck
3 x DAF 2300 Trucks
1 x DAF 65 180 Truck
2 x DAF 85 330 Trucks
1 x Scania 81 Truck
1 x Scania 93H 280 Truck
1 x Mercedes 3528 Truck

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 Gateway 2000 Colorbook Notebook computer and Excel Pro program to calculate 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 Environmental 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 temperatures 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.

Thirteen trucks made up the FPC-1® treated test fleet. Table 1 in the Appendices summarizes the percent change in fuel consumption based upon the change in carbon flow rate in the exhaust.

DISCUSSION

The Effect of FPC-1® Upon Smoke Density and Carbon Monoxide Emissions

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.

Carbon monoxide (CO) levels were measure using the Sun Electric SGA-9000 non-dispersive infrared analyzer. Like the Bacharach Smokemeter, this too is a recognized method for determining carbon monoxide levels in the exhaust of an internal combustion engine. The SGA-9000 measures CO as a percent of the total volume of gases in the exhaust stream. The baseline and treated fuel CO percentages are found on Table 2.

A reduction in smoke and CO 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 and CO are logical extensions of improved combustion created by FPC-1.

CONCLUSIONS

1) The fuel consumption change determined by the carbon balance method ranged from + 3.45 to - 13.37%. **The fleet averaged a 7.40% reduction in fuel consumed after FPC-1® fuel treatment and engine preconditioning**. The average reduction on fuel consumption is virtually identical to that realized by dozens of fleets in the U.S. and Australia.

2) **Smoke density was reduced approximately 18% with FPC-1® treated fuel**.

3) Carbon Monoxide levels were reduced approximately 18.5% with treated fuel.

4) The reductions in smoke and carbon monoxide emissions support the fuel consumption reductions.

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 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) was 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:	BFI	*Location*	Duiven, Netherlands	*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 75 240	*Mile/Hrs*	16694		
Equipment Type:	Garbage Truck	*ID #:*	BB-DL-84	*Baro*	29.71
Fuel Sp. Gravity(SG	.836	*Temp:*	60.2		
				Time:	1615

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	268.4	1.8	0.03	9	2.1	17.9	
	280	1.8	0.03	9	2.11	17.9	
	283.6	1.8	0.03	10	2.11	17.7	
	288.2	1.8	0.03	10	2.12	17.7	
2000	292.4	1.8	0.03	9	2.12	17.8	
2000	296.6	1.8	0.03	9	2.11	17.7	
2000	298	1.85	0.03	12	2.12	17.8	
2000	300.2	1.85	0.03	13	2.12	17.7	
2000	**288.425**	**1.813**	**.030**	**10.125**	**2.114**	**17.775**	Mean
0	**10.746**	**.023**	**.000**	**1.553**	**.007**	**.089**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.01E-05	0.0003	.021	.178	29.050	287,154	500,122

Company Name:	BFI	*Location:*	Duiven, Netherlands	*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 75 240	*Mile/Hrs:*	23013		
Equipment Type	Garbage Truck	*ID #:*	BB-DL-84	*Baro:*	29.71
Fuel Sp. Gravity:	.837	*Temp:*	49		
SG Corr Factor:	.999			*Time:*	8:25

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	280	1.7	0.02	13	2.1	17.6	
2000	280	1.7	0.02	12	2.09	17.6	
2000	280	1.7	0.03	14	2.05	17.6	
2000	279	1.7	0.03	11	2.05	17.6	
2000	280	1.7	0.02	13	2.05	17.6	
2000	280	1.7	0.02	13	2.05	17.6	
2000.000	**279.833**	**1.700**	**.023**	**12.667**	**2.065**	**17.600**	Mean
0	**.408**	**.000**	**.005**	**1.033**	**.023**	**.000**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.27E-05	0.000233333	.021	.176	29.035	294,373	526,340

Performance factor adjusted for fuel density: 525,710

****% Change PF= 5.12 %**

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

Company Name:	BFI	*Location*	Duiven, Netherlands	*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 2300	*Mile/Hrs*	136172		
Equipment Type:	Garbage Truck	*ID #:*	VN-04-YS	*Baro*	29.71
Fuel Sp. Gravity(SG	.835	*Temp:*	63.4	*Time:*	1642

