FPC-2 FUEL CATALYST TEST
FUEL EFFICIENCY & EMISSIONS REDUCTIONS BY FREIGHT CORP.
PORT AUGUSTA COAL OPERATIONS

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CONTENTS

Appendix

EXECUTIVE SUMMARY

The FPC Catalysts manufactured and marketed by Fuel Technology Pty Ltd have proven in laboratory and field testing to reduce fuel consumption in the range 3% to 8% under comparable load conditions and to also substantially reduce carbon emissions.

Following discussions with Manager Fuel Strategy, Mr Arnold Aranjo, and Manager Engineering Support Services, Mr Peter Hands, it was agreed that an FPC-2 fuel efficiency study should be conducted on a consist of three Freight Corp Class 82 locomotives which operate between Leigh Creek coal mine and the power station at Port Augusta.

Two locomotives were to be treated at each refuelling with the catalyst whilst the third locomotive would remain untreated as a control.

The two FPC-2 treated locomotives showed an average **4.7%** improved fuel efficiency whilst the control locomotive showed an average 0.6% reduction of fuel efficiency.

The treated locomotive also demonstrated a large percentage reduction in smoke in the range **38% to 47%**. Whilst the control locomotive showed a substantial increase in smoke over the same period.

INTRODUCTION

Baseline (untreated) fuel efficiency tests were conducted on three Clyde EMD Class 82 locomotives on 25th May 2000, employing the carbon mass balance (CMB) test procedure.

Fuel Technology Pty Ltd prepared one litre bottles of FPC-2 in order to simplify manual addition of the catalyst at each refuelling. Locomotives 8201 and 8204 were so treated over the period of the trial and locomotive 8202 remained untreated as a control comparison.

Treated tests were conducted on locomotives 8201 and 8204 and untreated test on 8202 on 19th July 2000. The results of this study are documented in this report.

TEST METHOD

Carbon Mass Balance (CMB) is a procedure whereby the mass of carbon in the exhaust is calculated as a measure of the fuel being burned. The elements measured in this test include the exhaust gas composition, its temperature and the gas flow rate calculated from the differential pressure and exhaust stack cross sectional area. Whilst this is an engineering standard test (AS2077-1982) in field testing we are unable to comply with the procedure in relation to employing a chassis dynamometer. However, in the case of power generation the alternator/generator substitutes as a mechanism to apply and measure load.

The carbon balance formulae and equations employed in calculating the carbon flow are contained in the *Appendix*. Measurements using Carbon Balance Techniques.

INSTRUMENTATION

Precision state of the art instrumentation is used to measure the concentrations of carbon containing gases in the exhaust stream and other factors related to fuel consumption and engine performance. The instruments and their purpose are listed below:-

Measurement of exhaust gas constituents HC, CO, CO_2 and O_2 by Horiba-Mexa 4 gas infra red gas analyser.

Temperature measurement by Fluke Model 52K/J digital thermometer.

Exhaust differential pressure by Air Instruments Model MP Precision Micromanometer.

Ambient pressure determination by use of Thommen 2000 TX altimeter/barometer.

The exhaust smoke particulates are also measured during this test program.

Exhaust gas extraction and filtration by means of a Bosch ETD 020.00 sampling pump.

Exhaust gas sample evaluation by use of Bosch ETD 020.50 diesel smoke evaluator.

The Horiba infra red gas analyser was serviced and calibrated prior to each series of engine efficiency tests.

TEST RESULTS

1. Fuel Efficiency

A summary of the CMB fuel efficiency results achieved in this test program are provided in the following Tables 1, 2 and 3 also graphically in Graphs 1, 2 and 3.

TABLE 1

LOCOMOTIVE 8201

Notch	Carbon Flow grms/sec	Carbon Flow kg/hr	Measured Hp	kg/Hp	% Change
2 untreated	21.734	78.2424	392	0.19960	
2 FPC treated	17.842	64.2312	348	0.18457	-7.5
4 untreated	52.532	189.1152	993	0.19045	
4 FPC treated	49.149	176.9364	997	0.17747	-6.8
6 untreated	88.64	319.1040	1597	0.19981	
6 FPC treated	85.382	307.3752	1599	0.19223	-3.8
8 untreated	153.382	552.1752	3021	0.18278	
8 FPC treated	148.347	534.0492	3021	0.17678	-3.3
Average untreated				0.19315997	
Average FPC treated				0.18276	**-5.4**

