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Fuel Technology

FPC-2 FUEL CATALYST TEST
FUEL EFFICIENCY & EMISSIONS REDUCTIONS BY
FREIGHT AUSTRALIA
SOUTH DYNON

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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 Rollingstock Division Locomotive Maintenance Centre, Mr Ray Kimpton, it was agreed that an FPC-2 fuel efficiency study should be conducted on two Freight Australia X Class locomotives which operate general freight services in Victoria.

Two locomotives were to be treated at each refuelling with the catalyst under controlled operations out of Geelong.

The two FPC-2 treated locomotives showed an average **7.9%** improved fuel efficiency.

The two treated locomotive also demonstrated a large average percentage reduction in smoke in the range **24% to 45%**.

INTRODUCTION

Baseline (untreated) fuel efficiency tests were conducted on two Clyde X Class locomotives on 23rd July 2000, employing the carbon mass balance (CMB) test procedure.

Fuel Technology Pty Ltd prepared 250ml bottles of FPC-2 in order to simplify manual addition of the catalyst at each refuelling. Locomotives X36 and X41 were so treated over the period of the trial.

Treated tests were conducted on locomotives X36 and X41 on 17th September 2000. The results of this study are documented in this report.

TEST METHOD

Carbon Mass Balance

This method is derived from the Australian Standards test procedure AS2077-1982 Carbon Mass Balance. The method is based on the principal that carbon entering the engine as a component of fuel must be exhausted from the engine as components of the exhaust gas, namely carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbon (HC). Using a Horiba infra-red exhaust gas analyser a probe is inserted into the exhaust stack. Measurements of stack diameter, exhaust gas components, temperature and pressure are recorded. Raw data is entered into a computer model and the mass per unit volume of components containing carbon CO, CO_2 and HC are analysed and used to calculate total carbon flow in grams/second.

In back to back, *untreated and treated* tests, the objective is to measure any change in carbon flow under as close to identical conditions as possible. As the X Class locomotive has two exhaust outlets the carbon flow measurements taken have been multiplied by a factor of two.

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

Bosch smoke tests were also conducted to analyse soot particulates in exhaust emissions. A Bosch sampling pump was used to take a defined quantity of exhaust smoke and pass it through a filter disc. The resultant filter disc is photoelectronically evaluated with a Bosch smoke meter evaluation unit. The result is expressed as a value between 0.0 (clean) and 9.9 (dirty).

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 and 2 also graphically in Graphs 1 and 2.