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1900	388.2	1.7	0.04	17	2.92	16.7	
1900	388.8	1.7	0.05	17	2.89	16.9	
1900	385.8	1.7	0.04	17	2.86	16.7	
1900	388.4	1.7	0.05	17	2.83	16.7	
1900	392.2	1.7	0.04	17	2.83	16.8	
1900	394.4	1.7	0.05	17	2.82	16.8	
1900.000	**389.633**	**1.700**	**.045**	**17.000**	**2.858**	**16.767**	Mean
0	**3.107**	**.000**	**.005**	**.000**	**.040**	**.082**	Std Dev

VFHC	**VFCO**	**VFCO2**	**VFO2**	**Mtw1**	**pf1**	**PF1**
1.70E-05	0.00045	.029	.168	29.129	212,452	407,078

Company Name:	BFI	*Location:*	Duiven, Netherlands	*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 2300	*Mile/Hrs:*			
Equipment Type	Garbage Truck	*ID #:*	VN-04-YS	*Baro:*	
Fuel Sp. Gravity:		*Temp:*			
SG Corr Factor:	#VALUE!			*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:	BFI	*Location*	Duiven, Netherlands	*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 85 330	*Mile/Hrs*	28934		
Equipment Type:	Garbage Truck	*ID #:*	VX-15-HX	*Baro*	29.71
Fuel Sp. Gravity(SG	.835	*Temp:*	65	*Time:*	1730

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1800	307	4	0.03	14	1.78	18	
1800	307.2	4	0.03	15	1.77	18	
1800	305	4	0.03	15	1.76	18	
1800	307.4	4	0.02	14	1.79	18	
1800	307.2	4	0.02	14	1.77	18	
1800.000	**306.760**	**4.000**	**.026**	**14.400**	**1.774**	**18.000**	Mean
0	**.994**	**.000**	**.005**	**.548**	**.011**	**.000**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.44E-05	0.00026	.018	.180	29.005	340,748	404,352

Company Name:	BFI	*Location:*	Duiven, Netherlands	*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 85 330	*Mile/Hrs:*	85253		
Equipment Type	Garbage Truck	*ID #:*	VX-15-HX	*Baro:*	29.71
Fuel Sp. Gravity:	.832	*Temp:*	49		
SG Corr Factor:	1.004			*Time:*	7:00

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1800	274	3.8	0.02	14	1.67	18	
1800	272	3.8	0.02	14	1.67	18	
1800	270	3.8	0.02	15	1.69	18.2	
1800	269	3.8	0.02	15	1.68	18.2	
1800	272	3.8	0.02	15	1.66	18.2	
1800	273	3.8	0.02	15	1.66	18.2	
1800.000	**271.667**	**3.800**	**.020**	**14.667**	**1.672**	**18.133**	Mean
0	**1.862**	**.000**	**.000**	**.516**	**.012**	**.103**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.47E-05	0.0002	.017	.181	28.994	362,277	430,855

Performance factor adjusted for fuel density: 432,403

****% Change PF= 6.94 %**

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

Company Name:	BFI	*Location*	Duiven, Netherlands	*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 85 330	*Mile/Hrs*	17567		
Equipment Type:	Garbage Truck	*ID #:*	BB-Gl-03	*Baro*	29.71
Fuel Sp. Gravity(SG	.835	*Temp:*	65		
				Time:	1740

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1700	283.2	1.4	0.03	12	1.72	18	
1700	283.6	1.4	0.03	12	1.71	18	
1700	284	1.4	0.03	12	1.72	18	
1700	284.2	1.4	0.03	15	1.69	18.1	
1700	283.6	1.4	0.03	14	1.69	18.1	
1700	283.4	1.4	0.03	14	1.69	18.1	
1700.000	**283.667**	**1.400**	**.030**	**13.167**	**1.703**	**18.050**	Mean
0	**.372**	**.000**	**.000**	**1.329**	**.015**	**.055**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.32E-05	0.0003	.017	.181	28.995	353,830	698,950

Company Name:	BFI	*Location:*	Duiven, Netherlands	*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 85 330	*Mile/Hrs:*	31229		
Equipment Type	Garbage Truck	*ID #:*	BB-Gl-03	*Baro:*	29.71
Fuel Sp. Gravity:	.837	*Temp:*	49		
SG Corr Factor:	.998			*Time:*	6:02

