Setting National Fuel Quality Standards

Standardising Diesel/Biodiesel Blends

Prepared by
Australian Government
Department of the Environment and Heritage

November 2006

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The Department of the Environment and Heritage commissioned Duncan Seddon and Associates Pty Ltd to examine the key technical issues associated with diesel/biodiesel blends, including warranty issues, potential management options and labelling. The report, "Standardising Biodiesel Blends – September 2006" has assisted in the development of this discussion paper. The views and opinions expressed in the report do not necessarily reflect those of the Australian Government. While reasonable efforts have been made to ensure that the contents of this publication are factually correct, the Australian Government does not accept responsibility for the accuracy or completeness of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the report. The report has been prepared at the request of the Department of the Environment and Heritage. Readers should exercise their own skill and care with respect to their use of the material published in the report and carefully evaluate the accuracy, currency, completeness and relevance of the material for their purposes.

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Foreword

The development of fuel quality standards is an important part of the Government's continuing work to improve air quality and deliver cleaner fuels. In September 2005 the Prime Minister, the Hon John Howard MP, released the report of the Biofuels Taskforce and announced a package of measures to help address market barriers and restore consumer confidence in the biofuels industry. Among these measures the Prime Minister announced that the Government would work with Australian fuels and transport industries to establish standard forms of biodiesel to provide certainty to the market. This paper represents an assessment of diesel/biodiesel blends - and we welcome your feedback.

Biodiesel is a relatively new alternative fuel for Australia. It has been used overseas in conventional diesel transport vehicles as a fuel, in neat form and blended with conventional automotive diesel, for some time. Production of biodiesel in Australia is increasing, however current production and use is not at a commercially significant level compared to automotive diesel. To encourage continued development of the biodiesel industry, and continued growth of consumer confidence in this fuel, it is vital to ensure only diesel/biodiesel blends of the highest quality are available. The Australian Government's *Fuel Quality Standards Act 2000* has an important role in this regard.

Transport is the most significant contributor to ambient air pollution in urban Australia, with cars and light commercial vehicles being the dominant source of transport pollutants.

New vehicle emission standards are the long-term foundation for maintaining and improving air quality. Australian Government environment, greenhouse, transport and industry agencies have therefore been working together with relevant industry sectors to improve the emissions performance of the transport fleet. The Government has already implemented fuel quality standards for petrol, automotive diesel, biodiesel (100%) and LPG (autogas) under the national *Fuel Quality Standards Act 2000*. The Act provides the framework for the implementation of improved fuel quality, outlining the way fuel quality is specified and managed. These standards are a major achievement and contribute significantly to reduction of greenhouse gas emissions and air pollutants from Australian road transport.

Any proposal to mandate, and improve, the quality of fuels used in Australia, has the potential to impact on an array of stakeholders. Wide ranging stakeholder input will help achieve fuel quality standards for diesel/biodiesel blends that meet the needs of Australian motorists and allows for optimum vehicle *and* environmental performance. I look forward to considering your views on the matter and urge you to make a submission.

Ian Campbell
Minister for the Environment and Heritage

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1. Introduction

The Government set a fuel quality standard for neat biodiesel (B100) in September 2003. The conventional nomenclature for describing diesel/biodiesel blends is BXX where the XX is the volume per cent of biodiesel in the blend, for example B20 is a blend of 20% biodiesel and 80% diesel. Most biodiesel is retailed in the form of a blend with diesel. There is currently no diesel/biodiesel blend fuel quality standard in Australia.

The Prime Minister's Biofuels Taskforce noted the international precedent for the marketing of B5, B20 and B100 diesel/biodiesel blends. Europe and the US have far greater experience with the use of diesel/biodiesel blends. A large proportion of Australian diesel vehicles are imported from the EU and the US. It is important to note that the range of feedstock used to produce biodiesel varies considerably from the predominant use of rapeseed or canola oil in Europe to soybean oil in the US. In Australia there is further variation with feedstocks including tallow, canola, palm and waste cooking oils all being used and/or considered.

The Biofuels Taskforce report noted that warranty acceptance is a key factor in growing the biodiesel industry domestically (at the retail level). Further, there are linkages between standards for biodiesel blends and taxation legislation, specifically the *Energy Grants (Cleaner Fuels) Scheme Act 2004* and the *Fuel Tax Act 2006*

1.1 - Objective of this paper

The objective of this paper is to seek comment on management options for standardising diesel/biodiesel blended fuels. The Australian Government aims to set fuel quality standards that allow for optimum vehicle and environmental performance. Informed public debate is necessary to ascertain how quality standards are best managed. This can involve decisions relating to the specifications and testing methods that are set for each parameter within any standard.

Duncan Seddon and Associates Pty Ltd were commissioned by the Department of the Environment and Heritage to examine the key technical issues associated with diesel/biodiesel blends, including warranty issues, potential management options and labelling. This report, "Standardising Biodiesel Blends – September 2006" is at Appendix A.

The views and opinions expressed in the report do not necessarily reflect those of the Australian Government. While reasonable efforts have been made to ensure that the contents of this publication are factually correct, the Australian Government does not accept responsibility for the accuracy or completeness of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the report. The report has been prepared at the request of the Department of the Environment and Heritage. Readers should exercise their own skill and care with respect to their use of the material published in the report and carefully evaluate the accuracy, currency, completeness and relevance of the material for their purposes.

This paper is open for public comment until **05 January 2007**. After review and assessment of comments received, a Government position paper will be circulated and further comment invited. The Department of the Environment and Heritage is obliged to undertake a Regulatory Impact Statement (RIS) as part of any standard setting process.

1.2 - Call for public submissions

In order to ensure that the most appropriate position on the issue of diesel/biodiesel blends is adopted, comment on this discussion paper is sought from all interested stakeholders and members of the public.

While comments are welcomed on any matter discussed in this paper, your attention is drawn to the specific questions raised throughout the text (in italics).

Unless marked as 'Confidential', all submissions will be treated as public documents, posted on the Department of the Environment and Heritage (DEH) website and provided to the Fuel Standards Consultative Committee (FSCC).

Written comments are requested by **Friday 05 January 2007** and should be sent to:

Diesel/Biodiesel Blends – Discussion Paper
Fuel and Used Oil Policy Section
Department of the Environment and Heritage
GPO Box 787
CANBERRA ACT 2601
(John Gorton building, PARKES ACT 2600)

Or submitted electronically to: **fuel.quality@deh.gov.au**

2. Background

The *Fuel Quality Standards Act 2000* provides the legislative framework for setting national fuel quality standards. It is the first step in providing a nationally consistent approach to improving the quality of fuel in Australia.

The objectives of the Act are to:

a) regulate the quality of fuel supplied in Australia in order to:

i) reduce the level of pollutants and emissions arising from the use of fuel that may cause environmental and health problems;

ii) facilitate the adoption of better engine technology and emission control technology;

iii) allow the more effective operation of engines; *and*

b) ensure that, where appropriate, information about fuel is provided when the fuel is supplied.

Fuel standards have been set for petrol, automotive diesel, biodiesel (B100) and LPG (autogas). Petrol/ethanol blended fuel has a fuel quality information standard i.e. labelling. A standard for fuel grade ethanol is currently being considered. Monitoring is undertaken to ensure compliance with the standards and penalties apply if standards are not met.

