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EVALUATION OF

FPC-1 FUEL PERFORMANCE CATALYST

AT

ARMCO STEEL

Report Prepared For

ARMCO Steel

By

U.H.I. Corporation
Provo, Utah

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I. INTRODUCTION

FPC-1 Fuel Performance Catalyst is the designation of a ferrous picrate aggregate developed to enhance the combustion of all liquid hydrocarbon fuels. The catalyst has undergone extensive testing at independent and university affiliated laboratories in light duty gasoline and diesel powered vehicles. These test procedures have included the EPA Standardized, Federal Test Procedures, (FTP), hot and cold cycles, the Highway Fuel Economy Test, (HFET), (both use carbon mass balance procedures), the SAE J-1082 Interstate and Suburban Fuel Economy tests, the Coordinated Research Council Cold Start Driveability Test and Steady-State engine Dynamometer testing.

These tests have provided documentation which show the FPC-1 formulation creates the following benefits:

1) Improved fuel economy, (3% to 10%).

2) Reduced emissions of harmful pollutants.

3) Improved driveability, (engine performance).

This report will discuss the results and conclusions of an engine performance evaluation using FPC-1 Fuel Performance Catalyst. The purpose of the evaluation is to provide meaningful and accurate information on the performance of FPC-1 so that ARMCO Steel Management will be able to determine the economic benefit from treatment of the gasoline fleet.

This test was conducted by the ARMCO Steel Maintenance Shop under the supervision of Mickey Davidson, Maintenance Director, in cooperation with UHI Corporation, manufacturer of the FPC-1 formulation. Baseline data was taken on February 20, 1985. The treated segment was completed on July 30, 1985. An explanation of the test procedures used to determine the effect of the catalyst on fuel economy and harmful emissions characteristics will be documented and the results summarized.

II. EVALUATION PROCEDURE

Carbon Mass Balance:

Until late 1973, vehicle fuel economy had been determined primarily by using various test track or road test procedures. In September, 1973, the U.S. Envirornental Protection Agency, (EPA), introduced a method of determining vehicle fuel economy in conjunction with its chassis dynamometer emissions test. This method determines fuel consumption based upon vehicle exhaust emissions through a "carbon mass balance" calculation rather than a direct measurement of fuel consumed.

Starting in 1974, the carbon balance method was used solely in the EPA, CVS cold start emissions test cycle, (LA-4 Cycle). In 1975, the cycle was modified adding a hot start, (FTP). Later, a highway test was also developed, (HFET).

A series of tests done by Ford Motor Company compared the traditional fuel measurement techniques, (volumetric or gravimetric), to the carbon balance method. The results, published in SAE Technical Paper Series, 75002, entitled, "Improving the Measurement of Chassis Dynamometer Fuel Economy", states:

> "fuel economy results obtained by carbon mass balance calculation of carbon containing components in the vehicle exhaust are at least as accurate and repeatable as those obtained by direct fuel measurement of fuel consumed."

It was from this concept that UHI Corporation, the manufacturer of FPC-1, derived the technique used by ARMCO for this test. Although not as controlled a test as obtainable in a laboratory using a chassis dynamometer, the method used has consistently proven to be far more accurate than monthly MPG fleet comparisons.

The technique uses state-of-the-art NDIR instruments measuring carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), and hydrocarbons (HC), with anemometers and thermocouples to measure exhaust airflow and temperature respectively.

Methodology:

The carbon balance technique uses exhaust gas analysis to determine changes in fuel consumption. In the field, the subject engines are put under steady state load and readings of exhaust gas emissions are recorded. The exhaust gases are measured in percent of total volume of the exhaust stream and parts per million.

Once recorded, the emissions are weighed mathematically to produce a total molecular weight of the carbon containing gases. Any change in the total mass or molecular weight of the carbon content of these gases indicates an equivalent change in fuel flow to the engine. The technique is used because it is reliable, easily reproduced, and minimizes uncontrolled variables found in field situations.

The engines were tested using the following procedure:

1) Engines were brought to operating temperature.

2) Engines were operated at 1500 RPM's, transmission in high gear and brakes locked.

3) Baseline readings of CO, CO2, O2, and HC were recorded using a Sun Electric Multiple Gas Analyzer-90, (MGA-90), an NDIR analyzer.

4) Exhaust temperature was taken with an I.M.C. Digital Thermocouple.

