ANALYSIS OF LOCOMOTIVE FUEL CONSUMPTION

April 1991-May 1992 (Inclusive)

BHP IRON ORE (GOLDSWORTHY) LTD OPERATIONS

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Executive Summary

During 1982/1984 an extensive fuel efficiency study was conducted by Fuel Technology Pty Ltd at the Goldsworthy Power Generation Plant, under the supervision of Goldsworthy Mining Limited, Engineering Management.

This study, covered in detail in a report dated March 1982, discussed three methods of controlled analysis, namely:

- *Specific Fuel Consumption tests at controlled loads*
- *Carbon Balance tests at controlled loads*
- *Statistical Analysis of Power Station daily out turn data by T.C. Brown, PhD (Cantab) BSc Hons (Monash)*

The results of the various studies were confirmed by Goldsworthy Mining Limited, Engineering Manager, Mr K.H. Dolman, as being in the range 2.4% to 4.0%, with 3.0% being a conservative average.

A decision was taken by Goldsworthy Mining Limited management to use the ferrous picrate catalyst (then known as CV100) in railway and mobile equipment fuel, in addition to its use in the power generation plant.

Treatment of fuel with the ferrous picrate catalyst (now known as FTC-1) continued until late September 1991. As the power generation plant is no longer in operation, the next area of more controlled operation, in terms of variables, is the railway and the purpose of this study is an attempt to determine any measurable deterioration in fuel efficiency following cessation of FTC fuel treatment. The study is based on locomotive operating data supplied by M.G. Howe, Railway Manager.

It is an accepted fact that operating data of the nature used in this analysis is subject to a number of variables affecting consumption other than the changes in fuel combustion efficiency. Nevertheless the study reported in the pages that follow indicate a measurable 4-6% increase in fuel consumption in the period immediately following the cessation of FTC fuel treatment. This has lead to our recommendation to re evaluate the benefits of fuel treatment under controlled conditions.

Locomotive Fleet Analysed

The BHP Iron Ore (Goldsworthy) Ltd locomotive fleet comprises mainly English-Electric units with one Clyde-GM locomotive. Brief details of locomotive makes, models and horse power are:

Locos 1 & 2	English-Electric	Model 6CSRKT - 950 HP
Locos 3 to 9	English-Electric	Model 12CSVT - 1950 HP
Loco 10	Clyde GM	Model JT42C - 3000 HP

Data Analysis & Methods Applied

Data provided by Railway Manager, Mr M.G. Howe, for this study comprises the following:

* *Individual locomotive fuel consumption in L/km averaged monthly*
* *Tonnage railway hauled each month*
* *Distance in kilometres fleet travelled each month*
* *Total fuel issued per month*
* *Individual fuel issued to locomotives per month*
* *Number of trains used per month*

Our study involves assessing performance of the locomotive fleet on a litres/kilometre basis.

A study has also been made of the tonnes of ore the railway has moved per litre of fuel, together with the analysis of the litres of fuel required to transport a tonne of ore.

A development of this study is to analyse:

The *work* accomplished - being the tonnes of iron ore carried over a stated distance in kilometres - and

The *energy* required to do this work - being the fuel consumed in litres.

From this input we can calculate the work accomplished per unit of energy input expressed as the operating efficiency in Tonne Kilometres/Litre (TKPL) by employing the formula.

$$\text{Tonne Kilometres/Litre} = \frac{\text{tonnes} \times \text{kilometres}}{\text{litres}}$$

Variation Fuel Efficiency with and without FTC Treatment

The main thrust of this analysis is to review the performance of the railway operation on a fleet basis. In our experience this approach tends to even out some of the operating variables.

The basic data for this study is shown in Schedule 1.