For more information on the Department's work on fuel quality go to:
http://www.deh.gov.au/atmosphere/fuelquality/index.html

A number of significant pressures exist to develop some form of standardisation of diesel/biodiesel blends under the *Fuel Quality Standards Act 2000*. The principal reason for seeking to ensure consistency in diesel/biodiesel blend fuel quality is an environmental one – the need to provide fuels that facilitate the adoption of emerging vehicle engine and emission control technologies, a key strategy in managing air pollution and greenhouse gas emissions. This is supported by the need to better manage those fuel parameters that do not impact directly on vehicle technology, but nevertheless contribute to ambient levels of pollutants identified as posing health or environmental problems. A need exists to ensure that the emission performance of diesel vehicles is not compromised by the quality of the fuel. The report presents information on fuel quality parameters that impact on both vehicle emissions and engine operability.

Biodiesel is currently subject to excise duty at the rate of 38.143 cents per litre. The excise duty is offset by a cleaner fuels grant payable under the *Energy Grants (Cleaner Fuels) Scheme Act 2004* so that biodiesel meeting the national fuel quality standard is effectively free of fuel tax. An excise manufacturer's licence must be held to produce biodiesel and biodiesel/diesel blends.

The *Fuel Tax Act 2006* provides for credits of the fuel tax payable on fuel used for eligible purposes. As biodiesel currently incurs zero effective fuel tax as a result of the cleaner fuels grant, it does not currently attract a fuel tax credit. Where a blend of biodiesel and diesel meets the diesel standard, it is treated as though entirely diesel for fuel tax credits. Where a blend does not meet the standard, claimants are able to claim for the fuel tax payable on the diesel component only, and therefore require certainty regarding the contents of the blend in order to calculate their entitlements correctly.

Extensive analysis and consultation were undertaken when developing both the automotive diesel and biodiesel (B100) fuel quality standards. Further information on this work can be found at:
http://www.deh.gov.au/atmosphere/fuelquality/standards/index.html.

Issues relating to the impacts of diesel use and setting fuel quality standards for diesel and biodiesel (B100) provide relevant background information on the development of diesel/biodiesel blend standards.

Biodiesel is used as a direct replacement for, or blend stock component with, petroleum based diesel fuel. Biodiesel can be made from a variety of vegetable oils and animal fats. The properties of biodiesel from different sources are discussed in the report[1]. Virgin or refined vegetable oils, or recycled waste cooking oils and greases, are not biodiesel.

Diesel can be refined from a variety of crude oil feedstock and each refinery differs in refinery processing units and set-up. The range of diesel fuels is discussed in the report[2].

2.1 - Issues with blending

The actual properties of commercial automotive diesel depend on the refining practices employed and the nature of the crude oils from which the fuel is produced.[3] Therefore the properties of automotive diesel produced differ between Australian refineries. The automotive diesel standard allows for a range of values for certain parameters with an upper and lower limit. For example, the density specification for diesel is 820 - 850 kg/m^3.

Biodiesel produced from different sources has different properties. The type of feedstocks used, including the nature and composition of fatty acids of the feedstock, will influence the character of the biodiesel. This is reflected in the biodiesel standard with the density parameter. Density for biodiesel is specified as being between 860 - 890 kg/m^3.

2.2 - Blend standards

The Biofuels Taskforce recognised the international practice of marketing B5, B20 and B100, with the dominant blends being B5 and B20[4]. However there are very limited, if any, examples of mandated diesel/biodiesel blend fuel quality standards in the world.

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[1] Standardising Biodiesel Blends – Duncan Seddon and Associates Pty Ltd, September 2005 – p11.
[2] Standardising Biodiesel Blends – Duncan Seddon and Associates Pty Ltd, September 2005 – p25.
[3] Standards Australia, 1998, AS 3570 (automotive diesel).
[4] Report of the Biofuels Taskforce to the Prime Minister, August 2005 – www.pmc.gov.au/biofuels - p.140

In the EU there are no quality standards for blends. B100 used as neat fuel and low level blends (less than or equal to B5) is common in the EU. Original equipment manufacturers (OEMs) have expressed concern regarding the use of higher blends (>5%) in the existing fleet due to issues concerning vehicle compatibility and the potential for increased emissions.[5][6]

In the US most of the experience with biodiesel has been with B20, with market share of diesel/biodiesel blends being approximately 75% B20, 24% B5/B2 and 1% B100.[7] The American Society for Testing and Materials (ASTM) Working Group WK 7852 has been working towards producing a biodiesel B20 standard. A critical issue in this process, which is still subject to debate, is the establishment of a stability specification in the biodiesel B100 D6751 standard.

3. Management options for standardising diesel/biodiesel blends

Fuel quality standards exist for automotive diesel, the Fuel Standard (Automotive Diesel) Determination 2001, and biodiesel B100, the Fuel Standard (Biodiesel) Determination 2003. Fuel supplied representing either of these fuels must meet the respective fuel quality standard. Despite the fact that there is no quality standard for diesel/biodiesel blends, various blends of diesel and biodiesel are currently available on the market in Australia. Blending two on-specification fuels does not guarantee the fuel quality of the resultant blend.

Australian biodiesel suppliers are unusual in their support and marketing of blend levels above 20% (B20). This appears to have been the result of a loophole in the previous legislation that provided an unintended taxation benefit for biodiesel blends, such as B49.

Under the *Fuel Tax Act 2006*, biodiesel/diesel blends that meet the diesel standard attract fuel tax credits as though the fuel were entirely diesel, although no fuel tax is currently payable on the biodiesel component. It was expected that blends containing only small amounts of biodiesel would meet the standard. In the absence of standards for biodiesel blends, some producers are claiming that blends up to B20 meet the diesel standard and therefore attract full fuel tax credits. However, it is unclear as to whether such blends actually meet the standard and as a result there is a lack of certainty for claimants wishing to correctly calculate their entitlements.

Quality analysis of diesel/biodiesel blends, from the variety of both diesel and biodiesel blend stocks, and vehicle and emissions testing of blends has not been carried out extensively in Australia. The Biofuels Taskforce concluded that there appeared to be limited testing of the suitability of biodiesel for use in engines. However, the Taskforce noted that due to the lack of diesel engine manufacturing capacity in Australia, engine manufacturers would be guided by overseas testing and practice.[8]

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[5] Fatty Acid Methyl Ester Fuels – Joint FIE Manufacturers Statement, issued June 2004

[6] World-Wide Fuel Charter – December 2002.

[7] Setting National Fuel Quality Standards – Paper 6 – National Standard for Biodiesel, 2003. p22.

[8] Report of the Biofuels Taskforce to the Prime Minister, August 2005 – www.pmc.gov.au/biofuels - p140.

Currently very limited support exists from diesel vehicle manufacturers for the use of diesel/biodiesel blends other than very low levels (<5%) in light duty diesel vehicles in the Australian market. This is in line with international practice. The Biofuels Taskforce report noted that warranty acceptance is a key factor in growing the biodiesel industry domestically.[9]

Developing a position on blend standards has to take into account the differing perspectives of biodiesel producers, others in the fuel industry, vehicle manufacturers, private consumers and business claimants of fuel tax credits. Consumer confidence in biodiesel and diesel/biodiesel blends is fragile and any management option should consider the needs of all stakeholders.

[9] Report of the Biofuels Taskforce to the Prime Minister, August 2005 – www.pmc.gov.au/biofuels - p140.