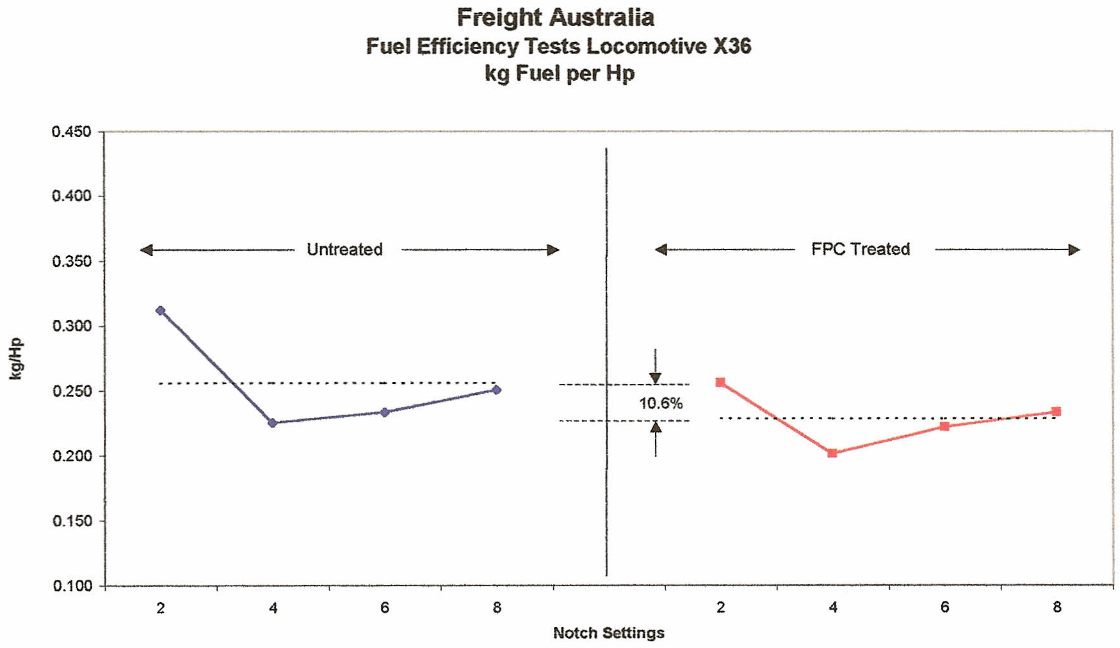
TABLE 1
LOCOMOTIVE X36

Notch	**Carbon Flow grams/sec**	**Carbon Flow kg/h**	**Measured Hp**	**kg/Hp**	**% Change**
2 untreated	6.461	46.5192	149	0.3122	
2 FPC treated	5.302	38.1744	149	0.2562	- 17.9
4 untreated	20.713	149.1336	660	0.2260	
4 FPC treated	18.630	134.1360	664	0.2020	-10.6
6 untreated	41.657	299.9304	1281	0.2227	
6 FPC treated	39.624	285.2928	1281	0.2507	- 4.9
8 untreated	63.837	459.6264	1833	0.2507	
8 FPC treated	59.555	428.7816	1833	0.2339	- 6.7
Average untreated				**0.2557**	
Average FPC treated				**0.2287**	**- 10.6**

TABLE 2
LOCOMOTIVE X41

Notch	Carbon Flow grams/sec	Carbon Flow kg/h	Measured Hp	kg/Hp	% Change
2 untreated	4.659	33.5448	153	0.2192	
2 FPC treated	4.444	31.9968	153	0.2091	- 4.6
4 untreated	21.075	151.7400	998	0.1520	
4 FPC treated	19.852	142.9344	998	0.1432	-5.8
6 untreated	43.396	312.4512	1736	0.1800	
6 FPC treated	41.633	299.7576	1717	0.1746	- 3.0
8 untreated	75.213	541.5336	2312	0.2342	
8 FPC treated	71.823	517.1256	2308	0.2241	- 4.3
Average untreated				**0.1963**	
Average FPC treated				**0.1877**	**- 4.4**