5) The test fleet was fueled with FPC-1 treated gasoline for a minimum 2,000 miles of "normal" operation.

6) Steps 1 through 5 were repeated with FPC-1 treated gasoline.

III. DISCUSSION OF DATA

The data from the baseline and treated tests were averaged on a cumulative basis. These averages were used to calculate total molecular weight of the carbon containing gases being scavenged from the engines. A performance factor for both baseline and treated fuel was then calculated and a relative change in fuel consumption was determined.

The formula used to calculate the performance factors is found in Figure I, as provided by Dr. G.J. Germane, PhD. Mechanical Engineering, Brigham Young University. Figure II presents the calculations and resultant percentage change in fuel consumption. Figure III shows the test fleet equipment list with I.D. numbers, engine type and mileages.

The following points are important when considering the information presented on the raw data sheets:

1) During testing with the MGA-90 exhaust gas analyzer, the meters are checked for calibration between each data point. The oxygen (O2) level can be read off either the RED scale (0-25%) or the BLUE scale (0-5%) depending on the oxygen volume emitted, however, the meter must be cali-

brated on the RED scale at 21% oxygen. This was not done during baseline testing on units 207, 241, 255, and 107, but was corrected upon discovery of the error. The smaller numbers to the left of the original readings of 02 are the corrections.

2) Unit 207 showed unburned hydrocarbon (HC) readings that were OFF THE SCALE during baseline. The upper limit of the HC scale is 2,000 ppm HC. Consequently, the 2,000 ppm number was used in the baseline computation of the engine performance factors. It was noted that with the FPC-1 Catalyst added to the fuel, HC was reduced in unit 207 to an average 1,210 ppm.

3) A significant variation in the carbon monoxide (CO) was recorded during treated fuel testing of unit 253, however, the average was similar to that of the baseline. Therefore, the data was used in the computation and comparison.

IV. CONCLUSIONS

The use of FPC-1 Fuel Performance Catalyst created a 12.7% reduction in fuel consumption. Emissions of all harmful pollutants were reduced.

FIGURE I

CARBON BALANCE TECHNIQUE

ASSUMPTIONS: C_8H_{15} and SG = .078
Time is constant
Load is constant
RPM is constant

DATA:

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 (F')
F = Flow (exhaust CFM)
SG = Specific gravity
VF = Volume fraction
  VFCO2 = "reading" divided by 100
  VFO2 = "reading" divided by 100
  VFHC = "reading" divided by 1,000,000
  VFCO = "reading" divided by 100

EQUATIONS:

$$\text{Mwt} = (\text{VFHC})(86) + (\text{VFCO})(28) + (\text{VFCO2})(44) + (\text{VFO2})(32) + [(1 - \text{VFHC} - \text{VFCO} - \text{VFO2} - \text{VFCO2})(28)]$$

$$\text{pf1 or pf2} = \frac{2952.3 \times \text{Mwt}}{86\,(\text{VFHC}) + 13.89\,(\text{VFCO}) + 13.89\,(\text{VFCO2})}$$

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

PERCENT INCREASE OR DECREASE IN FUEL ECONOMY:

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

FIGURE II

ARMCO STEEL

CUMULATIVE AVERAGES

Baseline		Treated	
CO2	10.28%	CO2	9.36%
O2	6.07%	O2	6.15%
HC	470 ppm	HC	274 ppm
CO	1.16%	CO	0.91%
Temp.	527.6'F	Temp.	535.33'F
Airflow	600 cfm	Airflow	600 cfm

VOLUME FRACTIONS

vfCO2	0.1028	vfCO2	0.0936
vfO2	0.0607	vfO2	0.0615
vfHC	0.000470	vfHC	0.000274
vfCO	0.0116	vfCO	0.0091

MOLECULAR WEIGHTS AND PERFORMANCE FACTORS

Mwt1	29.9149	Mwt2	29.7595
pf1	54201.3563	pf2	60589.5781
PF1	89215.4325	PF2	100511.0418

$$100511.0418 - 89215.4325 = 11295.6093$$

$$\frac{11295.6093}{89215.4325} \times 100 = 12.7\%$$

FIGURE III

ARMCO STEEL

EQUIPMENT LIST

Unit No.	Engine	Beginning Miles	Ending Miles
253	In-Line 6	60,980	66,689
207	V-6	47,871	50,530
241	In-Line 6	26,079	27,899
175	V-8	95,381	99,237
255	In-Line 6	60,416	65,977

AN EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST IN A LOCOMOTIVE ENGINE USING EXHAUST GAS ANALYSIS FOR FUEL ECONOMY MEASUREMENT

BY

ARMCO STEEL
BUTLER STEEL WORKS
BUTLER, PA.