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1700	270	1.4	0.02	10	1.55	18.4	
1700	270	1.4	0.02	10	1.55	18.5	
1700	271	1.4	0.03	10	1.54	18.4	
1700	272	1.4	0.03	10	1.56	18.4	
1700	273	1.4	0.02	10	1.56	18.3	
1700	273	1.4	0.02	11	1.56	18.3	
1700.000	**271.500**	**1.400**	**.023**	**10.167**	**1.553**	**18.383**	Mean
0	**1.378**	**.000**	**.005**	**.408**	**.008**	**.075**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.02E-05	0.000233333	.016	.184	28.984	389,128	762,364

Performance factor adjusted for fuel density: 760,538

****% Change PF= 8.81 %**

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

Company Name:	BFI	*Location*	Duiven, Netherlands		*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5	Inches		
Engine Type:	DAF 2300 Turbo	*Mile/Hrs*	345842			
Equipment Type:	Garbage Truck	*ID #:*	BN-05-XD		*Baro*	29.71
Fuel Sp. Gravity(SG	.844	*Temp:*	65			
					Time:	1750

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	386	3	0.06	22	2.63	16.9	
2000	393.6	3	0.06	25	2.62	16.8	
2000	392	3.2	0.06	22	2.6	17	
2000	393.8	3.2	0.06	24	2.6	17	
2000	394	3.2	0.06	22	2.59	17	
2000	392.4	3.2	0.06	23	2.59	17.1	
2000	395	3.2	0.06	24	2.57	17	
2000.000	**392.400**	**3.143**	**.060**	**23.143**	**2.600**	**16.971**	Mean
0	**2.996**	**.098**	**.000**	**1.215**	**.020**	**.095**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
2.31E-05	0.0006	.026	.170	29.096	231,206	326,350

Company Name:	BFI	*Location:*	Duiven, Netherlands		*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5	Inches		
Engine Type:	DAF 2300 Turbo	*Mile/Hrs:*				
Equipment Type	Garbage Truck	*ID #:*	BN-05-XD		*Baro:*	29.71
Fuel Sp. Gravity:	.837	*Temp:*				
SG Corr Factor:	1.008				*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	360.4	3.2	0.06	22	2.34	17.2	
2000	360.6	3	0.06	23	2.34	17.2	
2000	360.8	3.2	0.06	22	2.35	17.2	
2000	360.8	3.2	0.06	22	2.34	17.1	
2000	360.4	3.2	0.06	22	2.33	17.2	
2000	360.6		0.06	24	2.35	17.1	
2000.000	**360.600**	**3.160**	**.060**	**22.500**	**2.342**	**17.167**	Mean
0	**.179**	**.089**	**.000**	**.837**	**.008**	**.052**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
2.25E-05	0.0006	.023	.172	29.063	255,671	353,126

Performance factor adjusted for fuel density: 356,055

****% Change PF= 9.10 %**

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

Company Name:	BFI	*Location*	Duiven, Netherlands	*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 65 180	*Mile/Hrs*	41146		
Equipment Type:	Garbage Truck	*ID #:*	VX-34-DK	*Baro*	29.71
Fuel Sp. Gravity(SG	.835	*Temp:*	65.4	*Time:*	1814

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	281.8	0.75	0.03	12	2.03	17.8	
2000	285.4	0.75	0.03	12	1.99	17.9	
2000	288.4	0.8	0.03	15	1.96	17.7	
2000	290.6	0.8	0.03	17	1.94	17.6	
2000	290.8	0.8	0.03	15	1.94	18.1	
2000	291	0.8	0.03	15	1.93	18	
2000	291.6	0.8	0.03	17	1.93	17.9	
2000.000	**288.514**	**.786**	**.030**	**14.714**	**1.960**	**17.857**	Mean
0	**3.653**	**.024**	**.000**	**2.059**	**.037**	**.172**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.47E-05	0.0003	.020	.179	29.029	308,589	816,347

