Camden Council Biodiesel Trial

Third and Final Progress Report

June 2004

Vehicle Emissions Management
Roads and Traffic Authority
Centennial Plaza
260 Elizabeth Street

Table of Contents

EXECUTIVE SUMMARY

This report presents the results of exhaust emissions, fuel consumption and power tests on two waste collection vehicles operated by Camden Council using diesel and biodiesel fuels.

The standard fuel used as the reference for this program was automotive ultra low sulphur diesel (less than 50ppm). The biodiesel test fuel was B100 (100% biodiesel).

The two diesel vehicles used were International ACCO2350G waste collection vehicles powered by Cummins ISC 250 HP engines and fitted with Alison MD 3560 PR 5 speed automatic transmissions.

Each truck was operated on two garbage collection routes for a total of 600 hours of operation. After about 300 hours of operation the two vehicles swapped from one route to the other but each driver stayed with the original route they were assigned to. Testing occurred at approximately 160 hours, 450 hours and 600 hours.

The vehicles were tested using the dynamometer test method and equipment specified in the National Environment Protection (Diesel Vehicle Emissions) Measure for in-service vehicles – the DT80 test. Measurements of smoke opacity, particulate matter (PM), oxides of nitrogen (NOx), hydrocarbons (HC), carbon dioxide (CO_2) and power were taken. In addition, a range of air toxics was measured during the first round of testing, including volatile organic compounds (VOC), carbonyls and polycyclic aromatic hydrocarbons (PAH). Fuel consumption (FC) was calculated using the carbon balance method. The results of tests using automotive ultra low sulphur diesel and B100 were compared.

For B100 biodiesel fuel it was found that significant reductions were achieved for:

- Smoke (79%)
- PM emissions (91%)
- HC emissions (68%)
- CO2 emissions (4%)
- Power at 80 kph (17%)

The B100 biodiesel fuel had no significant affect on NOx emissions and fuel consumption.

The affect of the B100 biodiesel fuel on air toxics was found to be:

- Emission rates of the priority VOCs were significantly reduced. Styrene increased
- C1 – C3 aldehyde compounds were generally unaffected except possibly acetaldehyde, which showed some decrease
- PAH compounds decreased by 75%, although for both fuels, the PAH levels were generally close to detection limits therefore these observations should be treated as indicative only.

1.0 INTRODUCTION

This report describes a project, which was designed to establish the effect of replacing diesel with 100 percent biodiesel (B100) fuel on the exhaust emissions of waste collection vehicles operated by Camden Council.

2.0 BACKGROUND

Diesel vehicles make a disproportionately high contribution to air pollution from the transport sector. Emissions from diesel vehicles have the potential to cause adverse health effects and detract from urban amenity.

Fuel has been shown to have a significant effect on the emissions of a diesel vehicle. Alternatives to diesel, such as biodiesel, may offer both greenhouse and air quality benefits when used in combination with diesel or alone.

Camden Council have received funding from the NSW Department of Environment and Conservation (DEC) for a trial which is primarily intended to demonstrate the viability of operating their fleet of waste collection vehicles on 100 percent biodiesel (B100). With funding support from Department of the Environment and Heritage the RTA have provided emissions testing services to enable a comparison of the emission performance of the fuels to be made.

A recent paper by the United States Environment Protection Authority has also reported on the results of testing of biodiesel. These tests have shown B100 provides a significant reduction in particulates but may result in some increase in oxides of nitrogen. Camden Council will be working with the manufacturers of the engines of the test vehicles, Cummins, to attempt to minimise any increase in oxides of nitrogen emissions.

The DT80 test, developed by the National Environment Protection Council as an in-service test for diesel vehicles, meets the criteria for this project. The test has been used to date on almost 3,000 vehicles in Australia. An analysis of test results shows that the test is repeatable and that it can effectively discriminate between low and high emitting vehicles. A further benefit of this test method is that the test equipment can be made portable and can be moved to fleet premises.

3.0 PROJECT DESIGN

The emissions testing program was designed to provide an assessment of the effects on tailpipe emissions of oxides of nitrogen (NOx), particulates (PM) and smoke (opacity) when B100, rather than diesel, is used in the Council's fleet of waste collection vehicles. Some measurements were also made to assess the effect of the fuel change on toxic emissions, carbon dioxide and engine power.

The impact of this change in fuel type on fuel consumption, noise or odours, engine and fuel system wear or engine life and operability is outside the scope of the emission testing component of the Camden project, but may be included within the scope of the complete project.

4.0 EXPERIMENTAL AND TESTING PROTOCOL

4.1 Test Program

Two trucks are being used in the test program. They are each being operated on two garbage collection routes. Two drivers have been assigned to the program. The program is summarised in Table1.

Table 1: Program summary

	First 150 hrs operation		**Second 150 hrs operation**	**Third 150 hrs operation**	**Fourth 150 hrs operation**	
Test Phase		**1**		**2**		**3**
Truck 1						
Driver	1		1	2	2	
Fuel	Biodiesel		Biodiesel	Biodiesel	Biodiesel	
Route	1		1	2	2	
Truck 2						
Driver	2		2	1	1	
Fuel	Diesel		Diesel	Diesel	Diesel	
Route	2		2	1	1	

	Emissions Testing for Phase 2 occurred in the period from 300 to 450 hours of operation. For Phase 3 each vehicle was tested on both fuels.

4.2 Test Method

Two test methods were used for this project. They were the DT80 test as outlined in Attachment A and the D550 test as outlined in Attachment B.

4.3 Test Vehicles

The two test vehicles used for this trial were International ACCO 2350G waste collection vehicles powered by Cummins ISC 250 HP engines and fitted with Alison MD 3560 PR 5 speed automatic transmissions.

4.4 Test Fuels

The test fuels used were:

- Automotive Ultra Low Sulphur (50ppm) Diesel meeting the Australian standard for automotive diesel set under the Fuel Quality Standards Act 2000; and
- B100 biodiesel. The B100 biodiesel did not meet the Australian standard for biodiesel set under the Fuel Quality Standards Act. More detail on the parameters that were off-specification is provided at 5.0 Project Overview and at Attachment D.

Prior to the commencement of emissions testing both trucks had sufficient operation to ensure that the fuel tank contained only the test fuel and that any traces of the previous fuel used had been flushed out.

4.5 Tailpipe Emissions

Tailpipe emissions measured were:

- Oxides of nitrogen (NOx) (g/km/t)
- Particulate matter (PM) (mg/km/t))
- Average and maximum smoke opacity (%)
- Total hydrocarbons (HC) (mg/km/t)
- Carbon dioxide (CO_2) (g/km/t)

Fuel consumption, based on the carbon balance method, was calculated from the emissions of total hydrocarbon and carbon dioxide.

Maximum power developed at the rear wheels on the dynamometer at 80 kph was measured and recorded at the end of each test.

The following air toxics were sampled and measured in Phase 1 only:

- Volatile organic compounds (VOC)
    - Benzene,
    - Toluene,
    - Xylenes,
    - 1,3-Butadiene.
- Carbonyls
    - Formaldehyde,
    - Acetaldehyde,
    - Acrolein,
    - Acetone
    - Propionaldehyde.
- Polycyclic aromatic hydrocarbons (PAH)
    - The eighteen US EPA listed priority compounds plus 2-methylnapthalene

4.6 Other Parameters

A number of other parameters were also measured and recorded during testing for use in determining emissions. They are not reported but included:

- Ambient temperature, relative humidity and barometric pressure
- Test duration
- Diluted exhaust sample temperature

4.7 Testing Sequence

The testing sequence followed is set out in Table 2 below. Prior to the commencement of testing, each vehicle was installed on the dynamometer and warmed up.

Table 2: Testing sequence

Test Cycle	Fuel	Comment
Vehicle 1		
DT80	Diesel	Conditioning cycle (Not used for analysis)
Idle	Diesel	Allows for data recording and resetting instruments
DT80	Diesel	Testing cycle (Used for analysis)
Idle	Diesel	Allows for data recording and resetting instruments
DT80	Diesel	Testing cycle (Used for analysis)
Idle	Diesel	Allows for data recording and resetting instruments
D550	Diesel	Testing cycle (Run at request of CSIRO for air toxics in

Test Cycle	Fuel	Comment
		Phase 1 testing only)
Vehicle 2		
DT80	B100	Conditioning cycle.
Idle	B100	Allows for data recording and resetting instruments
DT80	B100	Testing cycle.
Idle	B100	Allows for data recording and resetting instruments
DT80	B100	Testing cycle.
Idle	B100	Allows for data recording and resetting instruments
D550	B100	Testing cycle (Run at request of CSIRO for air toxics in Phase 1 testing only)

4.8 Data Analysis and Reporting

For each fuel that was tested two DT80 test cycles and one D550 test cycle was run as per Table 2 on the diesel reference fuel and on the biodiesel test fuel. The two DT80 test results for each fuel were averaged and compared. The results for the single D550 test on each fuel were also compared. The D550 tests were not performed during Phase 2 or Phase 3 of the testing program.

5.0 PROJECT OVERVIEW

Diesel Test Australia (DTA) were contracted to provide testing services to the Roads and Traffic Authority for this project. They in turn then engaged the services of CSIRO to undertake the sampling and analysis of the air toxics component of the program and Intertek to undertake fuel analysis. DTA commenced testing Camden Council's fleet on 13 October 2003 after setting up their equipment in the Council's Works Depot at Narellan.