TABLE 2

LOCOMOTIVE 8202

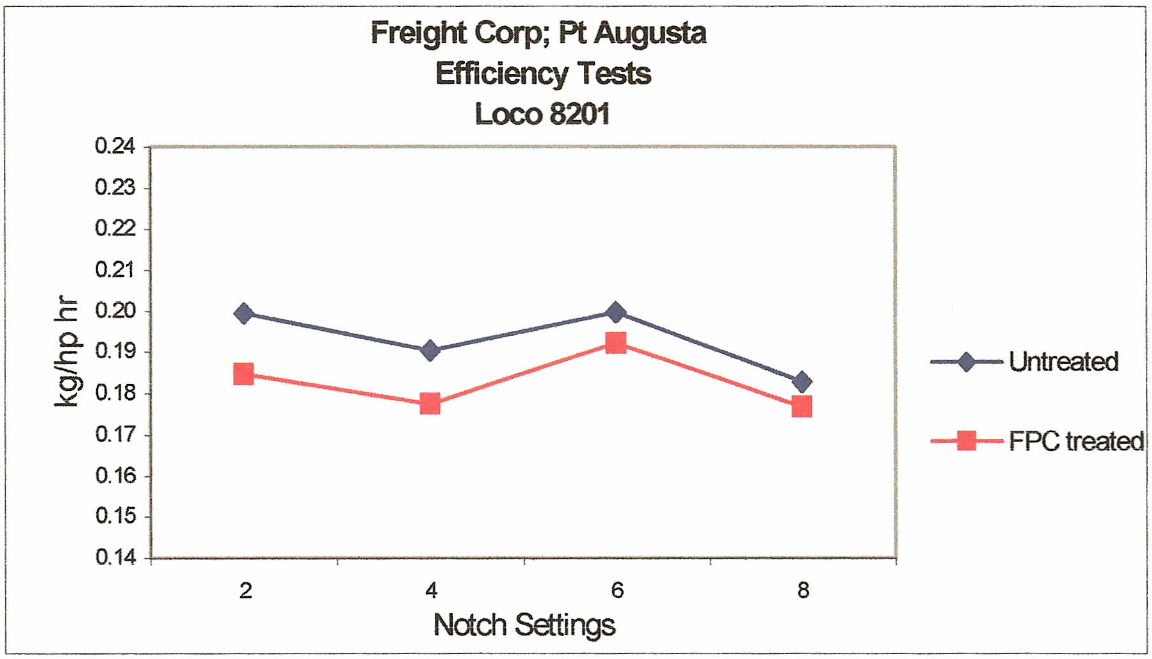
Notch	Carbon Flow grms/sec	Carbon Flow kg/hr	Measured Hp	kg/Hp	% Change
2 untreated	19.681	70.8516	350	0.20243	
2 untreated	19.355	69.6780	350	0.19908	-1.7
4 untreated	59.533	214.3188	997	0.21496	
4 untreated	59.058	212.6088	995	0.21368	-0.6
6 untreated	84.949	305.8164	1598	0.19137	
6 untreated	86.977	313.1172	1591	0.19681	2.8
8 untreated	159.541	574.3476	3026	0.18980	
8 untreated	163.056	587.0016	3024	0.19411	2.3
Average untreated				0.19964	
Average untreated				0.20092	**0.6**

