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EVALUATION OF FPC-1® FUEL PERFORMANCE CATALYST

AT

Magma Copper, Pinto Valley Mine, Globe, Arizona

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 and Magma Copper at the Pinto Valley Mine, Globe, Arizona, 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 conducted using the Bacharach Smokemeter method.

EQUIPMENT TESTED

7 x Haulpak 685E, 190 ton haul trucks powered by 16V149 DT engines.

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 hand held photo tachometer for engine speed (rpm) determination where dash mounted tachometers are not available.

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

1. 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.

Ten Haulpaks were tested during the baseline fuel test segment. Seven of the original ten were available at the time of the FPC-1 treated fuel retest. Table 1 below summarizes the percent change in fuel consumption.

Table 1:
Summary of Carbon Balance Fuel Consumption Changes

Unit	Engine	RPM	% Change Fuel Consumption
27	16V149	1600	- 7.67
28	16V149	1600	- 6.09
29	16V149	1600	- 7.39
31	16V149	1595	- 9.53
32	16V149	1600	- 7.01
39*	16V149	1600	- 13.58
43	16V149	1600	- 8.46

*** Anomaly (see Discussion, number 5)**

DISCUSSION

1. Fuel Density

Fuel specific gravity (density) for the baseline and treated tests are found on the computer printouts attached in the Appendices, as are the correction factors made to the FPC-1 treated fuel final engine performance factors (PF2). The correction factor adjusts the energy content of the treated fuel to that of the baseline fuel.

2. Emission Changes

Emissions of carbon monoxide (CO) were reduced approximately 15% after FPC-1 fuel treatment and engine preconditioning. Unburned hydrocarbons (HC) showed a slight, but insignificant reduction during the FPC-1 test.

The Magma Copper data are consistent with prior laboratory and field emissions data. Almost universally, when the gaseous products of incomplete combustion are low with base fuel, FPC-1 effects little change. This is particularly true with emissions of unburned hydrocarbons (measured as n-hexane). However, when these same gases are produced at higher base concentrations, FPC-1 is effective in lowering the emissions.

This is supported in the Magma Copper test fleet by the trucks experiencing higher baseline CO levels. After FPC-1 treatment and engine preconditioning, the higher CO levels were reduced (excepting Unit 29). The engines with low baseline CO levels realized no change in treated CO levels.

3. Intake Air Temperature and Pressure

Intake or ambient air temperatures were virtually identical on the average for both test segments. Barometric pressure was slightly lower during the treated fuel test segment. Any change in intake air temperature and/or pressure are corrected for in the carbon balance calculation. The equations for the carbon balance, including the corrections for ambient conditions are found on Figure 1 in the Appendices. A sample calculation is also found in the Appendices on Figure 2.

4. 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 tabled below.

Table 2:
Comparison of Smoke Spot Numbers

Unit No.	Base SS#	Treated SS#	% Change
28	4.5	3.5	- 22.2
32	4.0	3.5	- 12.5
39	3.5	3.0	- 14.3
27	4.0	2.5	- 37.5
29	4.0	3.0	- 25.0
31	4.5	3.5	- 22.2
43	3.5	3.0	- 14.3
Averages:	4.0	3.1	- 22.5

Reductions in smoke and CO are prime evidences 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.

5. Unit #39 Fuel Consumption Change

Unit #39 indicated a 13.58% reduction in fuel consumption. This change falls well outside of the range for the remaining six units tested and is almost twice the average. The raw data worksheet notes that a change to a higher range pressure gauge was made when Unit #39 was tested because of the higher baseline pressure readings (1.25 inches H_2O). When the treated test pressure readings were noted as being much lower than the base test readings, the pressure gauge (Magnehelic) was checked for calibration and found to read an absolute 0.10 "H_2O high. The absolute correction was made to the actual pressure readings. However, no additional pressure readings were taken. This may have been a procedural error on the part of the testing technicians that created an inaccuracy in the pressure data.

It should also be pointed out that Unit #39 experienced baseline pressure readings much higher than the fleet average to begin with. Therefore, the baseline pressure reading may have been erroneous or some mechanical problem that was later corrected may be the cause of the radical change in exhaust mass flow rate, and therefore, the outcome of the carbon mass balance for Unit #39.

CONCLUSIONS

1) With the anomaly (#39) removed from the sample, the fuel consumption change determined by the carbon balance method ranged from a - 6.09 to - 9.53%. The fleet averaged a 7.69% reduction in fuel consumed after FPC-1 fuel treatment and engine preconditioning.

2) Smoke density was reduced approximately 22%.

3) Carbon monoxide (CO) was reduced approximately 15%. Unburned hydrocarbon emissions were not affected by FPC-1 fuel treatment. Both gas levels were very low when running on base fuel, and therefore, the potential for improvement was diminished.

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, oil, and exhaust temperature, and exhaust pressure. No exhaust gas measurements were made until each engine had stabilized at the rpm selected for the test. # 2 diesel was used exclusively throughout the evaluation. Fuel specific gravity (density) and temperature were taken before testing.

The baseline fuel consumption test consisted of a minimum of five sets of measurements of CO_2, CO, HC, O_2, and exhaust temperature and pressure made at 90 second intervals. Each engine was tested in the same manner. Rpm, exhaust temperature, and exhaust pressure 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 density 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. All performance factors are rounded off to the nearest meaningful place in the sample.

COMPUTER PRINTOUTS

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)
T = Temperature (^{O}F)
CFM = Exhaust Flow
SG = Specific Gravity
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
ET = Exhaust temperature ^{O}F
VFHC = "reading" ÷ 1,000,000
VFCO = "reading" ÷ 100
$VFCO_2$ = "reading" ÷ 100
VFO_2 = "reading" ÷ 100

EQUATIONS:

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

$$pf1 \text{ or } pf2 = \frac{2952.3 \times Mwt}{86(VFHC)+13.89(VFCO)+13.89(VFCO_2)}$$

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

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

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

Figure 2.