INTRODUCTION

FPC-1 is the designation of a fuel catalyst formulated to improve the combustion of hydrocarbon fuels, thereby releasing more energy per unit of fuel consumed. Testing in the laboratory and the field has proven FPC-1 beneficial in many applications, including heavy duty diesel engines.

This evaluation program conducted by ARMCO Steel, Butler, Pennsylvania, was initiated to verify the benefits available to their locomotive fleet through the use of FPC-1. The evaluation program was approved and supervised by Mr. Mickey Davidson, Tractor Shop Foreman for ARMCO.

The test protocol selected for this segment of testing was a carbon mass balance technique derived from the E.P.A. test procedures, (FTP and HFET). An explanation of the technique is contained in Appendix 1. The baseline segment of the test was conducted by UHI Technicians on September 26, 1985. The concluding treated segment was conducted on November 15, 1985.

THE PRODUCT

FPC-1 contains a ferrous picrate catalyst formulated to enhance the combustion of liquid fossil fuels. The catalyst is suspended in a toluene and isopropyl alcohol carrier making it entirely miscible in all liquid oil based fuels (gasoline, diesel, heating oil, etc.). Therefore, mechanical mixing is not required in most bulk storage tanks.

Research indicates that the catalyst most likely functions to create a "chemically induced multiple flame center burn" within the cylinder. Laboratory tests show improved oxidation with a more even energy release.

LABORATORY TESTING

The active ingredient in FPC-1 has been tested for product performance verification by highly recognized independent and university affiliated laboratories using industry accepted test procedures. These testing laboratories include the following:

1. Automotive Testing Laboratories (ATL), Aurora, CO, (now located in Ohio),

2. System Controls, Inc., Anaheim, California, and

3. Deseret Professional Laboratory, Provo, Utah.

Test procedures used at the above mentioned laboratories are among the most recognized, both domestically and internationally. These include:

- The EPA Standardized Federal Test Procedures (FTP),
- The EPA Standardized Highway Fuel Economy Test (HFET),
- The Society of Automotive Engineers (SAE) J-1082 Interstate and Suburban Fuel Economy Tests,
- The Coordinating Research Council (CRC) cold start driveability test, and
- Computerized engine dynamometer testing (SAE paper 800412).

The information obtained from these in-depth product performance tests prove that the catalyst creates 1) a 3% to 10% improvement in fuel economy, 2) significant reductions in the emissions of harmful pollutants, and 3) an improved driveability (engine performance).

These same tests have also shown that the total effect of the catalyst is not seen immediately, but can take as long as 200 hours to realize. For example, the System Controls, Inc. test included the FTP, HFET, SAE J1082 interstate and SAE J1082 suburban cycles. All four procedures were done at regular intervals, approximating 0 miles, 1500 miles, and 3,000 miles with catalyst treated fuel. A greater improvement in fuel economy and reduced emissions were seen as engine mileage with the catalyst increased. The same was true for engine performance as demonstrated by the CRC cold start driveability test.

FIELD TESTING

Long term testing in the field has provided documentation showing that extended catalyst usage softens and removes hard carbon engine deposits, and inhibits further buildup. Additionally, visible smoke is greatly reduced. These same field tests, and others with FPC-1, continue to confirm laboratory findings.

METHODOLOGY

The test locomotive was run at rack 8 and 850 RPM during the exhaust gas analysis portion of the test. After exhaust temperature and engine water temperature stabilized, the following information was recorded using a Sun Electric Multiple Gas Analyzer-90 (an NDIR unit), and an IMC Digital Thermocouple:

- Percent CO_2
- Percent CO
- PPM Unburned Hydrocarbon (HC)
- Percent O_2
- Exhaust Temperature 'F
- Engine Water Temperature 'F

The procedure was repeated during the final test segment after FPC-1 had been added to the locomotive fuel and the locomotive operated in excess of 200 hours. The baseline and treated exhaust gases were then "weighed" mathematically to determine total molecular weight (mass) and engine performance factors. The performance factors were compared and a change in engine performance determined. This change in performance is equivalent to the change, negative or positive, in fuel consumption.