Company Name:	BFI	*Location:*	Duiven, Netherlands	*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 65 180	*Mile/Hrs:*			
Equipment Type	Garbage Truck	*ID #:*	VX-34-DK	*Baro:*	29.71
Fuel Sp. Gravity:	.837	*Temp:*	49		
SG Corr Factor:	.998			*Time:*	6:25

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	269	0.7	0.03	15	1.91	17.8	
2000	269	0.7	0.03	15	1.91	17.7	
2000	267	0.7	0.04	15	1.91	17.7	
2000	267	0.7	0.03	17	1.91	17.7	
2000	268	0.7	0.03	17	1.91	17.8	
2000	268	0.7	0.03	15	1.91	17.8	
2000.000	**268.000**	**.700**	**.032**	**15.667**	**1.910**	**17.750**	Mean
0	**.894**	**.000**	**.004**	**1.033**	**.000**	**.055**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.57E-05	0.000316667	.019	.178	29.017	316,002	873,438

Performance factor adjusted for fuel density: 871,346

****% Change PF = 6.74 %**

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

Company Name:	BFI	*Location*	Duiven, Netherlands	*Date:*	7-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 75 240	*Mile/Hrs*			
Equipment Type:	Garbage Truck	*ID #:*	BB-GJ-76	*Baro*	29.71
Fuel Sp. Gravity(SG	.835	*Temp:*	65	*Time:*	1720

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1800	264.2	1.4	0.03	12	1.96	18	
1800	268.8	1.4	0.03	13	1.95	18	
1800	275.6		0.03	12	1.95	17.9	
1800	277		0.03	13	1.93	17.9	
1800	278		0.03	12	1.92	17.9	
1800	280	1.4	0.03	13	1.92	17.9	
1800	280.8		0.03	13	1.9	18	
1800	280.8	1.4	0.03	13	1.89	18	
1800.000	**275.650**	**1.400**	**.030**	**12.625**	**1.928**	**17.950**	Mean
0	**6.063**	**.000**	**.000**	**.518**	**.025**	**.053**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.26E-05	0.0003	.019	.180	29.027	313,884	616,691

Company Name:	BFI	*Location:*	Duiven, Netherlands	*Test Date:*	17-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 75 240	*Mile/Hrs:*			
Equipment Type	Garbage Truck	*ID #:*	BB-GJ-76	*Baro:*	29.71
Fuel Sp. Gravity:	.835	*Temp:*			
SG Corr Factor:	1.000			*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1800	266	1.3	0.03	15	1.89	17.9	
1800	267.8	1.3	0.03	13	1.88	17.9	
1800	269	1.3	0.03	13	1.89	18	
1800	270	1.3	0.03	11	1.86	18	
1800	268	1.3	0.02	13	1.87	17.9	
1800	269	1.3	0.02	11	1.87	17.9	
1800.000	**268.300**	**1.300**	**.027**	**12.667**	**1.877**	**17.933**	Mean
0	**1.378**	**.000**	**.005**	**1.506**	**.012**	**.052**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.27E-05	0.000266667	.019	.179	29.018	322,677	654,602

Performance factor adjusted for fuel density: 654,602

****% Change PF= 6.15 %**

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

Company Name:	BFI	***Location***	Zaandam, Netherlands	***Date:***	8-Sep-94
Test Portion:	Baseline	***Stack Diam.***	3.5 Inches		
Engine Type:	Scania 93H 280	***Mile/Hrs***	242550		
Equipment Type:	Garbage Truck	***ID #:***	VJ-72-KH	***Baro***	29.53
Fuel Sp. Gravity(SG	.840	***Temp:***	71	***Time:***	1620

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1800	265.2	0.75	0.03	10	1.69	18.1	
1800	267.6		0.03	10	1.7	18.1	
1800	269	0.8	0.03	10	1.69	18.2	
1800	269.8	0.8	0.03	12	1.69	18.1	
1800	270	0.8	0.03	12	1.69	18.2	
1800	270	0.8	0.03	10	1.69	18.1	
1800	269.8	0.8	0.03	10	1.68	18.2	
1800	269.9	0.8	0.03	10	1.68	18.2	
1800.000	**268.913**	**.793**	**.030**	**10.500**	**1.689**	**18.150**	Mean
0	**1.708**	**.019**	**.000**	**.926**	**.006**	**.053**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.05E-05	0.0003	.017	.182	28.997	357,190	925,435

