Fuel Factor X -- Fuel Catalyst Evaluation
For
Fuel Efficiency and Emissions Reductions
With
Idaho National Laboratories
Utilizing
The Carbon Mass Balance Test Procedure

Final Report
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For

Fuel Factor X .

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Appendices

WHAT IS
THE
CARBON BALANCE TEST PROCEDURE?

PREFACE

Fuel consumption measurements by reliable and accredited methods have been under constant review for many years. The weight of engineering evidence and scientific theory favors the carbon balance method by which carbon measured in the engine exhaust gas is related to the carbon content of the fuel consumed. This method has certainly proven to be the most suitable for field-testing where minimizing equipment down time is a factor.

The inquiries of accuracy and reliability to which we refer include discussions from international commonwealth and government agencies responsible for the test procedure discussed herein. This procedure enumerates the data required for fuel consumption measurements by the "carbon balance" or "exhaust gas analysis" method. The studies conducted show that the carbon balance has been found to be a more precise fuel consumption test method than the alternative volumetric-gravimetric methods.

The carbon balance test is a fundamental part of the Australian Standards **AS2077-1982**. Further, the carbon balance test procedure has proven to be an intricate part of the United States EPA, FTP and HFET Fuel Economy Tests. Also, Ford Motor Company characterized the carbon balance test procedure as being "at least as accurate as any other method of volumetric-gravimetric testing." (**SAE Paper No. 750002 Bruce Simpson, Ford Motor Company**) Finally, the Carbon Balance procedure is incorporated in the Federal Register Voluntary Fuel Economy Labeling Program, Volume 39.

The following photographic report captures a few of the applicable steps necessary for conducting a reliable and accurate carbon balance test. As will be documented, every effort is made to insure that each test is consistent, repeatable, and precise. More importantly, it will be even clearer as to why the Carbon Balance Test has such a high degree of acceptance and reliability.

EXECUTIVE SUMMARY

The Fuel Factor X fuel catalyst manufactured and marketed by MyDailyChoice Inc. has proven, in laboratory and field-testing, to reduce fuel consumption in the range 3% to 10% under comparable load conditions. It also has proven to significantly reduce carbon emissions.

Following discussions with Chris Robinson (Fuel Factor X Representative) and Tad Pearson, Fuels Coordinator, Idaho National Laboratories, it was determined that a fuel consumption analysis should be conducted utilizing at least five (5) transportation busses. The designated equipment for this study included three (3) C-13 Caterpillar powered, Motor Coach Industries buses with a manufacture date of 3-07 and two (2) 60 Series Detroit Diesel powered, Motor Coach Industries busses with a manufacture date of 6-05. Engines with differing mileage accumulations were evaluated in an attempt to determine the affects of the Fuel Factor X fuel Catalyst on engines with varying use, horsepower and mileage. Further, the exclusive fuel type for the analysis was a B-20 (20% Soy oil) bio-diesel which is specifically used throughout the INL bus fleet.

It was determined that several engines be evaluated, ranging from relatively new, to those with higher miles. A baseline test was conducted after which the equipment was treated by pouring the Fuel Factor X fuel catalyst into an on-site 10,000 gallon fuel storage tank dedicated specifically for the use of the Carbon Mass Balance evaluation. Treatment was facilitated through the use of one (1) gallon containers of Fuel Factor X fuel catalyst, which were used to hand treat the bulk tank each time a new shipment of fuel was received. At a later date, the catalyst treated fuel test was then repeated following the same parameters. The results are contained within the body of this report.

Idaho National Laboratories is a Department of Energy test facility that utilizes a fleet of approximately 100 new to moderately new busses to transport employees to and from the site. The busses transport employees from surrounding areas, which include Rexburg, Idaho Falls, Blackfoot and Pocatello, Idaho.

A baseline test (untreated) was conducted on June 1, 2009 using the Carbon Mass Balance Test Procedure. After which, the pre-selected test equipment was treated by adding the Fuel Factor X fuel catalyst to a dedicated, on-site, 10,000 gallon bulk storage tank. On August 11, 2009, the test was then repeated (Fuel Factor X treated) following the same parameters. The results are contained within this report.

Finally, as part of the data accumulation process, fuel consumption related data was extracted from the onboard D-DEC and E-CAT (computer control) system, on each bus, in an attempt to replicate or substantiate the data and trends accumulated during the course of the CMB evaluation.

The data showed that the average improvement in fuel consumption, for all trucks tested, was 8.13%**,** during steady state testing, using the Carbon Mass Balance test procedure. Further, data extracted from the on board computer (ECU) for each bus evaluated documented as much as a 4.8% improvement in fuel economy. Further details will be discussed in the body of this report.

The treated engines also demonstrated a large percentage reduction in soot particulates, in the range 38%, and reductions in harmful exhaust related carbon fractions. Carbon dioxide reductions, based upon the measured reduction in fuel consumption, are also substantial.

INTRODUCTION

Baseline (untreated) fuel efficiency tests were conducted on all five (5) pieces of equipment on July 1, 2009, employing the Carbon Mass Balance (CMB) test procedure. Fuel Factor X . supplied sufficient quantities of Fuel Factor X fuel catalyst utilized to dose/treat the 10,000 on-site dedicated bulk fuel tank to insure that all test vehicles were adequately accounted for during the course of the evaluation. The test units were then operated on Fuel Factor X fuel catalyst treated fuel for at least 3,000 miles in order to achieve the complete conditioning period, which is documented in many laboratories and field studies. Tests conducted provide critical documentation, which proves that equipment operated with less than 2,000 to 3,000 treated miles demonstrate lower fuel consumption improvements because of the catalytic stabilization affects that take place while using Fuel Factor X fuel combustion catalyst. It should be noted that bus 474 did not accumulate the minimal mileage required to complete the catalyst conditioning process. The bus data is compiled and used accordingly in the body of this report.

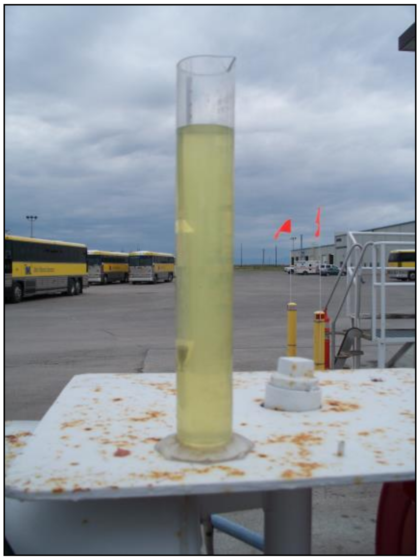
At the end of the treated engine-conditioning period (August 11, 2009), the engine tests were repeated, reproducing all engine parameters. The final results, along with the data sheets, are contained within this report. **Note:** Bus number 476 was out of commission and in the paint shop during the treated segment of the CMB evaluation. As such, only the E-Cat data is included in this report for bus 476.

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. The CMB is central to the both US-EPA (FTP and HFET) and Australian engineering standard tests (AS2077-1982), although in field-testing we are unable to employ a chassis dynamometer. However, in the case of a stationary equipment test, the engine can be loaded sufficiently to demonstrate fuel consumption trends and improvement potential.

