Energy Efficiency, Greenhouse Gas Reductions, Reduced Emissions and Maintenance Benefits of the FTC Decarbonizer /Combustion Catalyst

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Prepared by: Brid Walker
Cost Effective Maintenance
PO Box 3877, Mt Ommaney, Qld, Australia 4074
Unit 2 / 18 Boron St, Sumner, Qld, Australia 4074
Ph (+1) 7 3271 4138
Email: sales@costeffective.com.au

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1. INTRODUCTION

The FTC Decarbonizer fuel catalysts are part of a group of chemicals classified as metal based combustion catalysts, designed to improve energy efficiency with diesel and other fuels. Based on **ferrous picrate**, FTC Decarbonizer utilises iron in such a way that only minute traces are required to be effective. In fact, the chemical is required at a mere 56 parts per **billion.** This is by far the lowest treat rate of all current metal based catalysts. There are others based on iron, as well as manganese, magnesium, cerium and tin. However, these are required in concentrations 100's (even 1000's) of times greater than ferrous picrate. Some of these also produce harmful heavy-metal emissions.

In addition, ferrous picrate is presented as a fully soluble chemical, rather than a suspended solid. Some metal based catalysts have been known to cause increased wear to piston rings, liners and fuel systems, due to the higher concentrations required and their solid particle nature. Ferrous picrate has been shown to reduce wear, and often quite dramatically.

The FTC Decarbonizer fuel catalysts provide important economic benefits for large fleet users, including…

- energy savings in the 5-10% range (typically 6-8% for mine mobile)
- reduced exhaust particulate emissions (25% plus), and other undesirable emissions
- greenhouse benefits
- engine maintenance benefits, due to elimination of hard carbon deposits, and less abrasive soot.
- control of fuel growths

All this comes at a very low cost. In fact, even if the diesel price were to fall to AUD .10/L (USD .03/gal), FTC Decarbonizer would still pay for itself in fuel savings, for most large customers.

2. HISTORY OF FERROUS PICRATE

During 1944, Dr Harold Boardman and a group of researchers at the University of British Columbia were working on organo-metallic materials as possible alternatives to the use of Tetra ethyl lead as an octane booster in gasoline. While ferrous picrate proved unsuitable in this role, the research scientists noted that the addition of trace amounts improved combustion efficiency by measurable amounts.

With petroleum cheap and plentiful after World War II, no further work was progressed until 1971, when research was again taken up at the University of California Los Angeles and Brigham Young University, UTAH. This work established benefits of energy efficiency and reduced exhaust emissions.

Today, the technology is marketed by Cost Effective Maintenance under the FTC Decarbonizer name. The product is widely used for energy efficiency and emission control. It is also highly regarded as a low cost means of correcting cylinder glaze and de-coking engines, without mechanical repairs or equipment downtime. Control of microbial fuel growths without the use of highly toxic chemicals is also an important feature.

3. HOW DOES FTC DECARBONIZER WORK?

FTC Decarbonizer produces a faster fuel burn, which releases more of the fuel's energy closer to piston top dead centre, allowing more useful work to be performed. Thus, less fuel is consumed for the same power produced, and conversely, more power can be produced for the same fuel consumed. At the chemical level, this is how it happens…

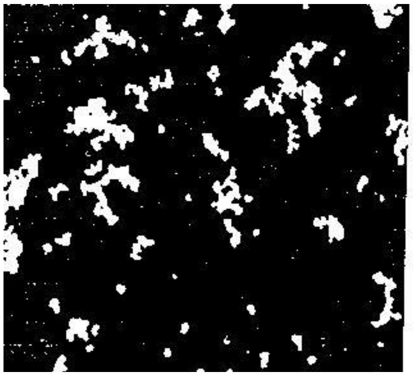
- Ferrous picrate burns at 400 to 4000 times faster than the fuel it is added to. When this occurs, the iron component becomes fully activated, well ahead of the start of the fuel burn. (All other metal based catalysts are activated during the fuel burn. This means that if they are to be effective at all, they must be used in much larger amounts to compensate for the slower activation process.)
- FTC Decarbonizer acts in several ways. Initially, the heat of the compressed air in the cylinder causes the ferrous picrate to crystallize out of solution, and combust strongly throughout the fuel air mix. This forms multiple points of flame initiation, rather than the fuel burn starting from a single point.
- It also produces smaller fuel droplet size, presenting a larger surface area for reaction.
- The activated iron also provides a rapid shuttle service between oxygen and the fuel.

