

EVALUATION OF FEROX™ TREATED FUEL

AT

McCARTNEY CONSTRUCTION CO., INC.
ANNISTON, AL

FOR USE IN ASTEC DOUBLE-BARREL
ASPHALT PLANT

Report Prepared by Lindsay Allen

FEROX PETROCHEMICAL CORPORATION
WINTER PARK, FL

FEBRUARY 3, 1993

EXECUTIVE SUMMARY

The Carbon Mass Balance test, conducted and completed at McCartney Construction on an ASTEC Industries, Inc. double-barrel asphalt plant on January 29, 1993, confirms that the addition of FEROX™ to the fuel will reduce fuel consumption and harmful emissions.

The overall reduction in fuel consumption during this test was determined to be 26.38% at a production level of 38 and 18.12% for a production level of 47.

Reduction of harmful emissions was determined to be 24.05% for CO, 8.66% for unburned hydrocarbons, 20.42% for CO₂ at a production level of 38. Reduction of harmful emissions were determined to be 16.42% for CO, 38.82% for unburned hydrocarbons, and 14.99% for CO₂ at a production level of 47.

Further studies into the long term effects of the use of FEROX™ treated fuel should be conducted. Tests should be conducted on other asphalt equipment to determine if production rates can be increased by reducing harmful emissions particularly in those areas (California) where stricter emissions controls are limiting production .

Finally, FEROX™ treated fuel should be used in all combustion equipment at McCartney Construction. The benefits of reduced fuel consumption, reduced emissions, reduced particulate emissions, and reduced maintenance costs apply to all combustion equipment, not just the asphalt plant, but also the loaders, haulers, pick-up trucks, and excavators.

INTRODUCTION

The formulation in the aftermarket combustion improver called FEROX™ has undergone extensive testing in EPA recognized independent and university affiliated laboratories. These tests have demonstrated that the improver can provide fuel savings, reduced emissions, and reduced operating and maintenance costs.

Field testing substantiates laboratory findings with even greater average improvements and also reveals the improver can be an effective means of further reducing operating costs by inhibiting the formation of hard carbon build-up on critical equipment surfaces.

This reports summarizes the results of controlled back-to-back field tests conducted in cooperation with McCartney Construction Company and Astec Industries, Inc., on a double-barrel asphalt plant that used fuel treated with and without FEROX™. The test procedure applied to determine fuel consumption was the Carbon Mass Balance Exhaust Emission Test at given equipment operating conditions.

Astec Industries, Inc. manufactures an open-flame double-barrel asphalt plant, in which production is being limited due to constraints associated with flame flight length. Material (aggregate) is falling through the flame, quenching the flame, causing high levels of CO and

unburned hydrocarbon emissions. Production is being limited, particularly in states enforcing stringent CO and HC emission standards (like California) because emissions are approaching upper limits. Astec has obtained a couple of gallons of FEROX and wants to run some treated fuel through the plant to determine the effect on emissions and fuel consumption. How long should they run the treated fuel through the machine before he will see any differences? What differences should they see?

DISCUSSION

TEST DESCRIPTION

An ASTEC asphalt plant owned by McCartney Construction Company, located in Anniston, AL was chosen for FEROX evaluation. The plant was brought up to normal operating conditions. Once stable operating conditions were established, exhaust readings were taken to determine baseline conditions (i.e. conditions with the use of No. 2 diesel fuel without FEROX treatment). This baseline tests consisted of measuring exhaust emission levels of CO₂, CO, unburned hydrocarbons, O₂, and exhaust temperatures, at 10 minute intervals.

Fuel was then treated with FEROX at the recommended ratio of 5000 parts fuel to 1 part FEROX. The same parameters were measured during the treated portion of the test as were measured during the baseline test.

A new exhaust particulate filter was installed before both the baseline and treated fuel test series.