The Carbon Mass Balance formula and equations employed in calculating the carbon flow are a supplied, in part, by doctors' of Combustion Engineering at the university and scientific research facility level.

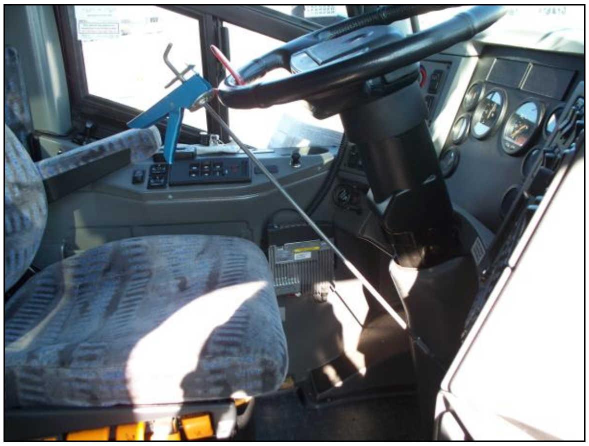
The Carbon Mass Balance test procedure follows a prescribed regimen, wherein every possible detail of engine operation is monitored to insure the accuracy of the test procedure. Cursory to performing the test, it is imperative to understand the quality of fuel utilized in the evaluation. As important, the quality of fuel must be consistent throughout the entirety of the process.



Fuel density and temperature tests are performed for both the baseline and treated segments of the evaluation to determine the energy content of the fuel. A .800 to .910 Precision Hydrometer, columnar flask and Raytek Minitemp are utilized to determine the fuel density for each prescribed segment of the evaluation.

Next, and essential to the Carbon Balance procedure, is test equipment that is mechanically sound and free from defect. Careful consideration and equipment screening is utilized to verify the mechanical stability of each piece of test equipment. Preliminary data is scrutinized to disqualify all equipment that may be mechanically suspect. Once the equipment selection process is complete, the Carbon Balance test takes only 10 to 20 minutes, per unit, to perform.

Once the decision is made to test a certain piece of equipment, pertinent engine criteria needs to be evaluated as the Carbon Balance procedure continues. When the selection process is complete, engine RPM is increased and locked in position. This allows the engine fluids, block temperature, and exhaust stream gasses to stabilize. Data cannot be collected when there is irregular fluctuation in engine RPM and exhaust constituent levels. Therefore, all engine operating conditions must be stable and consistent.



An aftermarket throttle position lock is utilized, as one method, to secure engine RPM. This provides a steady state condition in which consistent data can be collected. Should the engine RPM fluctuate erratically and uncontrollably, the test unit would be disqualified from further consideration.

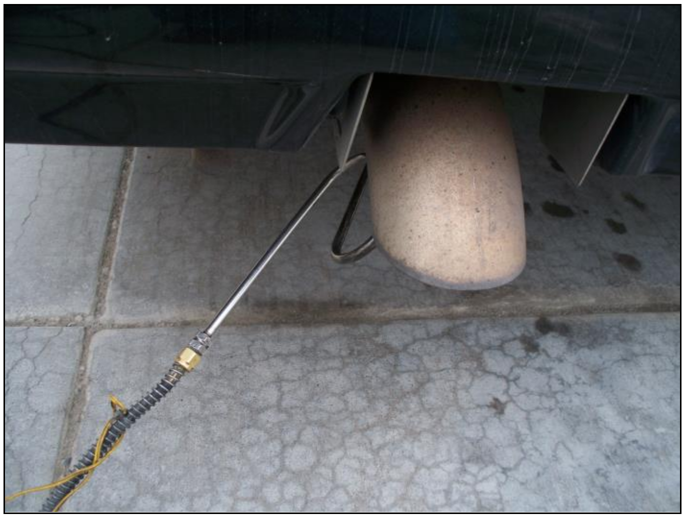
Next**,** engine RPM and fluid temperatures are monitored throughout the Carbon Balance evaluation. As important, exhaust manifold temperatures are monitored to ensure that engine combustion is consistent in all cylinders. It is imperative that the engine achieve normal operating conditions before any testing begins.

Once engine fluid levels have reached normal operating conditions the Carbon Balance study may begin. The above photograph shows that the engine RPM is locked in place at 1500 r.p.m. It should be noted that any deviation in r.p.m., temperature, either fluid or exhaust, would cause this unit to be eliminated from the evaluation due to mechanical inconsistencies.

Once all of the mechanical criteria are met, data acquisition can commence; it is necessary to monitor the temperature and pressure of the exhaust stream. Carbon Balance data cannot be collected until the engine exhaust temperature has peaked. Exhaust temperature is monitored carefully for this reason.

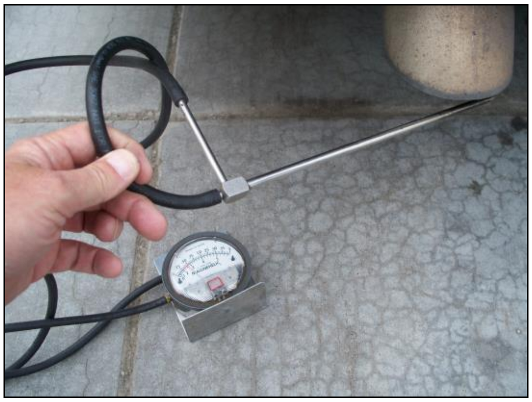
Once the exhaust temperature has stabilized, the test unit has reached its peak operating temperature. Exhaust temperature is critical to the completion of a successful evaluation, since temperature changes identify changes in load and RPM. As previously discussed; rpm and load must remain constant during the entirety of the Carbon Balance study.

When all temperatures are stabilized, and desired operating parameters are achieved; it is time to insert the emissions sampling probe into the exhaust tip of each piece of equipment utilized in the study group. The probe has a non-dispersive head, which allows for random exhaust sampling throughout the cross section of the exhaust.



While the emission-sampling probe is in place, and data is being collected, exhaust temperature and pressure are monitored throughout the entirety of the Carbon Balance procedure. This photograph shows the typical location of the exhaust emissions sampling probe.

While data is being collected, exhaust pressure is monitored, once again, as a tool to control load and rpm fluctuations. Exhaust pressure is proportional to load. Therefore, as one increases, or decreases, so in turn does the other. The Carbon Balance test is unique in that all parameters that have a dramatic affect on fuel consumption, in a volumetric test, are controlled and monitored throughout the entire evaluation. This ensures the accuracy of the data being collected. Exhaust pressure is nothing more than an accumulation of combustion events that are distributed through the exhaust matrix.



The above photograph shows one method in which exhaust pressure can be monitored during the Carbon Balance test procedure. In this case, exhaust pressure is ascertained through the use of a Magnahelic gauge. This type of stringent regime further documents the inherent accuracy of the Carbon Balance test.

At the conclusion of the Carbon Balance test, a soot particulate test is performed to determine the engine exhaust particulate level. This valuable procedure helps to determine the soot particulate content in the exhaust stream. Soot particulates are the most obvious and compelling sign of pollution. Any attempt to reduce soot particulates places all industry in a favorable position with environmental policy and the general public.

The above photograph demonstrates a typical method in which soot particulate volume is monitored during the Carbon Balance test. This method is the Bacharach Smoke Spot test. It is extremely accurate, portable, and repeatable. It is a valuable tool in smoke spot testing when comparing baseline (untreated) exhaust to catalyst treated exhaust.