- The final reaction in the chain of combustion reactions is oxidizing carbon monoxide to carbon dioxide. This is by far the slowest step, and bottle necks the overall process. It is regarded as very significant in the soot production process. FTC *Decarbonizer increases the speed of this step*, resulting in reduced exhaust particulate emissions.
- FTC Decarbonizer smoothes the combustion process. The heavier fuel molecules normally take much longer to burn, which can lead to the combustion speed varying as light and heavier molecules burn. The faster fuel burn smooths this out, reducing mechanical stress, as well as releasing the fuels energy faster, and providing more efficient mechanical use of it.

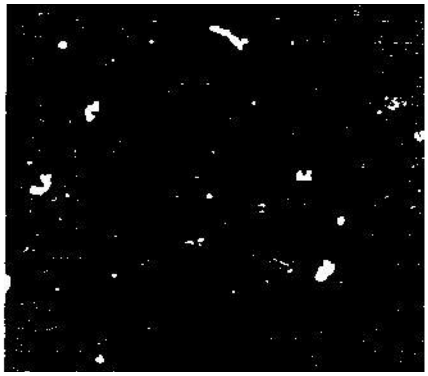
4. INDEPENDENT CONTROLLED TESTING

Independent laboratory type testing is a crucial step in determining the effectiveness of such products, since many of the operating variables which occur in commercial use can be eliminated, measured, or controlled. This provides a higher level of confidence in the results than can be achieved in field testing. However, many of these variables also cause inefficiencies in engine operation. For example, mobile equipment is usually subjected to varying loads, acceleration/deceleration cycles, and continual variations in combustion temperature. These transient conditions are a departure from the engine’s peak design efficiency, and cannot be replicated in controlled laboratory tests. As a result, laboratory test results will usually understate the magnitude of any efficiency gains possible in commercial use. Thus, controlled or long term statistical field trials are also a vital part of the evaluation procedure. A list of the major independent controlled testing is included in the Appendix, but the important contribution of a few of these follows.

4.1 University of California, Los Angeles (UCLA). 1971. Studies by Professor Albert Bush at the University of California, Los Angeles (UCLA) Engineering School demonstrated reduced levels of diesel exhaust particulates following ferrous picrate addition to the fuel. Professor Bush also found in his research that iron particulates in the exhaust stream were reduced significantly. He hypothesized that the reduced amount and number of large particles of soot resulted in reduced abrasive wear between piston ring and cylinder wall. Refer to photographs below.



*Particulate emissions from diesel exhaust **without** FTC Decarbonizer (3679 x 10^6 Particles /m^3)*



*Particulate emissions from diesel exhaust **with** FTC Decarbonizer (849 x 10^6 Particles /m^3)*

4.2 Brigham Young University, UTAH. GJ Germane, Prof Mech Eng. Dynamometer tests on a Ford petrol V8 at two RPM settings simulated urban and highway cycles, and confirmed efficiency benefits in excess of 8%, and 10.8% reduced CO emissions.

4.3 Automotive Testing Authority, Aurora, COLORADO. GJ Germane. EPA Federal Test Procedure (FTP) and Highway Fuel Efficiency Test (HFET) were used to confirm improvements in efficiency, hydrocarbons, NOx, and CO emissions in diesel engines. An Oldsmobile diesel had used catalyst treated fuel since new, and the other, a VW had never used it. An average 5.8% improvement was measured for the Oldsmobile, and 2.4% for the VW. This result supported the theory that part of the benefit would be due to removal of carbon deposits. This work also established benefits of reduced exhaust emissions, using the Carbon Mass Balance method.