TABLE 3

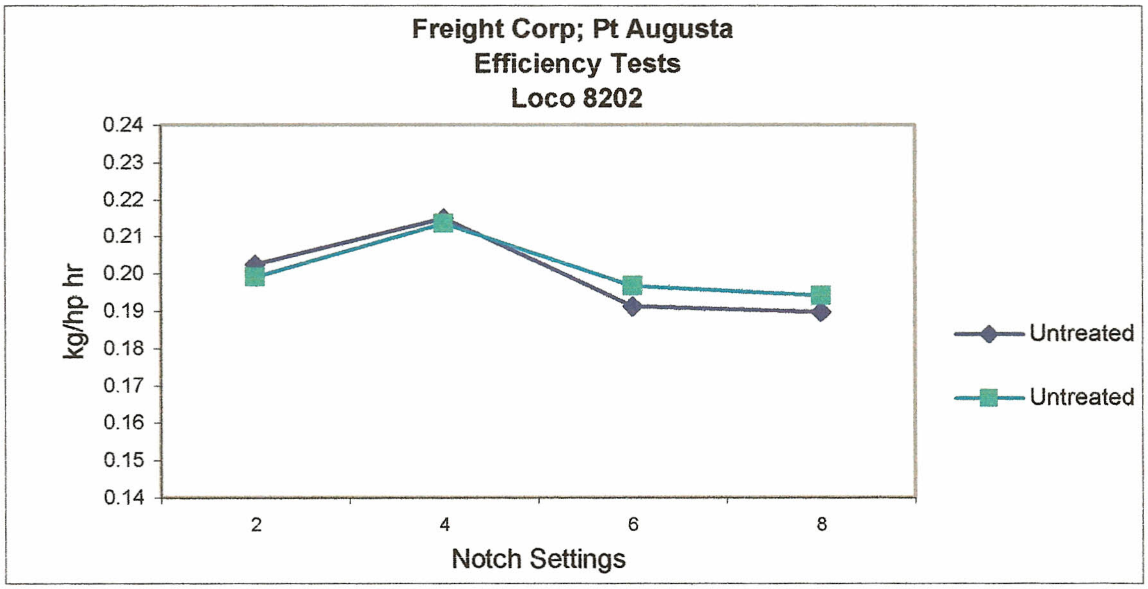
LOCOMOTIVE 8204

Notch	Carbon Flow grms/sec	Carbon Flow kg/hr	Measured Hp	kg/Hp	% Change
2 untreated	19.733	71.0388	339	0.20955	
2 FPC treated	18.353	66.0708	336	0.19664	-6.2
4 untreated	53.658	193.1688	1000	0.19317	
4 FPC treated	51.583	185.6988	999	0.18588	-3.8
6 untreated	84.214	303.1704	1600	0.18948	
6 FPC treated	81.365	292.9140	1599	0.18319	-3.3
8 untreated	156.674	564.0264	3007	0.18757	
8 FPC treated	151.737	546.2532	2991	0.18263	-2.6
Average untreated				0.19494	
Average FPC treated				0.18709	**-4.0**