Finally, the data being recorded is collected through a non-dispersive, infrared analyzer. Equipment such as this is EPA approved and CFR 40 rated. This analyzer has a high degree of accuracy, and repeatability. It is central to the Carbon Balance procedure in that it identifies baseline carbon and oxygen levels, relative to their change with catalyst treated fuel, in the exhaust stream. The data accumulated is extremely accurate, as long as the criteria leading up to the accumulation of data meets the same stringent standards. For this reason, the Carbon Balance test is superior to any other test method utilized. The CMB eliminates a multitude of variables that can adversely affect the outcome and reliability of any fuel consumption evaluation.

Identified above is one type of analyzer used to perform the Carbon Balance test. The analyzer is calibrated with known reference gases before the baseline and treated test segments begin. The data collected from this analyzer is then computed and compared to the exhaust matrix carbon content of the baseline and treated segment of the evaluation. Also, the data recognizes the carbon contained within the raw diesel fuel. A fuel consumption performance factor is then calculated from the data. The baseline performance factor is compared with the catalyst treated performance factor. The difference between the two performance factors identifies the change in fuel consumption during the Carbon Balance test procedure. **Note:** The Horiba MEXA emissions analyzer is calibrated with the same reference gas for both the baseline and treated segments of the evaluation. In this case, a Scott specialty Mother gas no. CYL#ALM018709 was utilized for calibration purposes.

Essential to performing the aforementioned test procedure is the method in which the task for dosing fuel is performed. It is critical to the success of the Carbon Mass Balance procedure to insure that the equipment evaluated be given meticulous care and consideration to advance the process of testing.

This well organized fuel consumption evaluation included two separate factors, which helped to improve the potential for success with this evaluation. First, markings were placed on the fuel doors of the busses included in this evaluation, identifying the disposition of the bus and the requirement for special handling. Second, a dedicated 10,000 gallon fuel tank was utilized to fill the busses (routine filling) to diminish the affects of missed catalyst treatment due to individual driver error and to provide a reliable source for fuelling wherein the B-20 (20% Soy oil) bio-diesel was utilized during the entirety of the evaluation.

INSTRUMENTATION

Precision state of the art instrumentation was 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 Series, four gas infrared analyser.

Note: The Horiba MEXA emissions analyser is calibrated with the same reference gas for both the baseline and treated segments of the evaluation. In this case, a Scott specialty mother gas no. CYL#ALM018709 was utilized for calibration purposes.

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

Exhaust differential pressure by Dwyer Magnahelic.

Ambient pressure determination by use of Brunton ADC altimeter/barometer.

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

Exhaust gas sample evaluation of particulate by use of a Bacharach True Spot smoke meter.

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

TEST RESULTS

Fuel Efficiency

A summary of the CMB fuel efficiency results achieved, in this test program, is provided in the following tables and appendices. **See Table I, and Individual Carbon Mass Balance results, in Appendix II.**

Table I: provides the final fuel consumption test results for all five (5) pieces of equipment, included in the evaluation, before and after Fuel Factor X fuel catalyst treatment **(see graph II, Appendix I)**.

TABLE I

Test Segment	**Miles**	**Fuel Change by %**
473		
Treated	7.771	**- 9.8%**
474		
Treated	1,829	**- 5.3%**
475		
Treated	5,134	**- 8.9%**
476		
Treated	4,397	**No CMB Data**
477		
Treated	4,274	**- 8.5%**
Average (Absolute)		**- 8.13%**

The computer printouts of the calculated CMB test results are located in **Appendix II.** The raw engine data sheets used to calculate the CMB are contained in **Appendix III**. The raw data sheets, and carbon balance sheets show and account for the environmental and ambient conditions during the evaluation.

Soot Particulate Tests

Concurrent with CMB data extraction, soot particulate measurements were conducted. The results of these tests are summarized in **Table II**. Reductions in soot particulates are the most apparent and immediate. Laboratory testing indicates that carbon and solid particulate reductions occur before observed fuel reductions. Studies show that a minimum 2,000 to 3,000 miles, Fuel Factor X fuel catalyst treated engine operation, are necessary before the conditioning period is complete. Then, and only then, will optimal fuel consumption improvements be observed. For the purpose of this evaluation, observed stack soot accumulation had diminished significantly between baseline and treated segments of the evaluation.

Table II

Fuel Type Density .840 Bio-diesel	**Soot Particulates**
473	
Untreated	2.96 mg/m^3
Treated	1.67 mg/m^3
	- 44%
474	
Untreated	3.63 mg/m^3
Treated	2.87 mg/m^3
	- 21%
475	
Untreated	17.17 mg/m^3
Treated	9.67 mg/m^3
	- 44%
476	
Untreated	**No Smoke**
Treated	**Test**
477	
Untreated	17.17 mg/m^3
Treated	9.98 mg/m^3
	- 42%
Average	**- 38%**

The reduction in soot particulate density (the mass of the smoke particles) was reduced by an average 38**%** after fuel treatment and engine conditioning with Fuel Factor X fuel catalyst **(See Graph 1, Appendix I).** Concentration levels were provided by Bacharach.

Electronic Control Unit Fuel Consumption Analysis

In conjunction with the CMB evaluation, a parallel analysis was performed utilizing the data accumulated and stored by the electronic control unit on each bus. Pertinent data, specific to documenting accurate fuel consumption information, was extracted and is included in **Table III** of this section. The following data identifies the results for all busses included in the evaluation.

Table III

	D-DEC 473	D-DEC 474	E-CAT 475	E-CAT 476	E-CAT 477
Overall Fuel Consumption:	B5.98 gph	B5.95 gph	B6.71	B6.40	B6.39
	T5.71 gph	T5.77 gph	T7.02	T6.69	T6.72
Average Load:	B44%	B40%	B27%	B27%	B27%
	T44%	T40%	T30%	T30%	T29%
Idle Percentage:	B15%	B10%	B20%	B14%	B12%
	T10%	T9%	T13%	T6%	T10%
Average Driving Speed:	N.A.	N.A	B42.2	B42.8	B43.4
	N.A.	N.A.	T44.7	T47.5	T44.1
Average Vehicle Speed:	N.A.	N.A.	B20.7	B19.7	B20.1
	N.A.	N.A.	T26.1	T22.5	T22.2

"B" denotes baseline period; "T" denotes treated period

Traditionally, D-DEC systems are less informative when providing information to help access the operational profile of a piece of equipment undergoing some type of scrutiny or testing procedure. Obvious, pertinent data such as "Average Driving Speed" and "Average Vehicle Speed" are more difficult to access from the D-DEC unit; however, the general trends of the data show the following scenario: for the fleet, **overall fuel consumption** was 6.5 (E-CAT) miles per gallon and 5.97 (D-DEC) gallons per hour for the baseline segment analysed. The catalyst treated segment of the evaluation provided an **overall fuel consumption** average of 6.81 (E-CAT) miles per gallon and 5.74 (D-DEC) gallons per hour; a reduction of 3.9% (D-DEC) in gallons per hour and a 4.8% (E-CAT) increase in fuel economy (miles per gallon) during the catalyst treated segment of the evaluation. These results were generated with an overwhelming bias toward the baseline data. For instance, **average load** for all busses tested was 13.9% higher during the catalyst treated segment of the evaluation. To further substantiate the load trend changes, **idle percentage** data documented a 32% decrease, in idle time, during the catalyst treated segment of the evaluation. Further load paradigm changes include a 6% increase in **average driving speed** and a **17%** increase in **average vehicle speed**; also observed during the catalyst treated segment of the evaluation. Other factors, which include higher average daily temperatures during the catalyst treated segment of the evaluation increased the non-nominal use of the refrigeration unit on each bus; again, projecting a negative effect on positive fuel economy performance. These factors and others should have more than negated the improvement documented during the catalyst treated segment of this evaluation.