EXPECTED OBSERVATIONS

The customer should see some immediate differences. Open-flame surface modification takes time, but they will see the change in the combustion chemistry immediately. They will see a reduction in unburned hydrocarbons, CO and particulate emissions. If, however, the carbon monoxide relates to reduction back from CO₂ and that reduction is occurring on catalytic surfaces within the equipment, then that reduction in CO will not occur until you have modified the surfaces of the equipment. In addition, the customer should see an immediate observable difference in the flame - as soon as treated fuel gets in there. They won't see an immediate drop in acid corrosion, although with continued use they should experience this benefit. Acid corrosion relates to vanadium, sodium and sulfur in the fuel. Vanadium pentoxide is formed as a result of the combustion of vanadium containing fuel. Vanadium Pentoxide allows the conversion of SO₂ to SO₃ which forms sulfuric acid. Cold-end corrosion results from the condensation of the sulfuric acid. FEROX will prevent the formation of vanadium pentoxide. It only allows the formation of lower vanadium oxides that are not catalytic with SO₂ to form sulfuric acid. If the customer has an existing piece of equipment that has a lot of vanadium pentoxide (i.e. has been burning fuels containing vanadium for some time), the process to modify the surface will take a little time.

ACTUAL EFFECTS ON EMISSIONS, FUEL CONSUMPTION, AND PARTICULATE FORMATION

Figure 1 depicts results obtained from the Carbon Mass Balance test of FEROX treated fuel in an ASTEC double-barrel asphalt plant. At the relatively lower production rate of 38, the overall reduction in emissions for carbon monoxide (CO) was 24.05%, unburned hydrocarbons (HC) was 8.66%, and carbon dioxide (CO₂) was 20.42%. Completing the carbon mass balance, we conclude an overall reduction in carbon emissions of 26.38% (which represents an overall reduction in fuel consumption, see Appendix 1 and 2 for raw data and an explanation of the carbon mass balance test). We have chosen to use "pf" (unadjusted performance factor) since the inlet suction is maintained at a constant level of 0.21 inches of water for both the baseline and treated. This coupled with constant delta P across the baghouse indicates the same volume flow rates for both baseline and treated portions of the test. Hence, no need for PF (adjusted performance factors). Similarly, for a higher production rate of 47% controller position, overall emission reductions in harmful emissions were CO = 16.42%, HC = 38.82%, and CO₂ = 14.99%. Again completing the overall carbon balance, we conclude an overall reduction in fuel consumption of 18.12%.

In addition, we experienced a decrease in particulate formation as indicated in Figure 2 - a photograph of particulate filters before and after the addition of FEROX. As can be seen in the photo, a significantly larger amount of particulates were caught by the filter used prior to fuel treatment.

MECHANISM FOR DECREASING PARTICULATE AND DEPOSIT FORMATION

During combustion you have intermediate particles that form. Without FEROX treatment, these particles tend to stick or agglomerate to each other as well as to combustion surfaces which are more difficult to combust. What FEROX does is to modify the surface chemistry characteristics of these particles so that they do not stick to each other nor do they stick to the surfaces. When these intermediate particles impact equipment surfaces they have a certain velocity and a certain mass, and they simply erode existing deposits away with time. Because FEROX modifies the surface of particles so that they do not stick to each other nor equipment surfaces, they do not re-adhere to the surface after a particle is eroded away. That's also why when engines are taken apart after long use, any particles that are present can easily be wiped away. FEROX treated fuel prevents re-deposition, it allows particles to erode existing deposited material which end up in the particulate ash until it is all gradually removed. In normal operations, this eroding and re-depositing is continually taking place.

EFFECT ON FLAME LENGTH

The customer will see a shortening of the flame length. Experience has shown that FEROX shortens the flame, keeping it more compact, keeping the heat of the flame closer to the tip, which keeps tips cleaner. It does this because it modifies the surface of the atomized particles causing more complete combustion sooner. We are not sure exactly how much shortening of the flame you can expect. It's not going to cut it in half or anything like that, but you should get a noticeable shortening.