GOLDSWORTHY LOCOMOTIVE FLEET							Schedule 1
Month	Tonnes	Distance km	Ltrs Fuel	Ltrs/km	Trains	TKPL	TKPL/Train
Apr-91	713742	87534	439756	5.02	124	142,071.27	1,145.74
May-91	658333	71231	388137	5.45	101	120,817.44	1,196.21
Jun-91	647579	65220	346950	5.32	121	121,732.53	1,006.05
Jul-91	662059	76617	418541	5.46	115	121,194.76	1,053.87
Aug-91	666707	68425	393065	5.74	117	116,060.77	991.97
Sep-91	582679	56766	313724	5.53	97	105,431.39	1,086.92
Oct-91	614888	72626	401953	5.53	110	111,099.70	1,010.00
Nov-91	527718	58020	328194	5.66	95	93,292.99	982.03
Dec-91	641066	70554	402743	5.71	114	112,304.30	985.13
Jan-92	661359	71512	408087	5.71	117	115,894.66	990.55
Feb-92	678925	66967	363284	5.42	114	125,151.59	1,097.82
Mar-92	588535	70018	405094	5.79	105	101,724.65	968.81
Apr-92	560592	48575	290678	5.98	93	93,680.14	1,007.31
May-92	558741	63252	363269	5.74	93	97,287.37	1,046.10
Note: FTC Fuel Treatment was stopped in late September 1991.							
This analysis looks at two periods; Apr 91-end Sep 91 & Oct 91 - May 92.							
Totals:							
Apr-Sep	#####	425,793	#######	32.53	675	727,308.15	6,480.76
Oct-May	#####	521,524	#######	45.54	841	850,435.39	8,087.75
Monthly Aves:							
Apr-Sep	655,183	70,966	383,362	5.42	113	121,218.03	1,080.13
Oct-May	603,978	65,191	370,413	5.69	105	106,304.42	1,010.97
Average % Change per month Apr-Sep 91 & Oct91-May92							
	Tonnes	Distance km	Ltrs Fuel	Ltrs/km	Trains	TKPL	TKPL/Train
	-8.48%	-8.86%	-3.50%	4.78%	-7%	-14.03%	-6.84%
Tonnes hauled per train decreased 1.4% from 5824 to 5745							
This data analysis indicates that fuel consumption in lts/km has increased 4.8% since the cessation of fuel treatment while the tonnage hauled in that period decreased by 8.5%. The net effect is that the tonne-kilometers per litre of fuel, which is a better indicator of work efficiency, has declined significantly since fuel treatment was stopped. That decline is also seen in the reduction in fuel efficiency per train unit: TKPL/Train.							

A graphical representation of data tabulated in Schedule 1 is shown on Figure 1 below.

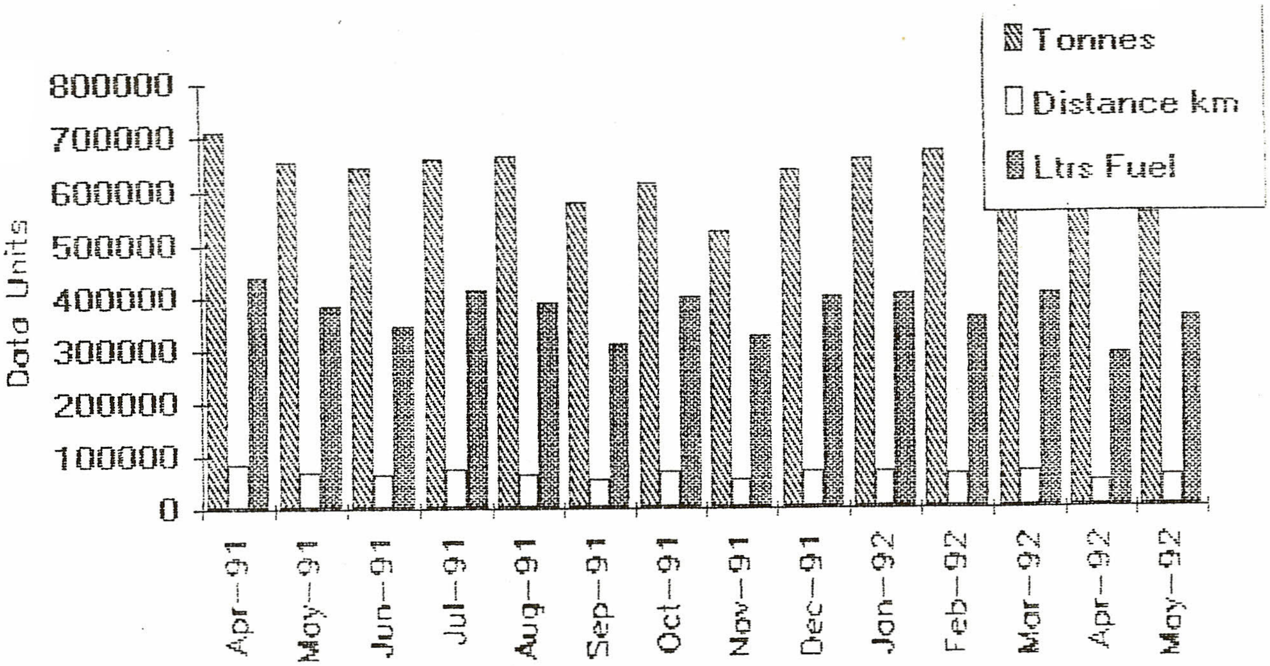

Fig. 1 Representation of Operating Data

The fleet fuel consumption in L/km is shown in Figure 2. Analysis of data indicates that consumption has increased 4.78% since cessation of fuel treatment.