Company Name:	BFI	***Location:***	Zaandam, Netherlands	***Test Date:***	16-Nov-94
Test Portion:	Treated	***Stack Diam:***	3.5 Inches		
Engine Type:	Scania 93H 280	***Mile/Hrs:***	254990		
Equipment Type	Garbage Truck	***ID #:***	VJ-72-KH	***Baro:***	29.53
Fuel Sp. Gravity:	.832	***Temp:***	52		
SG Corr Factor:	1.010			***Time:***	7:00

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1800	272	0.75	0.02	9	1.6	18.4	
1800	270	0.75	0.02	9	1.6	18.4	
1800	264	0.75	0.02	9	1.59	18.3	
1800	264	0.75	0.02	9	1.59	18.3	
1800	259	0.75	0.02	10	1.59	18.3	
1800	259	0.75	0.02	10	1.59	18.3	
1800	257	0.75	0.02	10	1.59	18.3	
1800.000	**263.571**	**.750**	**.020**	**9.429**	**1.593**	**18.329**	Mean
0	**5.740**	**.000**	**.000**	**.535**	**.005**	**.049**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
9.43E-06	0.0002	.016	.183	28.989	380,597	1,010,140

Performance factor adjusted for fuel density: 1,019,761

****% Change PF= 10.19 %**

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

Company Name:	BFI	*Location*	Zaandam, Netherlands	*Date:*	8-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	Mercedes 3528 280H	*Mile/Hrs*	291626		
Equipment Type:	Garbage Truck	*ID #:*	VB-43-NS	*Baro*	29.53
Fuel Sp. Gravity(SG	.841	*Temp:*	71	*Time:*	1645

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1900	234.6	3.2	0.03	10	1.85	18.1	
1900	243.4	3.2	0.03	10	1.83	18.2	
1900	260	3.2	0.03	14	1.83	18	
1900	270	3.2	0.03	14	1.8	17.9	
1900	279	3.2	0.03	12	1.87	18	
1900	281.6	3.2	0.03	12	1.81	18	
1900	285	3.2	0.03	12	1.79	18.1	
1900	285.6		0.03	12	1.8	18.1	
1900.000	**267.400**	**3.200**	**.030**	**12.000**	**1.823**	**18.050**	Mean
0	**19.605**	**.000**	**.000**	**1.512**	**.028**	**.093**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.20E-05	0.0003	.018	.181	29.014	331,523	427,124

Company Name:	BFI	*Location:*	Zaandam, Netherlands	*Test Date:*	16-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	Mercedes 3528 280H	*Mile/Hrs:*			
Equipment Type	Garbage Truck	*ID #:*	VB-43-NS	*Baro:*	29.53
Fuel Sp. Gravity:	.831	*Temp:*	52		
SG Corr Factor:	1.012			*Time:*	7:20

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
1900	265	3	0.03	9	1.76	18.1	
1900	266	3	0.02	10	1.76	18.1	
1900	268	3	0.03	10	1.83	18	
1900	268	3	0.02	10	1.75	18.1	
1900	269	2.9	0.02	10	1.75	18	
1900	268	2.9	0.02	10	1.75	18.1	
1900.000	**267.333**	**2.967**	**.023**	**9.833**	**1.767**	**18.067**	Mean
0	**1.506**	**.052**	**.005**	**.408**	**.031**	**.052**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
9.83E-06	0.000233333	.018	.181	29.006	343,214	459,203

Performance factor adjusted for fuel density: 464,663

****% Change PF= 8.79 %**

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

Company Name:	BFI	*Location*	Zaandam, Netherlands		*Date:*	8-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5	Inches		
Engine Type:	DAF 75	*Mile/Hrs*	25545			
Equipment Type:	Garbage Truck	*ID #:*	BB-DR-35		*Baro*	29.53
Fuel Sp. Gravity(SG	.841	*Temp:*	69			
					Time:	1808

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	278	1.2	0.04	13	1.98	17.8	
2000	282	1.2	0.04	13	1.97	17.9	
2000	283	1.2	0.04	12	1.97	17.8	
2000	283.2	1.2	0.04	12	1.95	17.8	
2000	284.2	1.2	0.04	13	1.96	17.9	
2000	284.2	1.2	0.04	13	1.96	17.4	
2000.000	**282.433**	**1.200**	**.040**	**12.667**	**1.965**	**17.767**	Mean
0	**2.324**	**.000**	**.000**	**.516**	**.010**	**.186**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.27E-05	0.0004	.020	.178	29.026	306,460	651,356