4.4 WA Institute of Technology. (J. Guld, 1985). As a final year engineering project, this study partially simulates field behaviour, by measuring specific fuel consumption under part load and full load at a range of engine speeds set at 200 rpm increments. Each setting has, of course, been stabilized, so transient inefficiencies that are inherent in field use are eliminated. Maximum design efficiency usually occurs at full load with commercial diesel engines. The study supported this, demonstrating efficiency gains across all load/rpm situations, with larger gains at lower loadings. Efficiency gains of up to 4.8% were measured.

Engine Load	Ppm Ferrous picrate	Engine RPMs	% Change BSFC on ferrous picrate
Full Power	**70**	**1600**	**na**
		1800	**-1.2**
		2000	**-2.4**
		2200	**-3.0**
		2400	**-2.5**
Half Power	**70**	**1600**	**na**
		1800	**-0.7**
		2000	**-2.9**
		2200	**-3.0**
		2400	**-3.2**
Full Power	**90**	**1600**	**-2.5**
		1800	**-2.0**
		2000	**-2.9**
		2200	**-3.9**
		2400	**-3.4**
Half power	**90**	**1600**	**na**
		1800	**-4.8**
		2000	**-3.3**
		2200	**-3.6**
		2400	**-4.5**

4.5 University of Perugia, ITALY. This study was conducted at both high load and low load conditions, showing larger benefits at lighter loads. Specific fuel consumption measurements (-3.5 to -5.7%) were accompanied with measurements of exhaust particulates (-25 to -40%), SO2 (-21%), carbon monoxide (-19.5 to -24%), CO2 and oxygen.

The results of the fuel economy tests are tabled below:

Table 1. Change in Fuel Consumption and Power Output after FTC-1® Fuel Treatment

Engine Load	Fuel Consumption Chg	Power Output Chg
None	-5.7%	*****
Low Load	-3.7%	+5.1%
High Load	-3.5%	+4.2%

The results of the emissions tests are found on Table 2 below:

Table 2. Change over Baseline in Exhaust Emissions after FT

C-1® Fuel Treatment

Component	Chg at Low Load	Chg at High Load
SO_2	-21.0%	***.**
CO	-19.5%	-24.0%
CO_2	- 5.3%	- 1.4%
O_2	1.7%	0.4%
smoke (opacity)	-40.0%	-25.0%

All emissions were positively affected by the addition of FTC Decarbonizer to the diesel fuel. However, of greatest interest is the effect upon sulfur dioxide (SO_2) emissions and the products of incomplete combustion (CO and smoke).

4.6 University of WA. 2005. (R. Gillander). Another final year engineering project, supported by Rio Tinto and other interests, this study was specifically relevant to mining applications. Both new engines and mid life engines were tested, at up to three load settings. FTC Decarbonizer showed improvements in both new and older engines, with greater benefits in the older engine, due to decarbonising effects. Higher benefits were again confirmed at lighter loads. FTC Decarbonizer improved efficiency by up to 2.6% in new engines and 5.5% in older engines.

4.7 Southwest Research Institute (SWRI, Texas), and Engine Systems Development Centre, CANADA. Testing at both these facilities was conducted on large locomotive engines using the following procedures

- Assoc American Railroads RP 503
- Simplified Fuel Additive Test (SFAT)
- Weigh Tank and Load cell system.

These tests confirmed economic energy efficiencies above the maximum design efficiency in new engines (1.74%), and greater benefits with used engines, and lower load settings (up to 7.0%).

4.8 State Electricity Commission, Western Australia. In a study to evaluate carbon control using low grade diesel fuel alternatives, the SECWA ran a KT19 Cummins engine on untreated fuel and FTC Decarbonizer treated fuel. Engine inspections determined that marked deposit control was provided by FTC Decarbonizer use.

4.9 BHP Petroleum Laboratories, Melbourne, Australia. Treatment with FTC Decarbonizer showed no measurable change to the physical and chemical properties of diesel fuel.