Figure 1 presents the equations for determining the molecular weight, performance factors and change in fuel consumption. Table 1 summarizes the results of the calculations and makes the comparison between the baseline and treated fuel consumption.

DISCUSSION AND CONCLUSION

The locomotive engine of this test program experienced an 8.8% improvement in fuel economy while consuming FPC-1 treated diesel. Also, emissions of carbon monoxide (CO) and unburned hydrocarbons (HC) were eliminated. Emissions of smoke and the frequent stack fires, as reported in an earlier memorandum attached in Appendix 2, were also eliminated. Soot build up on the inside of the smoke stacks is visibly reduced and the soot that is being deposited is drier. This is an indication that carbon build up inside the engine is likewise being effected.

Unfortunately, the locomotive engine could not be loaded during the exhaust gas analysis. This can affect the accuracy of the exhaust gas readings as the fuel flow to the engine when not loaded is substantially less than it would be if the engine were loaded and working to maintain the same RPM.

As a result, the volume of the gas most critical to the carbon mass balance (CO_2) is lessened and the amount of change created by the catalyst harder to read on the test instrument meter. Fortunately, the change created by the addition of the catalyst was large enough to be easily read off the CO_2 meter increasing the level of confidence in the fuel economy improvement number.

FIGURE I

CARBON BALANCE TECHNIQUE

ASSUMPTIONS:
- C8H15 and SG = 0.78
- Time is constant
- Load is constant
- RPM is constant

DATA:

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 (F')
F	=	Flow (exhaust CFM)
SG	=	Specific gravity
VF	=	Volume fraction

- VFCO2 = "reading" divided by 100
- VFO2 = "reading" divided by 100
- VFHC = "reading" divided by 1,000,000
- VFCO = "reading" divided by 100

EQUATIONS:

$$\text{Mwt} = (\text{VFHC})(86) + (\text{VFCO})(28) + (\text{VFCO2})(44) + (\text{VFO2})(32) + [(1 - \text{VFHC} - \text{VFCO} - \text{VFO2} - \text{VFCO2})\ (28)]$$

$$\text{pf1 or pf2} = \frac{2952.3 \times \text{Mwt}}{86\ (\text{VFHC}) + 13.89\ (\text{VFCO}) + 13.89\ (\text{VFCO2})}$$

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

PERCENT INCREASE OR DECREASE IN FUEL ECONOMY:

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

APPENDIX 1

EXPLANATION OF CARBON BALANCE TECHNIQUE

Historically, field evaluations have been difficult to control because of variables such as climate, terrain, fuel density, equipment condition, load changes, route changes, and human error. In the past, UHI has relied on fuel records made available by the personnel employed by our prospective customers.

Unfortunately, most field maintenance and accounting records are not accurate enough to show a five to ten percent improvement in fuel economy. These inconsistent records have made it virtually impossible to measure any fuel economy improvement through the use of FPC-1. Consequently, many potential customers had to be eliminated as possible users of FPC-1 because of the uncontrolled variables in their fuel measurement procedures.

To solve this problem, UHI spent several years researching and practicing a superior technique for accurately verifying FPC-1 performance to potential customers in their own equipment. This method, known as the "carbon mass balance" technique, is an in-direct method of measuring changes in fuel consumption that eliminates most of the uncontrolled variables and inaccurate record keeping problems. By in-direct, we mean that actual fuel flow is not measured; but rather, the products of combustion are measured.

Fuel is comprised of hydrogen and carbon. When combined with oxygen, (combustion), the liquid fuel is converted to a gaseous state. The primary gaseous products of combustion, having to do with fuel, are, carbon dioxide (CO2), carbon monoxide (CO), oxygen (O2), and unburned hydrocarbons (HC). These are scavenged from the system during the exhaust phase of the engine cycle.

These gases are easily measured with non-dispersive, infrared equipment, and their mass computed. Any change in their mass, corresponds to an equivalent change in fuel flow. Consequently, fuel consumption improvements, (fuel economy), can be measured indirectly by exhaust gas analysis. This is the method currently used by the EPA in the aforementioned FTP and HFET procedures. This same technique was also used and verified by Ford Motor Company in 1976. The result of Ford's study, published in SAE paper #75002, entitled, "Improving the Measurement of Chassis Dynamometer Fuel Economy", showed the carbon mass balance to be at least as accurate as volumetric and/or gravimetric techniques.