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94
Test Portion:	Baseline	*Stack Diam.*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs*	5054			
Equipment Type:	Haul Pac 190T	*ID #:*	27		*Baro*	30.00 Inches Hg.
Fuel Sp. Gravity(SG	0.8400	*Amb. Tem*	83	degrees F		
					Time:	955

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	310.6	0.8	0.01	11	1.94	17.1	
1600	311.6	0.8	0.01	12	1.93	17.1	
1600	312.8	0.8	0.02	14	1.93	17.1	
1600	312.8	0.8	0.02	14	1.93	17.1	
1600	311.8	0.8	0.02	13	1.94	17.1	
1600	313.2	0.8	0.02	14	1.94	17.1	
1600	313.8	0.8	0.01	13	1.94	17.1	
1600	314.2	0.8	0.02	13	1.94	17.1	
1600	314.6	0.8	0.02	14	1.94	17.1	
1600	315.6	0.8	0.02	14	1.94	17.1	
1600.000	**313.100**	**.800**	**.017**	**13.200**	**1.937**	**17.100**	Mean
0	**1.51217283**	**1.9868E-08**	**0.004830459**	**1.03279556**	**0.00483046**	**3.1789E-07**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.32E-05	0.00017	0.01937	0.171	28.9946856	314,079	103,011

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94
Test Portion:	Treated	*Stack Diam:*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs:*	5453			
Equipment Type	Haul Pac 190T	*ID #:*	27		*Baro:*	29.86 Inches Hg.
Fuel Sp. Gravity:	0.837	*Amb. Temp*		degrees F		
SG Corr Factor:	1.0036				*Time:*	830

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	308.2	0.775	0.02	14	1.85	17.3	
1600	305.6	0.775	0.02	14	1.82	17.2	
1600	307.2	0.775	0.01	14	1.83	17.2	
1600	307.8	0.775	0.01	14	1.81	17.3	
1600	309.2	0.775	0.01	15	1.82	17.1	
1600	309.6	0.775	0.02	16	1.83	17	
1600	310.4	0.775	0.01	14	1.84	17.2	
1600	310.4	0.775	0.01	15	1.83	17.1	
1600	310.6	0.775	0.01	15	1.81	17.1	
1600	311.2	0.775	0.01	15	1.82	17.2	
1600.000	**309.020**	**.775**	**.013**	**14.600**	**1.826**	**17.170**	Mean
0	**1.782507597**	**0**	**0.004830459**	**0.6992059**	**0.01264911**	**0.09486833**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.46E-05	0.00013	0.01826	0.1717	28.9798068	333,305	110,514

Performance factor adjusted for fuel density: 110,912

****% Change PF= 7.67 %**

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

7.28

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94
Test Portion:	Baseline	*Stack Diam.*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs*	5677			
Equipment Type:	Haul Pac 190T	*ID #:*	28		*Baro*	30.01 Inches Hg.
Fuel Sp. Gravity(SG	0.8370	*Amb. Tem*	88.4	degrees F		
					Time:	1110

RPM	Exh Temp (F)	Pv Incl.	% CO	HC ppm	% CO2	% O2	
1605	344	0.65	0.03	21	1.82	17.3	
1605	345.4	0.65	0.03	21	1.82	17.2	
1605	344	0.65	0.03	21	1.81	17.1	
1605	346.1	0.65	0.03	23	1.82	17	
1605	347.4	0.65	0.03	21	1.83	17	
1605	347.2	0.65	0.03	22	1.81	16.4	
1605	351.2	0.65	0.03	22	1.81	17	
1605	351.8	0.65	0.03	22	1.8	16.7	
1605	348.8	0.65	0.03	21	1.81	17.4	
1605	348.8	0.65	0.03	22	1.81	17.3	
1605.000	**347.470**	**.650**	**.030**	**21.600**	**1.814**	**17.040**	Mean
0	**2.718680235**	**0**	**0**	**0.6992059**	**0.00843274**	**0.30258149**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
2.16E-05	0.0003	0.01814	0.1704	28.9730928	331,470	123,281

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94
Test Portion:	Treated	*Stack Diam:*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs:*	6029			
Equipment Type	Haul Pac 190T	*ID #:*	28		*Baro:*	29.86 Inches Hg.
Fuel Sp. Gravity:	0.838	*Amb. Tem*	77.2	degrees F		
SG Corr Factor:	0.9988				*Time:*	

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	324.4	0.6	0.02	16	1.77	17.4	
1600	323.4	0.6	0.02	17	1.78	17.4	
1600	325.2	0.6	0.01	16	1.76	17.5	
1600	325	0.6	0.01	16	1.77	17.4	
1600	324.6	0.6	0.02	16	1.76	17.5	
1600	324.4	0.6	0.01	15	1.75	17.5	
1600	323.8	0.6	0.02	16	1.76	17.4	
1600	324.2	0.6	0.01	15	1.77	17.3	
1600	323.8	0.6	0.01	15	1.76	17.3	
1600	324.2	0.6	0.02	16	1.77	17.4	
1600.000	**324.300**	**.600**	**.015**	**15.800**	**1.765**	**17.410**	Mean
0	**0.551764845**	**7.0245E-09**	**0.005270463**	**0.63245553**	**0.00849837**	**0.07378648**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.58E-05	0.00015	0.01765	0.1741	28.9797164	344,088	130,946