Set out below are four options on managing the quality of diesel biodiesel blends and establishing standard forms of biodiesel in Australia. These options are not exclusive and they are not Government positions. Your comments on these options will help inform the development of a draft Government position. A further opportunity for comment will be provided once a Government position is drafted.

3.1 - Option 1 – B5 limit

The Biofuels Taskforce stated that it is generally accepted that a B5 blend, made from diesel and biodiesel that meet their respective fuel quality standards, will meet the diesel standard.[10] This may not always be the case, particularly in relation to density; nor has it been formally recognised under fuel standards legislation in Australia.

One management option to address the issue of diesel and biodiesel blends is to:

- amend the diesel standard to allow for up to 5% by volume of biodiesel, subject to the biodiesel component of the blend meeting the biodiesel standard *and*
- require that the resulting blend fully comply with the fuel quality standard for diesel (the Fuel Standard (Automotive Diesel) Determination 2001).

This option on its own would effectively cap permitted biodiesel blends at 5% (B5). While some diesel/biodiesel blends greater than B5 may meet the diesel standard, supply of these higher blend fuels would be prohibited under this management option. A comparable example is the restriction of ethanol in petrol to 10% by volume.

3.2 - Option 2 – B5 limit with density waiver

A variation on Option 1 is to:

- amend the diesel standard to allow for up to 5% by volume of biodiesel, subject to the biodiesel component of the blend meeting the biodiesel standard *and*
- require that the resulting blend complies with the fuel quality standard for diesel (the Fuel Standard (Automotive Diesel) Determination 2001) **except** for density[11].

3.3 - Issues – Options 1 and 2

In the EU, the EN 590 diesel standard applies also to blends of biodiesel up to 5% and the same properties and quality standards apply to the blend as well as the diesel. This includes the density parameter for diesel in the EN 590 standard which is set at 820-845 kg/m^3.

Higher blends are used in the EU, for example there is an informal standard for B30 in France, and these blends do not conform to the EN 590 diesel standard. Potential

[10] Report of the Biofuels Taskforce to the Prime Minister, August 2005 – www.pmc.gov.au/biofuels - p.140.

[11] The New Zealand biodiesel standard NZS 7500:2005 states that biodiesel "has a higher density than mineral diesel (860-900 kg/m3), but this density is not related to the presence of heavy molecules which result in poor combustion and the generation of PM. Therefore in biodiesel higher density is not as undesirable a property as in mineral diesel [NZS 7500:2005 – Automotive Biodiesel – Specification for manufacture and blending, Appendix A – Significance of properties specified for biodiesel (Informative)].

problems with this approach have been recognised, for example due to excessively high density pushing engines beyond their operating limits. This is especially the case for heavy trucks that are sensitive to these types of changes in fuel quality due to their severe operating regime. Blends above B5 are usually not available to the public and are predominantly supplied to captive fleets and niche markets.

The current practice in the US is to ensure that diesel meets the ASTM D975 diesel standard and the biodiesel meets the ASTM D6751 biodiesel standard prior to blending. Blends above B5 cannot meet the D975 diesel standard because it cannot meet the viscosity and distillation specifications, though B5 (and lower blends) can meet D975. Importantly, D975 does not specify a density limit. Low-level biodiesel blends that meet the D975 can generally be used interchangeably with conventional diesel as long as the biodiesel itself meets the D6751 and the cold flow properties of the blend are adequate for the particular geography, climate and time of the year the biodiesel is going to be used.

A B1-B5 fuel standard has been developed in Canada. For on-road vehicles, a B1 to B5 blend must meet the Canadian General Standard Board specification *CAN/CGSB-3.520 Automotive Low Sulphur Diesel Fuel Containing Low Levels of Biodiesel Esters (B1-B5).* This standard does not specify a density limit.

The major advantage of Option 1 for Australia is that OEMs in the Australian market generally accept the use of up to B5 in diesel vehicles. The acceptance of a density waiver, as included in Option 2, has not been canvassed with OEMs, and comment on this issue is invited.

Cold flow and stability issues, as identified and discussed in the report by Duncan Seddon and Associates Pty Ltd, are less likely to be a concern when blend levels are limited to B5.

Fuel storage, handling and distribution systems would not require extensive upgrades, replacement or dedicated systems.

A B5 limit allows for certainty and confidence in low level diesel/biodiesel blends to be generated, which may lead to subsequent acceptance of higher blends, both by vehicle manufacturers and consumers.

The obvious disadvantage of these management options from a biodiesel producer's point of view is that it limits the amount of biodiesel in a blend. If blends above B5 were prohibited it would substantially limit the biodiesel industry's current practices of marketing blends higher than B5.

Your comment is invited on management Options 1 and 2.

- ***Should biodiesel blends be capped at B5 and meet the diesel standard?***
- ***Should flexibility be allowed for density (or any other quality parameter)?***
- ***Is Option 1 or Option 2 your preferred management option?***

3.4 - B20 management options

The report by Duncan Seddon and Associates Pty Ltd (at Appendix A) considered two approaches for standardising blends of diesel and biodiesel. Both approaches set a limit of up to 20% by volume biodiesel in a diesel/biodiesel blend (i.e. B6 – B20) and are set out below as management options 3 and 4.

3.5 - Option 3 – B20 limit with a strict B20 standard

One approach is to cap biodiesel at up to 20% by volume and develop a comprehensive, strict B20 fuel quality standard. An example of this approach is the recent US Engine Manufacturers Association (EMA) position on B20 as discussed in the report by Duncan Seddon and Associates.

EMA and its members have established a specification for the development of biodiesel blends, of up to 20% by volume (B20), which is made with biodiesel either meeting the ASTM D6751 or EN 14214 biodiesel (B100) specifications, and which meet the B20 specification. Petroleum-based diesel used in blends is generally expected to meet the ASTM D975 diesel specification. The position states that "the specification does not imply or constitute any endorsement for use of B20 blends by EMA or its member companies" and that "the specification is not an approved national fuel standard, and should not be used as such."[12] A copy of the EMA position is at Appendix B.

In the Australian context this management option would require blending up to 20% by volume biodiesel that meets the biodiesel standard and diesel that meets the diesel standard, with extensive additional post-blending testing.

3.6 - Option 4 – B20 limit with a simplified B20 standard

A variation to Option 3 is to allow biodiesel to be blended up to 20% by volume using biodiesel that meets the biodiesel standard and diesel that meets the diesel standard with less extensive post-blending testing to meet a simplified B20 standard. The suggested post blending tests and values are set out on p61 of the report by Duncan Seddon and Associates and detailed in the table below.

Table 1 - Suggested post blending parameters, tests and values for B20

Parameter	**Test Method**	**Value**
Flash Point	ASTM D 93	61.5^{o}C (minimum)
Oxidative Stability	ASTM D 2274	25mg/L (maximum)
Total Acid Number	ASTM D 664	0.80mg KOH/L (max)
Water, Sediment and Solids	ASTM D 2709	0.05 vol% (maximum)
Filter Blocking Tendency	IP 387	2 (maximum)
Cold Filter Plugging Point	ASTM D 2500	Report value
Biodiesel Content	EN 14078	Report Value (20 max)
Phosphorus	ASTM D 4951	10mg/kg (maximum)
Alkali Metals	EN 14108	5mg/kg (maximum)
Alkaline Metals	EN 14538	5mg/kg (maximum)

[12] Engine Manufacturers Association – Test Specifications for Biodiesel Fuel, May 31 2006.