In order for the carbon balance to be meaningful, the test engine(s) must operate at identical loads for both the baseline and treated fuel test segments. The main objective of the carbon balance procedure conducted by UHI in the field is to prove that the addition of FPC-1 increases the energy output per unit volume of fuel, thereby reducing fuel consumption requirements to maintain the same load.

TABLE I

Average of Exhaust Gas Readings From 16V645E Locomotive Engine

Baseline		Treated	
CO2	1.2%	CO2	1.088%
O2	19.45%	O2	19.52%
HC	8.75%	HC	0
CO	0.0038%	CO	0
Ex. Temp.	315'F	Ex. Temp.	299'F
Air Flow	2500	Air Flow	2500

Volume Fractions

vfCO2	0.0120	vfCO2	0.01080
vfO2	0.1945	vfO2	0.1952
vfHC	0.00000875	vfHC	0
vfCO	0.000058	vfCO	0

Molecular Weight and Performance Factors

Mwt1	28.9705	Mwt2	28.9549
pf1	509225.2104	pf2	565654.3285
PF1	157859.8156	PF2	171732.6541

$$171732.6541 - 157859.8152 = 13872.8387$$

$$\frac{13872.8389}{157859.8150} \times 100 = 8.79\%$$

APPENDIX 2

MGA 90
Emissions Tests Analysis

Baseline Test Date Sept. 26 1985 Treated Test Date ______

Company Armco Steel

Year and Make of Equipment Locomotive B-84

Company Identification No. ______

Engine C.I.D. and Cylinders 16 Cylinder EMD 645-E Turbo

Serial Number ______

Precombustion [ ] After cooled [ ] Intercooled [ ] Turbo [✓] Natural Asp. [ ]

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ______ Scrubber ______

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Baseline Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Baseline Engine Hours or Mileage ______ Treated Engine Hours or Mileage ______

Baseline MGA Calibrated ______ Treated MGA Calibrated ______

RPM ______	Treated 1	Treated 2	Treated 3	Treated 4
CO_2				
O_2				
HC				
CO				

Rack 8

RPM 850	Baseline 1	Baseline 2	Baseline 3	Baseline 4	~~Water T. Exh~~
CO_2	1.2	1.2	1.2	1.2	1.2
O_2	19.9	19.3	18.2	19.4	19.45
HC	12	9	7	7	8.75
CO	.01	.005	00	00	.004
Water °	150°			150°	308 °F
Exh °	301°			315°	

5 Min Duration

MGA 90
Emissions Tests Analysis

Baseline Test Date ______ Treated Test Date Nov. 15, 1982

Company Armco Steel

Year and Make of Equipment Loco B-84

Company Identification No. ______

Engine C.I.D. and Cylinders 16 V EMD 645E Turbo

Serial Number ______

Mickey
284-2299
2305

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ______ Scrubber ______

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Baseline Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Baseline Engine Hours or Mileage ______ Treated Engine Hours or Mileage ______

Baseline MGA Calibrated ______ Treated MGA Calibrated ______

Rack 8

Water Temp 160 °F

RPM 850	Treated 1	Treated 2	Treated 3	Treated 4	#1 EXH 290 °F	
CO_2	1.0%	1.1%	1.1%	1.05%	1.1%	1.07%
O_2	19.5%	19.5%	19.5%	19.6%	19.5%	19.52
HC	0	0	0	0	0	
CO	0	0	0	0	0	

#4 EXH 294 °F

#5 EXH 299 °F
294 °F

RPM ___	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2				
O_2				
HC				
CO				

MGA 90
Emissions Tests Analysis

Baseline Test Date Sept. 26 1985 Treated Test Date ______

Company Armco Steel

Year and Make of Equipment Locomotive B-84

Company Identification No. ______

Engine C.I.D. and Cylinders 16 Cylinder EMD 645-E Turbo

Serial Number ______

Precombustion [ ] After cooled [ ] Intercooled [ ] Turbo [✓] Natural Asp. [ ]

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ______ Scrubber ______

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1____ #2____ #3____ Other ______