Performance factor adjusted for fuel density: 130,788

****% Change PF= 6.09 %**

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

6.22

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94
Test Portion:	Baseline	*Stack Diam.*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs*	9891			
Equipment Type:	Haul Pac 190T	*ID #:*	29		*Baro*	30.00 Inches Hg.
Fuel Sp. Gravity(SG	0.8380	*Amb. Tem*	83	degrees F		
					Time:	1210

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	315	0.75	0.01	16	1.79	18.4	
1600	315.2	0.75	0.01	16	1.79	18.4	
1600	315	0.75	0.01	17	1.78	17.9	
1600	315.2	0.75	0.01	14	1.77	17.8	
1600	315.2	0.75	0.01	14	1.77	17.8	
1600	314.8	0.8	0.01	15	1.79	17.8	
1600	315.2	0.8	0.01	17	1.79	17.8	
1600	315.6	0.8	0.02	17	1.8	17.6	
1600	316	0.8	0.02	17	1.8	17.6	
1600	316.2	0.8	0.02	17	1.8	17.7	
1600.000	**315.340**	**.775**	**.013**	**16.000**	**1.788**	**17.880**	Mean
0	**0.452646539**	**0.02635231**	**0.004830459**	**1.24721913**	**0.01135292**	**0.28982753**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.60E-05	0.00013	0.01788	0.1788	29.002208	340,338	113,574

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94
Test Portion:	Treated	*Stack Diam:*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs:*	299			
Equipment Type	Haul Pac 190T	*ID #:*	29		*Baro:*	29.86 Inches Hg.
Fuel Sp. Gravity:	0.834	*Amb. Tem*	78.2	degrees F		
SG Corr Factor:	1.0048				*Time:*	800

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	304.6	0.7	0.02	13	1.75	17.4	
1600	302	0.7	0.02	14	1.74	17.4	
1600	301.6	0.7	0.02	14	1.73	17.4	
1600	301.8	0.7	0.02	14	1.73	17.4	
1600	302	0.7	0.02	15	1.73	17.4	
1600	302.2	0.7	0.02	17	1.73	17.2	
1600	302	0.7	0.02	14	1.73	17.4	
1600	301.6	0.7	0.02	14	1.73	17.4	
1600	302	0.7	0.02	14	1.73	17.4	
1600	302	0.7	0.02	14	1.73	17.4	
1600.000	**302.180**	**.700**	**.020**	**14.300**	**1.733**	**17.380**	Mean
0	**0.871524845**	**0**	**4.3903E-10**	**1.05934991**	**0.00674949**	**0.06324555**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.43E-05	0.0002	0.01733	0.1738	28.9733094	349,470	121,380

Performance factor adjusted for fuel density: 121,962

****% Change PF= 7.39 %**

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

4-87

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94
Test Portion:	Baseline	*Stack Diam.*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs*	4183			
Equipment Type:	Haul Pac 190T	*ID #:*	31		*Baro*	30.00 Inches Hg.
Fuel Sp. Gravity(SG	0.8420	*Amb. Tem*	75.8	degrees F		
					Time:	917

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1595	327.4	0.7	0.02	13	2.05	17	
1595	327.6	0.7	0.02	13	2.06	17	
1595	328.4	0.75	0.02	13	2.05	16.9	
1595	328.8	0.75	0.02	13	2.08	16.9	
1595	325.4	0.75	0.02	13	2.08	16.9	
1595	328.4	0.75	0.02	14	2.06	16.8	
1595	329.8	0.75	0.02	15	2.08	16.8	
1595	330	0.75	0.02	15	2.09	16.8	
1595	329.6	0.75	0.03	16	2.09	16.9	
1595	330	0.75	0.02	15	2.12	16.9	
1595.000	**328.540**	**.740**	**.021**	**14.000**	**2.076**	**16.890**	Mean
0	**1.457699862**	**0.02108185**	**0.003162278**	**1.15470054**	**0.02170509**	**0.07378648**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.40E-05	0.00021	0.02076	0.1689	29.008572	292,774	100,832

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94
Test Portion:	Treated	*Stack Diam:*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs:*	4604			
Equipment Type	Haul Pac 190T	*ID #:*	31		*Baro:*	29.86 Inches Hg.
Fuel Sp. Gravity:	0.838	*Amb. Tem*	87	degrees F		
SG Corr Factor:	1.0048				*Time:*	1045

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1595	319.8	0.7	0.02	17	1.94	16.9	
1595	320.8	0.7	0.02	17	1.94	16.9	
1595	320.6	0.7	0.02	17	1.96	17	
1595	320.2	0.7	0.02	17	1.95	17	
1595	320.4	0.7	0.02	17	1.95	17	
1595	320.6	0.7	0.02	17	1.94	17	
1595	320.4	0.7	0.02	17	1.94	17	
1595	322	0.7	0.02	17	1.93	17	
1595	322	0.7	0.02	17	1.93	17.1	
1595	321.8	0.7	0.02	17	1.92	17	
1595.000	**320.860**	**.700**	**.020**	**17.000**	**1.940**	**16.990**	Mean
0	**0.789092306**	**0**	**4.3903E-10**	**0**	**0.01154701**	**0.05676462**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.70E-05	0.0002	0.0194	0.1699	28.990986	312,650	109,914

Performance factor adjusted for fuel density: 110,441

****% Change PF= 9.53 %**

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

9.05

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94	
Test Portion:	Baseline	*Stack Diam.*	10	Inches			
Engine Type:	16V149 DT	*Mile/Hrs*	3094				
Equipment Type:	Haul Pac 190T	*ID #:*	32		*Baro*	30.01	Inches Hg.
Fuel Sp. Gravity(SG	0.8300	*Amb. Tem*	78.8	degrees F			
					Time:	1015	