3.7 - Issues – Options 3 and 4

The advantage of establishing a B20 fuel quality standard is that it involves post-blending quality testing which would provide certainty to the market. This could, in part, resolve some of the serious consumer and vehicle manufacturer concerns related to some current diesel/biodiesel blend marketing practices.

A potential major disadvantage of options 3 and 4 is lack of acceptance of B20 fuel by diesel vehicle manufacturers in the Australian market. Extensive trials and testing combined with a strict B20 quality standard, similar to the EMA position, may assist in gaining OEM acceptance in the longer term depending on the results.

Depending on the parameters and values chosen, a B20 standard may act to restrict the types of biodiesel used in blends. For example, the EMA position includes a distillation specification that could seriously limit the types of biodiesel used to formulate the B100 used in a blend. This is discussed in further detail in the report by Duncan Seddon and Associates on p35.

A B20 standard would result in increased cost of testing, with both blend stock fuels and the resultant blend requiring analysis. The integrity of many test methods for diesel performance may be compromised if applied to B20. Further assessment and accreditation of test methods specific to B20 would be required prior to any standard setting.

The Duncan Seddon and Associates Pty Ltd report states that testing of B20 should be conducted at the retail pump to address concerns with contamination and deterioration in transport and storage. It may not be practical to conduct quality sampling and analysis at or near the point of blending under current blending practices. B20 blends may be required to be “quarantined” until results of analysis are finalised which may be impractical for suppliers and consumers of blends.

Storage, handling and distribution systems would require extensive upgrades or replacement for B20. As indicated in the report by Duncan Seddon and Associates (p 43) B20 is a stronger solvent that diesel. This results in B20 mobilising deposits in the supply chain and leads to filter blockages. To combat this, the report recommends that thoroughly cleaned and/or dedicated supply chains should be used for B20 and that filters should be placed strategically in the supply chain (retail pump, etc) (p36).

Your comments are invited on management Options 3 and 4.

- ***Should a full B20 fuel quality standard be developed as outlined in Option 3?***
- ***If so, which parameters should be included?***
- ***Should a simplified B20 standard be developed as outlined in Option 4?***
- ***If so, which parameters should be included?***

The four management options in this paper are not exclusive and are presented here to generate comment that will be used to inform development of a Government position on standardising blends of diesel and biodiesel in Australia. A further opportunity for comment will be provided once a Government position is prepared.

Your comments are invited on other fuel quality management options for biodiesel blends.

- ***Should a 'B5 only' cap be adopted or should both B20 and B5 blends be permitted?***
- ***Are there other management options that should be considered?***

4. Labelling

The current practice of marketing a range of diesel/biodiesel blended fuels, without mandatory labelling requirements, could lead to serious consumer protection issues and lack of certainty for claimants of fuel tax credits. The Biofuels Taskforce identified a gap in the current information being provided to consumers, in particular the percentage of biodiesel in the blend and the importance of making information available to assist consumers in making appropriate fuel choices.[13]

The Biofuels Taskforce concluded that labelling of higher biodiesel blends (above B5) was a necessary piece of consumer information and could be relatively straightforward, inline with the simplified ethanol label.[14]

4.1 - Ethanol labelling standard

The *Fuel Quality Standards Act 2000* includes a provision for setting information quality standards to ensure that, where appropriate, information about fuel is provided when the fuel is supplied.

Fuel suppliers who supply petrol containing ethanol must comply with the ethanol fuel quality information standard (labelling standard). The labelling standard is in place to inform consumers that the fuel they are purchasing contains ethanol.

The Australian Government capped the level of ethanol that can be added to petrol at 10% in July 2003. This was the result of vehicle testing that showed petrol containing ethanol blends of 20% or more may cause engine problems in some older vehicles.

The requirement to label ethanol blend petrol was introduced in 1 March 2004 and amended in January 2006 to simplify the labelling standard.

Service stations supplying ethanol blend petrol now have two options for complying with the new labelling standard. Pumps dispensing ethanol blend petrol must display clearly either the **exact percentage of ethanol** in the blend ***or*** that the fuel contains **"up to" a percentage of ethanol**. Both options allow suppliers to use their own corporate livery and include additional information if desired.

Retail suppliers of ethanol blend petrol other than from a service station also have two options for complying with the labelling standard. Buyers must either be provided

[13] Report of the Biofuels Taskforce to the Prime Minister, August 2005 – www.pmc.gov.au/biofuels - p.140.
[14] Report of the Biofuels Taskforce to the Prime Minister, August 2005 – www.pmc.gov.au/biofuels - p.140.

with a document stating the **exact percentage of ethanol** in the blend ***or*** that the fuel contains **"up to" a percentage of ethanol**, and these words should appear on each container of ethanol blend petrol.

The maximum permitted ethanol content in petrol remains capped at 10% volume by volume.

4.2 - Diesel/biodiesel blend labelling

B5 label

Limited data exists on the impact of the use of B5 blends in Australian conditions. As indicated, B5 blends may not necessarily meet the diesel standard. Therefore labelling of blends up to B5 may be required. Cautionary statements relating to use in engines on a B5 label may not be required as OEMs in the Australian market generally accept the use of up to B5 in diesel vehicles. A B5 label may simply state that the fuel contains up to 5% biodiesel.

Your comment is invited on labelling requirements for B5.

- ***Should B5 blends be labelled?***
- ***If so, is a statement that the fuel "contains 5% biodiesel" or "up to 5% biodiesel sufficient?***

Diesel/biodiesel blend label (>B5)

The Duncan Seddon and Associates Pty Ltd report (at Appendix A) includes suggested appropriate information labels for diesel/biodiesel BXX blends (>B5) and biodiesel (B100). Please note that these labels are not Government positions or proposals. The report notes that additional information such as "Check with your vehicle manufacturer before using this fuel in your motor vehicle" may be appropriate for labels for higher blends (>B5) of biodiesel such as B20 and for neat biodiesel (B100).

Neat biodiesel (B100) is more likely to be supplied to captive fleets and into niche markets (i.e. off-road, mining and construction) where customers are aware of the issues involved in the use of the fuel and have taken necessary steps to ensure it is suitable for use in their vehicles. The limitations of marketing B100 at the retail level are linked also to the lack of support from OEMs for the use of blends greater than B5 in light duty diesel vehicles.

Your comment is invited on labelling requirements for higher blends of diesel and biodiesel.

- ***Should higher blends and neat biodiesel (B100) be labeled?***
- ***If so, is statement of the biodiesel content (eg "this fuel contains 20% vol biodiesel") sufficient?***
- ***Is additional information required?***

- ***If so, what information should be included on a label for higher blends of biodiesel?***

APPENDIX A

Standardising biodiesel blends, 15 September 2006. Completed by Duncan Seddon & Associates Pty Ltd on behalf of the Australian Government, Department of the Environment and Heritage.

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STANDARDISING BIODIESEL BLENDS

Prepared for the Australian Government

Department of the Environment and Heritage

September 15th. 2006

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CONTENTS

EXECUTIVE SUMMARY

Biodiesel, comprising fatty acid esters, can be blended to many levels with diesel fuel. The conventional nomenclature for describing these blends is BXX, where XX is the volume percent of biodiesel present. Thus B20 is a blend of 20% biodiesel and 80% conventional diesel.