GRAPH 1



GRAPH 2



GRAPH 3

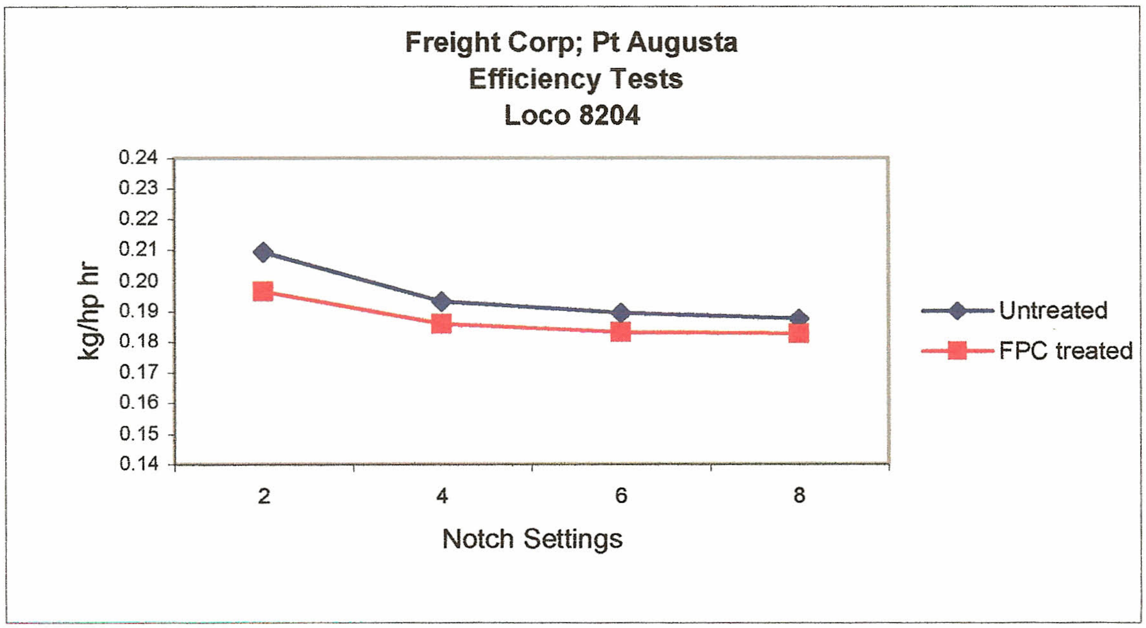


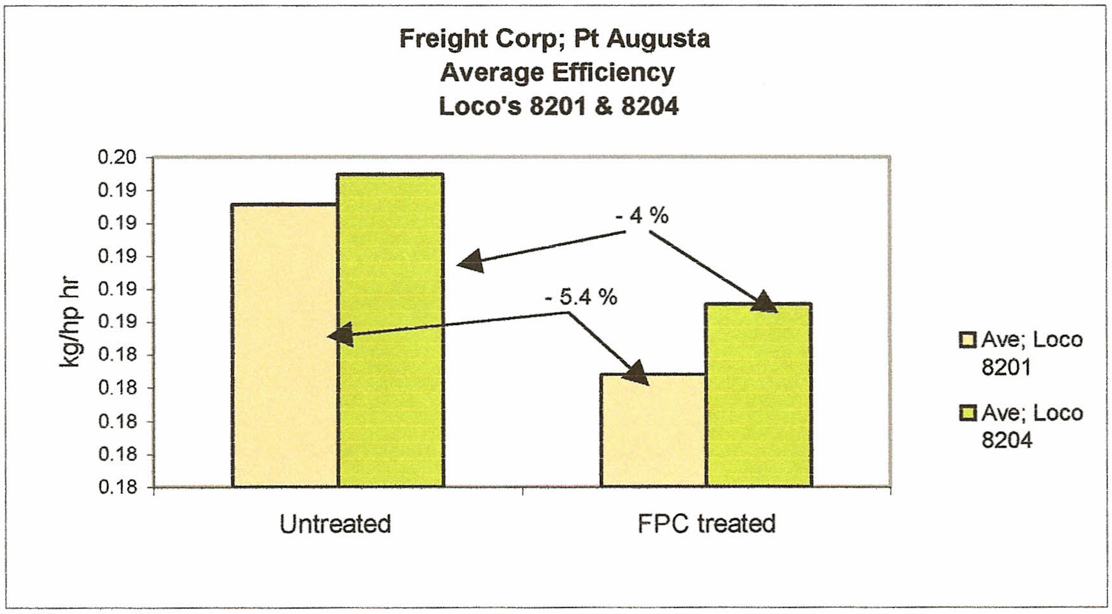
Table 4 provides the average test results of the two test locomotives 8201 and 8204. Graphs 4 and 5 express the change graphically.

TABLE 4

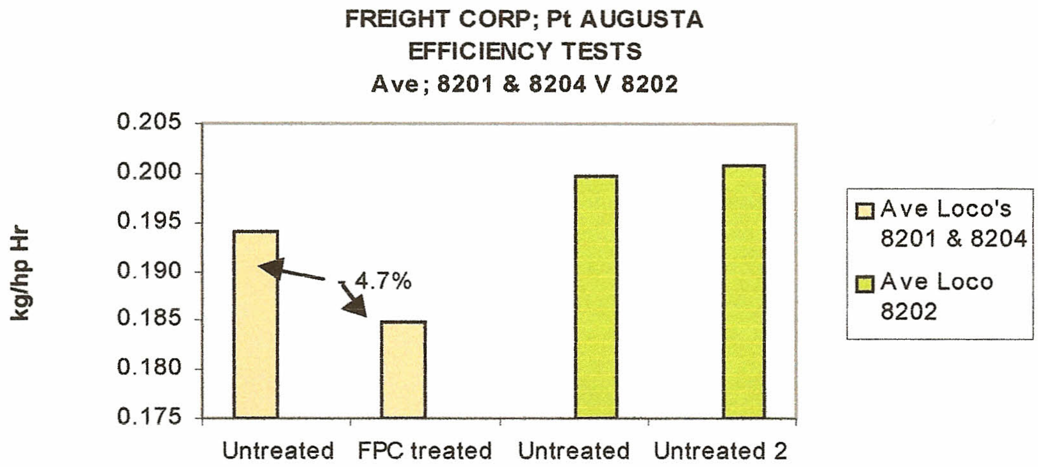
LOCOMOTIVE'S 8201 & 8204

	kg/Hp
Average untreated	0.19405
Average FPC treated	0.18492
% Change	**-4.7**

GRAPH 4



GRAPH 5



The computer printouts of the calculated CMB test results together with raw data sheets are contained in the *Appendix*.