We did notice a change in the flame. It appeared that the flame was brighter (indicating increase in heat intensity at the nozzle). It also appeared that the flame "condensed" somewhat. Although these observations are subjective, they do indicate a shortening of the flame and could explain a decrease in the effect of the aggregate quenching.

CONCLUSIONS

1. The use of fuel treated with FEROX[™] will result in reduction in fuel consumption. The overall reduction in fuel consumption during this test was determined to be 26.38% at a production level of 38 and 18.12% for a production level of 47.
2. The use of fuel treated with FEROX[™] will result in a reduction in harmful emissions. The overall reduction in harmful emissions during this test was determined to be 24.05% for CO, 8.66% for unburned hydrocarbons, 20.42% for CO₂ at a production level of 38. Reduction of harmful emissions were determined to be 16.42% for CO, 38.82% for unburned hydrocarbons, and 14.99% for CO₂ at a production level of 47.
3. The use of fuel treated with FEROX[™] will result in a reduction in particulate formation. Examination of particulate filters shows a significant reduction in particulate formation between tests using untreated and treated fuel.
4. The use of fuel treated with FEROX[™] should allow higher production rates for a given level of harmful emissions. This would be most beneficial in areas where production is being limited due to restrictions on emissions.

RECOMMENDATIONS

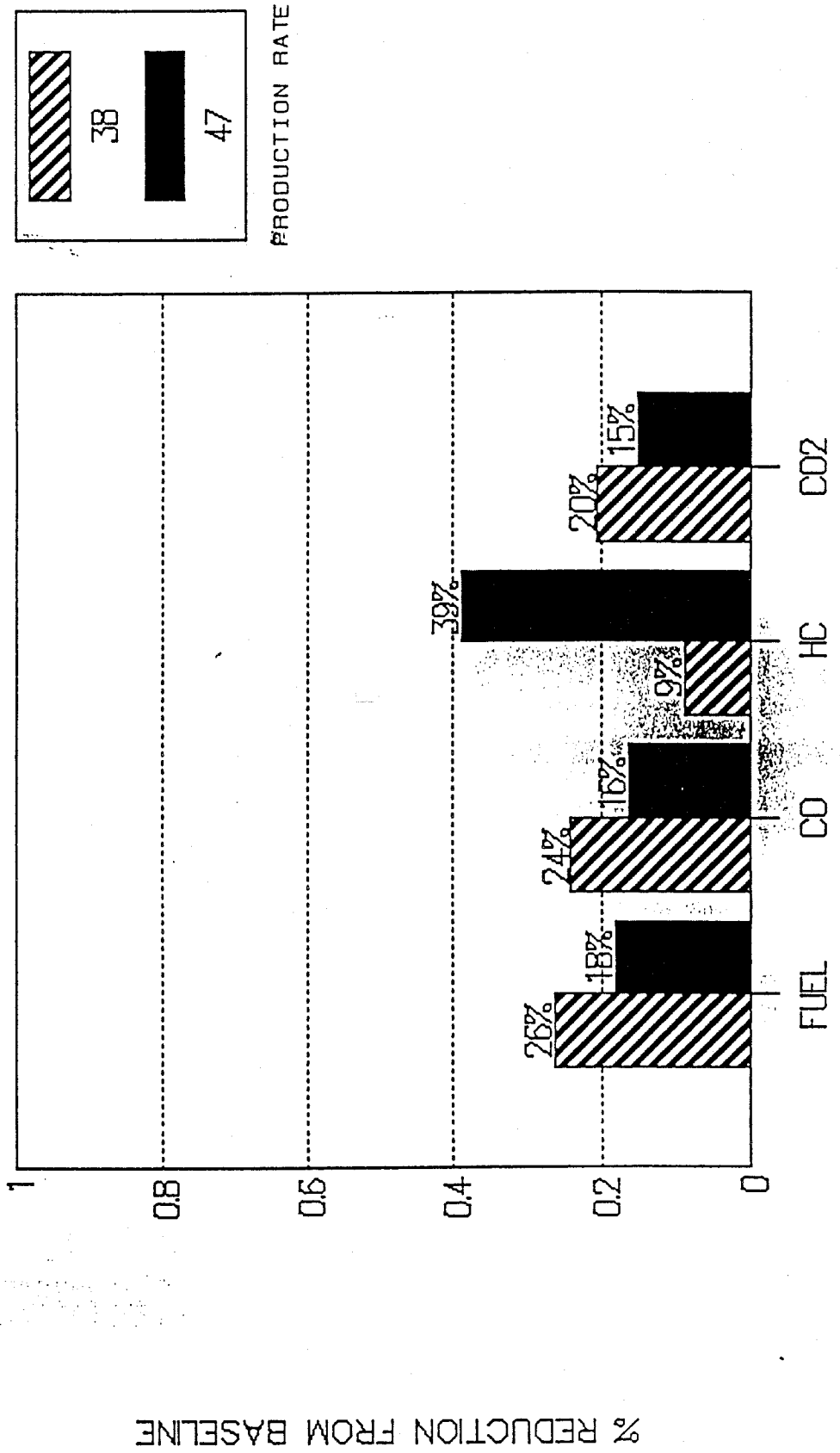
1. Continue the use of fuel treated with FEROX[™] in the double-barrel asphalt plant at McCartney Construction to take advantage of the longer term benefits derived from the use of FEROX[™] treated fuel. These benefits include but are not limited to fuel consumption per pound of mix produced; decreased maintenance costs; decreased acid corrosion; and improved burner operation.