In summary, although idle time diminished and average load, average driving speed, average vehicle speed and bus refrigeration requirements all increased, during the catalyst treated segment of the evaluation, the bus fleet managed to demonstrate as much as a 4.8% reduction in fuel consumption.

The correlation between the extracted ECU data and the compiled CMB data certifies the efficacy of the CMB procedure, and substantiates the data collected for both segments of the evaluation. Statistically, the proximity of both sets of finished data to a succinct point of deviation suggests that the data is not only credible, but reliable. The CMB negates the effects of environmental, vehicle and human interaction, which frequently adversely skews the data beyond repeatability.

Conclusion

These carefully controlled engineering standard test procedures conducted on all of the test equipment; provide clear evidence of reduced fuel consumption in the range of 8.13%**.** In general, improvements utilizing the Carbon Mass Balance test, under static test conditions, generate results 2% - 3% (percentage points) less than those results generated with an applied load. However, engine design can and will produce data equal to or equivalent to data collected utilizing other methods of fuel evaluation. It should be noted that bus 474 accumulated only minimal miles and detracted from the overall average of the test fleet. With continued catalyst conditioning, bus 474 should see continued improvements aligning it with the improvements observed in busses 473, 475 and 477. Excluding the minimal improvement data collected from bus 474, the fleet average documented a fuel economy improvement, with the CMB, of 9.06%.

In addition to the fuel consumption analysis, a detailed compilation of carbon emissions reductions were determined. The study documented a significant reduction in annual C02 emissions of 805 metric tonnes. Reductions in Nitrogen and Methane levels were also observed.

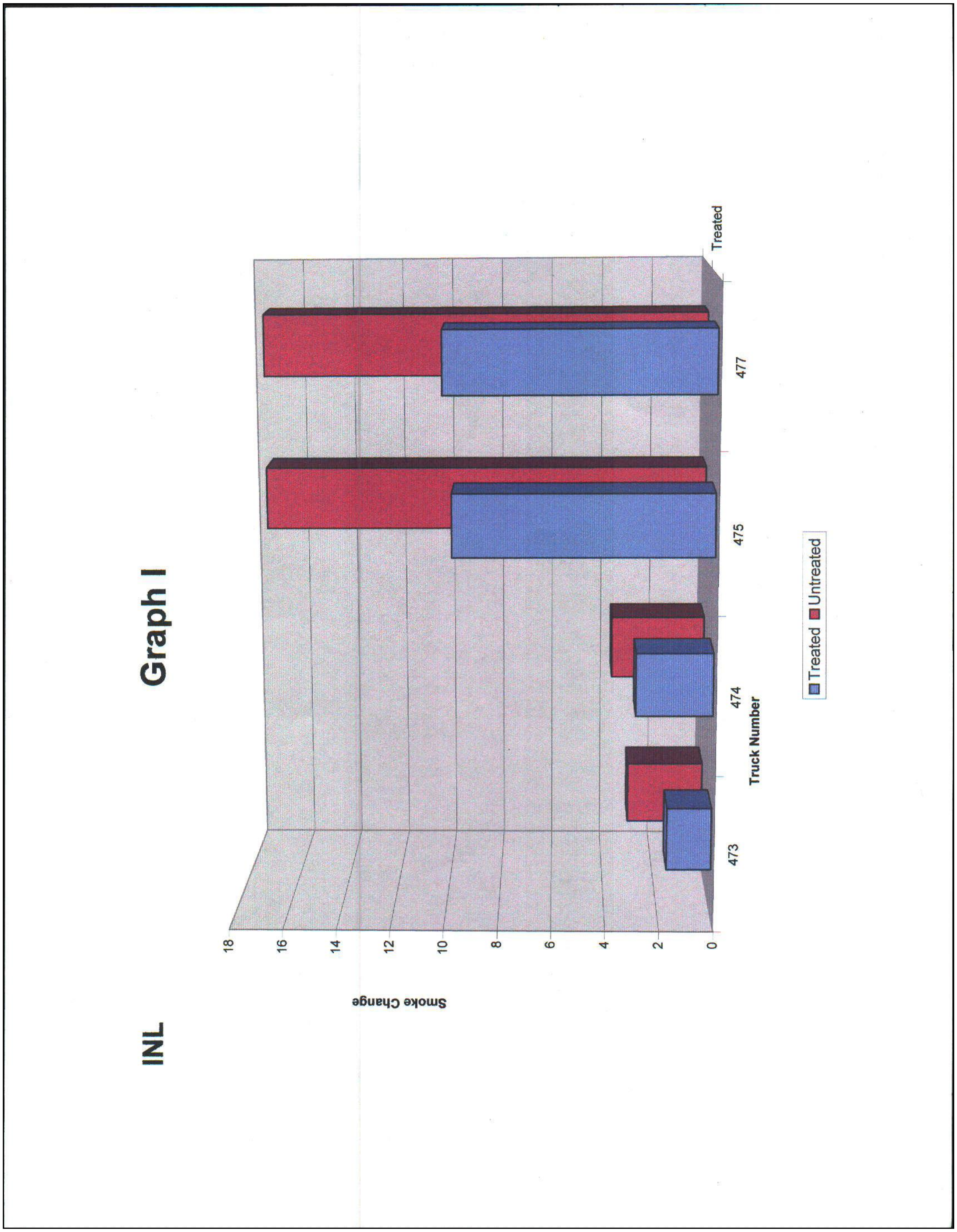
Further, the ECU propagated fuel consumption evaluation further documented the findings of the CMB evaluation. The data extracted from each of the truck mounted (on board) ECU's documented as much a 4.8% reduction in fuel consumption.

Fuel Factor X fuel catalyst's effect on improved combustion is also evidenced by the substantial reduction in soot particulates (smoke) in the range of 38% **(see Appendix I)**. Again, the soot particulate reductions showed a slightly lower composite average due to the minimal aggregate miles accrued on bus 474. Excluding the soot particulate data from 474, the fleet reduction in smoke was 43%.