B20 blends of 100% biodiesel (B100) and diesel are well known and used fuels in the US. The fuel is well characterised for vegetable oil derived biodiesel (fatty acid methyl esters, FAME) using soy and rapeseed (also known as Canola) with a wide range of diesel fuel compositions. Although there is a paucity of information concerning other sources of FAME, the properties of a B20 using materials similar to rape such as palm olein can be predicted. There is a paucity of information for B20 made from tallow or coconut oil.

Most diesel additives can be used with B20. An exception is that additives which are intended to alter the cold flow properties (cloud point and cold filter plugging point) show varying effects depending not only on the source of the vegetable oil (soy versus rapeseed) but also on the source (e.g. geographic source of the crop). Further, such additives appear to have little effect on tallow based B20.

Consequently a preferred approached to the adjustment of cold flow properties is to blend the fuel with lighter and lower boiling materials such as kerosene or heating oil. Thus a nominal B20 would have a reduced quantity of biodiesel after further blending.

The oil majors will produce fuels to the requirements of the engine and vehicle manufacturers. Despite statements of general support for renewable fuels most engine, vehicle manufacturers and fuel injection equipment suppliers do not support biodiesel blends in excess of 5% biodiesel (B5). Those companies that support the use of higher concentrations provide extensive advice to users. This advice is generally aimed at fleet operators or the informed amateur (farmers) who are able to perform complex (relative to the man in the street) vehicle checks and engine maintenance.

Vehicle manufacturers do not warranty fuel, rather the warranty covers *Materials and Workmanship*. Engine companies presented with an engine for a warranty claim first examine the engine for fuel related issues – for instance deposits in injectors engines and pumps which are not covered by the Materials and Workmanship warranty.

The recommended approach to standardising biodiesel blends is to standardise a BXX (where XX ranges from 06 to 20). The BXX blend would be regulated to be made from certified B100 and certified diesel fuel with the following additional test for BXX certification. This testing would be at the point of sale to the user:

- Flash point (to maintain safety and ensure that nothing has been added to help homogenise the blend but would compromise safety (such as ethanol)
- Oxidative stability and Total Acid Number (TAN) value to indicate potentially a reasonable storage life.
- Water, sediment and solids to maintain the quality of the blending process.
- CFPP to advise the user of the likely operating minimum ambient temperature.
- Biodiesel content (+/- 2%) for consumer information and to ensure that the content is within the regulated range (06 to a maximum of 20).
- Phosphorus and trace metals to help improve blend stability.

Suggested parameters to be tested, a suggested method and the regulated value are:

Parameter	**Test Method**	**Value**
Flash Point	ASTM D 93	61.5^{o}C (minimum)
Oxidative Stability	ASTM D 2274	25mg/L (maximum)
Total Acid Number	ASTM D 664	0.80mg KOH/L (max)
Water, Sediment and Solids	ASTM D 2709	0.05 vol% (maximum)
Filter Blocking Tendency	IP 387	2 (maximum)
Cold Filter Plugging Point	ASTM D 2500	Report value
Biodiesel Content	EN 14078	Report Value (20 max)
Phosphorus	ASTM D 4951	10mg/kg (maximum)
Alkali Metals	EN 14108	5mg/kg (maximum)
Alkaline Metals	EN 14538	5mg/kg (maximum)

It is important to back up the certification of a BXX fuel with an industry code of practice for the handling and use of a BXX blend where XX is greater than 05. Such an industry code should at a minimum recommend:

- In order to achieve homogeneity and consistency, the blending of certified B100 and diesel should be performed with mechanical agitation rather than splash blending.
- BXX should be stored and transported in new or cleaned tanks and pipelines to ensure minimum pick-up of sediment. This should be backed by, as appropriate, in-line filters in the delivery system.
- The storage and use of BXX should be less than six months from its date of blending and certification.
- The user be advised that the biodiesel blend should be used within a specified period (eg. Within one month of purchase)
- The user to be advised to check with the engine manufacturer of the suitability of a BXX blend for the owner's vehicle.
- The user of BXX to be advised of the propensity of the fuel to pick-up extraneous matter and to change filters regularly.
- The user be advised of the minimum operability temperature of the blend.

Producing a standard for a biodiesel blend would have to take account of the conflict between the proponents of a bio-fuels industry and the vehicle manufacturers. If no common ground can be reached on blends higher that 5% biodiesel (B5) then any standard would have to include a labelling regime which adequately provided the retail user with information to the limits of the use of higher blends. A suggestion is a label such as:

BIODIESEL BLEND B15

conforms to Australian Standard for biodiesel blends

FOR MOTOR VEHICLE USE

CHECK WITH YOUR MANUFACTURER BEFORE USING THIS FUEL IN YOUR MOTOR VEHICLE

Use within 1 month of purchase
Do not use if temperature is below $0_{o}C$
Change sump oil regularly

STANDARDISING BIODIESEL BLENDS

The Department of Environment and Heritage commissioned this Report on 29th May 2006. The objective of this report is to provide a background and detailed information on the technical parameters and associated issues relating to the standardisation of a mix of 20% biodiesel and 80% diesel, commonly known as B20.

In setting a standard it is the objective to ensure that the B20 meets the objectives of the Fuel Quality Act 2000. This Act has the objectives of

1. Regulate fuel quality to:
   a. reduce the level of pollutants and emissions arising from the use of fuel that may cause environmental and health problems,
   b. facilitate the adoption of better engine technology,
   c. allow the more effective operation of the engines, and
2. Ensure that, where appropriate, information about the fuel is provided when the fuel is supplied.

The Study was commissioned in two stages. In summary the tasks performed in each stage where:

Stage 1

Stage 1 of the study covered the background and technical issues raised by a desktop study aimed at defining the most appropriate approach to setting the standard. This stage also encompassed information received from the biodiesel industry and the refining industry. This stage encompassed four Tasks.

1. A desktop literature survey including discussion with the biodiesel industry and those parties involved in the distribution and retail of diesel fuel and biodiesel fuel. This was then used to develop a Matrix of the range of interactions of various diesel types and various types of biodiesel based on available source materials.
2. A desktop survey and industry consultation relating to the commonly used diesel and biodiesel fuel additives.
3. An analysis of the issues relating to quality analysis and test methods, particularly focusing on ASTM documents and the applicability of the test methods to B20 blends.

4. To define the areas of certainty and doubt in the formation of a B20 blend specification. To set out alternative approaches and recommend an approach to establishing a B20 fuel specification

Stage 2

5. A discussion of the operability, production and emissions consideration for each of the technical parameters.
6. Incorporate information of international B20 standards or guidelines
7. Explain the process of testing fuels against the parameters discussed.
8. Include a discussion on the warranty acceptance of biodiesel blends by the major international diesel engine manufacturers.
9. Identify appropriate labeling arrangements for B20 and B100.

The format of this report follows the stages as described above.

STAGE 1

Background

Vegetable oils have been used in diesel engines but have been shown to produce unacceptable emissions and engine wear. Use of the fatty acid esters from vegetable oils has been shown to produce viable alternative fuels and is commonly known as biodiesel. The term biodiesel is applied to fatty acid methyl esters (FAME) derived from vegetable oils or animal sources (tallow). Unless otherwise indicated the term biodiesel is used to mean a fuel comprising substantially FAME.