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	337.2	0.6	0.02	22	2.22	16.3	
1600	338.8	0.6	0.02	14	2.21	16.7	
1600	341	0.6	0.02	15	2.19	16.8	
1600	342.8	0.65	0.02	17	2.19	16.7	
1600	343	0.65	0.02	17	2.2	16.8	
1600	343.8	0.65	0.02	17	2.19	16.9	
1600	343.2	0.65	0.02	17	2.19	16.9	
1600	342.8	0.65	0.02	17	2.19	16.9	
1600	342.2	0.65	0.02	15	2.19	16.9	
1600.000	**341.644**	**.633**	**.020**	**16.778**	**2.197**	**16.767**	Mean
0	**2.240039682**	**0.025**	**3.29272E-10**	**2.27913239**	**0.01118034**	**0.19364917**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.68E-05	0.0002	0.02196667	0.167666667	29.0231064	276,950	103,973

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94	
Test Portion:	Treated	*Stack Diam:*	10	Inches			
Engine Type:	16V149 DT	*Mile/Hrs:*					
Equipment Type	Haul Pac 190T	*ID #:*	32		*Baro:*	29.86	Inches Hg.
Fuel Sp. Gravity:	0.834	*Amb. Tem*	79.6	degrees F			
SG Corr Factor:	0.9952				*Time:*	848	

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	329.6	0.55	0.02	15	2.12	16.8	
1600	331.2	0.55	0.02	15	2.13	16.7	
1600	332.2	0.55	0.02	15	2.14	16.8	
1600	333.8	0.575	0.01	14	2.14	16.7	
1600	334.2	0.575	0.01	14	2.12	16.5	
1600	334.6	0.575	0.01	15	2.13	16.6	
1600	334.8	0.6	0.01	14	2.12	16.6	
1600	335.4	0.6	0.01	15	2.12	16.7	
1600	336.6	0.6	0.02	15	2.14	16.7	
1600	336.8	0.6	0.02	15	2.12	16.6	
1600.000	**333.920**	**.578**	**.015**	**14.700**	**2.128**	**16.670**	Mean
0	**2.309785945**	**0.02188988**	**0.005270463**	**0.48304589**	**0.00918937**	**0.09486833**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.47E-05	0.00015	0.02128	0.1667	29.0081326	286,452	111,794

Performance factor adjusted for fuel density: 111,258

****% Change PF = 7.01 %**

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

7.52

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94	
Test Portion:	Baseline	*Stack Diam.*	10	Inches			
Engine Type:	16V149 DT	*Mile/Hrs*					
Equipment Type:	Haul Pac 190T	*ID #:*	39		*Baro*	30.00	Inches Hg.
Fuel Sp. Gravity(SG	0.8400	*Amb. Tem*	78	degrees F			
					Time:	941	

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	317.6	1.25	0.01	13	1.91	17	
1600	319.6	1.25	0.01	13	1.91	17	
1600	321.2	1.25	0.01	12	1.9	17.1	
1600	321.6	1.25	0.01	12	1.9	17	
1600	322.2	1.25	0.01	13	1.91	17.1	
1600	322.6	1.25	0.01	13	1.91	17.1	
1600	323.2	1.25	0.01	13	1.9	17.1	
1600	323.2	1.25	0.01	13	1.9	17.1	
1600	323	1.25	0.01	12	1.9	17.1	
1600	323	1.25	0.01	12	1.9	17	
1600.000	**321.720**	**1.250**	**.010**	**12.600**	**1.904**	**17.060**	Mean
0	**1.838356754**	**0**	**2.19515E-10**	**0.51639778**	**0.00516398**	**0.05163978**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.26E-05	0.0001	0.01904	0.1706	28.9877708	320,555	84,576

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94	
Test Portion:	Treated	*Stack Diam:*	10	Inches			
Engine Type:	16V149 DT	*Mile/Hrs:*	9295				
Equipment Type	Haul Pac 190T	*ID #:*	39		*Baro:*	29.86	Inches Hg.
Fuel Sp. Gravity:	0.832	*Amb. Tem*	93.4	degrees F			
SG Corr Factor:	1.0095				*Time:*	1120	

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	326.4	1.05	0.01	15	1.84	16.8	
1600	326	1.05	0.01	15	1.83	16.8	
1600	325	1.05	0.01	12	1.82	17.2	
1600	326.4	1.08	0.01	12	1.81	17.2	
1600	326.6	1.08	0.01	12	1.81	17.3	
1600	326.8	1.08	0.01	13	1.84	17.2	
1600	327.8	1.08	0.01	13	1.83	17.1	
1600	326.8	1.08	0.01	13	1.83	17.1	
1600	325.8	1.08	0.01	12	1.83	17.3	
1600	326.4	1.08	0.01	12	1.84	17.3	
1600.000	**326.400**	**1.071**	**.010**	**12.900**	**1.828**	**17.130**	Mean
0	**0.730296743**	**0.01449138**	**2.19515E-10**	**1.197219**	**0.01135292**	**0.18885621**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.29E-05	0.0001	0.01828	0.1713	28.9784282	333,610	95,153

Performance factor adjusted for fuel density: 96,057

****% Change PF= 13.58 %**

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

12.51

Company Name:	Magma	*Location*	Pinto Valley		*Date:*	4/14/94
Test Portion:	Baseline	*Stack Diam.*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs*	3053			
Equipment Type:	Haul Pac 190T	*ID #:*	43		*Baro*	30.00 Inches Hg.
Fuel Sp. Gravity(SG	0.8420	*Amb. Tem*	75.2	degrees F		
					Time:	845