By October 17, 2003 both biodiesel trial vehicles together with 14 other vehicles from Camden Council's fleet had been tested. The biodiesel truck (XXG 983) and the diesel reference truck (XYG 403) were services on October 15 after approximately 160 and 178 hours of operation respectively, and then tested the next day (Phase 1 testing). Regulated tailpipe emissions as well as air toxics were sampled and measured. Maximum power at 80 kph was also measured.

Fuel samples were taken from both trial vehicles during Phase 1 testing and these were sent for analysis. The laboratory analysis report for the diesel sample indicates compliance with the Australian standard for automotive diesel set under the Fuel Quality Standards Act 2000. The level of sulphur was recorded as 30ppm. A copy of the certificate of analysis is at Attachment D1. The biodiesel analysis certificate indicates that the fuel did not comply with the fuel quality standard for ester content, which recorded a value of 93.2% (refer to Attachment D2). This is slightly below the minimum specified value of 96.5%.

Phase 2 testing on the biodiesel truck and the diesel truck was done on February 4 and February 5, 2004 respectively where fuel samples were taken for analysis. The laboratory test reports for the fuel samples revealed that the biodiesel fuel was off grade for at least 4 parameters (refer to Attachment D4) and thus did not comply with the fuel quality standard. The sulphur content for the diesel fuel sample was found to be marginally out of specifications for ultra low sulphur diesel at 60ppm (refer to Attachment D3).

The third and final emission test phase was completed on 14 April 2004 when the biodiesel truck was tested on both biodiesel and diesel fuel. The diesel reference truck had previously undergone its final testing on 6 April when it was tested on both diesel and biodiesel fuel. Subsequent analysis of the biodiesel fuel present in the biodiesel truck during emissions testing, and a sample taken from Council's storage tank and used for testing the diesel truck on biodiesel, revealed that the biodiesel did not comply with the fuel quality standard. The laboratory analysis reports for the biodiesel fuel samples are at Attachment D6 and D8 where they show that the samples were off grade for twelve of the twenty-one tests performed. Attachment D5 and D7 provide the laboratory analysis reports for the diesel fuel samples. These show that the diesel fuel complied with the fuel quality standards.

6.0 RESULTS

6.1 Tailpipe Emissions – Phase 1

6.1.1 DT80 Emissions

The DT80 tailpipe emissions as well as maximum power and fuel consumption for the biodiesel truck and the diesel reference truck for Phase 1 are summarised in Table 3 below. Detailed results for both vehicles, as well as the results for another 14 of Camden Council's diesel trucks, are contained in Attachment C1.

Table 3: Phase 1 DT80 results for the diesel and biodiesel vehicles

Vehicle	**Average Opacity (%)**	**PM (mg/km/t)**	**NOx (g/km/t)**	**HC (mg/km/t)**	**CO_2 (g/km/t)**	**FC (L/100km)**	**Maximum Power (kW) (at 80kph)**
Diesel	0.49	1.72	0.48	4.62	90.5	60.6	121
Diesel	0.52	1.48	0.51	4.44	89.9	60.3	121
Average for diesel truck	0.51	1.60	0.49	4.53	90.2	60.5	121
Biodiesel	0.01*****	0.30	0.47	1.69	84.5	60.5	106
Biodiesel	0.13*****	0.31	0.48	1.90	85.0	60.9	106
Average for biodiesel truck	0.07	0.30	0.47	1.79	84.7	60.7	106
Percentage difference between average for each truck	-86.1	-81.2	-4.1	-60.4	-6.0	+0.4	-12.4

***NOTE:** There is a large difference between the two smoke opacity results for the biodiesel truck that is not evident in any of the other results.

The biodiesel and the diesel reference vehicle are both International ACCO 2350G trucks fitted with Cummins engines. Figures 1, 2 and 3 compare the emissions of the two trial vehicles with six other International ACCO 2350G vehicles from the Council's fleet.