Treated Fuel: Diesel #1____ #2____ #3____ Other ______

Baseline Fuel: Premium____ Regular____ Unleaded____ Other ______

Treated Fuel: Premium____ Regular____ Unleaded____ Other ______

Baseline Engine Hours or Mileage____ Treated Engine Hours or Mileage____

Baseline MGA Calibrated ______ Treated MGA Calibrated ______

Rack 8

RPM 850	Treated 1	Treated 2	Treated 3	Treated 4
CO_2	1.3%	1.3%	1.2%	1.3%
O_2	19.5%	19.3%	19.5%	19.3%
HC	9 ~~15~~ ppm	5 ppm	0	3 ppm
CO	0%	0	0	0

#1 Exh: 305°F
Water: 150°F

#4 Exh: 310°F

Rack 8

RPM 850	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2	1.2	1.2	1.2	1.2
O_2	19.9	19.3	19.2	19.4
HC	12	9	7	7
CO	.01	.005	00	00
Water °	150°			150°
Exh °	301°			315°

~~Water T. Exh~~

5 Min Duration

Base	Treated
28.9207	28.9520
508,483	575,113

$$\frac{66,630}{13\%}$$

MGA 90

Emissions Tests Analysis

Baseline Test Date Feb 20, 1985 Treated Test Date ______

Company ARMCO STEEL

Year and Make of Equipment ______

Company Identification No. #253 # [illegible] (60980 mi)

Engine C.I.D. and Cylinders [illegible] King Cab INLINE 6

Serial Number ______

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ______ Scrubber ______

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Baseline Fuel: Premium ___ Regular ___ Unleaded ✓ Other ______

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Baseline Engine Hours or Mileage ______ Treated Engine Hours or Mileage ______

Baseline MGA Calibrated ______ Treated MGA Calibrated ______

RPM ______	Treated 1	Treated 2	Treated 3	Treated 4
CO_2				
O_2				
HC				
CO				

Cyl. Temp: 576

RPM 1500	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2	10.5%	10.6%	11%	11%
O_2	5.5%	5.1%	5%	5%
HC	62	70	60	55%
CO	1.7%	1.6%	1.6%	1.8%

MGA 90
Emissions Tests Analysis

Baseline Test Date 2-20-85 Treated Test Date ____________

Company ARMCO STEEL

Year and Make of Equipment ____________

Company Identification No. 207 47,871

Engine C.I.D. and Cylinders V-6 345

Serial Number ____________

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ____________ Scrubber ____________

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1____ #2____ #3____ Other ____________

Treated Fuel: Diesel #1____ #2____ #3____ Other ____________

Baseline Fuel: Premium____ Regular____ Unleaded ✓ Other ____________

Treated Fuel: Premium____ Regular____ Unleaded____ Other ____________

Baseline Engine Hours or Mileage_____ Treated Engine Hours or Mileage_____

Baseline MGA Calibrated____________ Treated MGA Calibrated____________

RPM ____	Treated 1	Treated 2	Treated 3	Treated 4
CO_2				
O_2				
HC				
CO				

RPM ____	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2	7.5	7.5	7.5	7.5
O_2	10% 2	10% 2	10% 2	10% 2
HC	OFF SCALE	OFF SCALE	OFF SCALE	OFF SCALE
CO	.35	.5	.55	.6

Cyl. Temp. 408

MGA 90
Emissions Tests Analysis

Baseline Test Date 2-20-85 Treated Test Date ________

Company ARMCO STEEL

Year and Make of Equipment ARMCO

Company Identification No. 255 60,416

Engine C.I.D. and Cylinders 6 INLINE

Serial Number ________

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ____ Treated Ambient Temperature ____

Catalytic Converter ________ Scrubber ________

Baseline Engine Temperature ____ Treated Engine Temperature ____

Baseline Fuel: Diesel #1___ #2___ #3___ Other ________

Treated Fuel: Diesel #1___ #2___ #3___ Other ________

Baseline Fuel: Premium___ Regular___ Unleaded ✓ Other ________

Treated Fuel: Premium___ Regular___ Unleaded___ Other ________

Baseline Engine Hours or Mileage____ Treated Engine Hours or Mileage____

Baseline MGA Calibrated________ Treated MGA Calibrated________

RPM____	Treated 1	Treated 2	Treated 3	Treated 4
CO_2				
O_2				
HC				
CO				

RPM____	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2	10	10	10	10
O_2	52 1	52 1	52 1	52 1
HC	80	70	60	60
CO	2,5	2,25	2,5	2,5