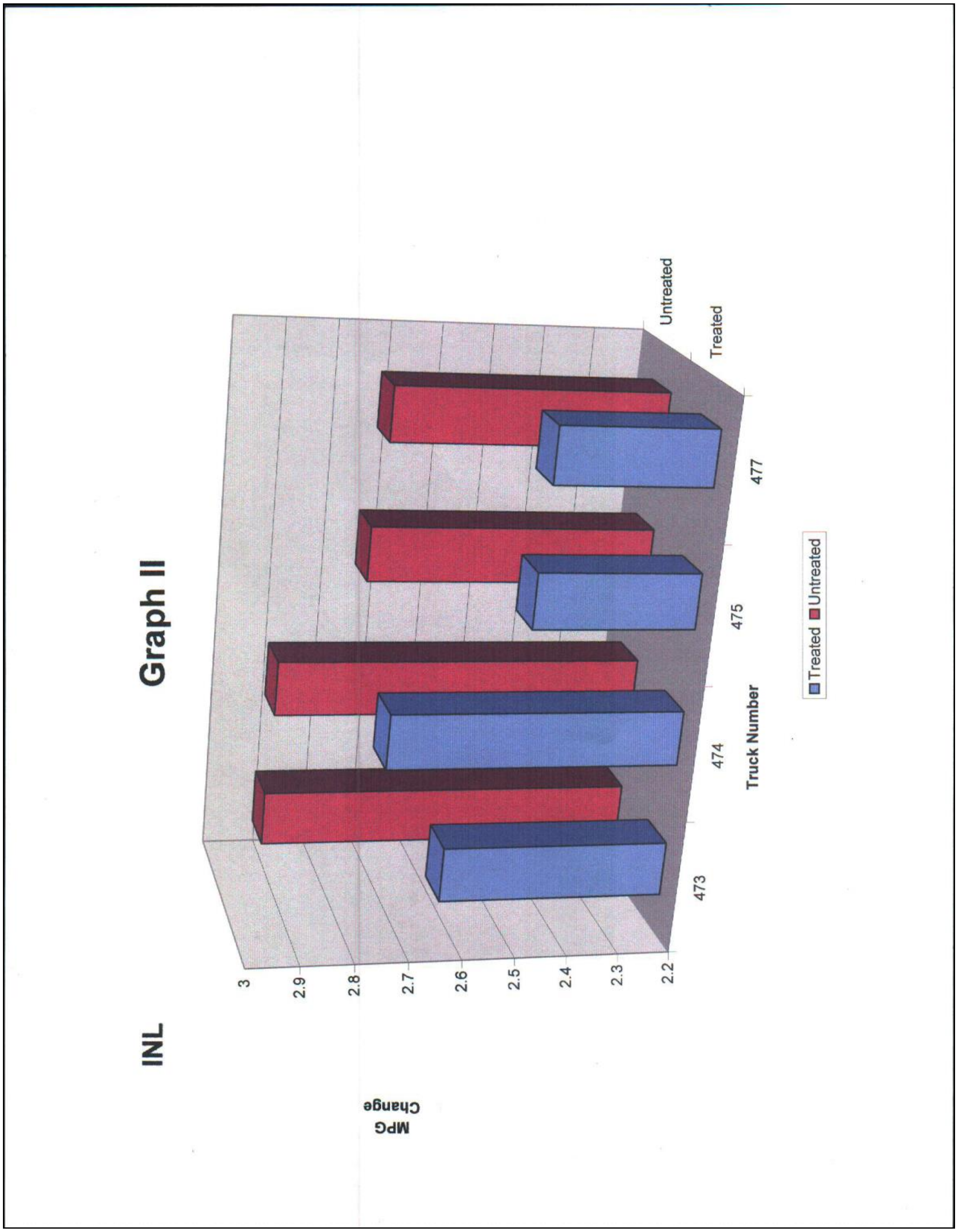
Additional to the fuel economy benefits measured and a reduction in soot particulates, a significant reduction, over time, in engine maintenance costs will be realized following treatment with Fuel Factor X. These savings are achieved through lower soot levels in the engine lubricating oil, which is a result of more complete combustion of the fuel. Engine wear rates are reduced resulting in less carbon build-up in the combustion area. Fuel Factor X also acts as an effective biocide should you experience water bottoms in fuel storage tanks; and, an excellent fuel system lubricant, which improves fuel system lubrication with today’s low sulphur diesel fuels.

Appendix I

Exhaust Particulate and Fuel Graphs



Soot Particulate Graph I



Fuel Consumption Graph

Appendix II

Carbon Mass Balance
Compilation Sheets

CARBON BALANCE RESULTS

COMPANY :	INL	LOCATION :	Scoville, Idaho
EQUIPMENT :	2005 Motor Coach	UNIT NR. :	473
ENG. TYPE :	Series 60 Detroit Diesel	MODEL :	Motor Coach Industries
RATING :	Private Hauler	FUEL :	Diesel; .840 Bio-diesel (B-20)

BASELINE TEST **DATE : 01/06/09**

ENGINE MILES:	324,687	ENG. RPM:	1500
AMB. TEMP (C) :	18.4	STACK(mm):	123.75
BAROMETRIC (mb)	1026	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	349	349	349	349	349	349	0.00
EXHST TEMP (C):	166.2	166.5	166.7	166.6	166.4	166	0.12
HC (ppm) :	9	10	10	9	10	9.6	5.71
CO (%) :	0.02	0.02	0.02	0.02	0.02	0.020	0.00
CO2 (%) :	2.98	2.99	2.98	2.99	2.99	2.99	0.18
O2 (%) :	10.18	10.20	10.21	10.20	10.22	10.20	0.15
CARB FLOW(g/s):	2.912	2.922	2.911	2.921	2.922	2.918	0.18
REYNOLDS NR. :	8.08E+04						

TREATED TEST **DATE : 011/8/09**

ENGINE MILES:	332,458	ENG. RPM:	1500
AMB. TEMP (C) :	18.7	STACK(mm):	123.75
BAROMETRIC(mb):	1023	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	349	349	349	349	349	349	0.00
EXHST TEMP (C):	166.5	166.7	166.8	166.7	166.8	167	0.07
HC (ppm) :	7	6	7	6	6	6.4	8.56
CO (%) :	0.01	0.01	0.01	0.01	0.01	0.010	0.00
CO2 (%) :	2.71	2.70	2.71	2.71	2.70	2.71	0.20
O2 (%) :	10.01	9.99	9.98	10.02	10.01	10.00	0.16
CARB FLOW(g/s):	2.636	2.625	2.635	2.635	2.625	2.631	0.21

REYNOLDS NR. : 8.07E+04 TOTAL HOURS ON TREATED FUEL : 7771

PERCENTAGE CHANGE IN FUEL CONSUMPTION ((TREATED-BASE)/BASE*100) : **-9.8 %**

REMARKS:

CARBON BALANCE RESULTS

COMPANY :	INL	LOCATION :	Scoville, Idaho
EQUIPMENT :	2005 Motor Coach	UNIT NR. :	474
ENG. TYPE :	Series 60 Detroit Diesel	MODEL :	Motor Coach Industries
RATING :	Private Hauler	FUEL :	Diesel; .840 Bio-diesel (B-20)

BASELINE TEST **DATE : 01/06/09**

ENGINE MILES:	267,805	ENG. RPM:	1500
AMB. TEMP (C) :	18.5	STACK(mm):	123.75
BAROMETRIC (mb)	1027	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	361	361	361	361	361	361	0.00
EXHST TEMP (C):	168.7	168.7	168.9	168.7	168.6	169	0.06
HC (ppm) :	11	11	10	11	10	10.6	5.17
CO (%) :	0.02	0.02	0.02	0.02	0.02	0.020	0.00
CO2 (%) :	2.94	2.93	2.94	2.92	2.93	2.93	0.29
O2 (%) :	10.34	10.32	10.30	10.32	10.30	10.32	0.16
CARB FLOW(g/s):	2.917	2.907	2.915	2.897	2.907	2.909	0.27
REYNOLDS NR. :	8.20E+04						