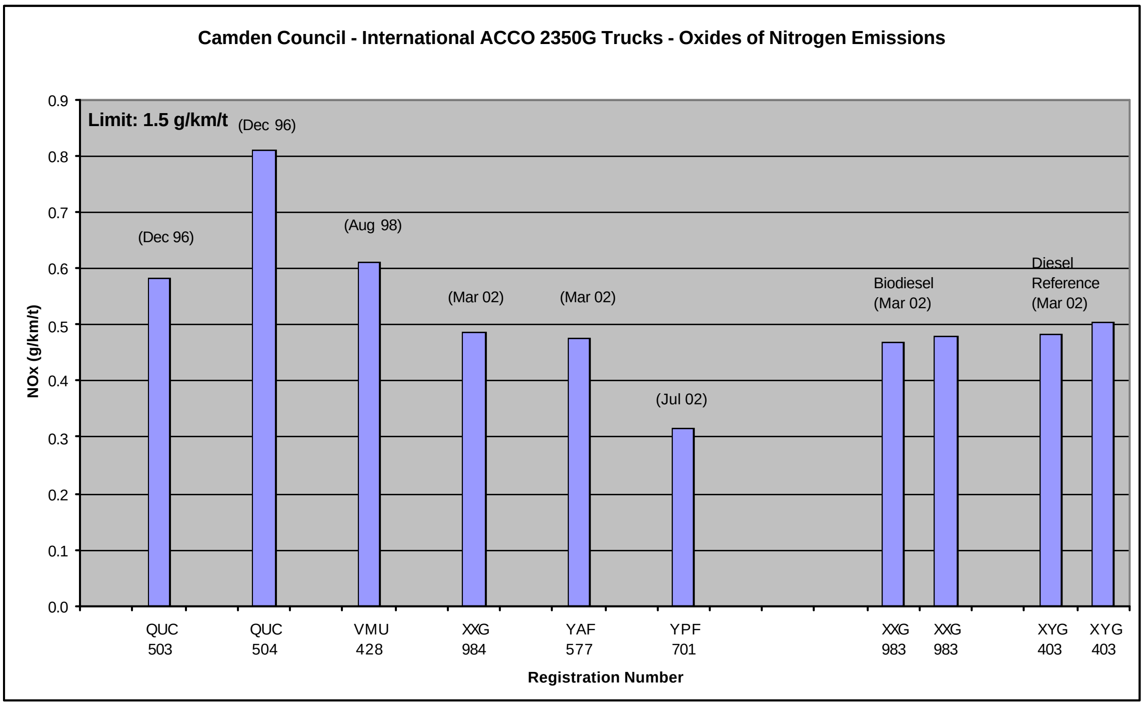


Figure 1: Phase 1 NOx results for trial and other council fleet vehicles

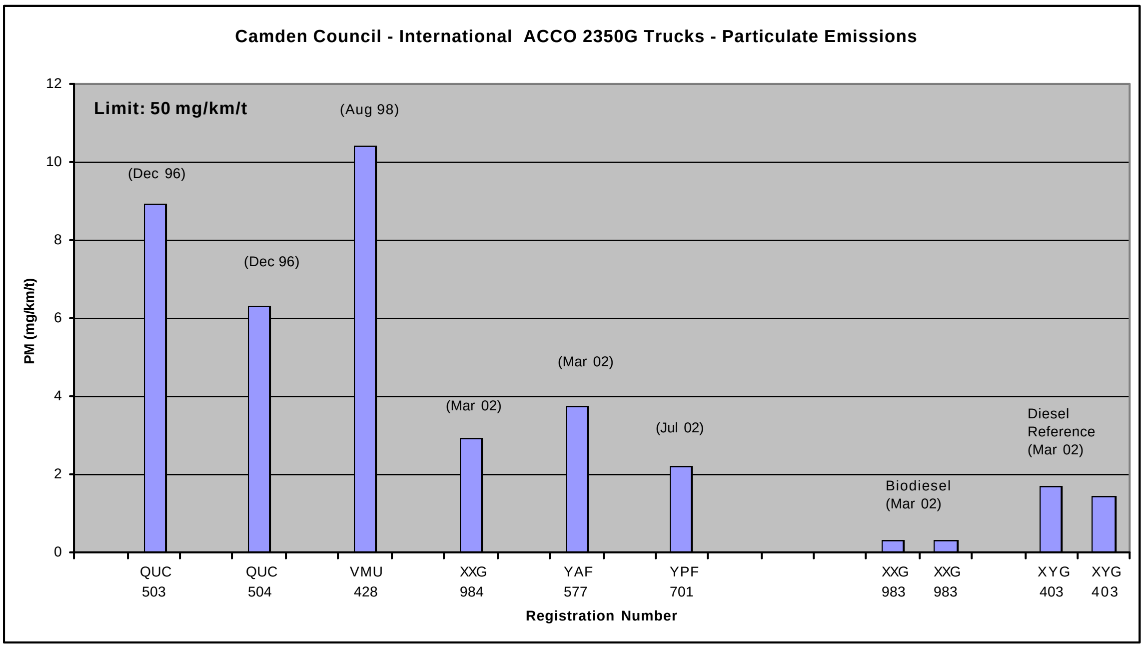


Figure 2: Phase 1 PM results for trial and other council fleet vehicles

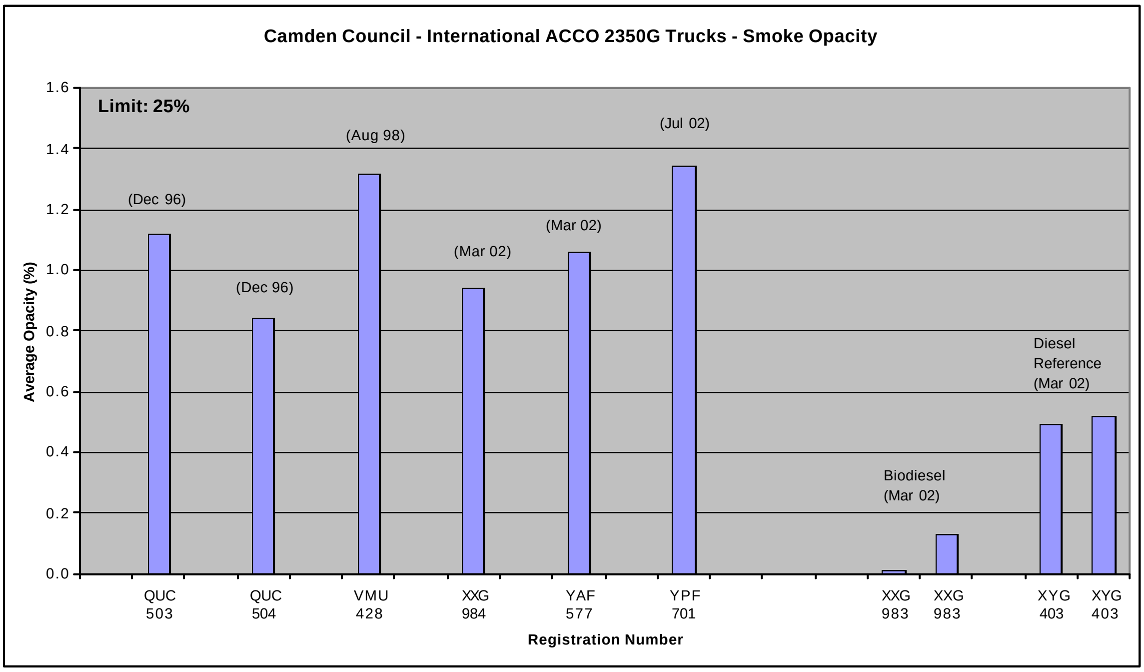


Figure 3: Phase 1 Opacity results for trial and other council fleet vehicles

As can be seen from Table 3 there was an improvement in opacity, PM and NOx when comparing the biodiesel truck with the diesel reference truck. However, fuel consumption increased and there was a drop in maximum power. A note of caution is given here that these results may include differences that may be due in part to the relative emissions performance of each vehicle as well as a difference in the fuels.

The average opacity and PM results for the two test vehicles are much better than the average from six other vehicles of similar make from Council's fleet and, but to a much lesser degree, so are the NOx results as seen in Figures 1 to 3. This may be due in part to the test vehicles being specially prepared for the trial and in part to being originally certified to a lower emission standard. The emissions from both test vehicles are also significantly lower than the in-service limit for their class.

In comparing the biodiesel truck results with the diesel reference truck results there is an 82% reduction in PM emissions and an 86% reduction in average smoke opacity. The reduction in PM emissions for the biodiesel truck when compared to the diesel reference truck is within the range of spread of results from other studies (US EPA report – A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions). The US EPA study does not report smoke opacity results.

The biodiesel truck had 4% lower NOx emissions than the diesel reference truck and this suggests that the efforts of Cummins in optimising for biodiesel has been successful. Other studies (US EPA report) have shown an increase, from slightly below zero to about 25%, in NOx if B100 is used. The improved NOx performance has not been at the expense of PM or smoke.

The smoke opacity results for the biodiesel truck show a large difference between the two tests. This was investigated, as it was not sure if the difference was due to a change in the vehicle during testing or a problem had developed with the smoke opacity meter and sampling system. An examination of the second-by-second opacity data for the second test revealed an unusually large peak in the data that is not consistent with other tests or with either of the other acceleration modes for that test. Also, an inspection of the PM and NOx second-by-second data did not show a corresponding peak thus indicating that there had not been a change in the vehicle during either test. Discussions with DTA seem to suggest that these abnormally high opacity peaks do occur infrequently and are possibly caused by soot that has built up on the inside wall of the sample hose breaking away and being drawn through the analyser. In addition, the two trial vehicles are very clean when it comes to visible smoke and this has meant that the opacity meter was operating at the very low end of its capabilities.

The fuel consumption results show a slight increase and this is to be expected. They have been included for comparative purposes only as the actual on-road fuel usage will be the definitive parameter for determining the benefits for fuel consumption.

6.1.2 D550 Emissions

For the purpose of air toxics sampling and measurement, CSIRO requested the D550 cycle be run in addition to the two DT80 tests. The D550 test is a steady state test at constant load equivalent to a fully laden truck negotiating a 5% gradient at 50km/h. Dynamometer loading was set at 90kW at 50km/h for these tests. Table 4 shows the emissions results from the single D550 test done on the biodiesel and diesel reference vehicle. As can be seen from Table 4 the emissions of average opacity and PM for the biodiesel truck are lower than for the diesel truck while NOx emissions are higher.

Table 4: Phase 1 D550 test results for the diesel and biodiesel vehicles

Vehicle	**Average Opacity (%)**	**PM (mg/km/t)**	**NOx (g/km/t)**	**HC (mg/km/t)**	**CO_2 (g/km/t)**	**FC (l/100km)**
Diesel	0.44	0.604	0.496	3.46	88.6	59.4
Biodiesel	0.05	0.129	0.536	2.74	93.5	67.0
Percentage difference between each truck	-88.6	-78.6	+8.1	-21.0	+5.6	+12.9

The average opacity and PM results on the D550 test for the biodiesel truck are substantially lower than for the diesel reference truck (89% and 79% lower respectively). The results are similar in magnitude to the difference achieved between the biodiesel truck and the diesel reference truck for the DT80 test. HC emissions for the biodiesel truck were 21% lower than the diesel reference truck. For the D550 test, NOx was 8% higher for the biodiesel truck than for the diesel reference truck. This is more in line with results from other studies. CO_2 emissions and fuel consumption both increased for the biodiesel truck by 6% and 13% respectively over the diesel reference truck.

6.2 Toxic Emissions – Phase 1

A summary of CSIRO's results is presented below. The full complement of results and a discussion of the results can be found in CSIRO's report ET/IR 656 at Attachment E to this report.

6.2.1 VOC Emissions

Biodiesel fuel produced a significant reduction in emission rates of VOC compounds, as can be seen in Figure 4 (Source: CSIRO Report ET/IR 656).

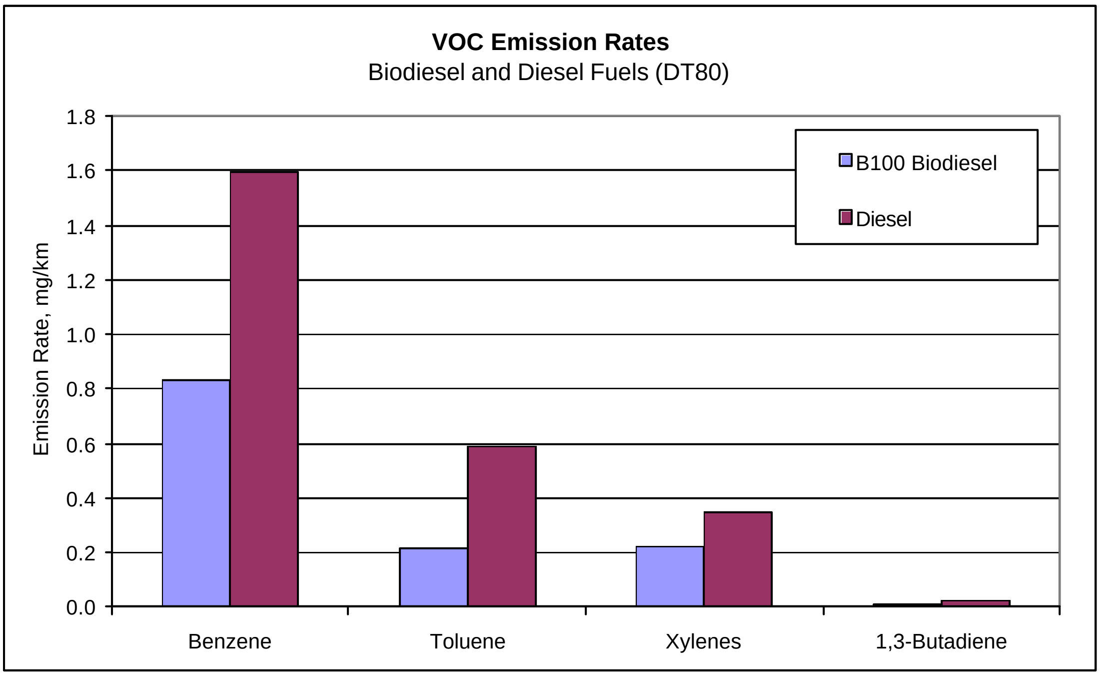


Figure 4: Comparison of VOC emission rates (mg/km) for biodiesel and diesel trucks

6.2.2 Aldehyde Emissions

With the exception of acetaldehyde, emissions of C1 – C3 aldehydes were similar for diesel and B100 biodiesel, as can be seen in Figure 5 (Source: CSIRO Report ET/IR 656).