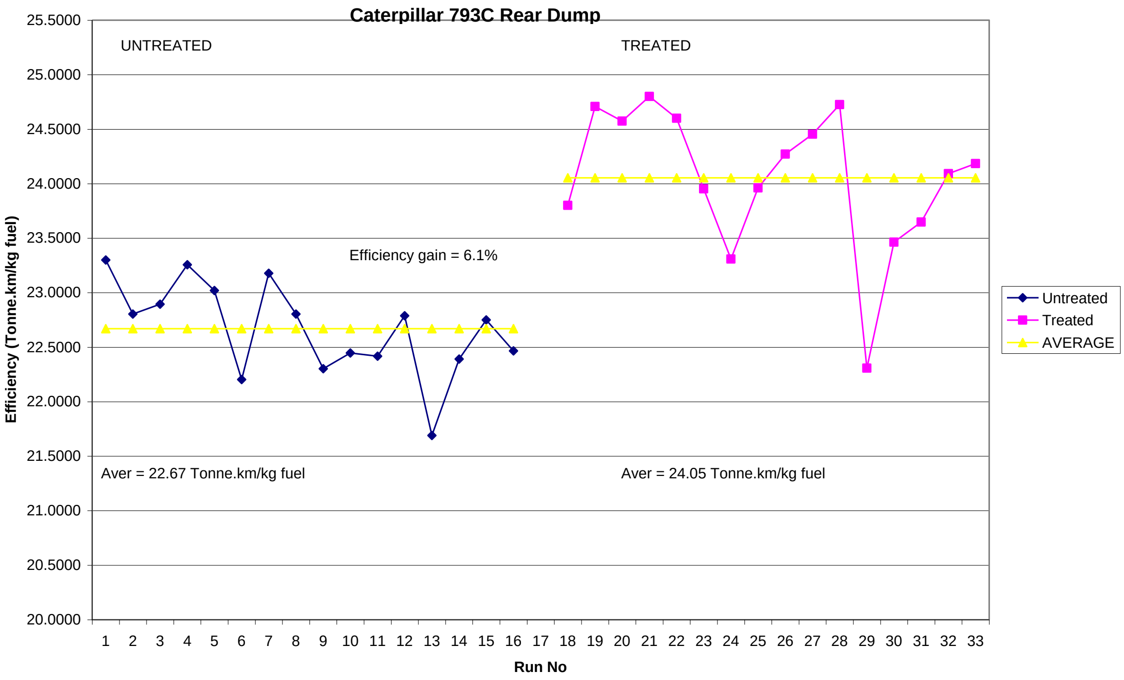
5. CONTROLLED FIELD TRIALS/STATISTICAL RESULTS

In SAE Technical Paper Series 831204, Parsons (Finning Tractor & Equipment) and Germane (Brigham Young University) studied 3 large fleets (heavy earthmoving, bus and mining). Statistical analysis of the fuel consumption demonstrated energy efficiency gains in the 7 to 8 % range.

The authors theorized that if fuel efficiency were to improve, it would be accompanied by a measurable reduction in engine carbon. Engine inspection throughout the trial clearly showed a pattern of marked reduction in the levels of hard carbon. By the completion of the trials, engines were free of all hard carbon build up. The only evidence of carbon was a light coating of soot, which was easily removed with a rag to reveal a clean metal surface. This pattern has been recognized as a feature of FTC Decarbonizer use.

Cost Effective Maintenance recommend and use only test procedures that comply with strict engineering standards, and can be scientifically validated. These include Carbon Mass Balance (AS2077-1982), SAE Type II Truck Test, Specific Fuel Consumption, Bosch Smoke Test, Bacharach Smoke (ASTM D2156-63T).

The graph below is from an SAE Type II Truck Test conducted on a Caterpillar 793C at a Queensland, Australia mine site. The procedure and results were validated by the mine's project manager, Operating Excellence Dept, and the maintenance superintendent.