The engine performance data logged during each test sequence is summarised in Tables 5, 6 and 7. The raw data sheets are contained in the *Appendix*.

It will be noted in Table 6 covering the control locomotive 8202 that amperage data is incomplete and thus the engine horsepower has not been calculated. We have in our BSFC calculations assumed no change from the baseline horsepower.

Treated engine horsepower results correlate well with the baseline in that the variation is less than 1% with the exception of locomotive 8201 where at Notch 2 a substantial 11.1% reduction in power is recorded. The large reduction in carbon flow rate corresponds with this power reduction.

TABLE 5

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TABLE 6

Baseline Test Date: 25/05/00
Untreated Test Date: (Control Test Loco)

Unit No. 8202	Engine EMD 710G3A	Notch	EMD Rack (inches)	Lube Oil Pressure	Water Temp; °C	RPM	Main Gen Volts	Total Amps	Gen. Output Watts (Volts x Amps)	Engine HP (Watts/700)	HP % Change
(baseline) (untreated)		2	1.50 1.49	45 56	74 68	343 340	370 393	662	244,940 0	350 0	-100.0%
(baseline) (untreated)		4	1.34 1.32	68 80	84 75	570 570	632 635	1104 1097	697,728 696,595	997 995	-0.2%
(baseline) (untreated)		6	1.21 1.20	75 82	90 81	731 735	807 809	1386 1377	1,118,502 1,113,993	1,598 1,591	-0.4%
(baseline) (untreated)		8	0.85 0.84	80 84	91 86	906 904	1129 1135	1876 1865	2,118,004 2,116,775	3,026 3,024	-0.1%

TABLE 7

Baseline Test Date: 25/05/00
Treated Test Date:

Unit No. 8204	Engine EMD 710G3A	Notch	EMD Rack (inches)	Lube Oil Pressure	Water Temp; °C	RPM	Main Gen Volts	Total Amps	Gen. Output Watts (Volts x Amps)	Engine HP (Watts/700)	HP % Change
(baseline) (treated)		2	1.46 1.46	40 47	75 63	331 331	364 361	652 652	237,328 235,372	339 336	-0.8%
(baseline) (treated)		4	1.32 1.30	58 72	87 73	574 576	633 632	1106 1107	700,098 699,624	1,000 999	-0.1%
(baseline) (treated)		6	1.18 1.16	69 76	88 80	735 735	808 807	1386 1387	1,119,888 1,119,309	1,600 1,599	-0.1%
(baseline) (treated)		8	0.78 0.78	80 82	92 85	907 908	1127 1122	1868 1866	2,105,236 2,093,652	3,007 2,991	-0.6%

2. Bosch Smoke Tests

Concurrent with CMB data extraction, Bosch smoke measurements were conducted on each locomotive at the four test throttle Notch settings. The results of these tests are summarised in Table Nos. 8, 9 and 10 and graphically in Graph No. 6.

TABLE 8

Locomotive 8201

Notch	Untreated	Treated	% Change
2	0.3	0.1	-66.7
4	0.4	0.2	-50.0
6	0.5	0.3	-40.0
8	0.5	0.3	-40.0
Average	0.43	0.23	**-47.1**