TREATED TEST **DATE : 011/8/09**

ENGINE MILES:	269,634	ENG. RPM:	1500
AMB. TEMP (C) :	18.7	STACK(mm):	123.75
BAROMETRIC(mb):	1025	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	361	361	361	361	361	361	0.00
EXHST TEMP (C):	168.8	169.1	169.3	169.2	169.1	169	0.11
HC (ppm) :	9	10	10	10	9	9.6	5.71
CO (%) :	0.01	0.02	0.02	0.01	0.01	0.014	39.12
CO2 (%) :	2.78	2.78	2.79	2.78	2.79	2.78	0.20
O2 (%) :	10.26	10.24	10.26	10.27	10.26	10.26	0.11
CARB FLOW(g/s):	2.746	2.755	2.764	2.745	2.755	2.753	0.29
REYNOLDS NR. :	8.19E+04						

TOTAL HOURS ON TREATED FUEL : 1829

PERCENTAGE CHANGE IN FUEL CONSUMPTION ((TREATED-BASE)/BASE*100) : **-5.3 %**

REMARKS:

CARBON BALANCE RESULTS

COMPANY :	INL	LOCATION :	Scoville, Idaho
EQUIPMENT :	2007 Motor Coach	UNIT NR. :	475
ENG. TYPE :	C-13 Caterpillar	MODEL :	Motor Coach Industries
RATING :	Private Hauler	FUEL :	Diesel; .840 Bio-diesel (B-20)

BASELINE TEST **DATE : 01/06/09**

ENGINE MILES:	99,977	ENG. RPM:	1500
AMB. TEMP (C) :	18.5	STACK(mm):	123.75
BAROMETRIC (mb)	1027	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	286	286	286	286	286	286	0.00
EXHST TEMP (C):	183.7	183.8	183.6	183.5	183.7	184	0.06
HC (ppm) :	9	10	10	10	10	9.8	4.56
CO (%) :	0.02	0.02	0.02	0.02	0.02	0.020	0.00
CO2 (%) :	3.16	3.18	3.16	3.18	3.18	3.17	0.35
O2 (%) :	10.36	10.38	10.34	10.36	10.34	10.36	0.16
CARB FLOW(g/s):	2.741	2.758	2.742	2.759	2.759	2.752	0.35

REYNOLDS NR. : 7.18E+04

TREATED TEST **DATE : 011/8/09**

ENGINE MILES:	105,111	ENG. RPM:	1500
AMB. TEMP (C) :	18.7	STACK(mm):	123.75
BAROMETRIC(mb):	1025	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	286	286	286	286	286	286	0.00
EXHST TEMP (C):	183.9	183.7	183.8	183.7	183.9	184	0.05
HC (ppm) :	6	5	5	5	5	5.2	8.60
CO (%) :	0.01	0.01	0.01	0.01	0.01	0.010	0.00
CO2 (%) :	2.91	2.90	2.90	2.91	2.90	2.90	0.19
O2 (%) :	10.27	10.28	10.28	10.29	10.28	10.28	0.07
CARB FLOW(g/s):	2.513	2.505	2.504	2.513	2.504	2.508	0.19

REYNOLDS NR. : 7.17E+04 TOTAL HOURS ON TREATED FUEL : 5134

PERCENTAGE CHANGE IN FUEL CONSUMPTION ((TREATED-BASE)/BASE*100) : **-8.9 %**

REMARKS:

CARBON BALANCE RESULTS

COMPANY :	INL	LOCATION :	Scoville, Idaho
EQUIPMENT :	2007 Motor Coach	UNIT NR. :	477
ENG. TYPE :	C-13 Caterpillar	MODEL :	Motor Coach Industries
RATING :	Private Hauler	FUEL :	Diesel; .840 Bio-diesel (B-20)

BASELINE TEST **DATE : 01/06/09**

ENGINE MILES:	96,604	ENG. RPM:	1500
AMB. TEMP (C) :	18.4	STACK(mm):	123.75
BAROMETRIC (mb)	1026	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	286	286	286	286	286	286	0.00
EXHST TEMP (C):	185.1	185.4	185.3	185.4	185.3	185	0.07
HC (ppm) :	9	9	9	8	9	8.8	5.08
CO (%) :	0.02	0.02	0.02	0.02	0.02	0.020	0.00
CO2 (%) :	3.14	3.16	3.16	3.15	3.16	3.15	0.28
02 (%) :	10.34	10.32	10.33	10.32	10.33	10.33	0.08
CARB FLOW(g/s):	2.718	2.735	2.735	2.725	2.735	2.730	0.27

REYNOLDS NR. : 7.17E+04

TREATED TEST **DATE : 011/8/09**

ENGINE MILES:	100,878	ENG. RPM:	1500
AMB. TEMP (C) :	18.6	STACK(mm):	123.75
BAROMETRIC(mb):	1027	LOAD:	Static

	TEST 1	*TEST 2*	*TEST 3*	*TEST 4*	*TEST 5*	AVERAGE	% ST.DEV
PRES DIFF (Pa):	286	286	286	286	286	286	0.00
EXHST TEMP (C):	185.1	185.3	185.5	185.3	185.5	185	0.09
HC (ppm) :	5	5	6	5	6	5.4	10.14
CO (%) :	0.01	0.01	0.01	0.01	0.01	0.010	0.00
CO2 (%) :	2.89	2.90	2.89	2.89	2.90	2.89	0.19
02 (%) :	10.25	10.26	10.25	10.26	10.26	10.26	0.05
CARB FLOW(g/s):	2.495	2.503	2.494	2.494	2.503	2.498	0.18

REYNOLDS NR. : 7.17E+04 TOTAL HOURS ON TREATED FUEL : 4274

PERCENTAGE CHANGE IN FUEL CONSUMPTION ((TREATED-BASE)/BASE*100) : **-8.5 %**

REMARKS:

Appendix III

Raw Data Sheets

473 5

Carbon Mass Balance Field Data Form

Company: INL Location: Scoville, Idaho Date: 6-1-09

Water Temp: 0 Oil Pres: 0 Fan Clutch: 0 Smoke No: 2.96 mg/m³ Exhaust Diameter: 123.75 ~~Inches~~ mm

Test Portion: Baseline: X Treated: ______ Engine Make/Model: 6-05 Motor Coach Ind. Air Inlet Velocity: 0

Exhaust Manifold Temp: 0 [✓ Miles]/Hours: 324687 ID#: 473 Fuel Specific Gravity: 20% Bio .840@17.1°C

Type of Equipment: Series 60 Detroit Diesel Bus Exhaust Side: Left Rear Barometric Pressure: 1026

RPM: 1500 Load: Static- Lights off - A.C. off- Flashers on Oil Pressure Temp. 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
Bio-Diesel	166.2°C	349	.02	9	2.98	10.18	18.4°C	Yes		9:29 Am.
	166.5°C	349	.02	10	2.99	10.20				
	166.7°C	349	.02	10	2.98	10.21				
	166.6°C	349	.02	9	2.99	10.20				
	166.4°C	349	.02	10	2.99	10.22	18.4°C			9:39 Am