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	300	1.1	0.01	10	1.44	18	
1600	301.6	1.1	0.01	10	1.44	18	
1600	302	1.15	0.01	10	1.44	18	
1600	302	1.15	0.01	10	1.46	17.9	
1600	302.4	1.15	0.01	10	1.46	18	
1600	302.6	1.15	0.01	10	1.46	18	
1600	303.2	1.15	0.01	10	1.46	18	
1600	302.8	1.15	0.01	10	1.46	17.9	
1600	303.4	1.15	0.01	10	1.46	17.9	
1600	304.6	1.15	0.01	10	1.46	17.8	
1600.000	**302.460**	**1.140**	**.010**	**10.000**	**1.454**	**17.950**	Mean
0	**1.21856017**	**0.02108185**	**2.19515E-10**	**0**	**0.00966092**	**0.07071068**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.00E-05	0.0001	0.01454	0.1795	28.95122	418,492	114,187

Company Name:	Magma	*Location:*	Pinto Valley		*Test Date:*	5/5/94
Test Portion:	Treated	*Stack Diam:*	10	Inches		
Engine Type:	16V149 DT	*Mile/Hrs:*	3471			
Equipment Type	Haul Pac 190T	*ID #:*	43		*Baro:*	29.83 Inches Hg.
Fuel Sp. Gravity:	0.832	*Amb. Tem*	90	degrees F		
SG Corr Factor:	1.0119				*Time:*	1330

RPM	Exh Temp (F)	Pv Inch	% CO	HC ppm	% CO2	% O2	
1600	299.6	1.05	0.01	13	1.43	18.7	
1600	299.8	1.05	0.01	12	1.42	17.8	
1600	299.6	1.05	0.01	15	1.4	17.9	
1600	300.2	1.05	0.01	15	1.4	17.8	
1600	300	1.05	0.01	15	1.4	17.8	
1600	301.8	1.05	0.01	17	1.39	17.7	
1600	301.8	1.05	0.01	17	1.4	17.9	
1600	302	1.05	0.01	10	1.4	18	
1600	301.4	1.05	0.01	8	1.4	18.3	
1600	302	1.05	0.01	10	1.41	17.8	
1600.000	**300.820**	**1.050**	**.010**	**13.200**	**1.405**	**17.970**	Mean
0	**1.060188662**	**0**	**2.19515E-10**	**3.11982906**	**0.01178511**	**0.30568684**	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw2	pf2	PF2
1.32E-05	0.0001	0.01405	0.1797	28.9443656	432,193	122,394

Performance factor adjusted for fuel density: 123,851

****% Change PF= 8.46 %**

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

7-19

SAMPLE CALCULATION FOR THE CARBON MASS BALANCE
ID #27

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)

$$pf1 = \frac{2952.3 \times 28.995}{86(0.0000132)+13.89(0.00017)+13.89(0.01937)}$$

pf1 = ~~314,083~~ 329.702

Equation 4 (CFM Calculations)

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

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

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

CFM = 2358.37

Equation 5 (Corrected Performance Factor)

$$PF1 = \frac{329,702 \text{ ~~314,083~~ (313.1 deg F + 460)}}{2358.37 \text{ CFM}}$$

PF1 = 102,960 104,080

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)

$$pf2 = \frac{2952.3 \times 28.980}{86(0.0000146)+13.89(0.00013)+13.89(0.01826)}$$

pf2 = 333,308

Equation 4 (CFM Calculations)

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

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

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

CFM =2320.51

Equation 5 (Corrected Performance Factor)

$$PF2 = \frac{333,308\ (309.02 \text{ deg F} + 460)}{2320.51\ \text{CFM}}$$

= 110,459

Specific Gravity Correction Factor

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

.840-.837/.840+1=1.003

PF2 = 110,459 x Specific Gravity Correction

PF2 = ~~110,459~~ 115,949 x 1.0036

PF2 = ~~110,857~~ 116,363

Equation 6 (Percent Change in Engine Performance Factor:)

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

% Change PF = [(~~110,857~~ 115,949 - ~~102,960~~ 108,080)/~~102,960~~ 108,080](100)

*= ~~+7.67~~ 7.28

*** Equates to a ~~7.67%~~ 7.28 reduction in fuel consumption.**

RAW DATA WORK SHEETS

Company: Magma Location: Pinto Valley Test Date: 4-14-94
Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 10 Inches

Engine Make/Model: ~~2QV149 QT~~ 16V149QT Miles/Hours: 5054 I.D.#: 27
Type of Equipment: Haul Pac - 190 T

Fuel Specfic Gravity: .840 @: ~~78~~ 83.0 (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 9:45
Finish 9:55

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	310.6	.80	.01	11	~~1.94~~ ~~19.4~~	17.1	
1600	311.6	.80	.01	12	~~1.93~~ ~~19.3~~	17.1	
1600	312.8	.80	.02	14	~~1.93~~ ~~19.3~~	17.1	
1600	312.8	.80	.02	14	~~1.93~~ ~~19.3~~	17.1	
1600	311.8	.80	.02	13	~~1.94~~ ~~19.4~~	17.1	
1600	313.2	.80	.02	14	~~1.94~~ ~~19.4~~	17.1	
1600	313.8	.80	.01	13	~~1.94~~ ~~19.4~~	17.1	
1600	314.2	.80	.02	13	~~1.94~~ ~~19.4~~	17.1	
1600	314.6	.80	.02	14	~~1.94~~ ~~19.4~~	17.1	
1600	315.6	.80	.02	14	~~1.94~~ ~~19.4~~	17.1	

Smoke 4.0

Eng. Temp 170.