Biodiesel is a well-established alternative fuel. The interest in alternative fuels coupled with the prevailing oil price is encouraging rapid growth and private sector investment in the industry. When compared to other alternative fuels, biodiesel has the advantage of having very similar properties to conventional automotive diesel. This facilitates substitution as either 100% biodiesel or blends with conventional diesel.

The conventional nomenclature for describing biodiesel/diesel blends is BXX where the XX is the volume percent of biodiesel in the blend, for example B20 is a blend of 20% biodiesel and 80% conventional diesel.

There are some differences between biodiesel and conventional fuel. Except in specific circumstances, these differences do not manifest themselves in biodiesel/diesel blends with a biodiesel content of 5% or less. Thus original engine manufacturers, expressed in the World-Wide Fuel Charter[1], generally accept biodiesel/diesel blends to a level of 5% in low sulphur (<30ppm sulphur), Category 3 diesel fuel.

The availability of suitable feedstock, especially in rural locations has led to an interest in individuals making their own biodiesel. An Australian specification for 100% biodiesel (B100) was established in 2003 and there are many trials on the use of B100 around the world. However, in some parts the use of B100 in a retail environment is precluded and biodiesel is produced for blending with conventional diesel fuel. This is particularly the case in the US where the B20 blend is common fuel blend.

Differences between diesel and biodiesel

Fundamental differences between biodiesel and diesel influence the properties of blends higher in biodiesel concentration than B5. The key differences that adversely influence properties of the biodiesel blend are:

- The production of biodiesel does not involve a distillation process whereas (except for additives) diesel is produced from distilled hydrocarbon streams. The consequence is that the biodiesel components of the blend will contain heavy materials subject to thermal cracking in the hotter parts of the delivery system and the engine, hence potentially increasing engine fouling.
- Biodiesel contains a high level of olefins relative to diesel, which as a consequence of hydrotreatment to reduce sulphur is generally low in olefins. Olefins lead to poor thermal stability leading to coking and poor oxidative stability leading to inferior storage life.

- Biodiesel contains oxygen, which as well as lowering the energy content of the blend, fundamentally influences the injection and burning properties of the blend increasing the emissions of nitrogen oxides.
- The oxygen of biodiesel results in higher solvating and detergent power than hydrocarbons. Biodiesel will absorb more water and suspend solids better than diesel.
- The generally larger molecules of biodiesel result in higher cloud points and cold filter plugging points than conventional diesel. These parameters set the lower operability temperature of the fuel, hence, a high cloud point fuel cannot be used at low ambient temperatures.

However, the presence of oxygen in the blend improves some properties of the blend relative to the conventional diesel used in the blend. Biodiesel has higher viscosity and in particular lubricity than diesel, especially low sulphur diesel. This improves the engine wear properties in the blend. Oxygen greatly reduces the amount of particulate matter and hydrocarbon emissions. In addition biodiesel does not contain aromatics. As a consequence the emitted particulate matter is considered to be more benign than the particulate matter emitted by conventional diesel.

One way to improve the properties of biodiesel would be to hydrogenate the olefins and esters and reduce the molecules present to hydrocarbons and distil the required lighter fractions away from the longer chain heavier fractions. However, these processes would be unduly onerous and costly to the production of biodiesel.

As an aside, we note that one Australian refinery is proposing to include tallow into the refinery process for producing diesel. This affects the above processes and the products (known as Renewable Diesel) are no different from conventional diesel. For the purposes of this work, this product is not considered as a biodiesel/diesel blend and not considered any further in this Study.

Diesel Blending

Conventional diesel is manufactured from various refinery process streams with the requisite boiling range. As a consequence the basic properties of the diesel will be different for different types of crude oil processed and the nature and operation of the refineries unit operations. This means that each refinery produces diesel of different character, which changes according to the crude oils being processed.

Worldwide there is a move for lower sulphur diesel and fuel harmonisation. This serves to reduce the variation but there are still some significant differences between refineries and crude runs.

In addition there is an increase in interest in the production of synthetic (zero sulphur) diesel from gas or coal, including Australia using the Fischer-Tropsch process. Such diesel is highly refined and contains no aromatics. It represents an extreme in the types of diesel available. It is generally used as a blend-stock to improve the quality of inferior diesel streams.

In meeting the cold flow specification for diesel, in particular in achieving the cold flow properties, refiners can change the crude oil type, add lighter materials such as kerosene (to the limit of the flash point) or use cold flow improving additives.

Properties of Biodiesel from Different Sources

The main issue is characterising the key differences in the compositions of both biodiesel and diesel that would lead to blending issues in the production of a B20 blend.

It is well known that biodiesel produced from different sources have different properties. In general biodiesel with a higher content of saturated fatty acid esters has higher stability, cetane and a lower level of NOx emissions. However, saturated fatty acids lead to inferior cold flow properties. Larger biodiesel producers are able to produce biodiesel from a range of feedstock and to blend the products to achieve a desired outcome. This is similar to the refineries using different streams of different properties to achieve a final diesel. However, the different properties of the biodiesel produced from different sources flows through to the properties of B20 blends.

Fatty Acids

The principal components of biodiesel are fatty acid methyl esters (FAMEs) derived from the vegetable oils and animal fats of the source materials. Although there are a very large number of possible fatty acids, in practice the range is restricted. Further, although the range of possible source materials is very large, certain specific fatty acids are represented in relatively large amounts in virtually all of the sources. This means that despite large differences in sources, the resulting fatty acid esters are the same, the difference being in the relative amounts of the principal types present.

By convention the fatty acids are named by the length of the carbon chain and the degree of unsaturation (number of double bonds present) as Cn:m, where *n* is the number of carbon atoms in the chain and *m* the number of double bonds present.

However, plant and animal biochemistry restricts the formation of fatty acids to even numbers of carbon atoms with odd numbers being rare. Further the dominant chains are 16 and 18 carbon atoms long with the olefins dominated by C18 species. Thus the dominant fatty acids present are C16:0, C18:0, C18:1, C18:2 and C18:3.

Long chains generally impart high cetane but this falls as the degree of unsaturation rises. As the number of double bonds rises the propensity to oxidise in the presence of air rises, leading to instability. However, unsaturation leads to better cold temperature properties.

The above leads to the proposition that the general properties of the biodiesel fuels can be predicted from a knowledge of the fatty acid ester composition of the biodiesel. Most feedstock in the US is soybean with a relatively high degree of unsaturation, hence relatively poor oxidative stability but good cold flow properties. In Europe rapeseed is the main source of biodiesel. This has better oxidative stability whilst maintaining good cold flow properties. In many parts of South East Asia, particularly Malaysia, palm oil is used for producing biodiesel. Crude palm oil has a high level of saturation which imparts good oxidative stability but poorer cold flow properties.

Desktop Literature Survey

Limitations to survey

The literature on biodiesel is vast and a comprehensive literature search is beyond the scope of this report. The literature searches concentrated on the use of B20 fuel and focussed on what was considered to be the main data sources. It will be realised that this restriction may result in some key documents being missed. The databases searched where:

British Library: general information and books on biodiesel

Society of Automotive Engineers (SAE): technical papers concerning B20

US Patents: Patents concerning B20 blends

European Patents: patents concerning biodiesel B20 blends

Scopus Search Engine (Elsevier): academic papers concerning B20

American Society for Testing Materials (ASTM): Test methods and working party reports concerning the specification for diesel and biodiesel.

National Renewable Energy Laboratory (NREL): papers on biodiesel.