P 473

Carbon Mass Balance Field Data Form

Company: INL Location: Scoville, Idaho Date: 8-11-09

Water Temp: 0 Oil Pres: 0 Fan Clutch: 0 Smoke No: 1.67mg/m³ Exhaust Diameter: 123.75 ~~Inches~~ mm

Test Portion: Baseline: ____ Treated: X Engine Make/Model: 6-05 Motor Coach Ind. Air Inlet Velocity: 0

Exhaust Manifold Temp: 0 [✓ Miles]/Hours: 332,458 ID#: 473 Fuel Specific Gravity: .840 @ 17.4°C

Type of Equipment: Series 60 Detroit Diesel Bus Exhaust Side: Left Rear Barometric Pressure: 1023

RPM: 1500 Load: Static - Flashers on - A.C off - Lights off Oil Pressure Temp. 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio Diesel	166.5°C	349	.01	7	2.71	10.01	18.7°C	Yes		10:37 A.m
	166.7°C	349	.01	6	2.70	9.99				
	166.8°C	349	.01	7	2.71	9.98				
	166.7°C	349	.01	6	2.71	10.02				
	166.8°C	349	.01	6	2.70	10.01	18.7°C			10:47 A.m.

474

Carbon Mass Balance Field Data Form

Company: INL Location: Sceville, Idaho Date: 6-1-07

Water Temp: 0 Oil Pres: 0 Fan Clutch: 0 Smoke No: 3.63 mg/m^3 Exhaust Diameter: 123.75 ~~Inches~~ mm

Test Portion: Baseline: X Treated: Engine Make/Model: 6-0-5 Motor Coach Ind. Air Inlet Velocity: 0

Exhaust Manifold Temp: 0 [✓ Miles]/Hours: 267805 ID#: 474 Fuel Specific Gravity: .840 @ 17.1°C

Type of Equipment: Series 60 Detroit Diesel Bus Exhaust Side: Left Rear Barometric Pressure: 1027

RPM: 1500 Load: static – Lights off – Flashers on – AC off Oil Pressure Temp. 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio Diesel	168.7°C	361	.02	11	2.94	10.34	18.5°C	Yes		10:35 A.m.
	168.7°C	361	.02	11	2.93	10.32				
	168.9°C	361	.02	10	2.94	10.30				
	168.7°C	361	.02	11	2.92	10.32				
	168.6°C	361	.02	10	2.93	10.30	18.6°C			10:45 A.m.

3.5
474

Carbon Mass Balance Field Data Form

Company: INL Location: Scoville, Idaho Date: 8-11-09

Water Temp: 0 Oil Pres: 0 Fan Clutch: 0 Smoke No: 2.87 mg/m3 Exhaust Diameter: 123.75 ~~Inches~~ mm

Test Portion: Baseline: ___ Treated: X Engine Make/Model: 6-05 Motor Coach Ind. Air Inlet Velocity: 0

Exhaust Manifold Temp: 0 [✓ Miles]/Hours: 269,634 ID#: 474 Fuel Specific Gravity: .840 @17.4°

Type of Equipment: Series 60 Detroit Diesel Bus Exhaust Side: Left Rear Barometric Pressure: 1025

RPM: 1500 Load: Static - AC off - Lights off - Flashers on Oil Pressure Temp. 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio-Diesel	168.8°C	361	.01	9	2.78	10.26	18.7°C	Yes		10:05 Am
	169.1°C	361	.02	10	2.78	10.24				
	169.3°C	361	.02	10	2.79	10.26				
	169.2°C	361	.01	10	2.78	10.27				
	169.1°C	361	.01	9	2.79	10.26	18.7°C			10:15 Am.

Carbon Mass Balance Field Data Form

Company: INL Location: Scoville, Idaho Date: 6-1-09

Water Temp: 0 Oil Pres: 0 Fan Clutch: 0 Smoke No: 17.17 mg/m³ Exhaust Diameter: 123.75 ~~Inches~~ mm

Test Portion: Baseline: X Treated: ___ Engine Make/Model: 3-07 Motor Coach Ind. Air Inlet Velocity: 0

Exhaust Manifold Temp: 0 [✓ Miles]/Hours: 99977 ID#: 475 Fuel Specific Gravity: .840@12.1°C

Type of Equipment: C-13 Caterpillar Bus Exhaust Side: Left Rear Barometric Pressure: 1027

RPM: 1500 Load: static - Lights off - AC off - Flashers on Oil Pressure Temp. 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio-Diesel	183.7°C	286	.02	9	3.16	10.36	18.5°C	Yes		10:11 Am.
	183.8°C	286	.02	10	3.18	10.38				
	183.6°C	286	.02	10	3.16	10.34				
	183.5°C	286	.02	10	3.18	10.36				
	183.7°C	286	.02	10	3.18	10.34	18.6°C			10:27 A-m.

710
4.5

Carbon Mass Balance Field Data Form

Company: INL **Location:** Scoville, Idaho **Date:** 8-11-09

Water Temp: 0 **Oil Pres:** 0 **Fan Clutch:** 0 **Smoke No:** 9.67 mg/m³ **Exhaust Diameter:** 123.75 ~~**Inches**~~ mm

Test Portion: Baseline: ____ **Treated:** X **Engine Make/Model:** 3-07 Motor Coach Ind. **Air Inlet Velocity:** 0

Exhaust Manifold Temp: 0 [✓ **Miles**]/**Hours:** 105111 **ID#:** 475 **Fuel Specific Gravity:** .840@17.4°c

Type of Equipment: C-13 Caterpillar Bus **Exhaust Side:** Left Rear **Barometric Pressure:** 1025

RPM: 1500 **Load:** Static - AC off - Lights off - Flashers on **Oil Pressure Temp.** 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio-Diesel	183.9°c	286	.01	6	2.91	10.27	18.7°c	Yes		9:10 Am
	183.7°c	286	.01	5	2.90	10.28				
	183.8°c	286	.01	5	2.90	10.28				
	183.7°c	286	.01	5	2.91	10.29				
	183.9°c	286	.01	5	2.90	10.28	18.7°c			9:20 Am

477 ● #8

Carbon Mass Balance Field Data Form

Company: INL **Location:** Scoville, Idaho **Date:** 6-1-09

Water Temp: 0 **Oil Pres:** 0 **Fan Clutch:** 0 **Smoke No:** 17.21 mg/m3 **Exhaust Diameter:** 123.75 ~~**Inches**~~ mm

Test Portion: Baseline: X **Treated:** ___ **Engine Make/Model:** 3-07 Motor Coach Ind. **Air Inlet Velocity:** 0

Exhaust Manifold Temp: 0 **[✓ Miles]/Hours:** 96,604 **ID#:** 477 **Fuel Specific Gravity:** .840 B17.82

Type of Equipment: C-13 Caterpillar Bus **Exhaust Side:** Left Rear **Barometric Pressure:** 1026