GRAPH 1



GRAPH 2

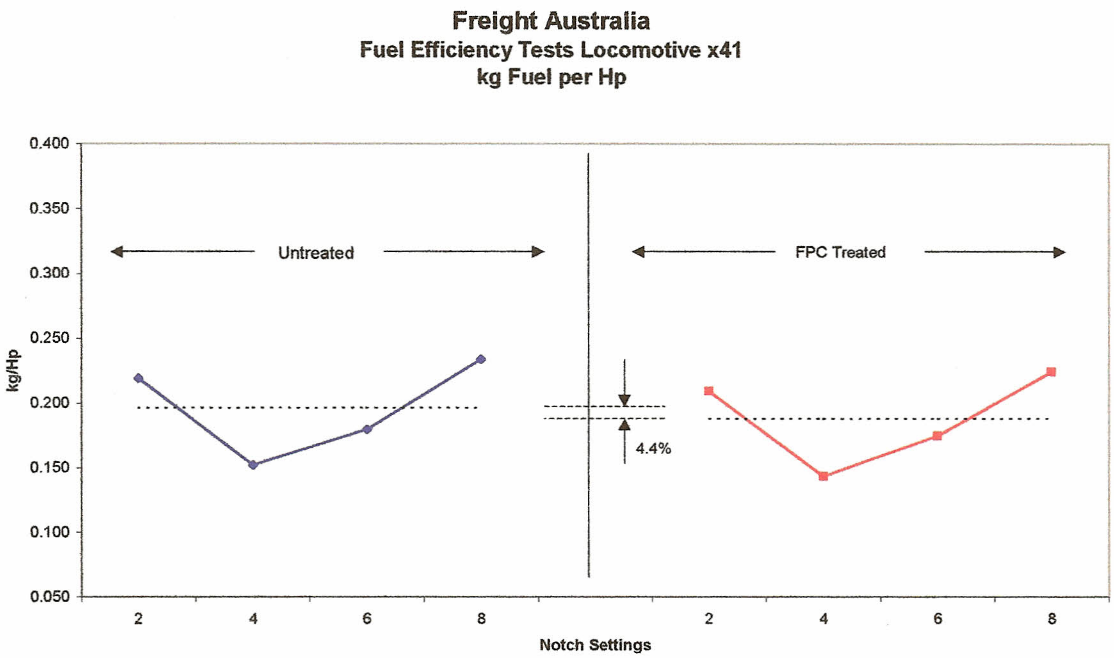
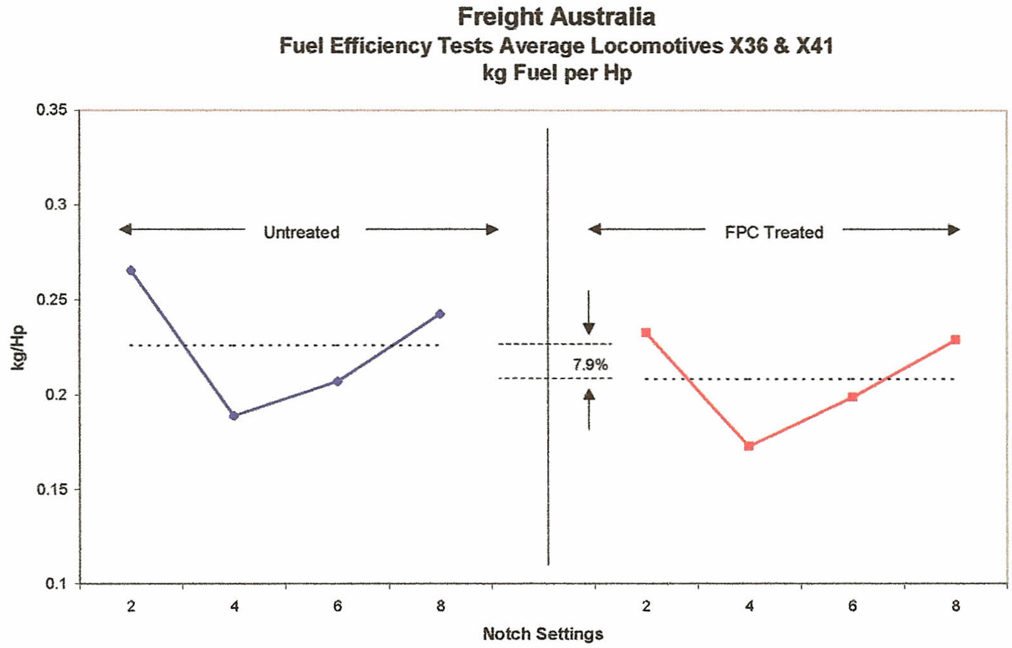


Table 3 provides the average test results of the two test locomotives X36 and X41. Graph 3 expresses the change graphically.

TABLE 3
LOCOMOTIVES X36 and X41

	kg/Hp
Average untreated	0.2260
Average FPC treated	0.2082
% CHANGE	**- 7.9**

GRAPH 3



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 4 and 5. The raw data sheets are contained in the *Appendix*.

Treated engine horsepower results correlate well with the baseline in that the variation is less than 1.1%.

TABLE 4

Baseline Test Date: 23/07/00
Treated Test Date:

Unit No. X36	Engine EMD 567 E	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)		2	1.50	49	53		260	400	104,000	149	
(treated)			1.50	46	61		260	400	104,000	149	0.0%
(baseline)		4	1.32	53	60		550	840	462,000	660	
(treated)			1.32	56	70		550	845	464,750	664	0.6%
(baseline)		6	1.08	52	76		780	1150	897,000	1,281	
(treated)			1.08	56	69		780	1150	897,000	1,281	0.0%
(baseline)		8	0.87-0.92	55	83		930	1380	1,283,400	1,833	
(treated)			0.92	56	73		930	1380	1,283,400	1,833	0.0%

TABLE 5

Baseline Test Date: 23/07/00
Treated Test Date:

Unit No. X41	Engine EMD 645E	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)		2	1.64	59	55		155	250	107,260	153	
(untreated)			1.64	38	64		155	250	107,260	153	0.0%
(baseline)		4	1.24	56	61		420	645	698,880	998	
(untreated)			1.24	50	61		420	645	698,880	998	0.0%
(baseline)		6	1.00	56	63		555	850	1,215,450	1,736	
(untreated)			1.00	52	66		550	845	1,201,750	1,717	-1.1%
(baseline)		8	0.75-0.79	52	68		640	975	1,618,560	2,312	
(untreated)			0.75	50	75		640	970	1,615,360	2,308	-0.2%

2. <u>Bosch Smoke Tests</u>

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. 6 and 7 and graphically in Graph No. 4.