Filter less tha. 13

Names of Customer Personnel Participating in Test:

Flinders LeRoy

Signature of Technicians:

Stuart

Company: HAGAN Location: PINTO VALLEY Test Date: 5-5-94

Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 10 Inches

Engine Make/Model: 16V149 Miles/Hours: 5453 I.D.#: 27

Type of Equipment: HAULAGE

Fuel Specific Gravity: .837 @: 77° (°F)

Barometric Pressure: N/A inches of Mercury Start Time: 8:30 AM

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	308.2	.775	.02	14	1.85	17.3	
1600	305.6	.775	.02	14	1.82	17.2	
1600	307.2	.775	.01	14	1.83	17.2	
1600	307.8	.775	.01	14	1.81	17.3	
1600	309.2	.775	.01	15	1.82	17.1	
1600	309.6	.775	.02	16	1.83	17.0	
1600	310.4	.775	.01	14	1.84	17.2	
1600	310.4	.775	.01	15	1.83	17.1	
1600	310.6	.775	.01	15	1.81	17.1	
1600	311.2	.775	.01	15	1.82	17.2	

SMOKE 2.5

AIR LEAK. LESS THAN 12

WATER TEMP 170°F

Names of Customer Personnel Participating in Test: ED. 8:45 AM

_____ _____

Signature of Technicians:

S. C. FURGUS K. R. LEBARON

Company: Magma Location: Pinto Valley Test Date: 4-14-94
Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 10 Inches
Engine Make/Model: ~~3dv149 OT~~ 16V149 OT Miles/Hours: 5677 I.D.#: 28
Type of Equipment: Haul Pac - 190 Ton

Fuel Specific Gravity: .837 @: 88.4 (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 10:55
Finish 11:10

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1605	344.0	.65	.03	21	1.82	17.3	
1605	345.4	.65	.03	21	1.82	17.2	
1605	344.0	.65	.03	21	1.81	17.1	
1605	346.1	.65	.02	23	1.82	17.0	
1605	347.4	.65	.03	21	1.83	17.0	
1605	347.2	.65	.03	22	1.81	16.4	
1605	351.2	.65	03	22	1.81	17.0	
1605	351.8	.65	.03	22	1.80	16.7	
1605	348.8	.65	.03	21	1.81	17.4	
1605	348.8	.65	.03	22	1.81	17.3	

Data taken with fan off

Smoke #5

Air Filter less than 10

Water Temp 178°

Names of Customer Personnel Participating in Test:

_____ _____

Signature of Technicians:

Flinders, LeBaron Stewart

Company: Magna Location: Pinto Valley Test Date: 5-5-94

Test Portion: Baseline:_____ Treated: X Exhaust Stack Diameter: 10 Inches

Engine Make/Model: IH/145 Miles/Hours: 6029 I.D.#: 28

Type of Equipment: Hauler 681E

Fuel Specific Gravity: .838 @: 77.2 (°F)

Barometric Pressure: 29.46 inches of Mercury Start Time:_____

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	324.4	.60	.02	16	1.77	17.4	
1600	323.4	.60	.02	17	1.78	17.4	
1600	325.2	.60	.01	16	1.76	17.5	
1600	325.0	.60	.01	16	1.77	17.4	
1600	324.6	.60	.02	16	1.76	17.5	
1600	324.4	.60	.01	15	1.75	17.5	
1600	323.8	.60	.02	16	1.76	17.4	
1600	324.2	.60	.01	15	1.77	17.3	
1600	323.8	.60	.01	15	1.76	17.3	
1600	324.2	.60	.02	16	1.77	17.4	

Air Test. Less Than 15

H_2O Temp 170° F

Smoke: 3.5

Names of Customer Personnel Participating in Test:

_____ _____

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: Magma / Location: _____ Test Date: 4-14-94
Test Portion: Baseline: / Treated: _____ Exhaust Stack Diameter: 10 Inches

Engine Make/Model: 16V149 DT Miles/Hours: 9891 I.D.#: 29
Type of Equipment: _____

Fuel Specfic Gravity: .838 @: 83.0 (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 12:10 PM

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	315.0	.75	.01	16	1.79	18.4	
1600	315.2	.75	.01	16	1.79	18.4	
1600	315.0	.75	.01	17	1.78	17.9	
1600	315.2	.75	.01	14	1.77	17.8	
1600	315.2	.75	.01	14	1.77	17.8	
1600	314.8	.80	.01	15	1.79	17.8	
1600	315.2	.80	.01	17	1.78	17.6	
1600	315.6	.80	.02	17	1.80	17.6	
1600	316.0	.80	.02	17	1.80	17.6	
1600	316.2	.80	.02	17	1.80	17.7	

Smoke: 4.0

Air Filter Less 10

H_2O Temp. 170 °F

Names of Customer Personnel Participating in Test:

_____ _____

Signature of Technicians:

Tim Deck _____

Carbon Mass Balance Field Data Form

Company: Hughes Location: Pinto Valley Test Date: 5-5-94
Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 10 Inches
Engine Make/Model: 16V149 Miles/Hours: 299 I.D.#: 29
Type of Equipment: _____
Fuel Specfic Gravity: .834 @: 78.2 (°F)
Barometric Pressure: _____ inches of Mercury Start Time: 8:00 AM

Air Tem. 75.3

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	304.6	.70	.02	13	1.75	17.4	
1600	302	.70	.02	14	1.74	17.4	
1600	301.6	.70	.02	14	1.73	17.4	
1600	301.8	.70	.02	14	1.73	17.4	
1600	302.0	.70	.02	15	1.73	17.4	
1600	302.2	.70	.02	17	1.73	17.2	
1600	302.00	.70	.02	14	1.73	17.4	
1600	301.6	.70	.02	14	1.73	17.4	
1600	302	.70	.02	14	1.73	17.4	
1600	302	.70	.02	14	1.73	17.4	