RPM: 1500 **Load:** Static - Flashers on - AC off - Lights off **Oil Pressure Temp.** 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio-Diesel	185.1°C	286	.02	9	3.14	10.34	18.4°C	Yes		9:46 Am
	185.4°C	286	.02	9	3.16	10.32				
	185.3°C	286	.02	9	3.16	10.33				
	185.4°C	286	.02	8	3.15	10.32				
	185.3°C	286	.02	9	3.16	10.33	18.5°C			9:56 A-m

477

Carbon Mass Balance Field Data Form

Company: INL **Location:** Scoville, Idaho **Date:** 8-11-09

Water Temp: 0 **Oil Pres:** 0 **Fan Clutch:** 0 **Smoke No:** 9.98 mg/m³ **Exhaust Diameter:** 123.75 ~~Inches~~ mm

Test Portion: Baseline: ~~0~~ N.A. **Treated:** X **Engine Make/Model:** 3-07 Motor Coach Ind. **Air Inlet Velocity:** 0

Exhaust Manifold Temp: 0 [✓ **Miles**]/**Hours:** 100,878 **ID#:** 477 **Fuel Specific Gravity:** .840@12.4°C

Type of Equipment: C-13 Caterpillar Bus **Exhaust Side:** Left Rear **Barometric Pressure:** 1027

RPM: 1500 **Load:** Static - Flashers on - AC off - Lights off **Oil Pressure Temp.** 0

Fuel Type	Exhaust Temp °C	P Inches Of H_2O	CO	HC PPM	CO_2	02	Ambient Temp. C.	Instrument Calibration	Observer	Time Begin To Time End
20% Bio-Diesel	185.1°C	286	.01	5	2.89	10.25	18.6°C	Yes		9:31 Am
	185.3°C	286	.01	5	2.90	10.26				
	185.5°C	286	.01	6	2.89	10.25				
	185.3°C	286	.01	5	2.89	10.26				
	185.5°C	286	.01	6	2.90	10.26	18.6°C			9:41 am

Appendix IV

Carbon Footprint Data

Calculation of Greenhouse Gas Reductions

Assumptions: **Fleet Average (all locations)**

* Fuel Type = Diesel
*Annual Fuel Usage = 1,000,000 gallons, or 3,800,000 litres.
*Average 8.1% reduction in fuel usage with Fuel Factor X fuel catalyst.

Discussion:

When fuel containing carbon is burned in an engine, there are emissions of carbon dioxide (CO_2, methane (CH_4), nitrous oxide (N_20), oxides of nitrogen (NO_x), carbon monoxide (CO), non methane volatile organic compounds (NMVOC's) and sulfur dioxide (SO_2). The amount of each gas emitted depends on the type and quantity of fuel used (the "activity"), the type of combustion equipment, the emissions control technology, and the operating conditions.

The International Greenhouse Partnerships Office section of the Federal Government Department of Science Industry and Technology has produced a workbook outlining how to calculate the quantities of greenhouse gas emissions (see Workbook attached) and is accepted internationally as the accepted approach. The workbook illustrates an example of how to calculate the mass of CO_2 for example on page 21, Table 3.1 and Example 3.1:

> The CO_2 produced from burning 100 litres of diesel oil is calculated as follows:
>
> * the CO_2 emitted if the fuel is completely burned is 2.716 kg CO2/litre (see Appendix A, Table A1)
>
> * the oxidation factor for oil-derived fuels is 99% (see Table 3.1)
> Therefore, the CO_2 produced from burning 100 litres of fuel is:
>
> 100 litres x 2.716 kg CO_2/litre x .99 = 268.88 kg

Based on the above calculations, the Greenhouse gas reductions for C02 are as follows:

Test Data Basis	Fuel Usage litres	kg CO_2 per litre fuel	Oxidation Factor	System CO_2 kg	System CO_2 tonnes
"Baseline"	3,800,000	2.716	0.99	10,195,020	10,195
"Treated"	3,492,200	2.716	0.99	9,389,967	9,390
C02 reductions with Fuel Factor X fuel catalyst				**798,277**	**805**

The reduction of C02 greenhouse emissions in the amount of 805 tonnes (888 tons) is significant! Carbon Dioxide accounts for approximately 99.6% of the total greenhouse gas emissions produced. In other words, when diesel oil is burned in an internal combustion engine, the CH4 and N20 emissions contribute less than 0.4% of the greenhouse emissions. This low level is typical of most fossil fuel combustion systems and often is not calculated.

However, by way of additional information, the reduction in CH_4 and N_20 are calculated as follows:

CH_4 Emissions Reduction

* the specific energy content of the fuel is 36.7 MJ/litre (see Table A1), so the total energy in 100 litres is 3,670 MJ, or 3.67 GJ

* the CH_4 emissions factor for diesel oil used in an internal combustion engine is 4.0 g/GJ (see Table A2) so the total CH_4 emitted is 3.67 x 4 = 18.0g

"Baseline" [18.0g/100 litres] x [3,800,000] x [1kg/1000g] = 684 kg

"Treated" [18.0g/100 litres] x [3,492,200] x [1kg/1000g] = 629 kg

CH_4 Reduction = 55 kg

N_2O Emissions Reduction

* the N_2O emissions factor for diesel oil used in an internal combustion engine is 1,322 g/GJ so the total N2O emitted is 3.67 x 0.6 = 2.7 g

"Baseline" [2.7g/100 litres] x [3,800,000] x [1kg/1000g] = 103 kg

"Treated" [2.7g/100 litres] x [3,492,200] x [1kg/1000g] = 94 kg

N_2O Reduction = 9 kg

Appendix V

Estimated Fuel Savings

Estimated Monthly and Annual Fuel Savings With Catalyst Use

The attached information is included as an estimate only and is utilized to establish the magnitude of cost savings derived through the use of the Fuel Factor X Fuel Catalyst. All numbers are estimates and should not be considered absolute values.

Estimated: CMB

	Carbon Balance Estimate Only!
Monthly Fuel Consumption:	83,333 gals. .
Monthly Fuel Costs ($2.25/gal.):	$187,499.00
Improvement in Fuel Efficiency:	.081
Monthly Gross Fuel Savings:	$15,187.00

Estimated Gross Annual Savings Based On 1,000,000 Gallons of Diesel Fuel Consumed:	**$182,249.00**

Using the fuel savings data produced from the Carbon Mass Balance test procedure, the results show that Idaho National Laboratories could potentially reduce annual fuel consumption costs by a minimum of $182,249.00. Other cost reducing factors that will enhance the use of the Fuel Factor X fuel catalyst include reduced repairs due to carbon related failures; extended oil change intervals as experienced by other Fuel Factor X fuel catalyst customers; reduced fuel system repairs with the additional fuel system lubricant contained in the catalyst; and, increased engine life. These factors and many more are the reason that so many companies are opting to implement Fuel Factor X fuel catalyst as part of their preventive maintenance program.

Other benefits in using Fuel Factor X fuel catalyst are as follows:

Demulsifier:	Removes water from fuel.
Biocide:	Helps control bacterial growth in fuel.
Polymerization Retardant:	Helps prevent the formation of solids in fuel.
Dispersant:	Helps to eliminate existing solids in fuel.
Lubricant:	Lubricates the fuel system (fuel pump and injectors).
Detergent:	Cleans the fuel pump and injectors.
Corrosion Inhibitor:	Protects against fuel tank corrosion.
Metal Deactivator:	Prevents catalytic oxidation.