2. Use fuel treated with FEROX[™] in all combustion equipment at McCartney Construction. This includes but not limited to: loaders, haulers, excavators, and pick-up trucks. The benefits of reduced fuel consumption, reduced harmful emissions, reduced particulate emissions, and reduced maintenance costs apply to all combustion equipment not just the asphalt plant.

3. Begin using fuel treated with FEROX[™] in all ASTEC equipment, particularly that equipment in which production is being limited due to emissions standards.

REDUCTIONS W/ FERROX TREATED FUEL FIELD TRIALS ASTEC ASPHALT PLANT

FIGURE 1



APPENDICES

CARBON MASS BALANCE FIELD DATA FORM

COMPANY: ASTEC
 BASELINE: TREATED: TEST DATE: 01/29/93
 EQUIPMENT TESTED: ASPHALT PLANT MILES: N/A
 ENGINE TYPE: COUBLE BARREL HOURS: 3 YEARS
 EXHAUST STACK DIA. (IN): 20 ID#:
 BP(Hg): 25.5 T (F): 63
 FUEL: NO. 2 DIESEL SG: .8475 T (F): 64 AFTER TEST T (F):
 AMBIENT T (F): 64 START TIME: 3:00 PM

RUN TIME	EXH. TEMP	PV	CO	HC	CO2	O2	REMARKS
1 3:10	203.40	N/A	0.92	31	3.16	15.00	PRODUCTION = 38
2 3:20	197.00		0.90	35	3.00	15.00	
3 3:30	194.70		0.88	38	3.02	14.60	CAL
4 3:40	192.20		0.85	38	3.06	15.20	
5 3:50	194.60		0.88	39	2.94	15.10	
6 4:00	190.00		0.93	43	3.09	15.00	
7							
8							
9							
10							

FINISH TIME:
 AVERAGE 195.32 0.00 0.89 37 3.04 14.98
 VFCO VPHC VFCO2 VFO2
 0.0089 3.73E-05 0.0304 0.1498

MOLECULAR WEIGHT 29.0887
 pf2 156073.3
 PF2 (ADJUSTED) ERR
 CHANGE pf = 26.381
 CHANGE PF = ERR

CO HC CO2 O2
 EMISSION REDUCTIONS 24.05% 18.66% 20.22% 0.22%
 (MEASURED AS % CHANGE IN VOL %)