6. HOW DOES FTC DECARBONIZER COMPARE WITH OTHER CATALYSTS?

With the high diesel price, many "fuel saving" offerings have entered the market place. A few of these appear to have some scientific backing. Most combustion catalysts are based on metallic compounds. FTC Decarbonizer uses iron (in the form of ferrous picrate). There are other catalysts based on iron (e.g. Ferrosene), manganese, cerium, etc. In all known cases to date FTC Decarbonizer offers the following advantages…

- FTC Decarbonizer uses a harmless metal.
- It is presented in the fuel as soluble and molecular, rather than a suspended particle.
- FTC Decarbonizer is more efficient. Each ferrous picrate molecule contains just one iron atom. It is required at 56 parts per **billion.** Each atom of iron, as uniquely presented in this compound, is several hundreds to several thousands of times more effective than the metal in other catalyst formulations.
- FTC Decarbonizer is economical, down to a fuel cost of just AUD 0.10/L (USD 0.03/Gal)

7. SOME OTHER IMPORTANT BENEFITS OF FTC DECARBONIZER USE.

7.1 Greenhouse Gas Reduction. Carbon dioxide emissions are reduced by an amount equal to the reduction in fuel use. For each tonne of fuel used, about 3 tonnes of CO2 are produced. The use of FTC Decarbonizer provides an immediate reduction in Greenhouse Gas (GHG) emissions of 6-8% for most mining operations.

In July 1989, RJ Searls presented a paper to the Australasian Institute of Mining and Metallurgy's **Mineral Fuel Alternatives and the Greenhouse Effect** seminar, entitled "The Reduction of Greenhouse Gases by

Combustion Catalysis”. He presented the view that use of this technology would provide some very important breathing space prior to development and commercialization of alternative fuels, as the main solution to GHG emissions. The importance of this, was that the technology was already proven, and commercialized.

The greenhouse effect is a very real problem, which needs to be addressed particularly by the large energy users. FTC Decarbonizer offers the opportunity to do so, and achieve a very large economic benefit as well.

7.2 Exhaust Particulates and Wear Reduction. Early studies by AF Bush at UCLA involved micro-photography of diesel particulates. This work confirmed that the number of exhaust particles emitted was substantially reduced with ferrous picrate use. Combustion soot also reaches the crankcase oil, due to compression blow-by.

Unit Rig 4000 MTU.

A Bosch smoke test was also undertaken while conducting the CMB (Carbon Mass Balance) test and the results are shown in the following table. Unit 42 was untreated and used as a test control unit.

Bosch Smoke Results

Unit No.	Untreated 13/5/03	Treated 31/7/03	Variation
34 Top Exhaust	1.4	0.8	
34 Bottom Exhaust	1.0	0.9	
AVERAGE	**1.2**	**0.85**	**- 29%**
35 Top Exhaust	0.5	0.3	
35 Bottom Exhaust	0.8	0.4	
AVERAGE	**0.65**	**0.35**	**-46 %**
42 Top Exhaust	0.2	0.2	
42 Bottom Exhaust	0.2	0.2	
AVER (Control)	**0.2**	**0.2**	**N/C**
Average Excluding # 42	**0.925**	**0.6**	**-35%**

Caterpillar 793C

A Bosch smoke test was also undertaken while conducting the CMB test and the results are shown in the following table.

Bosch Smoke Results

Unit No.	Untreated 26/7/05	Treated 29/8/05	Variation
1269 Top Exhaust	1.3	1.1	
1269 Bottom Exhaust	1.4	0.9	
AVERAGE	**1.35**	**1.0**	**- 26%**

The Bosch Scale reads from 0.1 (very clean) to 9.9 (very dirty).

7.3 Other Emissions. A trial was carried out at Londonderry under the control of NSW (Australia) Mines Department between 11 Oct. 1978 and 15 Oct.1978 on a Perkins D3.152 direct injection diesel engine. Exhaust gas checked by NSW Mines Department using Mobile gas chromatograph laboratory. Catalyst test data in brackets.

RPM	**Gross BHP**	**Visible Smoke**	**0_2 % Vol**	**$C0_2$ % Vol**	**C0 ppm**	**NOX ppm**	**NO ppm**	**Hydrocarbons As ppm CH_4**
1200	22.5	Very slight haze	8.7	8.7	530	1800	1750	60
	(22.5)	“	(9.3)	(8.3)	(420)	(1840)	(1700)	(25)
% Variation			*+6.9*	*-4.6*	*-20.7*	*+2.2*	*-2.9*	*-58.3*
2000	36	Slight brown haze	7.7	9.5	1140	1180	1130	145
	(36)	“	(8.0)	(9.2)	(1040)	(1180)	(1140)	(110)
% Variation			*+3.9*	*-3.2*	*-8.8*	*N/C*	*+0.9*	*-24.1*
2000	37.5	Slight brown haze	7.1	9.8	1380	1250	1180	165
	(37.5)	“	(7.4)	(9.5)	(1260)	(1210)	(1140)	(125)
	(28.0)	“	(7.2)	(9.7)	(1310)	(1300)	(1300)	(125)
% Variation			*+4.2*	*-3.1*	*-8.7*	*-3.3*	*-3.5*	*-32*