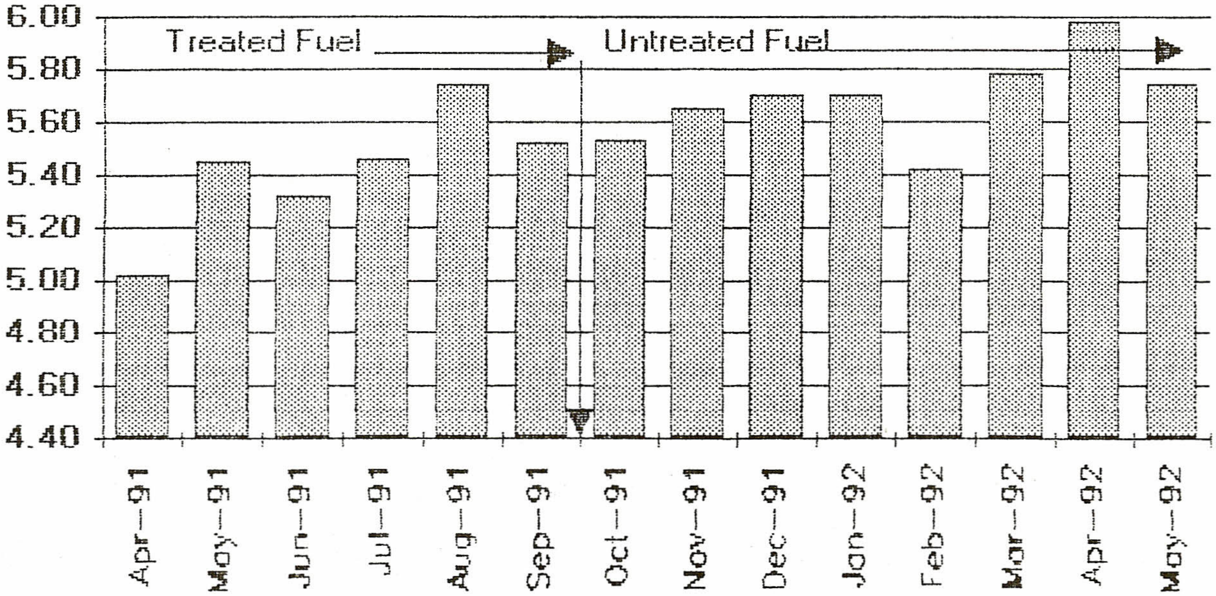

Fig. 2 Fleet Fuel Consumption

The fleet operating efficiency expressed as Tonne Kilometres/Litre of fuel (TKPL) is shown in Figure 3. The fleet efficiency has declined 14.03% since cessation of fuel treatment.

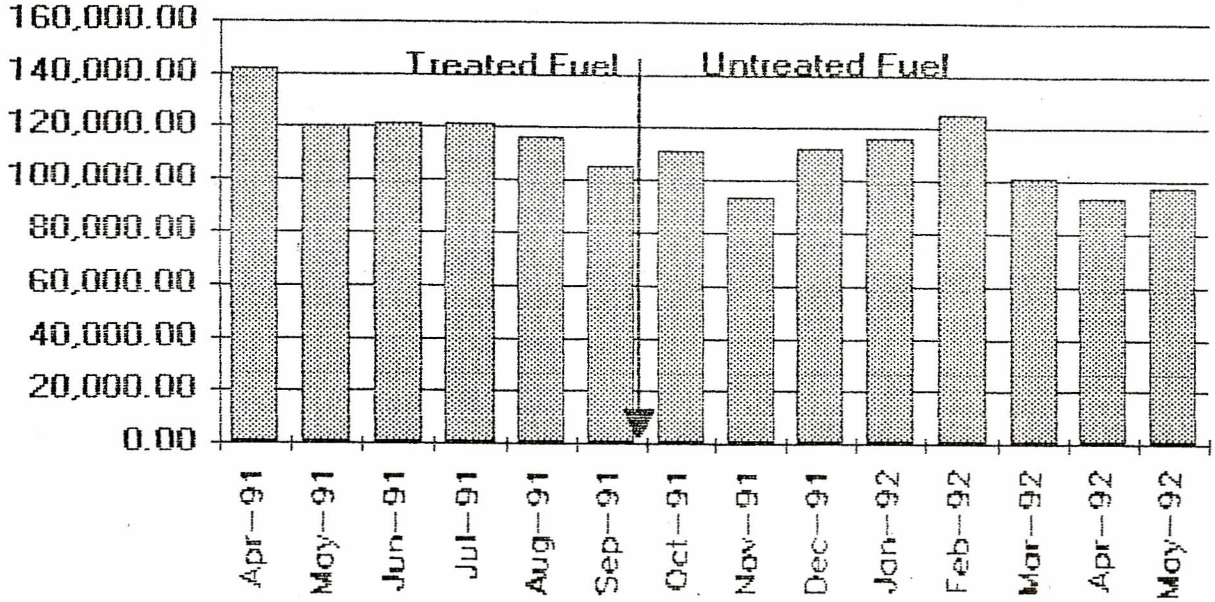

Fig. 3 Fleet TKPL Performance

The operating efficiency expressed as Tonne Kilometres/Litre of fuel on a per train basis is shown in Figure 4. An efficiency decline of 6.84% since removal of the FTC catalyst from fuel.