COMBUSTION FUEL TECHNOLOGY
 CARBON MASS BALANCE CALCULATION PROGRAM

FILE: \QUATTRO\CBAL.WKQ
 DATE CREATED: AUGUST 12, 1992
 UPDATED WITH PF ADJUSTED: SEPTEMBER 21, 1992

CARBON MASS BALANCE FIELD DATA FORM

COMPANY: ASTEC

BASELINE: ~~XXXXXX~~ TREATED: TEST DATE: 01/29/93
 EQUIPMENT TESTED: ASPHALT PLANT MILES: N/A
 ENGINE TYPE: DOUBLE BARREL HOURS: 3 YEARS
 EXHAUST STACK DIA. (IN): 20 ID#:
 BP(Hg): 25.5 # T (F): 63
 FUEL: NO. 2 DIESEL SG: .845 # T (F): 64 AFTER TEST T (F):
 AMBIENT T (F): 64

START TIME: 12:00 NOON

RUN TIME	EXH. TEMP	PV	CO	HC	CO2	O2	REMARKS
1 12:00	199.50	N/A	1.11	37	3.95	14.70	PRODUCTION = 38.5
2 12:10	201.80		1.21	43	3.68	14.50	CAL
3 12:20	196.60		1.11	39	3.68	15.40	
4 12:30	199.00		1.13	44	3.84	15.20	CAL
5 12:40	200.40		1.20	43	3.84	15.20	
6 12:50	203.80		1.25	40	3.68	15.50	CAL
7 1:00	204.60		1.14	44	3.85	14.50	CAL
8 1:10	204.40		1.26	37	4.09	14.60	CAL
9							
10							

FINISH TIME:

AVERAGES 201.26 0.00 1.18 41 3.83 14.95
 VPCO VPEC VPCO2 VPO2
 0.0118 4.09E-05 0.0383 0.1495

MOLECULAR WEIGHT: 29.21257
 pf1: 123495
 PF1 (ADJUSTED): ERR

COMBUSTION FUEL TECHNOLOGY
 CARBON MASS BALANCE CALCULATION PROGRAM

FILE: \QUATTRO\CBAL.WKQ
 DATE CREATED: AUGUST 12, 1992
 UPDATED WITH PF ADJUSTED: SEPTEMBER 21, 1992

CARBON MASS BALANCE FIELD DATA FORM

COMPANY: ASTEC
 BASELINE: ~~XXXXXX~~ TREATED: TEST DATE: 01/29/93
 EQUIPMENT TESTED: ASPHALT PLANT MILES: N/A
 ENGINE TYPE: DOUBLE BARREL HOURS: 3 YEARS
 EXHAUST STACK DIA. (IN): 20 ID#:
 BP(Hg): 25.5 T (F): 63
 FUEL: NO. 2 DIESEL SG: .845 T (F): 64 AFTER TEST T (F):
 AMBIENT T (F): 64 START TIME: 2:20 PM

RUN TIME	EXH. TEMP	PV	CO	HC	CO2	O2	REMARKS
1 2:20 PM	216.00	N/A	1.68	39	4.12	13.90	PRODUCTION = 47.0
2 2:30	199.00		1.71	46	4.15	13.20	
3 2:40	199.00		1.71	48	4.19	13.00	CAL
4 2:45			1.41	39	3.96	14.00	
5 2:50	206.40		1.45	39	3.90	13.80	
6 3:00			1.66	44	4.10	13.20	
7							
8							
9							
10							