US National Biodiesel Board

Papers and articles in the possession of Duncan Seddon & Associates Pty. Ltd.

Sources of Biodiesel

We are concerned with the principal sources of biodiesel in Australia. There are many thousands of different vegetable oils available and all have the potential for producing biodiesel. In addition large volumes of animal fats (tallow) are available in Australia and New Zealand from the large-scale meat processing industries.

However, although the range of potential feedstock is large, in practice the range is restricted by the volumes of materials are available either grown in Australia or the region. Internet searches and discussions with key players identified the most likely sources of biodiesel. These are summarised in Table 1.

Table 1 - Potential Sources of Biodiesel and Typical Analysis of Fatty Acids Present

		C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C22:1	Ref.
	Iodine No	0	0	0	0	0	0	89.87	181.0	273.5	0	74.98	
Neem	69					30		55	15				Int.
Karanja						18		71	11				Int.
Mahua	55-70					45.2		37	14.3				Int.
Jetropha	<120					20		46	35				Int.
Cotton	90-140	0	0	0	0.8	22.9	3.1	18.5	54.2	0.5	0	0	Yuan
Sunflower	110-143	0	0	0	0.1	6	5.9	16	71.4	0.6	0	0	Yuan
Soybean	**117-143**	**0**	**0**	**0**	**0.1**	**10.3**	**4.7**	**22.5**	**54.1**	**8.3**	**0**	**0**	Yuan
Sesame	104-120	0	0	0	0	10	5	41	43	0	0	0	KO
Safflower	126-152	0	0	0	0.1	6.6	3.3	14.4	75.5	0.1	0	0	Yuan
Coconut	6-12	8.3	6	46.7	18.3	9.2	2.9	6.9	1.7	0	0	0	Yuan
Olive	75-94	0	0	0	0	11	3.6	75.3	9.5	0.6	0	0	Yuan
Palm	35-61	0.1	0.1	0.9	1.3	43.9	4.9	39	9.5	0.3	0	0	Yuan
Palm Olein	**86-107**	**0**	**0**	**0.3**	**1.15**	**40.55**	**4.25**	**41.1**	**11.9**	**0.35**	**0.4**		FAO
Peanut	80-106	0	0	0	0	10.4	8.9	47.1	32.9	0.5	0	0.2	Yuan
Corn	103-140	0	0	0	0	9.9	3.1	29.1	56.8	1.1	0	0	Yuan
Rapeseed	**94-120**	**0**	**0**	**0**	**0**	**2.7**	**2.8**	**21.9**	**13.1**	**8.6**	**0**	**50.9**	Yuan
Canola		0	0	0	0.1	3.9	3.1	60.2	21.1	11.1	0	0.5	Yuan
Tallow (B)	**35 – 48**	**0**	**0.1**	**0.1**	**3.3**	**25.2**	**19.2**	**48.9**	**2.7**	**0.5**	**0**	**0**	Yuan
Tallow (L)	41	0	0	0	4.6	24.6	30.5	36.0	4.3	0	0	0	KO
Lard	53-77	0	0.1	0.1	1.4	25.5	15.8	47.1	8.9	1.1	0	0	Yuan
Linseed	168-204	0	0	0	0	4.92	2.41	19.7	18.03	54.94	0	0	Yuan

B = beef, L = lamb: References: Int. = Internet, Yuan[2], KO[3], FAO[4]

The fatty acid composition of a biodiesel or natural product can be determined by gas chromatography (g.c.). Iodine reacts quantitatively with double bonds and the degree of unsaturation can be estimated by the iodine value. Each natural product has a fatty acid composition that often ranges over several percent, depending on such variables as the climate and soil. The values given in the Table are typical averages and are used to illustrate the key points. The principal sources for biodiesel production in Australia are indicated in **bold** in Table 1

Soybean

Soybean is the mainstay of biodiesel production in the USA. As indicated it has a high level of olefins, particularly di- and tri-oilefins (C18:2 and C18:3 groups). This high level of unsaturation gives the oil a high iodine value and low oxidative stability.

Rape and Canola

Rapeseed is the basis for biodiesel in Europe. Rapeseed oil contains a high level of the C22:1 fatty acid (erucic acid) which can be toxic. A genetic modification has a low erucic acid content and is commonly referred to as Canola. Canola is widely grown and the dominant form of rapeseed in many countries. The literature is often ambiguous in the type grown. It is assumed that in Australia the dominant form is Canola. Rape contains less of the di-olefin C18:2 than soy and has an iodine number < 120. It has higher oxidative stability.

Palm Oil

Crude palm oil (CPO) is a major traded commodity. Malaysia is a key player in the trade and many plantations have been established to feed the growing demand for biodiesel. Palm oil contains lower levels of olefins (iodine number < 80) and high concentrations of the C16:0 fatty acid, palmatic acid. This makes the oil relatively stable but it has inferior cold flow properties. CPO is often separated into an olefin rich fraction called Palm Olein and a saturates rich fraction known as Palm Stearin. The latter has a high melting point and would not normally be used for biodiesel. Palm Olein has good flow properties and a modest level of olefins (iodine number < 110). Palm olein is often imported into Australia as a biodiesel feedstock.

Animal fats (tallow)

Animal fats (tallow) are widely available at low cost from Australia’s large meat processing industry. Tallow from beef, sheep and pig (lard) are very similar. They contain relatively little olefins (iodine number < 80 and for beef and lamb <50) and a commensurate high level of saturates, in particular C16:0 and C18:0, palmatic and stearic acids). This imparts good oxidative stability but poor cold flow properties.

Waste Cooking Oils

Waste cooking oils can be used for the production of biodiesel in the same way as virgin vegetable oils and animal fats. The fatty acid present will be dependent upon the original source of the oil, Canola being a major source. Waste cooking oils are often collected by recyclers for the production of biodiesel but the volumes are limited to the availability of the waste stream.

However, a critical feature of the waste cooking oil stream is the level of contaminants and other extraneous matter that can be present. These include a high level of oxidation products as a consequence of the open air heating of the oils, a high water content and a high level of dissolved solids. Because the production of biodiesel does not involve a distillation step, many of these contaminants can potentially be passed on to the fuel.

Other Sources of Vegetable Oil

As well as these feed-stocks of principal interest, there are some natural products produced in large volumes that have usually have an economic value too high for the routine production of biodiesel. However, many of these oils could come into the system from occasional gluts or off-specification products. Some are being actively developed for biodiesel production. Others enter the stream as used cooking oil.

Neem, Karanja, Mahua and Jetropha oils are produced as natural (Organic) insecticides but are under active consideration as a base for biodiesel production in India[5].

Coconut oil has been proposed as a biodiesel feed in the Philippines[6]. This oil has fatty acids of much lower molecular weight than other vegetable oils with a high proportion of <C14:0 fatty acids. Although these are saturated (hence of high oxidative stability) the lower molecular weights improves the cold flow properties relative to palm oil or tallow.

Sunflower and Safflower are under active development for biodiesel as an alternative to soybean. Sunflower oil can also enter the stream via used cooking oil.

Sesame, olive and peanut and corn oil, although generally too expensive, could be used and can enter the biodiesel feed stream as used cooking oil.

However, for the most part the main interest is on soybean, rape and palm oil and tallow as the main basis for biodiesel production in Australia.

Some oils and fats produced in large volumes have been omitted from the list because of price (butterfat) or unusual properties (castor oil). Occasional gluts or off-spec material may make these an occasional feedstock. This has not been considered as part of this analysis.