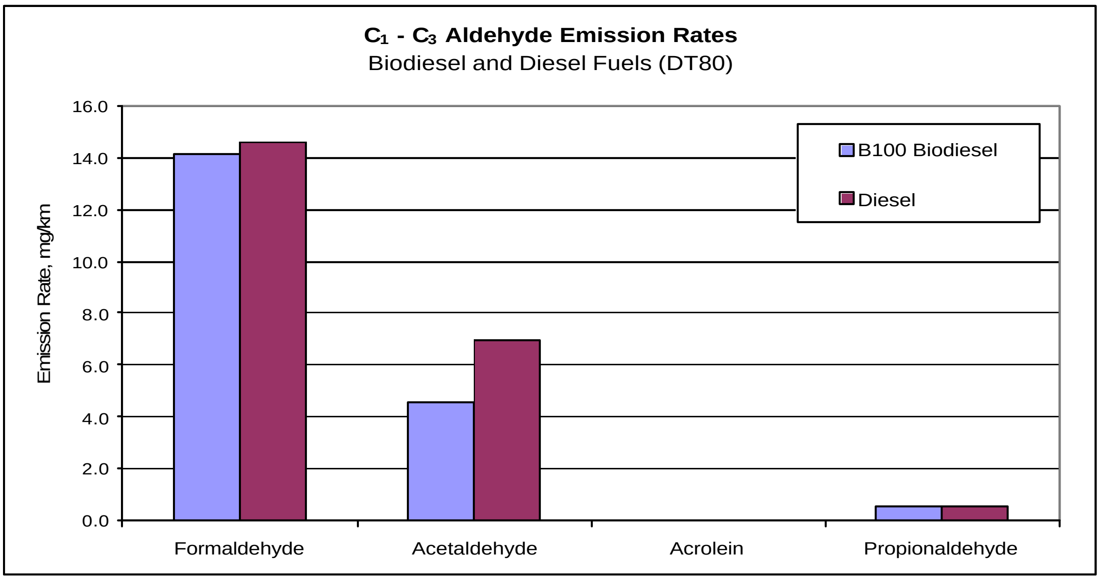


Figure 5: Comparison of $C_1 – C_3$ aldehyde emission rates (mg/km) for biodiesel and diesel trucks

6.2.3 PAH Emissions

Of the PAH components measured, most were close to the analytical detection limit so results should be treated with caution. Figure 6 (Source: CSIRO Report ET/IR 656) shows the results for PAH detected in the exhaust, and most of these are vapour phase components.

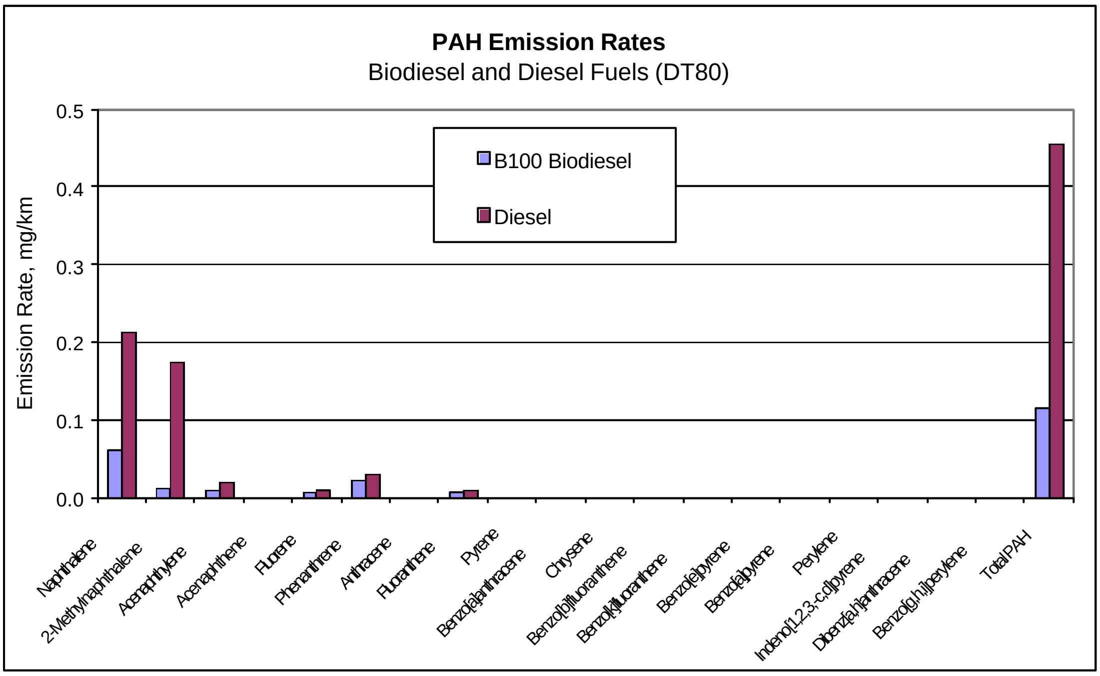


Figure 6: Comparison of PAH emission rates (mg/km) for biodiesel and diesel truck

6.3 Tailpipe Emissions – Phase 2

The emissions of average opacity, PM, NOx and CO_2 for Phase 2 are shown in Table 5 for the DT80 test together with fuel consumption and maximum power. The HC emissions were not measured during Phase 2. Detailed results are at Attachment C2. The Table shows a reduction in opacity, PM and CO_2, and an increase in NOx emissions for the biodiesel truck compared to the diesel truck. Fuel consumption increased and there was a drop in maximum power. Here again a note of caution is given that these results may include differences that may be due in part to the relative emissions performance of each vehicle as well as a difference in the fuels.

Table 5: Phase 2 DT80 results for the diesel and biodiesel vehicles

Vehicle	Average Opacity (%)	PM (mg/km/t)	NOx (g/km/t)	CO_2 (g/km/t)	FC (l/100km)	Maximum Power (kW) (at 80kph)
Diesel	0.69	2.97	0.41	89.9	60.3	129
Diesel	0.73	3.24	0.37	84.8	56.8	129
Average for diesel truck	0.71	3.11	0.39	87.4	58.5	129
Biodiesel	0.12	0.32	0.41	81.5	58.4	113
Biodiesel	0.12	0.30	0.41	83.4	59.0	113
Average for biodiesel truck	0.12	0.31	0.41	81.9	58.7	113
Percentage difference between average for each truck	-83.1	-89.9	+5.6	-6.2	+0.3	-12.5

Absolute values of emissions, fuel consumption and power are in broad agreement with Phase 1 results. With the exception of NOx emissions, the biodiesel truck when compared to the diesel reference truck produced similar reductions during Phase 2 testing to that achieved during Phase 1. NOx emissions for the biodiesel truck when compared to the diesel reference truck increased by about 6% for Phase 2.

6.4 Tailpipe Emissions – Phase 3

The emissions of average opacity, NOx and PM for Phase 3 are shown in Table 6 for the DT80 test with detailed results at Attachment C3.

Table 6: Phase 3 DT80 results for the diesel and biodiesel vehicles

Vehicle	Average Opacity (%)	PM (mg/km/t)	NOx (g/km/t)	HC (mg/km/t)	CO_2 (g/km/t)	FC (l/100km)	Maximum Power (kW) (at 80kph)
Diesel	0.25	3.18	0.44	7.68	90.7	60.8	125
Diesel	1.06	1.83	0.41	6.04	91.8	61.6	125
Average for diesel truck	0.66	2.51	0.43	6.86	91.3	61.2	125
Biodiesel	0.04	0.24	0.43	4.11	84.1	60.3	116
Biodiesel	0.34	0.22	0.44	4.16	85.2	61.1	116
Average for biodiesel truck	0.19	0.23	0.44	4.14	84.6	60.7	116
Percentage difference between average for each truck	-71.0	-90.9	+2.0	-39.7	-7.3	-0.9	-7.2

The mean results for Phase 3 are in broad agreement with Phase 1 and 2 results. As can be seen from Table 6 there was an improvement in opacity, PM, HC and CO_2 emissions of 71%, 91%, 40% and 7% respectively when comparing the biodiesel truck with the diesel reference truck. However, there was an increase in NOx emissions of 2%, a reduction in fuel consumption of 1% and a drop in maximum power of 7%. Here again a note of caution is given that these results may include differences that may be due in part to the relative emissions performance of each vehicle as well as a difference in the fuels.

6.5 Tailpipe Emissions – Both Vehicles on Both Fuels

During Phase 3 of the emissions testing program the diesel reference truck and the biodiesel truck were tested on both diesel and biodiesel fuel. Because the trial was based on using a different vehicle for each of the two fuels it was not known if any changes observed in the results would be due to the fuel alone or a combination of the fuel and the individual vehicle concerned. Table 7 provides the average results for the two tests done on both vehicles for each fuel, and the percentage change for biodiesel compared to diesel fuel.

Table 7: Phase 3 DT80 average results for both vehicles on both fuels

Fuel Type	Average Opacity (%)	PM (mg/km/t)	NOx (g/km/t)	HC (mg/km/t)	CO_2 (g/km/t)	FC (l/100km)	Maximum Power (kW) (at 80kph)
Diesel Truck (XYG 403)							
Diesel (average)	0.66	2.51	0.43	6.86	91.3	61.2	125
Biodiesel (average)	0.44	0.36	0.47	4.25	87.1	62.4	108
Percentage difference between fuels for diesel truck	-33.6	-85.8	+9.5	-38.1	-4.6	+2.0	-13.6
Biodiesel Truck (XXG 983)							
Diesel (average)	0.85	3.27	0.41	11.18	88.6	59.4	133
Biodiesel (average)	0.19	0.23	0.44	4.14	84.7	60.7	116
Percentage difference between fuels for biodiesel truck	-77.5	-93.0	+6.8	-63.0	-4.4	+2.2	-12.8
Average for both vehicles							
Diesel (average)	0.75	2.89	0.42	9.02	89.9	60.3	129
Biodiesel (average)	0.31	0.29	0.45	4.19	85.9	61.6	112
Percentage difference between fuels for both trucks	-58.3	-89.9	+8.2	-53.5	-4.5	+2.1	-13.2

As can be seen from Table 7 there was an improvement in opacity, PM, HC and CO_2 emissions of 58%, 90%, 54% and 4.5% respectively when comparing biodiesel fuel with diesel fuel across two supposedly identical trucks. However, NOx emissions and fuel consumption increased by 8% and 2% respectively and there was a drop of 13% in maximum power. There are some observable differences when comparing these results to those in Table 6. What is also evident, but to a lesser degree, is a difference in the emissions performance of the two vehicles and this is explored in more detail in Section 6.6 below.