FINISH TIME: 3:00 PM
 AVERAGES 205.10 0.00 1.60 43 4.07 13.52
 VPCO VPHC VPCO2 VPO2
 0.0160 4.25E-05 0.0407 0.1352

MOLECULAR WEIGHT: 29.19433
 pfl: 108870.1
 PF1 (ADJUSTED): ERR

CARBON MASS BALANCE FIELD DATA FORM

COMPANY: ASTEC
 BASELINE: TREATED: ~~XXXXXX~~ X TEST DATE: 01/29/93
 EQUIPMENT TESTED: ASPHALT PLANT MILES: N/A
 ENGINE TYPE: DOUBLE BARREL HOURS: 3 YEARS
 EXHAUST STACK DIA. (IN): 20 ID#:
 BP(Hg): 25.5 @ T (F): 63
 FUEL: NO. 2 DIESEL SG: 0.8475 @ T (F): 64 AFTER TEST T (F):
 AMBIENT T (F): 64
 START TIME: 4:00 PM

RUN TIME	EXH. TEMP	PV	CO	HC	CO2	O2	REMARKS
1 4:05 PM	195.32 N/A		1.34	26	3.46	14.60	PRODUCTION = 48.7
2							
3							
4							
5							
6							
7							
8							
9							
10							

FINISH TIME:
 AVERAGE 195.32 0.00 1.34 26 3.46 14.60
 VPCO VPHC VPCO2 VPO2
 0.0134 2.60E-05 0.0346 0.1460

MOLECULAR WEIGHT 29.13911
 pf2 128599.5
 PF2 (ADJUSTED) ERR
 CHANGE pf = 18.12
 CHANGE PF = ERR

EMISSIONS REDUCTION
 CO2 138.8211
 HC 114.991
 O2 -8.011
 (MEASURED AS % CHANGE IN VOL %)

FEROX PETROCHEMICAL CORPORATION

RAW DATA

FIELD TEST ASTEC CORPORATION

01/29/93

MACHINE: ASTEC DOUBLE BARREL ASPHALT PLANT

NO. 2 DIESEL FUEL - SPECIFIC GRAVITY: 0.845

TIME	TEMP	CO	HC	CO2	O2	COMMENTS
12:00 PM	199.5	1.11	37	3.95	14.7	PRODUCTION = 38
12:10	201.8	1.21	43	3.68	14.5	CAL
12:20	196.6	1.11	39	3.68	15.4	
12:30	199	1.13	44	3.84	15.2	CAL
12:40	200.4	1.2	43	3.84	15.2	
12:50	203.8	1.25	40	3.68	15.5	CAL
1:00	204.6	1.14	44	3.85	14.5	CAL
1:10	204.4	1.26	37	4.09	14.6	CAL
AVERAGES:	201.26	1.18	40.88	3.83	14.95	
ST.DEV.:	2.70	0.06	2.80	0.14	0.39	
2:20 PM	216	1.68	39	4.12	13.9	PRODUCTION = 47
2:30	199	1.71	46	4.15	13.2	
2:40	199	1.71	48	4.19	13	CAL
2:45		1.41	39	3.96	14	
2:50	206.4	1.45	39	3.9	13.8	
3:00		1.66	44	4.1	13.2	
AVERAGES:	205.10	1.60	42.50	4.07	13.52	
ST. DEV.:	6.98	0.12	3.69	0.10	0.39	
ADDED CATALYST 3:00 PM						ELECTRONIC RECALIBRATION
3:10	203.4	0.92	31	3.16	15	PRODUCTION = 38
3:20	197	0.9	35	3	15	
3:30	194.7	0.88	38	3.02	14.6	CAL
3:40	192.2	0.85	38	3.06	15.2	
3:50	194.6	0.88	39	2.94	15.1	
4:00	190	0.93	43	3.09	15	
AVERAGES:	195.32	0.89	37.33	3.04	14.98	
ST.DEV.:	4.22	0.03	3.68	0.07	0.19	
4:05	202.8	1.34	26	3.46	14.6	PRODUCTION = 48
4:10	207.4	1.59	26	4.14	13.2	PRODUCTION = 57
4:15	209.4	1.71	31	4.7	12	CAL

4:20
4:30

220.4
220

1.48
1.38

19
17

4.52
4.58

12.9 PRODUCTION = 67
12.4 CAL