Significant reduction in exhaust gas pollutants, in particular hydrocarbon emissions. Also, increase in power (1.3%) after catalyst added to fuel. Engine in as new condition and “conditioning period” limited. (Further improvements may have been possible with an extended conditioning period.)

7.4 Maintenance Benefits. Work by AF Bush (UCLA) showed reduced amounts of iron in exhaust emissions. He theorized that lowered production of exhaust soot also reduced abrasive wear between piston ring and liner.

Field trials by JB Parsons (Finning Tractor & Equipment) and GJ Germane (Brigham Young University) were presented in SAE Technical Paper Series # 831204, confirming an active decarbonizing of combustion and exhaust spaces with the use of ferrous picrate.

Operation	**Equipment**	**Efficiency Change %**	**Lube Oil Soot Change %**	**Wear Metal Change (Fe) %**
Western Australia Gold Mine	Komatsu HD465-3 Komatsu HD785-3	7.7%	-56%	-14.7%
Western Australia Coal Mine	Caterpillar 789 (plus others)	7.1%	-10%	-21%
Queensland Coal Mine	Euclid CH120/CH150	7.3%	-58%	-33%
Western Australia Gold Mine	Caterpillar 773B, 777B Leibherr 994	7.4%	-16.7%	Not determined

The following case studies confirm reduced levels of soot and iron in lubricating oil:

Cummins piston as removed from engine
after 15,000 hrs use on FTC Decarbonizer
treated fuel.

Examples of Maintenance Benefits.

- **Exhaust valve failures eliminated** in Detroit Diesel 16V92 engines.
- **Reduced incidence of exhaust valve failures** in Cummins 1710's powering Euclid coal haulers
- **Caterpillar Dozer using FTC Decarbonizer idled for 2 days** at a Queensland, Australia, coal mine, when operations moved to another pit. Unexpectedly, the engine didn't glaze.
- **Caterpillar D10 Dozer using FTC Decarbonizer idled for 3 days** at a Papua New Guinea copper mine, when the operator left work sick. Unexpectedly, the engine didn't glaze.
- **Caterpillar D348 engines were dropping exhaust valves** (due to heavy carbon build up on valve stems) at 3000-4000hr intervals in coal hauler operation at a Queensland, Australia, mine. FTC Decarbonizer was introduced, the failures disappeared.
- Caterpillar fleet (Western Australia mining contractor) had heavy engine carbon problem. **FTC Decarbonizer introduction resulted in engine life more than doubling.**

7.5 CONTROL OF FUEL GROWTHS. The FTC Decarbonizer formulations contain a biocide, which concentrates in tank bottoms and biological growths to kill and control fuel growths at relatively safe, low concentration levels. This has proven very beneficial at numerous locations by eliminating equipment downtime, labor and fuel filter costs associated with this problem. It has also resulted in much reduced bulk tank maintenance.

Prepared by: Brid Walker
Cost Effective Maintenance
PO Box 3877, Mt Ommaney, Qld, Australia 4074
Unit 2 / 18 Boron St, Sumner, Qld, Australia 4074
Ph (+1) 7 3271 4138
Email: sales@costeffective.com.au

APPENDICES:

APPENDIX 1. Mobile Mining Evaluations

APPENDIX 2. List of Independent Testing Authorities

APPENDIX 3. Documented Reports/Papers on Ferrous Picrate

APPENDIX 4. Haul Truck Fuel Consumption Measurement

Appendix 1. Mobile Mining Evaluations

****NOTE:** Tests highlighted in **bold** print meet scientific engineering protocols.****

QUEENSLAND, AUSTRALIA COAL MINE

Date	Site Engineer	Type Test	Units measured	Efficiency benefit
1984	KJ Brown	Operational (short term statistical study)	Litres.hrs/T.km	Aver 11.5%
1989-90	Steve Lloyd/ John Keogh	**CMB (AS2077-1982) 4 Haulers**	Grams/sec Carbon used	Aver 7.1% Range 5.8 to 7.8
1990	Steve Lloyd/ John Keogh	**ASTM D 2156-63T Exhaust particulates**	Bacharach units	Aver 27% reduction
1990	Steve Lloyd/ John Keogh	12 months statistical Review	L/hr Fleet average	8.2%
1990	John Keogh	Observations and subjective comment	Valve failures in Cummins 1710 dramatically reduced, less visible smoke, less engine carbon	
1992-1993	Bob Pinkerton	Demountable fuel tank, 5 min fast idle, no load	Litres consumed	Aver 3.3%
1997	Mark Rough	**SAE Type II Truck test (2 Cat 784B)**	Tonne.km/kg fuel	Aver 7.1% Range 5.3 to 11.7%
1996-1997	Stores records	Comparison various untreated periods	Litres. Whole of mine use	Range 6-9%

NORTHERN TERRITORY, AUSTRALIA MANGANESE MINE

Date	Site Engineer	Type Test	Units measured	Efficiency benefit
1991	Dave Trembath	**CMB (AS2077-1982)** **5 Cat 785**	Gms/sec carbon used	6.2% Range 3.5 to 7.4%
1991	Dave Trembath	**ASTM D 2156-63T** **Exhaust particulates**	Bacharach units	21.3%
1998	Randy Gates	**SAE Type II Truck** **Cat 785B**	Tonne.km.kg fuel	7.6%
1998	Randy Gates	**SAE Type II Truck**	Haul cycle time (Secs)	5.7%
1998	Randy Gates	**Specific Fuel Cons** **Allen #6 Genset**	kWhr/kg fuel (# load settings)	2.9% Range 2.7 to 3.0%
1998	Randy Gates	Power station data	kWhr/kg fuel	3.2 to 5.1% (2 engines)

QUEENSLAND, AUSTRALIA COAL MINE

Date	Site Engineer	Type Test	Units measured	Efficiency benefit
1990	Gerry Dempsey Joe Little	**CMB (AS2077-1982)** **2 Euclid CH220**	Gms/sec carbon used	Aver 13% Range 10.6 to 15.4%
1990	Gerry Dempsey Joe Little	**ASTM D 2156-63T** **Exhaust Particulates**	Bacharach units	34%
1990	Gerry Dempsey Joe Little	Statistical. Daily mine fuel meter readings	Litres/day	8.5%
1990-2005	Store records Meter readings	Comparison various untreated periods	Litres. Whole of mine use	Range 5 to 9%

QUEENSLAND, AUSTRALIA COAL MINE (Validated by Operating Excellence Group)

Date	Site Engineer	Type Test	Units measured	Efficiency benefit
2001	Brent Findlay Scott Degenhardt Neil Reynoldson	**SAE Type II Truck** **Cat 784B, Cat 793C**	T.km/kg fuel	Aver 5.9%
		RD34 Loaded	"	6.1%
		CH33 Loaded	"	15.5%
		CH33 Empty	"	5.7%

PAPUA NEW GUINEA COPPER MINE

Date	Site Engineer	Type Test	Units measured	Efficiency benefit
1992	Alan Main	**CMB AS2077-1982** **3 Cat 789**	Gms/sec carbon used	Aver 5.1% before conditioning process was completed.
1992	Alan Main	Injector rack setting Cat 789 (Static Load)	Mm	Reduced from 9.3 to 9.0mm
	Alan Main	Time to reach stall out	Secs	Reduced indicating more power
	Alan Main James Hoyt	Up ramp haul out time	Min:sec	Reduced
	Alan Main	Fuel consumption records		Early trend identified