6.6 Relative Emissions Performance of the Test Vehicles

In terms of emissions performance there appears to be a difference between the diesel reference truck and the biodiesel truck. Table 8 provides the same data as Table 7 but arranged in a different format to show the relative emissions performance of the two vehicles. Averaged over the two fuels, opacity, NOx and CO_2 emissions, and fuel consumption are lower by 5%, 6%, 3% and 3% respectively for the biodiesel truck (XXG 983) when compared to the diesel truck (XYG 403). Whereas PM and HC emissions, and maximum power are all higher by 22%, 38% and 7% respectively. Although for some of the emissions the difference is small we can conclude that the two vehicles have different emissions performance. Also, one can assume that the relative emissions performance of the two trucks remained reasonably constant throughout the trial period of 600 hours of operation since they were both built to the same specifications, and were subjected to the same maintenance regime and similar work routines.

Table 8: Relative emissions performance of the diesel reference truck and the biodiesel truck for Phase 3

Vehicle	Average Opacity (%)	PM (mg/km/t)	NOx (g/km/t)	HC (mg/km/t)	CO_2 (g/km/t)	FC (l/100km)	Maximum Power (kW) (at 80kph)
Diesel fuel							
Diesel (average)	0.66	2.51	0.43	6.86	91.3	61.2	125
Biodiesel (average)	0.85	3.27	0.41	11.18	88.6	59.4	133
Percentage difference between trucks for diesel fuel	+29.0	+30.6	-4.5	+63.1	-3.0	-3.0	+6.4
Biodiesel fuel							
Diesel (average)	0.44	0.36	0.47	4.25	87.1	62.4	108
Biodiesel (average)	0.19	0.23	0.44	4.14	84.7	60.7	116
Percentage difference between trucks for biodiesel fuel	-56.3	-35.9	-6.8	-2.6	-2.8	-2.8	+7.4
Average for both fuels							
Diesel (average)	0.55	1.43	0.45	5.55	89.2	61.8	117
Biodiesel (average)	0.52	1.75	0.42	7.66	86.6	60.0	125
Percentage difference between trucks for both fuels	-5.0	+22.3	-5.7	+37.9	-2.9	-2.9	+6.9

6.7 Normalised Results

Although the two vehicles used for this trial have been built to the same specification they are different in terms of their emissions performance. So in order to report the impacts of the use of biodiesel fuel over the trial period it is necessary to take account of the effect of the relative emissions performance of both test vehicles. Table 9 shows the mean results for the three test phases where the biodiesel truck results have been normalised by subtracting an amount equal to the percentage difference between the two vehicles as shown in Table 8. This can be represented by:

Normalised biodiesel result = Result as recorded – Adjustment

Or in terms of vehicle and fuel effects:

Fuel Effects = [Vehicle Effects + Fuel Effects] – Vehicle Effects

Where:

Vehicle Effects = Results as Recorded multiplied by the Percentage difference between trucks (average for both fuels taken from Table 8)

Table 9: Average normalised results for the 3 test phases

Vehicle	**Average Opacity (%)**	**PM (mg/km/t)**	**NOx (g/km/t)**	**HC (mg/km/t)**	**CO_2 (g/km/t)**	**FC (l/100km)**	**Maximum Power (kW) (at 80kph)**
Phase 1 Results							
Diesel (average)	0.51	1.60	0.49	4.53	90.2	60.5	121
Biodiesel (average)	0.07	0.23	0.50	1.11	87.2	62.5	99
Phase 1 % change for biodiesel	-85.4	-85.4	+1.4	-75.4	-3.3	+3.4	-18.4
Phase 2 Results							
Diesel (average)	0.71	3.11	0.39	-	87.4	58.5	129
Biodiesel (average)	0.13	0.24	0.44	-	84.3	60.4	105
Phase 2 % change for biodiesel	-82.2	-92.2	+11.7	-	-3.5	+3.2	-18.5
Phase 3 Results							
Diesel (average)	0.66	2.51	0.43	6.86	91.3	61.2	125
Biodiesel (average)	0.20	0.18	0.46	2.57	87.1	62.4	108
Phase 3 % change for biodiesel	-69.5	-92.9	+7.9	-62.6	-4.6	+2.0	-13.6
Average for all 3 phases							
Diesel (average)	0.62	2.41	0.44	5.69	89.6	60.1	125
Biodiesel (average)	0.13	0.22	0.47	1.84	86.2	61.8	104
Overall % change for biodiesel	-78.7	-90.9	+6.6	-67.7	-3.8	+2.9	-16.8

Table 9 shows the impact of switching from the use of diesel fuel to biodiesel fuel in two International ACCO 2350G trucks powered by Cummins ISC 250HP engines. As can be seen from the figure average opacity, PM, HC, CO2 and power at 80 kph reduced by 79%, 91%, 68%, 4% and 17% respectively. They are significant reductions as an *analysis of variance* test performed on the normalised data indicates that at a 0.05 level of significance there is a statistically significant difference in the mean results for diesel and B100 biodiesel. These results indicate that there are air quality and greenhouse benefits to be gained in the way of reduced smoke, PM, HC and CO2 emissions for B100 biodiesel. However, there is a significant penalty on performance with the drop in power from B100 biodiesel. While it can be seen that NOx and FC increased by 7% and 3% respectively an *analysis of variance* test at a 0.05 level of significance indicates there is no difference between the mean results for diesel and B100 biodiesel. The results are broadly consistent with other biodiesel studies.

7.0 CONCLUSIONS

Testing for Camden's biodiesel trial show that for B100 biodiesel fuel when compared to ultra low sulphur diesel significant reductions were achieved for:

- Average smoke opacity (79%)
- PM emissions (91%)
- HC emissions (68%)
- CO_2 emissions, a greenhouse gas (4%)
- Maximum power at 80 kph (17%)

There was no significant difference between diesel and B100 biodiesel for NOx emissions and fuel consumption.

For air toxics it was found that:

- Emission rates of the priority VOCs were significantly reduced in the vehicle operated using the biodiesel fuel compared to the vehicle run using diesel fuel. Styrene was found to increase.

- C_1 - C_3 aldehyde compounds were generally unaffected under biodiesel except possibly acetaldehyde, which showed some decrease in emissions.

- A total reduction of 75% was found for PAH compounds although for both fuels, the PAH levels were generally close to detection limits and the associated increase in relative error requires that these observations be treated as indicative only.

ATTACHMENT A: DT80 Test

A1 Test Procedure

Before each test record vehicle details and conduct a pre-test safety inspection.

- Secure vehicle on dynamometer. Vehicles should be tested using the fuel present in the vehicle tank when it is submitted for testing.
- Set dynamometer to simulate the correct load and inertia for the vehicle under test.
- Start sampling
- Idle for 60 seconds
- Accelerate rapidly to 80 km/hr under simulated inertia using wide open throttle

Decelerate by removing all pressure from the accelerator pedal and gently applying brakes to standstill

- Idle for 10 seconds
- Accelerate rapidly to 80 km/hr under simulated inertia using wide open throttle
- Decelerate by removing all pressure from the accelerator pedal and gently applying brakes to standstill
- Idle for 10 seconds
- Accelerate rapidly to 80 km/hr under simulated inertia using wide open throttle
- Maintain speed at 80 km/hr for 60 seconds – stop sampling. Bring vehicle to rest.

A2 Test Equipment

The test system has been designed to enable transportation to any site and to allow quick deployment. The system consists of the following:
Chassis dynamometer
Sample handling system
Emissions instrumentation
Data acquisition/reporting system

The dynamometer has:
Twin rollers for easy wheel positioning and security
Idler rollers for bogie axle vehicles
14 tonne axle load capacity
Modular assembly and quick disconnect/tie down system
A drivers aid with test instructions and dynamometer output display
Inertia simulation on acceleration
Real-time data acquisition and printout

With the exception of the sample used for opacity measurement the vehicle exhaust is diluted and the emissions analysers draw samples from the dilution tunnel.

The particulate matter sample is kept below 125°F (51.7°C) in accordance with U.S. EPA CFR specifications and is measured using a laser light photometer calibrated for the particle size range found in diesel exhausts.

NOx is calculated from the measurement of NO and corrected for atmospheric conditions at the test site and time of sampling in accordance with U.S. EPA light-duty in-service testing protocols. As NO is the actual pollutant measured on which NOx is calculated there is no deterioration of the sample due to the NO2 dissolving in water condensation.

Atmospheric conditions (air temperature, pressure and relative humidity) are measured and recorded during each test to enable the results to be corrected to standard temperature and pressures.

Smoke is measured using a partial flow opacimeter sampling raw exhaust. Percentage opacity is measured continuously and average and maximum opacities are calculated from this data.

The data acquisition system is designed to enable results to be calculated on site at the completion of a test.

A3 Data Collected

A3.1 Pre-Test Data

Table A1 details the data to be collected on each vehicle before testing is commenced. Apart from any adjustments to enable safe operation of the vehicle during the test, the person undertaking the pre-test inspection shall not undertake any work to alter the "as delivered" condition of the vehicle, as this would defeat the objective of assessing real world emissions.