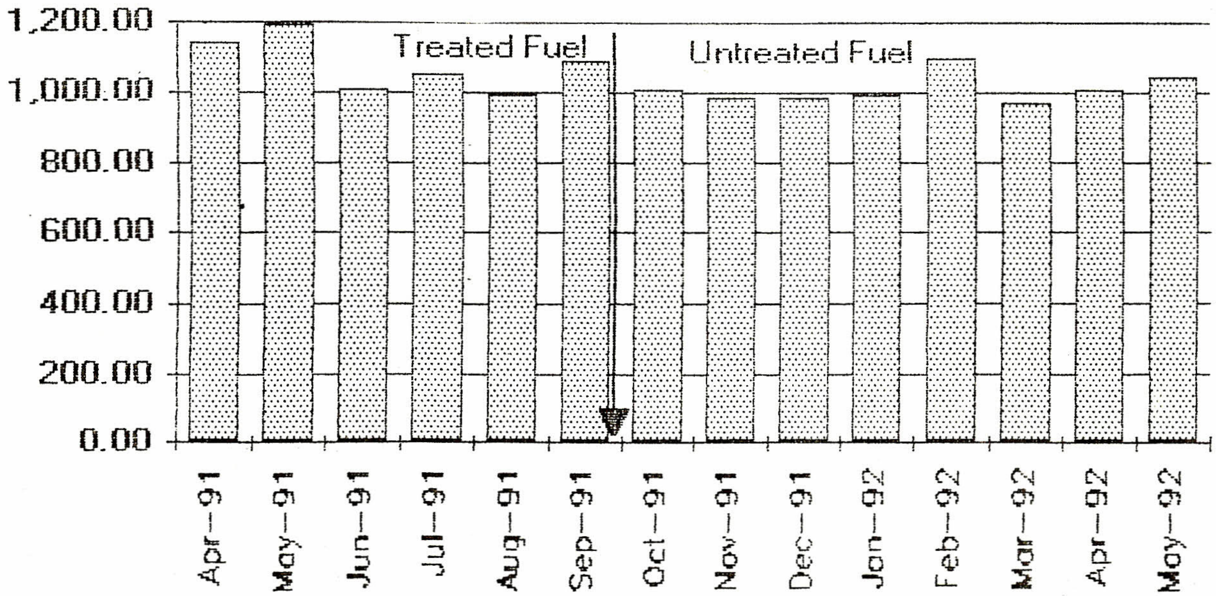

Fig. 4 Per Train TKPL Performance

The analysis of the nine individual locomotives indicate only one unit (Unit # 1) has shown an improved performance since FTC treatment ceased. All others (Units 2, 3, 5, 6, 7, 9 & 10) show reduced fuel efficiency ranging from a low of 0.8% (Unit # 2) to a high of 7.2% (Unit # 6). The model 12CSVT English Electric locomotives show the biggest level of change since FTC removal from the fuel averaging 5.1%.

Conclusion

Our experience has shown engines operating under constant speed/constant load conditions in power generation plants, provide the optimum levels of efficiency. The same engines operating employed in locomotives under variable loads and speeds operation will show a greater improvement in fuel efficiency than in power plants when the fuel is treated with the FTC catalyst.

Measured by the best engineering standard techniques the English Electric engines which operated at the Goldsworthy Power Station demonstrated levels of efficiency gain in the range 2.4% to 3.5% when operating on FTC treated fuel. Similar engines operating in railroad service have in the foregoing study indicated a decrease in efficiency in the region of 5% following removal of FTC fuel treatment. We believe that by employing standard engineering methods for determining fuel consumption the locomotives used in this study will demonstrate fuel savings by FTC fuel treatment resulting in significant cost savings to the operators.

When the railway fleet is analysed on a per train basis of Tonne Kilometres/Litre the decrease in efficiency measures 6.84%, a significant escalation in the energy required to move a mass of iron ore from the mine site to the Finucane Island benefication plant.

RECOMMENDATION

We recommend a series of Carbon Balance efficiency tests to measure the fuel consumption of the subject locomotives before and after FTC fuel treatment. These tests could be scheduled to not interfere with railway operating parameters.