WESTERN AUSTRALIA IRON ORE MINE

Date	**Site Engineer**	**Type Test**	**Units measured**	**Efficiency benefit**
2002	David Hales	**SAE Type II Truck** **2 Cat 789**	Tonne.km/kg fuel	Aver 5.2%
		DT 137		5.0%
		DT 140		5.3%

WESTERN AUSTRALIA GOLD MINE

Date	**Site Engineer**	**Type Test**	**Units measured**	**Efficiency benefit**
2003	Lou Fornaro	**SAE Type II Truck** **3 x Cat 793B**	Tonne.km/kg fuel	**Aver 5.6%**
		DT 202		4.6%
		DT 206		6.6%
		DT 225		5.6%

WESTERN AUSTRALIA NICKEL MINE

Date	**Site Engineer**	**Test Type**	**Units measured**	**Efficiency benefit**
2005	Tim Riley	**CMB AS2077-1982** **Cat 793C (#1269)**	Gm/sec carbon used	7.9% Aver
		SAE Type II Truck	Tonne.km/kg fuel	
		Cat 793C (#1269)		5.7%
		Cat 793C (#1581)		4.0%
		Bosch Exhaust Particulates	Bosch units	26%

WESTERN AUSTRALIA IRON ORE MINE

Date	**Site Engineer/ Independent Validation**	**Test Type**	**Units measured**	**Efficiency benefit**
1984	KH Dolman/ Dr TC Brown (Monash Univ)	**Statistical analysis (Monash University)**		2.43 to 4.0%
1984	KH Dolman	**CMB AS2077-1982**	Gm/sec carbon used	Aver3.5%
1984	KH Dolman	**Specific Fuel Consumption**	L/kw.hr	Aver 2.9% (over 3 load settings)
1984				Use expanded to railroad and mobile mining

QUEENSLAND, AUSTRALIA COAL MINE (Caterpillar, MTU, Komatsu engines)

Date	**Site Engineer**	**Test Type**	**Units measured**	**Efficiency benefit**
2002	W. Ewald	**SAE Type II Truck** **2 x Komatsu 630E**	Tonne.km/kg fuel	6.2%
2004	W. Ewald	12 month statistical analysis (whole of fleet)	Tonnes shifted/L fuel	8.3%

Appendix 2. List of Independent Testing Authorities

The ferrous picrate combustion catalyst has been successfully validated by numerous independent testing authorities, including those below…

1. University of Western Australia (UWA), Perth, Western Australia
2. Western Australia Institute of Technology, Perth, Western Australia
3. Southwest Research Institute (SWRI), San Antonio, TEXAS
4. New South Wales Department of Mines, Australia
5. Curtin University, Perth, Western Australia
6. University of Perugia, Institute of Energy, ITALY
7. Indian Institute of Petroleum, Dehradum, INDIA
8. Automotive Testing Laboratory, Aurora, COLORADO
9. Systems Control Laboratory, Anaheim, CALIFORNIA
10. University of California, Los Angeles (UCLA)
11. Brigham Young University, UTAH
12. University of British Columbia, CANADA
13. BHP Petroleum Laboratory, Melbourne Victoria, Australia
14. State Energy Commission, Western Australia
15. Engine Systems Development Centre (ESDC)

Some of the test procedures used include…

1. Laboratory Dynamometer Studies
2. Association of American Railroads Recommended procedure AAR RP 503
3. Indian Petroleum Conservation Research Assoc. TATA 692 Engine Test
4. US EPA Federal Test Procedure (FTP)
5. US EPA Highway Fuel Economy Test (HFET)
6. SAE J 1082 Suburban (SAE 2)
7. SAE J 1082 Interstate (SAE 1)
8. Coordinating Research Council (CRC) Driveability Tests
9. Determination of physical and chemical properties of fuel
10. Engine deposit inspection – Low grade diesel substitute

Appendix 3. Documented Reports/Papers on Ferrous Picrate

The following papers document some of the many studies conducted on the ferrous picrate combustion catalyst, currently marketed in Australasia under the FTC Decarbonizer range of products by Fuel Technology Pty Ltd, and their distributor, Cost Effective Maintenance.

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PO Box 3877, Mt Ommaney, Queensland, 4074, Australia