Table A1 – Pre-Test Data – Item To Be Provided

Vehicle Details	
Registration Number	
Vehicle Make	
Vehicle Model	
Odometer reading	……..................km
Compliance Date	
Tare Mass & GVM	
Test Mass	
Fuel type	

A3.2 Test Data

Table A2 details the data to be collected from each vehicle undergoing the vehicle testing.

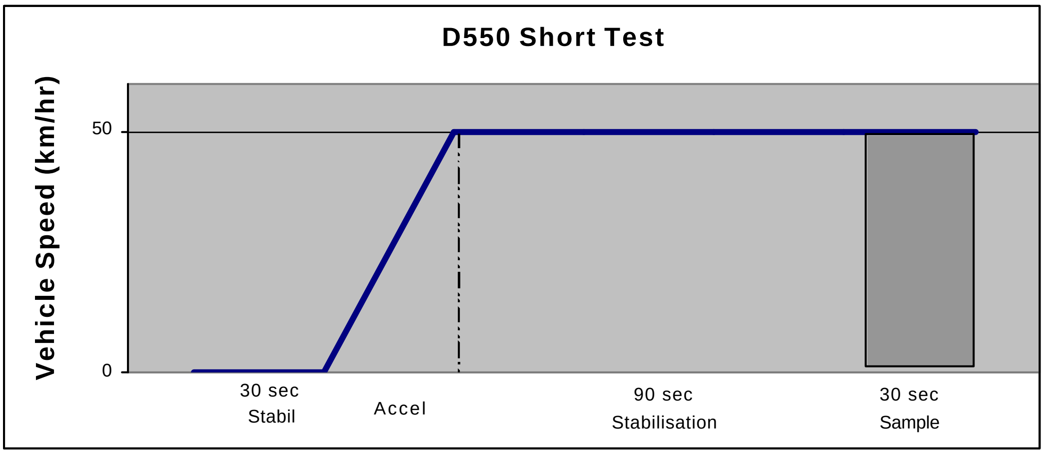
Table A2 — Test Data To Be Provided

Time vehicle arrives	Hr:min
Time test commences	Hr:min
Test duration	Seconds
Distance travelled during test	Km
NOx emissions	g/km & g/km/tonne
Particulate mass emissions	g/km & g/km/tonne
Smoke emissions	Average & maximum (% opacity)
Time vehicle departs	Hr:min
Second by second data for the above pollutants matched to the respective speed trace	
Comments on any operational issues	

ATTACHMENT B: D550 Test

The D550 test is detailed in Anyon P, 1995*, Diesel Inspection and Maintenance. The D550 Short Test*. A copy of this paper can be found on the Environment Protection and Heritage Council's web site under the Diesel Vehicle Emissions Preparatory Projects, Project 2: In-Service Emissions Performance, Phase 1 – Drive Cycles, Attachment 3 (www.ephc.gov.au/nepms/diesel/diesel_prepare.html).

This Steady-state test is carried out at a dynamometer load equivalent to a fully laden vehicle driving up a 5% gradient at 50 km/h. This represents a near full-load condition for most vehicles. As it is a constant load, constant-speed test, it requires only a simple power dynamometer. The test is designed so that there is no need to establish maximum power or torque outputs.



ATTACHMENT C: Test Results

C1 Tailpipe Emissions – Phase 1

Fleet No	Vehicle Make	Vehicle Model	Odometer (km)	Compli-ance Date	Test Mass (kg)	Fuel Type	Test Number	Date	Average Opacity (%)	Maximum Opacity (%)	NOx (g/km.t)	PM (mg/km.t)	HC (mg/km/t)	CO_2 (g/km)	Fuel (L/100km)	Max Power (kW)
QZM 171	Mitsubishi	FM	89,411	Feb-94	9750	Diesel	8141-1	13-10-03	2.65	10.12	0.75	18.01				
UUH 922	Isuzu	FVZ1400A	123,528	Oct-97	15880	Diesel	8143-1	13-10-03	7.47	46.15	0.80	25.81				
QZV 057	Mitsubishi	FK600	72,771	Mar-97	7135	Diesel	8145-1	14-10-03	7.80	27.13	0.31	32.87				
WXD 934	Isuzu	FVR900A	30,945	Jun-00	11490	Diesel	8147-1	14-10-03	2.25	17.39	0.30	15.11				
WXC 754	Isuzu	FSR700A	71,857	Mar-00	8795	Diesel	8149-1	14-10-03	8.87	35.07	0.50	44.68				
YTT 271	Isuzu	N3 NP	1,754	Apr-03	5580	Diesel	8151-1	14-10-03	2.81	31.08	0.38	6.86				
QUC 503	International	ACCO 2350G	125,728	Dec-96	18170	Diesel	8153-1	14-10-03	1.12	8.13	0.58	8.92				
QUC 504	International	ACCO 2350G	105,160	Dec-96	18170	Diesel	8155-1	14-10-03	0.84	4.44	0.81	6.31				
XXG 984	International	ACCO 2350G	30,349	Mar-02	17930	Diesel	8158-1	14-10-03	0.94	9.46	0.48	2.94				
UXM 333	Mitsubishi	Canter	34,959	Jan-98	3568	Diesel	8160-1	14-10-03	13.29	56.44	0.56	69.43				
QXZ 834	Mitsubishi	Canter	77,348	Mar-97	4770	Diesel	8162-1	15-10-03	10.01	35.09	0.41	27.62				
YAF 577	International	ACCO 2350G	27,997	Mar-02	14050	Diesel	8166-1	15-10-03	1.06	7.92	0.47	3.77				
VMU 428	International	ACCO 2350G	130,067	Aug-98	12800	Diesel	8168-1	15-10-03	1.32	5.58	0.61	10.43				
YPF 701	International	ACCO 2350G	8,680	Jul-02	17840	Diesel	8170-1	15-10-03	1.34	8.89	0.32	2.22				
XXG 983	International	ACCO 2350G	25,364	Mar-02	18010	B100 Biodiesel	8178-1	16-10-03	0.01	1.18	0.47	0.30	1.69	1521.3	60.53	106
XXG 983	International	ACCO 2350G	25,364	Mar-02	18010	B100 Biodiesel	8179-1	16-10-03	0.13	8.01	0.48	0.31	1.90	1530.7	60.90	106
XYG 403	International	ACCO 2350G	26,140	Mar-02	18010	Diesel	8184-1	16-10-03	0.49	4.03	0.48	1.72	4.62	1629.1	60.63	121
XYG 403	International	ACCO 2350G	26,140	Mar-02	18010	Diesel	8185-1	16-10-03	0.52	3.89	0.51	1.48	4.44	1619.3	60.26	121

C2 Tailpipe Emissions – Phase 2

Fleet No	Vehicle Make	Vehicle Model	Compli-ance Date	Test Mass (kg)	Fuel Type	Test Number	Date	Average Opacity (%)	Maximum Opacity (%)	NOx (g/km.t)	PM (mg/km.t)	CO_2 (g/km)	Fuel (l/100km)	Max Power (kW)
XXG 983	International	ACCO 2350G	Mar-02	18010	B100 Biodiesel	8440-1	4-2-04	0.12	1.60	0.41	0.32	1467.5	58. 39	112.8
XXG 983	International	ACCO 2350G	Mar-02	18010	B100 Biodiesel	8441-1	4-2-04	0.12	0.85	0.41	0.30	1484.0	59.04	112.8
XYG 403	International	ACCO 2350G	Mar-02	18010	Diesel	8454-1	5-2-04	0.69	9.62	0.41	2.97	1619.5	60.26	128.9
XYG 403	International	ACCO 2350G	Mar-02	18010	Diesel	8455-1	5-2-04	0.73	9.62	0.37	3.24	1527.2	56.83	128.9

C3 Tailpipe Emissions – Phase 3

Fleet No	Vehicle Make	Vehicle Model	Compli-ance Date	Test Mass (kg)	Fuel Type	Test Number	Date	Average Opacity (%)	Maximum Opacity (%)	NOx (g/km.t)	PM (mg/km.t)	HC (mg/km/t)	CO_2 (g/km)	Fuel (l/100km)	Max Power (kW)
XYG 403	International	ACCO 2350G	Mar-02	18010	Diesel	8884-1	6-4-04	0.25	6.36	0.44	3.18	7.68	1634.3	60.83	125
XYG 403	International	ACCO 2350G	Mar-02	18010	Diesel	8886-1	6-4-04	1.06	6.05	0.41	1.83	6.04	1653.9	61.55	125
XYG 403	International	ACCO 2350G	Mar-02	18010	B100 Biodiesel	8889-1	6-4-04	0.02	1.60	0.46	0.34	4.35	1566.1	62.32	108
XYG 403	International	ACCO 2350G	Mar-02	18010	B100 Biodiesel	8891-1	6-4-04	0.85	8.10	0.47	0.37	4.15	1572.2	62.56	108