SMOKE 3.0

Air Less. Less Than 15

H_2O Temp 170 °F

End: 8:20 AM

Names of Customer Personnel Participating in Test:

_____ _____

.834 - .834

Signature of Technicians:

S. C. Flowers K. L. Leonard

Carbon Mass Balance Field Data Form

Company: Magma Location: Pinto Valley Test Date: 4-14-94
Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 10 Inches
Engine Make/Model: ~~730 149 OT~~ 160 149 OT Miles/Hours: 4183 I.D.#: 31
Type of Equipment: Haul Pac 190 T

Fuel Specific Gravity: .842 @: 75.8 (°F)

Barometric Pressure: _____ inches of Mercury

Start Time: 9:00 a.m.
Finish 9:17

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1595	327.4	~~.165~~ .170	.02	13	~~2.05~~ 2.05	17.0	
1595	327.6	.170	.02	13	~~20.6~~ 2.06	17.0	
1595	328.4	.175	.02	13	~~20.5~~ 2.05	16.9	
1595	328.8	.175	.02	13	~~20.5~~ 2.03	16.9	
1595	325.4	.175	.02	13	~~20.8~~ 2.08	16.9	
1595	328.4	.175	.02	14	~~20.6~~ 2.06	16.8	
1595	329.8	.175	.02	15	~~20.8~~ 2.08	16.8	
1595	330.0	.175	.02	15	~~20.9~~ 2.09	16.8	
1595	329.6	.175	.03	16	~~20.6~~ 2.06	16.9	
1595	330.0	.175	.02	15	~~21.2~~ 2.12	16.9	

Smoke 4.8

Eng Temp 170°

Filter less than 4

Names of Customer Personnel Participating in Test:

Flinders LeBaron

Signature of Technicians:

Stewart

Company: HAGEN Location: PINTO VALLEY Test Date: 5-5-94

Test Portion: Baseline: _____ Treated: X Exhaust Stack Diameter: 10 Inches

Engine Make/Model: 16V149 Miles/Hours: 4604 I.D.#: 31

Type of Equipment: HAULPAK 685E

Fuel Specific Gravity: .838 @: 82.3 (°F)

Barometric Pressure: 29.60 inches of Mercury Start Time: 10:45 AM

Air Temp. 97.0 °F

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1595	319.8	.70	.02	17	1.94	16.9	
1595	320.8	.70	.02	17	1.94	16.9	
1595	320.6	.70	.02	17	1.96	17.0	
1595	320.2	.70	.02	17	1.95	17.0	
1595	320.4	.70	.02	17	1.95	17.0	
1595	320.6	.70	.02	17	1.94	17.0	
1595	320.4	.70	.02	17	1.94	17.0	
1595	322 ~~320.6~~	.70	.02	17	1.93	17.0	
1595	322	.70	.02	17	1.93	17.1	
1595	321.8	.70	.02	17	1.92	17.0	

SMOKE: 3.5

Air Rest. Less Than 5

H_2O Temp 170 °F

Names of Customer Personnel Participating in Test: EG 10:59 AM

_____ _____

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: Magma Location: Pinto Valley Test Date: 4-14-94
Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 10 Inches
Engine Make/Model: ~~20V149T~~ 16V149OT Miles/Hours: 3094 I.D.#: 32
Type of Equipment: Haul Pac - 190T

Fuel Specfic Gravity: .838 @: 78.8 (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 10:15 AM

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
~~1600~~	~~320.8~~		~~.02~~	~~14~~	~~1.80~~	~~17.5~~	
1600	337.2	.60	.02	22	2.22	16.3	
1600	338.8	.60	.02	14	2.21	16.7	
1600	341.0	.60	.02	15	2.19	16.8	
1600	342.8	.65	.02	17	2.19	16.7	
1600	343.0	.65	.02	17	2.20	16.8	
1600	343.8	.65	.02	17	2.19	16.9	
1600	343.2	.65	.02	17	2.19	16.9	
1600	342.8	.65	.02	17	2.15	16.9	
1600	342.2	.65	.02	15	2.19	16.9	

SMOKE 4.0
FAN LOCKED ON AFTER 1ST DATA POINT
AIR FILTER LESS THAN 5
WATER TEMP 170°

Names of Customer Personnel Participating in Test: FINISH 10:31 AM

_____ _____

Signature of Technicians:

Flinders, LeBaron Stewart

Company: Magma Location: Pinto Valley Test Date: 5-5-94
Test Portion: Baseline: ______ Treated: X Exhaust Stack Diameter: 10 Inches

Engine Make/Model: 16V149 Miles/Hours: 3480 I.D.#: 32
Type of Equipment: Haulpak

Fuel Specfic Gravity: .834 @: 87.8 (°F)

Barometric Pressure: 29.86 inches of Mercury Start Time: 8:48 AM

Air Temp. 79.6 °F

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	329.6	.55	.02	15	2.12	16.8	
1600	331.2	.55	.02	15	2.13	16.7	
1600	332.2	.55	.02	15	2.14	16.8	
1600	333.8	.575	.01	14	2.14	16.7	
1600	334.2	.575	.01	14	2.12	16.5	
1600	334.6	.575	.01	15	2.13	16.6	
1600	334.8	.60	.01	14	2.12	16.6	
1600	335.4	.60	.01	15	2.12	16.7	
1600	336.6	.60	.02	15	2.14	16.7	
1600	336.8	.60	.02	15	2.12	16.6	

Smoke 3.5

Air Rest. Less Than 5

H_2O Temp 170 °F Fan Locked On

Names of Customer Personnel Participating in Test: End: 9:05 AM

______ ______

.834

Signature of Technicians:

S. C. Furbee K R Lebam

Carbon Mass Balance Field Data Form

Company: Magma Location: Pinto Valley Test Date: 4-14-94
Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 10 Inches