Company Name:	BFI	*Location:*	Zaandam, Netherlands		*Test Date:*	16-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5	Inches		
Engine Type:	DAF 75	*Mile/Hrs:*	35736			
Equipment Type	Garbage Truck	*ID #:*	BB-DR-35		*Baro:*	29.53
Fuel Sp. Gravity:	.835	*Temp:*	55			
SG Corr Factor:	1.007				*Time:*	8:00

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	273	1.1	0.03	13	1.83	18	
2000	272	1.1	0.03	13	1.83	18	
2000	274	1.1	0.03	15	1.82	18	
2000	274	1.1	0.03	15	1.81	18	
2000	274	1.1	0.03	15	1.81	18	
2000	275	1.1	0.03	15	1.8	18	
2000.000	**273.667**	**1.100**	**.030**	**14.333**	**1.817**	**18.000**	Mean
0	**1.033**	**.000**	**.000**	**1.033**	**.012**	**.000**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.43E-05	0.0003	.018	.180	29.011	332,266	733,238

Performance factor adjusted for fuel density: 738,469

****% Change PF= 13.37 %**

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

Company Name:	BFI	*Location*	Zaandam, Netherlands	*Date:*	8-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 2300 Turbo	*Mile/Hrs*	91590		
Equipment Type:	Garbage Truck	*ID #:*	VN-52-RX	*Baro*	29.53
Fuel Sp. Gravity(SG	.835	*Temp:*	0.835		
				Time:	1827

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	369	2.2	0.04	10	2.86	16.5	
2000	374.6	2.2	0.04	12	2.91	16.5	
2000	380	2.2	0.04	10	2.86	16.6	
2000	380	2.2	0.04	13	2.83	16.7	
2000	384.6	2.2	0.04	13	2.84	16.7	
2000.000	**377.640**	**2.200**	**.040**	**11.600**	**2.860**	**16.600**	Mean
0	**5.989**	**.000**	**.000**	**1.517**	**.031**	**.100**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.16E-05	0.0004	.029	.166	29.122	212,899	354,975

Company Name:	BFI	*Location:*	Zaandam, Netherlands	*Test Date:*	16-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 2300 Turbo	*Mile/Hrs:*	97611		
Equipment Type	Garbage Truck	*ID #:*	VN-52-RX	*Baro:*	29.53
Fuel Sp. Gravity:	.832	*Temp:*			
SG Corr Factor:	1.004			*Time:*	

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	372	2.1	0.04	15	2.67	16.9	
2000	374	2.05	0.04	15	2.65	16.9	
2000	375	2.05	0.03	15	2.65	16.9	
2000	377	2.05	0.03	15	2.64	16.9	
2000	378	2.05	0.02	15	2.64	16.9	
2000	378	2.05	0.03	15	2.65	16.9	
2000.000	**375.667**	**2.058**	**.032**	**15.000**	**2.650**	**16.900**	Mean
0	**2.422**	**.020**	**.008**	**.000**	**.011**	**.000**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.50E-05	0.000316667	.027	.169	29.101	229,829	395,704

Performance factor adjusted for fuel density: 397,126

****% Change PF= 11.87 %**

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

Company Name:	BFI	*Location*	Zaandam, Netherlands	*Date:*	8-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 2300	*Mile/Hrs*	152659		
Equipment Type:	Garbage Truck	*ID #:*	VF-10-BG	*Baro*	29.53
Fuel Sp. Gravity(SG	.845	*Temp:*	63.9		
				Time:	1905

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	339	2.2	0.05	13	2.61	16.9	
	340	2.2	0.05	13	2.6	16.9	
	339.8	2.2	0.05	15	2.57	17	
	339.6	2.2	0.05	15	2.57	17	
	339.4	2.2	0.05	15	2.55	17	
	339	2.2	0.05	15	2.55	17	
2000.000	**339.467**	**2.200**	**.050**	**14.333**	**2.575**	**16.967**	Mean
#DIV/0!	**.413**	**.000**	**.000**	**1.033**	**.025**	**.052**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.43E-05	0.0005	.026	.170	29.091	234,735	382,361