Exh. Temp. 555

MGA 90

Emissions Tests Analysis

Baseline Test Date 2-20-85 Treated Test Date ______

Company ARMCO STEEL

Year and Make of Equipment ______

Company Identification No. 175 95 381

Engine C.I.D. and Cylinders V-8

Serial Number ______

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ______ Scrubber ______

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Baseline Fuel: Premium ___ Regular ___ Unleaded ✓ Other ______

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Baseline Engine Hours or Mileage ______ Treated Engine Hours or Mileage ______

Baseline MGA Calibrated ______ Treated MGA Calibrated ______

RPM ______	Treated 1	Treated 2	Treated 3	Treated 4
CO_2				
O_2				
HC				
CO				

RPM ______	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2 (RPM 1600)	11.2	11	11	10.5
O_2	5.5% 1.2	6.0% 1.1	6.0% 1.1	5.0% 2
HC	80	90	90	90
CO	.55	.7	.8	.7

Cth Temp 671

5.5

MGA 90
Emissions Tests Analysis

Baseline Test Date ____________ Treated Test Date 7/30/85

Company ____________

Year and Make of Equipment ____________

Company Identification No. #207 47,871

Engine C.I.D. and Cylinders V-6

Serial Number ____________

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ____ Treated Ambient Temperature ____

Catalytic Converter ____________ Scrubber ____________

Baseline Engine Temperature ____ Treated Engine Temperature ____

Baseline Fuel: Diesel #1 ____ #2 ____ #3 ____ Other ____________

Treated Fuel: Diesel #1 ____ #2 ____ #3 ____ Other ____________

Baseline Fuel: Premium ____ Regular ____ Unleaded ✓ Other ____________

Treated Fuel: Premium ____ Regular ____ Unleaded ____ Other ____________

Baseline Engine Hours or Mileage ____ Treated Engine Hours or Mileage 50530

Baseline MGA Calibrated ____________ Treated MGA Calibrated ____________

Cyl Temp 408

RPM 1500	Treated 1	Treated 2	Treated 3	Treated 4	
CO_2	9	9	9		Ave. 9 %
O_2	7.5	7.5	7.5		7.5 %
HC	1220	1200	1210		1210 ppm
CO	.33	.3	.4		0.343 %

RPM ____	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2				
O_2				
HC				
CO				

MGA 90
Emissions Tests Analysis

Baseline Test Date ________ Treated Test Date 6 7/30/85

Company ________

Year and Make of Equipment Chevy 1980

Company Identification No. #241 26079

Engine C.I.D. and Cylinders Custom Deluxe (In Six)

Serial Number ________

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ____ Treated Ambient Temperature ____

Catalytic Converter ________ Scrubber ________

Baseline Engine Temperature ____ Treated Engine Temperature ____

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ________

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ________

Baseline Fuel: Premium ___ Regular ___ Unleaded ✓ Other ________

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ________

Baseline Engine Hours or Mileage ____ Treated Engine Hours or Mileage 27899

Baseline MGA Calibrated ________ Treated MGA Calibrated ________

Eth Temp. 428

RPM 1500	Treated 1	Treated 2	Treated 3	Treated 4	AVE.
CO_2	11	11	11		11%
O_2	4.5	4.6	4.6		4.57%
HC	20	20	20		20 ppm
CO	0	0	0		0

RPM ____	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2				
O_2				
HC				
CO				

MGA 90
Emissions Tests Analysis

Baseline Test Date ______ Treated Test Date 7/30/85

Company ______

Year and Make of Equipment ______

Company Identification No. #175 95381

Engine C.I.D. and Cylinders V-8

Serial Number ______

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ______ Treated Ambient Temperature ______

Catalytic Converter ______ Scrubber ______

Baseline Engine Temperature ______ Treated Engine Temperature ______

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ______

Baseline Fuel: Premium ___ Regular ___ Unleaded ✓ Other ______

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ______

Baseline Engine Hours or Mileage ______ Treated Engine Hours or Mileage 99237

Baseline MGA Calibrated ______ Treated MGA Calibrated ______

Cyl. Temp 640

RPM 1600	Treated 1	Treated 2	Treated 3	Treated 4	Ave.
CO_2	9				9%
O_2	5				5.%
HC	85				85 ppm
CO	1.15				1.15%

RPM ___	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2				
O_2				
HC				
CO				

MGA 90
Emissions Tests Analysis

Baseline Test Date 2-20-85 Treated Test Date ____

Company Armco Steel

Year and Make of Equipment ____

Company Identification No. #241 (16079 4.)