Engine Make/Model: ~~2DT149DT~~ 16V149DT Miles/Hours: _____ I.D.#: 39
Type of Equipment: Haul Pac - 190 T

Fuel Specfic Gravity: .840 @: 78.0 (°F)

Barometric Pressure: _____ inches of Mercury Start Time: 9:25
Finish 9:41

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	317.6	1.25	.01	13	~~1.91~~	17.0	
1600	319.6	1.25	.01	13	~~1.91~~ 1.91	17.0	
1600	321.2	1.25	.01	12	~~1.90~~ 1.90	17.1	
1600	321.6	1.25	.01	12	~~1.90~~ 1.90	17.0	
1600	322.2	1.25	.01	13	~~1.91~~ 1.91	17.1	
1600	322.6	1.25	.01	13	1.91 ~~1.91~~	17.1	
1600	323.2	1.25	.01	13	1.90 ~~1.90~~	17.1	
1600	323.2	1.25	.01	13	1.90 ~~1.90~~	17.1	
1600	323.0	1.25	.01	12	1.90 ~~1.90~~	17.1	
1600	323.0	1.25	.01	12	1.90 ~~1.90~~	17.0	

Smoke 3.5
Engine Temp. 165°
Filter less than 7

Names of Customer Personnel Participating in Test:

Flinders LeBaron

Signature of Technicians:

Stewart

Carbon Mass Balance Field Data Form

Company: MAGNA Location: PINTO VALLEY Test Date: 5-5-94

Test Portion: Baseline: _____ Treated: / Exhaust Stack Diameter: 10 Inches

Engine Make/Model: 6V149 Miles/Hours: ~~9295~~ 9295 I.D.#: 39

Type of Equipment: HALCOMB 685E

Fuel Specific Gravity: .832 @: 93 4 (°F)

Barometric Pressure: 29.50 inches of Mercury Start Time: 10:20 AM

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	326.4	1.05	.01	15	1.84	16.8	
1600	326.0	1.05	.01	15	1.83	16.8	
1600	325.0	1.05	.01	12	1.82	17.2	
1600	326.4	1.06	.01	12	1.81	17.2	
1600	326.6	1.06	.01	12	1.81	17.3	
1600	326.8	1.08	.01	13	1.84	17.2	
1600	327.8	1.03 ~~1.05~~	.01	13	1.83	17.1	
1600	326.8	1.03 ~~1.05~~	.01	13	1.83	17.1	
1600	325.8	1.03 ~~1.05~~	.01	12	1.83	17.3	
1600	326.4	1.03 ~~1.05~~	.01	12	1.84	17.3	

SMOKE: 3

AIR RES. LESS THAN 8

H_2O TEMP. 170°F.

Names of Customer Personnel Participating in Test:

CHG TO HIGHER RANGE MAGNEHELIC CALIBRATED OIL .10 "H_2O

COLLEEN-KEARNS

Signature of Technicians:

_____ _____

Carbon Mass Balance Field Data Form

Company: Magma Location: Pinto Valley Test Date: 4-14-94
Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 10 inches
Engine Make/Model: ~~2000 149 DT~~ 16V149DT Miles/Hours 3053 I.D.#: 43
Type of Equipment: Haulpak - 190 T

Used bottom stack

Fuel Specfic Gravity: .842 @: 75.2 (°F)

Barometric Pressure: _____ inches of Mercury

Start Time: 8:37
Finish 8:45

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	300	~~1.1~~	.01	10	1.44	18.0	
1600	301.6	1.1	.01	10	1.44	18.0	
1600	302	1.15	.01	10	1.44	18.0	
1600	302	1.15	.01	10	1.46	17.9	
1600	302.4	1.15	.01	10	1.46	18.0	
1600	302.6	1.15	.01	10	1.46	18.0	
1600	303.2	1.15	.01	10	1.46	18.0	
1600	302.8	1.15	.01	10	1.46	17.9	
1600	303.4	1.15	.01	10	1.46	17.9	
1600	304.6	1.15	.01	10	1.46	17.8	

Smoke 3.5

Eng. Temp. 175°

Filter 6 or less

Names of Customer Personnel Participating in Test:

Flinders LeBaron

Signature of Technicians:

Stewart

Carbon Mass Balance Field Data Form

Company: Macks Location: Pinto Valley Test Date: 5-5-94
Test Portion: Baseline:_____ Treated: ✓ Exhaust Stack Diameter: 10 Inches

Engine Make/Model: 160/49 Miles/Hours: 3471 I.D.#: 43
Type of Equipment: Haulpak 685E

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

Barometric Pressure: 29.53 inches of Mercury Start Time: ~~11:30 AM~~ 1:30 PM

RPM	Exhaust Temp °F	P Inches of H_2O	% CO	HC ppm	% CO_2	% O_2	NO_x
1600	299.6	1.05	.01	13	1.43	18.7	
1600	299.8	1.05	.01	12	1.42	17.8	
1600	299.6	1.05	.01	15	1.40	17.9	
1600	300.2	1.05	.01	15	1.40	17.8	
1600	300.0	1.05	.01	15	1.40	17.8	
1600	301.8	1.05	.01	17	1.39	17.7	
1600	301.8	1.05	.01	17	1.40	17.9	
1600	302.0	1.05	.01	10	1.40	18.0	
1600	301.4	1.05	.01	8	1.40	18.3	
1600	302.0	1.05	.01	~~8~~ 10	1.41	17.8	

Spec. E: 3.0

Air Rec. Less Than E

Hot Temp 170°F

Names of Customer Personnel Participating in Test:

_____ _____

.832 (A)
.842 (B)

Signature of Technicians:

_____ _____