Company Name:	BFI	*Location:*	Zaandam, Netherlands	*Test Date:*	16-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 2300	*Mile/Hrs:*	157,755		
Equipment Type	Garbage Truck	*ID #:*	VF-10-BG	*Baro:*	29.53
Fuel Sp. Gravity:	.833	*Temp:*	53		
SG Corr Factor:	1.014			*Time:*	1905

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	343	1.9	0.04	15	2.58	17	
2000	344	1.9	0.04	15	2.6	16.9	
2000	342	1.9	0.04	15	2.57	17	
2000	342	1.9	0.04	13	2.56	17	
2000	344	1.9	0.04	15	2.56	17	
2000	344	2	0.04	15	2.56	16.9	
2000.000	**343.167**	**1.917**	**.040**	**14.667**	**2.572**	**16.967**	Mean
0	**.983**	**.041**	**.000**	**.816**	**.016**	**.052**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.47E-05	0.0004	.026	.170	29.091	235,906	412,644

Performance factor adjusted for fuel density: 418,504

****% Change PF= 9.45 %**

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

Company Name:	BFI	*Location*	Zaandam, Netherlands	*Date:*	8-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	DAF 2500	*Mile/Hrs*	320345		
Equipment Type:	Garbage Truck	*ID #:*	VB-65-DY	*Baro*	29.53
Fuel Sp. Gravity(SG	.845	*Temp:*			
				Time:	1928

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	299.4	1.8	0.07	19	1.99	17.7	
	300	1.8	0.07	19	1.99	17.7	
	300	1.8	0.07	19	1.99	17.1	
	300	1.8	0.07	19	2	17.7	
	299.4	1.8	0.07	19	2.01	17.7	
	299.4	1.8	0.07	19	2.01	17.7	
2000.000	**299.700**	**1.800**	**.070**	**19.000**	**1.998**	**17.600**	Mean
#DIV/0!	**.329**	**.000**	**.000**	**.000**	**.010**	**.245**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.90E-05	0.0007	.020	.176	29.025	296,523	520,535

Company Name:	BFI	*Location:*	Zaandam, Netherlands	*Test Date:*	16-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	DAF 2500	*Mile/Hrs:*	331283		
Equipment Type	Garbage Truck	*ID #:*	VB-65-DY	*Baro:*	29.53
Fuel Sp. Gravity:	.835	*Temp:*			
SG Corr Factor:	1.012			*Time:*	7:35

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	303	1.85	0.06	17	2.11	17.5	
2000	305	1.85	0.06	17	2.1	17.5	
2000	307	1.85	0.05	17	2.1	17.6	
2000	308	1.85	0.05	17	2.1	17.6	
2000	310	1.85	0.05	17	2.09	17.6	
2000	311	1.85	0.05	17	2.09	17.6	
2000.000	**307.333**	**1.850**	**.053**	**17.000**	**2.098**	**17.567**	Mean
0	**3.011**	**.000**	**.005**	**.000**	**.008**	**.052**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.70E-05	0.000533333	.021	.176	29.039	285,416	496,696

Performance factor adjusted for fuel density: 502,574

****% Change PF= -3.45 %**

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

Company Name:	BFI	*Location*	Zaandam, Netherlands	*Date:*	8-Sep-94
Test Portion:	Baseline	*Stack Diam.*	3.5 Inches		
Engine Type:	Scania 81	*Mile/Hrs*	228753		
Equipment Type:	Garbage Truck	*ID #:*	86-NB-64	*Baro*	29.53
Fuel Sp. Gravity(SG	.844	*Temp:*			
				Time:	1945

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	304	1.8	0.03	15	2.32	17.3	
	308	1.8	0.03	15	2.31	17.2	
	308.6	1.8	0.03	17	2.28	17.4	
	310	1.8	0.03	17	2.27	17.4	
	310.8	1.8	0.03	19	2.27	17.4	
	309.2	1.8	0.03	19	2.26	17.4	
2000.000	**308.433**	**1.800**	**.030**	**17.000**	**2.285**	**17.350**	Mean
#DIV/0!	**2.388**	**.000**	**.000**	**1.789**	**.024**	**.084**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.70E-05	0.0003	.023	.174	29.061	265,566	468,863