Engine C.I.D. and Cylinders ~~##~~ Custom Deluxe INLINE 6

Serial Number ____

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ____ Treated Ambient Temperature ____

Catalytic Converter ____ Scrubber ____

Baseline Engine Temperature ____ Treated Engine Temperature ____

Baseline Fuel: Diesel #1 ____ #2 ____ #3 ____ Other ____

Treated Fuel: Diesel #1 ____ #2 ____ #3 ____ Other ____

Baseline Fuel: Premium ____ Regular ____ Unleaded ✓ Other ____

Treated Fuel: Premium ____ Regular ____ Unleaded ____ Other ____

Baseline Engine Hours or Mileage ____ Treated Engine Hours or Mileage ____

Baseline MGA Calibrated ____ Treated MGA Calibrated ____

RPM ____	Treated 1	Treated 2	Treated 3	Treated 4
CO_2				
O_2				
HC				
CO				

Ch. Temp 428

RPM ____	Baseline 1	Baseline 2	Baseline 3	Baseline 4	
CO_2	~~12%~~	~~13%~~	13%	12.8	12.8
O_2	~~4.0%~~	~~3.2%?~~	3.75	4%, 8	4%, 8
HC	~~85~~	~~40~~	25	20	20
CO		~~.04~~	0	0	0

NOT WARM

MGA 90
Emissions Tests Analysis

Baseline Test Date ____________ Treated Test Date 7/30/85

Company ____________

Year and Make of Equipment Kwr. Car

Company Identification No. #253 WELD SHOP 60980

Engine C.I.D. and Cylinders in line 6

Serial Number ____________

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ____ Treated Ambient Temperature ____

Catalytic Converter ____________ Scrubber ____________

Baseline Engine Temperature ____ Treated Engine Temperature ____

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ____________

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ____________

Baseline Fuel: Premium ___ Regular ___ Unleaded ✓ Other ____________

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ____________

Baseline Engine Hours or Mileage ____ Treated Engine Hours or Mileage 66689

Baseline MGA Calibrated ____________ Treated MGA Calibrated ____________

Exhaust Temp. 576

RPM 1500	Treated 1	Treated 2	Treated 3	Treated 4	Ave.
CO_2	10	10	10	10	10 %
O_2	5.6	5.5	4.8	4.5	5.1 %
HC	5	4	6	7	5.5 ppm
CO	.9 ?	1.7 ?	1.7 ?	1.7 ?	1.5 %

RPM ____	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2				
O_2				
HC				
CO				

MGA 90
Emissions Tests Analysis

Baseline Test Date ____________ Treated Test Date 7/30/85

Company ____________

Year and Make of Equipment ____________

Company Identification No. #255 60,416

Engine C.I.D. and Cylinders IN Line 6

Serial Number ____________

Precombustion ☐ After cooled ☐ Intercooled ☐ Turbo ☐ Natural Asp. ☐

Baseline Ambient Temperature ____ Treated Ambient Temperature ____

Catalytic Converter ____________ Scrubber ____________

Baseline Engine Temperature ____ Treated Engine Temperature ____

Baseline Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ____________

Treated Fuel: Diesel #1 ___ #2 ___ #3 ___ Other ____________

Baseline Fuel: Premium ___ Regular ___ Unleaded ✓ Other ____________

Treated Fuel: Premium ___ Regular ___ Unleaded ___ Other ____________

Baseline Engine Hours or Mileage ____ Treated Engine Hours or Mileage 65977

Baseline MGA Calibrated ____________ Treated MGA Calibrated ____________

Exh Temp.
550 START
610 END

RPM 1500	Treated 1	Treated 2	Treated 3	Treated 4	Ave.
CO_2	7.2	7.4	7.5		7.37%
O_2	8.5	8	8		8.17%
HC	10	20	20		16.7 ppm
CO	1.8	1.4	1.4		1.53%

RPM ____	Baseline 1	Baseline 2	Baseline 3	Baseline 4
CO_2				
O_2				
HC				
CO				