Fleet No	Vehicle Make	Vehicle Model	Compli-ance Date	Test Mass (kg)	Fuel Type	Test Number	Date	Average Opacity (%)	Maximum Opacity (%)	NOx (g/km.t)	PM (mg/km.t)	HC (mg/km/t)	CO_2 (g/km)	Fuel (l/100km)	Max Power (kW)
XXG 983	International	ACCO 2350G	Mar-02	18010	B100 Biodiesel	8907-1	14-4-04	0.04	0.66	0.43	0.24	4.11	1514.5	60.27	116
XXG 983	International	ACCO 2350G	Mar-02	18010	B100 Biodiesel	8908-1	14-4-04	0.34	2.91	0.44	0.22	4.16	1534.5	61.06	116
XXG 983	International	ACCO 2350G	Mar-02	18010	Diesel	8911-1	14-4-04	0.75	7.62	0.41	2.80	10.37	1578.7	58.77	133
XXG 983	International	ACCO 2350G	Mar-02	18010	Diesel	8912-1	14-4-04	0.94	11.12	0.41	3.75	12.00	1611.6	59.99	133

ATTACHMENT D: Fuel Certificates Of Analysis

D1 Automotive Ultra Low Sulphur Diesel – Phase 1

Intertek Caleb Brett

Intertek Caleb Brett
ABN 56001722854
Clyde Laboratory
Durham Street Rosehill
New South Wales 2142
Telephone (02) 9897-8509
Facsimile (02) 9897-8069

CLYDE LABORATORY – TEST REPORT

SAMPLE **DIESEL Sample 2 Camden XYG 403 16/10/2003** **SAMPLE No:** **M 629A-03**

REFERENCE **Diesel Test Australia** **DATE** **24/10/2003**

SAMPLE ORIGIN:
1 sample arrived from Camden Council (Registration XYG 403)

RESULTS:

Test	Method	Units	Results
Density @ 15 deg C	D4052	kg/m3	**855.6**
Sulphur	D5453	ppm	**30**
Colour	D1500	---	**1.0**
Flash Point	D93	degC	**89**
Filterability	IP387		**1.02**
Cetane Index	D4737		**50.2**
Viscosity @ 40C	D445	mm2/s	**3.40**
Ash	D482	%mass	**<0.01**
Carbon Residue	D4530	%mass	**0.06**
Water and Sediment	D2709	%vol	**<0.01**
Copper Corrosion	D130		**1A**
Oxidation Stability	D2274	mg/L	**4.3**
Lubricity	IP450	microns	**399**
Conductivity	D2624	pS/m	**560**
Aromatic Hydrocarbon			
Mono aromatic	IP391	%mass	**19.1**
Di aromatic	IP391	%mass	**10.2**
Tri+ aromatic	IP391	%mass	**3.4**
Poly aromatic	IP391	%mass	**13.6**
Total Aromatic	IP391	%mass	**32.7**
Distillation			
10% rec	D86	degC	**252.9**
50% rec	D86	degC	**279.4**
90% rec	D86	degC	**325.1**
95% rec	D86	degC	**336.8**

COMMENTS:

Laboratory Officer: G. Agosti

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D2 Biodiesel (B100) – Phase 1

Intertek Caleb Brett

Intertek Caleb Brett
ABN 56001722854
Clyde Laboratory
Durham Street Rosehill
New South Wales 2142
Telephone (02) 9897-8509
Facsimile (02) 9897-8069

CLYDE LABORATORY -- TEST REPORT

SAMPLE **BIODIESEL** **SAMPLE No:** **M 630A-03**

REFERENCE **Diesel Test Australia Darren Pattison** **DATE** **23/12/2003**

SAMPLE ORIGIN:
Sample # 1, B100 Bio Diesel, 16/10/2003 Camden XXG983

RESULTS:

Test	Method	Units	Results	Spec.
Density @ 15 deg C	D1298	kg/m3	**881.1**	860 - 890
Sulphur	D5453	ppm	**19**	50
CFPP	D2500	degC	**+1**	
Flash Point	D93	degC	**150**	120 min
Viscosity @ 40C	D445	mm2/s	**4.660**	3.5-5.0
Sulfated Ash	D874	%mass	**< 0.005**	0.02 max
Carbon Residue	D4530	%mass	**0.02**	0.05 max
Water and Sediment	D2709	%vol	**< 0.005**	0.05 max
Copper Corrosion	D130		**1A**	3 max
Particultes	D5452	Mg/L	**1**	24 max
Acid Value	D664	mgKOH/	**0.27**	0.80 max
Cetane Number	D613		**55.0 @**	51.0 min
90% rec (vacuum dist)	D1160@	degC	**353 @**	360 max
Ester Content	PrEN 14103	% mass	**** 93.2 #**	96.5 min
Total Glycerol	D6584@	% mass	**0.20 @**	0.25 max
Free Glycerol	D6584@	%mass	**0.014 @**	0.02 max
Phosphorus	D4951@	ppm	**4 #**	10 max
Oxidation Stability	PrEN 14112		**1.0 &**	6 hours @ 110°C max
Ca, Mg	PrEN14108 & 14109	ppm	**1.3 #**	<&=5 max
Na, K	PrEn 14538	PPM	**3 &**	<&=5 max
Alcohol Content	PrEn 14110	% m/m	**< 0.02 #**	< 0.20

COMMENTS: **This report relates specifically to the sample as received.**
 # Results on these tests from ITS Probe
@ The results on these tests from ITS Caleb Brett Singapore
& Results on these tests from ITS Sunbury
**** sample off grade for these tests**

Laboratory Manager: Andrew Hoy

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D3 Automotive Ultra Low Sulphur Diesel – Phase 2

Intertek Caleb Brett

Intertek Caleb Brett
ABN 56001722854

Clyde Laboratory
Durham Street Rosehill
New South Wales 2142

Telephone (02) 9897-8509
Facsimile (02) 9897-8069

CLYDE LABORATORY -- TEST REPORT

SAMPLE **DIESEL** **SAMPLE No:** **M 063-04**

REFERENCE **Diesel Test Australia**
Darren Pattison
Purchase Order #272
DATE **18/02/2004**

SAMPLE ORIGIN:
Sample #2 – 05/02/2004, Camden City Council, Straight Diesel

RESULTS:

Test	Method	Units	Results	Diesel 500 specification
Density @ 15 deg C	D1298	kg/m3	**841.6**	**820.0 to 860.0**
Sulphur	D5453	ppm	**60**	**500 max**
Flash Point	D93	degC	**79**	**61.5 min**
Viscosity @ 40C	D445	mm2/s	**3.202**	**2.0 to 4.5**
Ash	D482	%mass	**<0.005**	**0.01 % max**
Carbon Residue	D4530	%mass	**<0.01**	**0.20% max**
Water and Sediment	D2709	%vol	**<0.010**	**0.05% max**
Copper Corrosion	D130		**1a**	**1 max**
Colour	D1500		**1.5**	**2.0 max**
95% rec (distillation)	D86	degC	**349.5**	**371 max**
Filterability	IP387		**1.02**	**2.0 max**
Electrical Conductivity	D2624	pS/m	**520**	**50 min**
Lubricity	IP450	microns	**204**	**460 max**
Cetane Index	D4737		**55.6**	**46 min**
Oxidation Stability	D2274	mg/L	**1.1**	**25 max**
Mono Aromatics	IP391	%mass	**19.4**	
Di Aromatics	IP391	%mass	**6.5**	
Tri Aromatics	IP391	%mass	**2.4**	
Poly Aromatics	IP391	%mass	**8.9**	

COMMENTS: **This report relates specifically to the sample as received.**
**** sample off grade for these tests**

Laboratory Supervisor: Leanne Johnston

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D4 Biodiesel (B100) – Phase 2

Intertek Caleb Brett

Intertek Caleb Brett
ABN 56001722854

Clyde Laboratory
Durham Street Rosehill
New South Wales 2142

Telephone (02) 9897-8509
Facsimile (02) 9897-8069

CLYDE LABORATORY -- TEST REPORT

SAMPLE BIODIESEL **SAMPLE No:** M 064-04

REFERENCE Diesel Test Australia, Darren Pattison, Purchase Order 272 **DATE** 15/03/2004

SAMPLE ORIGIN:
Sample # 1, B100 Bio Diesel, 04/02/2004, from Camden City Council

RESULTS:

Test	Method	Units	Results	Spec.
Density @ 15 deg C	D1298	kg/m3	**881.3**	860 - 890
Sulphur	D5453	ppm	**40**	50
CFPP	IP309	degC	**+6**	
Flash Point	D93	degC	**105 ****	120 min
Viscosity @ 40C	D445	mm2/s	**4.725**	3.5-5.0
Sulfated Ash	D874	%mass	**<0.010**	0.02 max
Carbon Residue	D4530	%mass	**0.05 ++**	0.05 max
Water and Sediment	D2709	%vol	**<0.010**	0.05 max
Copper Corrosion	D130		**1a**	3 max
Particultes	D5452	Mg/L	**12.6**	24 max
Acid Value	D664	mgKOH/	**0.08**	0.80 max
Cetane Number	D613		**59.5@**	51.0 min
90% rec (vacuum dist)	D1160@	degC	**355@**	360 max
Ester Content	PrEN 14103	% mass	**92.8# ****	96.5 min
Total Glycerol	D6584@	% mass	**0.280@ ****	0.25 max
Free Glycerol	D6584@	%mass	**0.006@**	0.02 max
Phosphorus	D4951@	ppm	**3#**	10 max
Oxidation Stability	PrEN 14112		**1&**	6 hours @ 110°C max
Ca, Mg	PrEN14108 & 14109	ppm	**<2#**	<&=5 max
Na, K	PrEn 14538	PPM	**<4&**	<&=5 max
Alcohol Content	PrEn 14110	% m/m	**0.23# ****	< 0.20

COMMENTS: This report relates specifically to the sample as received.
 # Results on these tests from ITS Probe
@ The results on these tests from ITS Caleb Brett Singapore
& Results on these tests from ITS Sunbury
**** sample off grade for these tests**
++ sample just on the limit for this test