Company Name:	BFI	*Location:*	Zaandam, Netherlands	*Test Date:*	16-Nov-94
Test Portion:	Treated	*Stack Diam:*	3.5 Inches		
Engine Type:	Scania 81	*Mile/Hrs:*	233015		
Equipment Type	Garbage Truck	*ID #:*	86-NB-64	*Baro:*	29.53
Fuel Sp. Gravity:	.834	*Temp:*	54		
SG Corr Factor:	1.012			*Time:*	5:10

RPM	Exh Temp	Pv Inch	CO	HC	CO2	O2	
2000	309	1.6	0.03	15	2.33	17.3	
2000	309	1.6	0.02	17	2.33	17.3	
2000	311	1.6	0.02	17	2.34	17.1	
2000	311	1.7	0.02	15	2.34	17.2	
2000	308	1.7	0.02	17	2.34	17.3	
2000	307	1.7	0.02	17	2.33	17.3	
2000	308	1.7	0.02	17	2.34	17.3	
2000.000	**309.000**	**1.657**	**.021**	**16.429**	**2.336**	**17.257**	Mean
0	**1.528**	**.053**	**.004**	**.976**	**.005**	**.079**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.64E-05	0.000214286	.023	.173	29.065	260,920	480,282

Performance factor adjusted for fuel density: 485,973

****% Change PF= 3.65 %**

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

Table 1:
Summary of Carbon Balance Fuel Consumption Changes

Unit	Engine	% Change Fuel Consumption
BBDL84	DAF	- 5.12
BBGJ76	DAF	- 6.15
BBDR35	DAF	- 13.37
VB65DY	DAF	+ 3.45 (1)
VF10BG	DAF	- 9.45
VN52RX	DAF	- 11.84
BN05XD	DAF	- 9.10
VX34DK	DAF	- 6.74
BBGI03	DAF	- 8.81
VX15HX	DAF	- 6.94
86NB64	Scania	- 3.65
VJ72KH	Scania	- 10.19
VB43NS	Mercedes	- 8.79
	Average:	**- 7.40%**

(1) Statistical Anomaly, however included in the fleet average

Table 2:
Comparison of Smoke Spot Numbers

Unit No.	Base SS#	Treated SS#		
BBDL84	4.0	4.0		
VX15HX	5.0	4.5		
BBGI03	5.0	4.0		
BN05XD	4.5	3.5		
VX34DK	3.5	3.0		
BBGJ76	3.5	4.0		
VJ72KH	3.5	2.5		
VB43NS	6.5	5.0		
BBDN35	4.5	4.0		
VN52RK	5.0	4.0		
VF10BG	3.5	3.0		
VB65DY	4.0	3.5		
86NB64	5.5	3.0		
Average:	**4.5**	**3.7**	**% Chg:**	**- 17.8**

Table 3:
Summary of Carbon Monoxide (CO) Changes

Unit No.	Base CO	Treated CO	
BBDL84	.030	.023	
VX15HX	.026	.020	
BBGI03	.030	.023	
BN05XD	.060	.060	
VX34DK	.030	.032	
BBGJ76	.030	.027	
VJ72KH	.030	.020	
VB43NS	.030	.023	
BBDN35	.040	.030	
VN52RX	.040	.032	
VF10BG	.050	.040	
VB65DY	.070	.053	
86NB64	.030	.021	
Average:	**.038**	**.031**	**%Chg: -18.4**

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 $H_2 0$
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:

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

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

$$CFM = \frac{(d/2)^2\pi}{144}\left(1096.2\sqrt{\frac{Pv}{1.325(PB/ET+460)}}\right)$$

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

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)

$$CFM = \frac{(d/2)^2\pi}{144}\left(1096.2\sqrt{\frac{Pv}{1.325(PB/ET+460)}}\right)$$

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

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

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)

$$CFM = \frac{(d/2)^2\pi}{144}\left(1096.2\sqrt{\frac{Pv}{1.325(PB/ET+460)}}\right)$$

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 ^0F

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

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.

RAW DATA WORK SHEETS