TABLE 9

Locomotive 8202

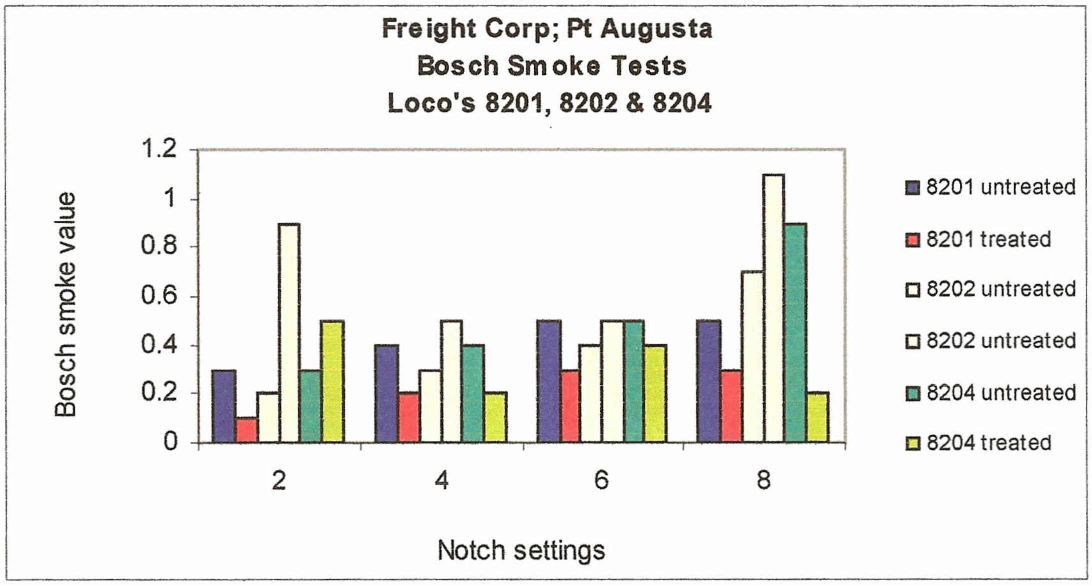
Notch	Untreated	Untreated	% Change
2 *	0.2	0.9	350.0
4	0.3	0.5	66.7
6	0.4	0.5	25.0
8	0.7	1.1	57.1
Average	0.40	0.75	**87.5**

TABLE 10

Locomotive 8204

Notch	Untreated	Treated	% Change
2*	0.3	0.5	66.7
4	0.4	0.2	-50.0
6	0.5	0.4	-20.0
8	0.9	0.2	-77.8
Average	0.53	0.33	**-38.1**

GRAPH 6



Smoke measurements taken at throttle Notch setting 2 for both locomotives No 8202 and 8204 appear to be outliers and vary substantially from the results obtained at the other three Notch settings.

It is interesting to note that the Bosch smoke readings for test locomotives 8201 and less smoke particulates, whilst the control locomotive 8202 shows an 87.5% increase in smoke particulates.

The Bosch smoke filters are contained in the *Appendix.*

3. Greenhouse Gas Reduction

Assuming that the average **4.7%** measured improved fuel efficiency was applied to the total Freight Corp diesel consumption of 120 ML per annum, this would translate to a **16,306 tonnes per annum reduction in CO_2 emissions** based on the formula outlined in Worksheet 1 of the *"Electricity Supply Business Greenhouse Change Workbook"*, our estimate is based on the following calculations:-

	(120,000 KL x 38.6 x 74.9)	÷	1000	=	346,937 tonnes
- 4.7%	(114,360 KL x 38.6 x 74.9)	÷	1000	=	330,631 tonnes

CO_2 reduction by application FPC-2

346,937 - 330,631 = 16,306 tonnes

CONCLUSION

These carefully controlled engineering standard test procedures conducted on three Freight Corp Class 82 locomotives at Port Augusta provide clear evidence of reduced fuel consumption in the range 2.6% to 7.5%, **averaging 4.7%,** for the two test locomotives 8201 and 8204 (based on averaging BSFC at each of four test throttle Notch settings).

The catalyst's effect on improved combustion is also evidenced by the substantial reduction in soot particulates (smoke) for the two test locomotives ranging from **38%** to **47%** whilst the control locomotive 8202 showed an increased 87.5% smoke over the same test period.

A fuel efficiency gain of **4.7%** over the entire Freight Corp fleet would reduce CO_2 emissions by **16,306 tonnes per annum**. This could equate to an economic benefit if and when a mechanism for emissions trading is established in Australia under the Kyoto greenhouse gas protocol.

Additional to the fuel economy benefits measured and a reduction in smoke and greenhouse gas emissions, a significant reduction over time in engine maintenance costs will be realised following introduction of FPC-2. These savings are achieved by lower soot levels in lubricating oil produced by more complete combustion of the fuel thereby reducing wear rates and resulting in less carbon build-up in combustion areas. FPC also acts as an effective biocide. Experience in North America has also demonstrated a substantial reduction in track wayside fires following introduction of the catalyst to the fuel supply.

Appendix "D"

Fuel Technology Pty Ltd
Measurements using Carbon Balance Techniques