Laboratory Supervisor: Leanne Johnston

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D5 Automotive Ultra Low Sulphur Diesel – Phase 3

Intertek Caleb Brett

Intertek Caleb Brett
ABN 56001722854
Clyde Laboratory
Durham Street Rosehill
New South Wales 2142
Telephone (02) 9897-8509
Facsimile (02) 9897-8069

CLYDE LABORATORY -- TEST REPORT

SAMPLE DIESEL **SAMPLE No:** M 168-04

REFERENCE Diesel Test Australia
Julian Anderson
PO # 285
DATE 15/04/2004

SAMPLE ORIGIN:
A sample arrived on 08/04/2004 from Diesel Test Australia.
The sample was diesel from a Camden Truck

RESULTS:

Test	Method	Units	Results	Diesel 50 specification
Density @ 15 deg C	D1298	kg/m3	850.7	820.0 to 860.0
Sulphur	D5453	ppm	34	50 max
Flash Point	D93	degC	80	61.5 min
Viscosity @ 40C	D445	mm2/s	3.735	2.0 to 4.5
Ash	D482	%mass	<0.005	0.01 % max
Carbon Residue	D4530	%mass	0.02	0.20% max
Water and Sediment	D2709	%vol	# < 0.005	0.05% max
Copper Corrosion	D130		1A	1 max
Colour	D1500		<0.5	2.0 max
95% rec (distillation)	D86	degC	341.7	371 max
Filterability	IP387		1.03	2.0 max
Electrical Conductivity	D2624	pS/m	420	50 min
Lubricity	IP450	microns	410	460 max
Cetane Index	D4737		53.6	46 min
Oxidation Stability	D2274	mg/L	3.7	25 max
Mono Aromatics	IP391	%mass	20.8	
Di Aromatics	IP391	%mass	4.2	
Tri Aromatics	IP391	%mass	0.8	
Poly Aromatics	IP391	%mass	5.0	

COMMENTS: This report relates specifically to the sample as received.
 # results from ITS Botany
**** sample off grade for these tests**

Laboratory Supervisor: Leanne Johnston

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D6 Biodiesel (B100) – Phase 3

Intertek Caleb Brett

Intertek Caleb Brett
ABN 56001722854

Clyde Laboratory
Durham Street Rosehill
New South Wales 2142

Telephone (02) 9897-8509
Facsimile (02) 9897-8069

CLYDE LABORATORY -- TEST REPORT

SAMPLE BIODIESEL **SAMPLE No:** M 173-04

REFERENCE Diesel Test Australia
Julian Anderson
PO # 287

DATE 10/05/2004

SAMPLE ORIGIN: A sample of Biodiesel arrived in the lab on 16/04/2004, sampled from a truck on 14/04/2004

RESULTS:

Test	Method	Units	Results	Spec.
Density @ 15 deg C	D1298	kg/m3	**886.9**	860 - 890
Sulphur	D5453	ppm	**50.3 ****	50 max
CFPP	D2500	degC	**9**	
Flash Point	D93	degC	**67 ****	120 min
Viscosity @ 40C	D445	mm2/s	**6.254 ****	3.5-5.0
Sulfated Ash	D874	%mass	**<0.005**	0.020 max
Carbon Residue	D4530	%mass	**0.13 ****	0.050 max
Water and Sediment	D2709	%vol	**#0.15****	0.050 max
Copper Corrosion	D130		**1A**	3 max
Particultes	D5452	Mg/L	**140 ****	24 max
Acid Value	D664	mgKOH/g	**0.95 ****	0.80 max
Cetane Number	D613		**@52.7**	51.0 min
90% rec (vacuum dist)	D1160	degC	**@420****	360 max
Ester Content	PrEN 14103	% mass	**& 80.0****	96.5 min
Total Glycerol	D6584	% mass	**@0.70****	0.25 max
Free Glycerol	D6584	%mass	**@<0.001**	0.02 max
Phosphorus	D4951	ppm	**& 1**	10 max
Oxidation Stability	PrEN 14112		**$ 0.4 ****	6 hours @ 110°C min
Na, K	PrEN14108 14109	ppm	**$ < 1**	<&=5 max
Ca, Mg	PrEn 14538	PPM	**& < 1**	<&=5 max
Alcohol Content	PrEn 14110	% m/m	**& 0.44 ****	< 0.20

COMMENTS: **This report relates specifically to the sample as received.**
@ The results on these tests from ITS Caleb Brett Singapore
& The results on these tests from ITS PROBE
$ The results on these tests from ITS Sunbury
 # The results for this test from ITS Botany
**** sample off grade for these tests**

Laboratory Supervisor: Leanne Johnston

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D7 Automotive Ultra Low Sulphur Diesel – Phase 3 – Bowser Sample

Intertek Caleb Brett

CLYDE LABORATORY -- TEST REPORT

Intertek Caleb Brett
ABN 56001722854

Clyde Laboratory
Durham Street Rosehill
New South Wales 2142

Telephone (02) 9897-8509
Facsimile (02) 9897-8069

SAMPLE **DIESEL** **SAMPLE No:** **M172-04**

REFERENCE **Diesel Test Australia** **DATE** **19/04/2004**
Julian Anderson
PO # 287

SAMPLE ORIGIN:
A sample of diesel arrived in the lab on 16/04/2004, sampled from a drum on 14/04/2004

RESULTS:

Test	Method	Units	Results	Diesel 50 specification
Density @ 15 deg C	D1298	kg/m3	**850.7**	**820.0 to 860.0**
Sulphur	D5453	ppm	**28**	**50 max**
Flash Point	D93	degC	**82**	**61.5 min**
Viscosity @ 40C	D445	mm2/s	**3.716**	**2.0 to 4.5**
Ash	D482	%mass	**<0.005**	**0.01 % max**
Carbon Residue	D4530	%mass	**0.01**	**0.20% max**
Water and Sediment	D2709	%vol	**#< 0.005**	**0.05% max**
Copper Corrosion	D130		**1A**	**1 max**
Colour	D1500		**<0.5**	**2.0 max**
95% rec (distillation)	D86	degC	**339.8**	**371 max**
Filterability	IP387		**1.02**	**2.0 max**
Electrical Conductivity	D2624	pS/m	**100**	**50 min**
Lubricity	IP450	microns	**387**	**460 max**
Cetane Index	D4737		**53.4**	**46 min**
Oxidation Stability	D2274	mg/L	**17.6**	**25 max**
Mono Aromatics	IP391	%mass	**21.7**	
Di Aromatics	IP391	%mass	**4.7**	
Tri Aromatics	IP391	%mass	**0.9**	
Poly Aromatics	IP391	%mass	**5.6**	

COMMENTS: **This report relates specifically to the sample as received.**
 # Result for this test from ITS Botany
**** sample off grade for these tests**

Laboratory Supervisor: Leanne Johnston

w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received.

D8 Biodiesel (B100) – Phase 3 – Bowser Sample

Intertek Caleb Brett
ABN 56001722854
Clyde Laboratory
Durham Street Rosehill
New South Wales 2142
Telephone (02) 9897-8509
Facsimile (02) 9897-8069

Intertek Caleb Brett

CLYDE LABORATORY -- TEST REPORT

SAMPLE **BIODIESEL** **SAMPLE No:** **M 169-04**

REFERENCE **Diesel Test Australia** **DATE** **10/05/2004**
Julian Anderson
PO # 285

SAMPLE ORIGIN: Sample received on 08/04/2004
Sample is Ex Camden B100 Drum

RESULTS:

Test	Method	Units	Results	Spec.
Density @ 15 deg C	D1298	kg/m3	**886.1**	860 - 890
Sulphur	D5453	ppm	**44**	50 max
CFPP	D2500	degC	**> 24**	
Flash Point	D93	degC	**78****	120 min
Viscosity @ 40C	D445	mm2/s	**6.120****	3.5-5.0
Sulfated Ash	D874	%mass	**< 0.010**	0.020 max
Carbon Residue	D4530	%mass	**0.10****	0.050 max
Water and Sediment	D2709	%vol	**#0.400****	0.050 max
Copper Corrosion	D130		**1A**	3 max
Particultes	D5452	Mg/L	**737.2****	24 max
Acid Value	D664	mgKOH/	**1.256****	0.80 max
Cetane Number	D613		**@54.2**	51.0 min
90% rec (vacuum dist)	D1160	degC	**@431****	360 max
Ester Content	PrEN 14103	% mass	**& 81.0 ****	96.5 min
Total Glycerol	D6584	% mass	**@0.72****	0.25 max
Free Glycerol	D6584	%mass	**@< 0.001**	0.02 max
Phosphorus	D4951	ppm	**& < 1**	10 max
Oxidation Stability	PrEN 14112		**$ 0.8 ****	6 hours @ 110°C min
Na,K	PrEN14108 14109	ppm	**$< 1**	<&=5 max
Ca,Mg	PrEn 14538	PPM	**& < 1**	<&=5 max
Alcohol Content	PrEn 14110	% m/m	& 0.44 **	< 0.20

COMMENTS: **This report relates specifically to the sample as received.**
@ The results on these tests from ITS Caleb Brett Singapore
& The results on these tests from ITS Probe
 # The results on these tests from ITS Botany
$ The results on these tests from ITS Sunbury UK
**** sample off grade for these tests**

Laboratory Manager: Andrew Hoy
w:lab\data\winword\forms\market\its diesoline.doc 02/06/2003
Results were obtained on the sample as received. 7

ATTACHMENT E: CSIRO Air Toxics Report