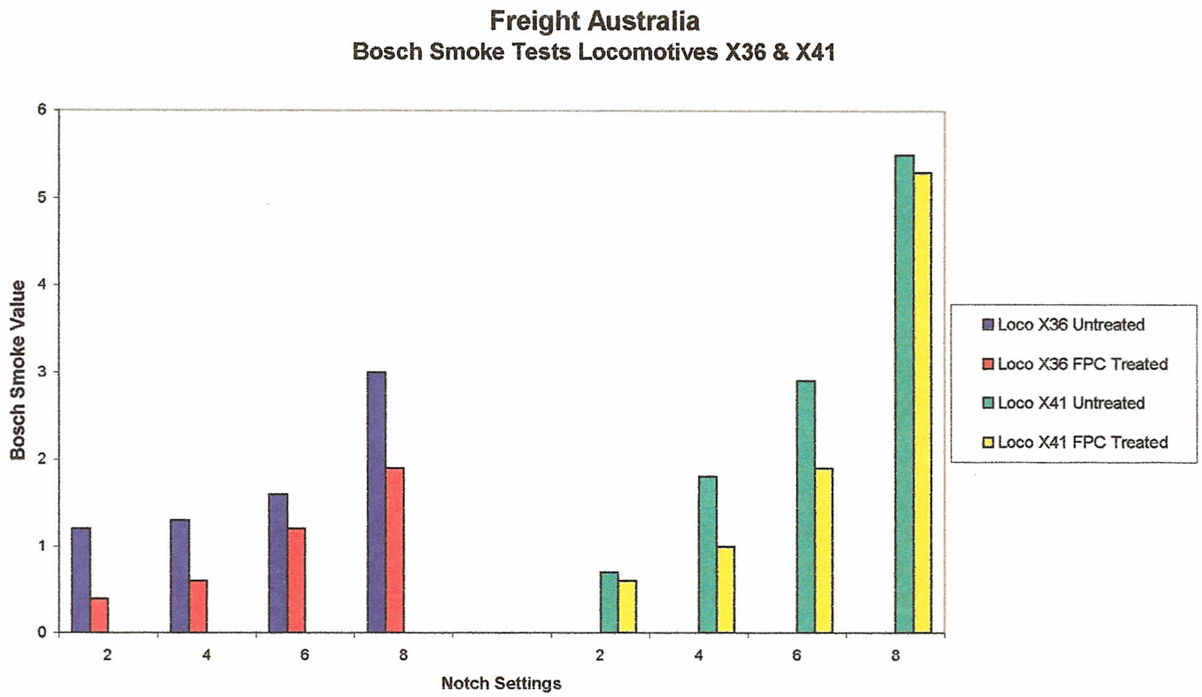
TABLE 6
LOCOMOTIVE X36

Notch	Untreated	Treated	% Change
2	1.2	0.4	- 66.7
4	1.3	0.6	- 53.8
6	1.6	1.2	- 25.0
8	3.0	1.9	- 36.7
AVERAGE	**1.8**	**1.0**	**- 45.5**

TABLE 7
LOCOMOTIVE X41

Notch	Untreated	Treated	% Change
2	0.7	0.6	- 14.3
4	1.8	1.0	- 44.4
6	2.9	1.9	- 34.5
8	5.5	5.3	- 3.6
AVERAGE	**2.7**	**2.2**	**- 24.2**

GRAPH 4



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

3. Greenhouse Gas Reduction

Assuming that the average **7.9%** measured improved fuel efficiency was applied to the total Freight Australia diesel consumption of 26 ML per annum, this would translate to a **5939 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:-

	(26,000 KL x 38.6 x 74.9)	÷	1000	=	75,170 tonnes
- 7.9%	(23,946 KL x 38.6 x 74.9)	÷	1000	=	69,231 tonnes

CO_2 reduction by application FPC-2

75,170 - 69,231 = 5,939 tonnes

CONCLUSION

These carefully controlled engineering standard test procedures conducted on two Freight Australia X Class locomotives at South Dynon provide clear evidence of reduced fuel consumption in the range 4.4% to 10.6%, **averaging 7.9%,** for the two test locomotives X36 and X41 (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 **24%** to **45%**.

A fuel efficiency gain of **7.9%** over the entire Freight Australia fleet would reduce CO_2 emissions by **5,939 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.

CONTENTS

Appendix

Appendix"C"

Bosch Smoke Results