Linseed oil is included in the above Table as an example of certain oils that should be avoided. The high level of the tri-olefin C18:3 leads to very poor oxidative stability and gum formation when used to produce biodiesel.

Predicting the Properties of Biodiesel

A typical biodiesel (B100) will comprise a mixture of fatty acid esters from a range of source materials. The composition of the B100 can be determined by g.c. Algorithms have been developed for the prediction of cetane, vapour pressure and normal boiling point from knowledge of the fatty acid ester composition[7]. Blending rules[8] have also been developed for density, cetane number, heating value and cloud point to accuracy better than 2%.

Biodiesel has a higher viscosity than diesel. However, viscosity is not so easily predicted from knowledge of the viscosities of the fatty acid esters and the problem has been the subject of more intense studies[9]. Allen and Watts[10] have formulated algorithms for the prediction of viscosity, surface tension and mean droplet size for biodiesel from knowledge of the fatty acid composition. Tat and Van Gerpen[11] have produced a blending equation that allows the kinematic viscosity to be calculated as a function of the biodiesel fraction.

Impact of Higher Alcohols in Ester Formation

Biodiesel is predominantly produced by methanol esterification of natural product fatty acids. At this time this is predominantly an economic decision, as methanol is the cheapest alcohol. There is some interest in ethanol as this is a renewable resource rather than methanol, which is derived from fossil fuels. Using ethanol and butanol instead of methanol in soy biodiesel results in a lowering of the cloud point, and pour point and an increase in the cetane number. Unfortunately, viscosity also increases: Table 2[12].

Table 2 - Impact of Different Alcohols on Biodiesel (B100) Properties

Ester	Cetane	HV (kJ/kg)	Viscosity (cSt)	Cloud Pt. (^oC)	Pour Pt. (^oC)
Methyl	46.2	39,800	4.08	2	-1
Ethyl	48.2	40,000	4.41	1	-4
Butyl	51.7	40,700	5.24	-3	-7

Environmental Impact of B20 Blends

Part of this Study has the objectives of ensuring that B20 meets the objectives of the *Fuel Quality Standards Act 2000* in reducing the levels of emissions arising from the fuel. In a major study of the impact of biodiesel fuels and air quality workers at Environ[13] found that the use of B20 in place of conventional diesel would:

- Reduce particulate matter by 8.9%
- Reduce carbon monoxide by 13.1%
- Reduce Volatile Organic Compounds by 17.9%
- Reduce sulphur dioxide by 20%
- Raise the nitrogen oxide emission by 2.4%

The impact of biodiesel on reported air pollutant concentrations would be below the resolution of the measurements. These results are very similar to the results of the Newcastle trials of diesel and a B20 blend[14].

Caltex Australia has issued a Material Safety Data Sheet (MSDS) for B20[15]. This indicates B20 is similar to diesel fuel. Some reported features are:

- Vapour pressure <2mm Hg
- NOHSC exposure limit TWA (oil mist) 5mg/m^3
- Flash point >87^{o}C
- Auto-ignition temperature >200^{o}C
- LD50(oral, rat) = 7,500mg/kg

- Toxic to aquatic organisms and may cause long term effects in the aquatic environment. The material should be prevented from entering waterways, drains and sewers.

Other specific issues are:

Sulphur Content

The sulphur content of biodiesel is limited to 10 ppm as of February 1st 2006[16]. Since sulphur is ubiquitous in the environment and biodiesel is not a distilled product nor is it subjected to desulphurisation procedures, there is the potential for biodiesel to bring sulphur into a low sulphur diesel B20 blend. High sulphur levels have been observed in some biodiesel[17].

Environmental NOx Emissions

The benefits of using biodiesel in reducing particulate and unburnt hydrocarbon emissions are well known. Also well known is deterioration in the NOx emissions, which increase by about 5% over conventional diesel.

This subject has been addressed from several different standpoints in studies by McCormick *et alia*[18] who compared the NOx emission of a B20 (made from soy based B100 and a certified diesel fuel) with the same fuel containing additives. The following were effective in reducing the NOx emissions

<u>Fuel Additives</u>

Adding the cetane improvers (DTBP or EHN) was found to be effective in reducing NOx. The additive ferrocene was also effective but this resulted in increased particulate emissions. B20 blends of biodiesel and low sulphur diesel (<10ppm) with additives other than iron have also been proposed[19].

Anti-oxidants such as butylated hydroxy toluene have also been shown to reduce NOx emissions[20]. These additives have also been proposed to improve storage life of biodiesel, which is discussed below. Of note is that not all anti-oxidants are as effective[21].

Blending with highly refined diesel

Blending high volumes of Fischer-Tropsch diesel or lowering the base fuel aromatic content reduces NOx emissions. Fischer-Tropsch diesel blends have been proposed to improve other properties of biodiesel[22]. Building on these observations of McCormick, Esen *et alia*[23] have proposed B20 blends based on highly refined diesel or Fischer-Tropsch diesel using bulk modulus of compressibility as the selection criterion. This fits the theory that the NOx increase observed when using biodiesel blends is a consequence of engine timing changes in the injector system.

Influence of Biodiesel Feedstock

An inverse relationship between the iodine value of biodiesel and the increase in NOx emissions has been known for some time[24]. McCormick *et alia*'s work showed that biodiesel produced from a feedstock with less unsaturation than soy (yellow grease) resulted in lower NOx emissions than the soy based B20. Animal fat based biodiesel in B20 fuels has been shown to reduce NOx emissions by 3.2 – 6.2% relative to soy based blends[25]. A variation of this is to reduce the degree of unsaturation (iodine value) of soy based diesel by the addition of less saturated species, hydrogenation of the soy or addition of shorter chained and fatty esters. In terms of iodine number, this means using feedstock with a number < 100 to get a NOx neutral effect.

Soot

Biodiesel (B20) reduces particulate emissions relative to conventional diesel[26]. There exist structural differences in the soot produced from low sulphur diesel and that from B20 blends[27]. Biodiesel soot is generally considered more benign.

Impact on engine components

Operation and Wear

Fraer *et alia*[28] report that in a major study on the US Postal service fleet, including a tear-down analysis, the use of B20 resulted in normal wear on major engine components. One minor difference observed was in that B20 appeared to promote the formation of sludge. A detailed analysis led to the view that this was a consequence of off-specification biodiesel containing excess sodium that promoted the formation of sludge from the lubricating oil. Sodium hydroxide or methoxide is used as the catalyst effecting the esterification of the oil or fat. In theory it should be removed from the biodiesel by a subsequent wash process[29]. The efficiency of this wash can be measured by determining the residual alkali metal content of the B100, which is limited to <5 ppm in the B100 specification.

Impact on Elastomer Components

A series of elastomers commonly used in automotive applications have been shown to be fully compatible with a B20 fuel based on soy methyl ester[30]. This is in contrast to earlier reports of problems with some elastomers[31] (particularly nitrile rubbers).

Impact ON Lubrication Oil

Like all other fuels, the combustion of biodiesel is incomplete and leads to fatty acid ester contamination of the lubricating oil in the engine sump[32]. This leads to a fall in the viscosity of the lubrication oil[33].

Impact OF Lubrication Oil

Sem[34] has shown that biodiesel (B100, soy) causes carbon deposits and varnishes on pistons that are materially influenced by the quality of the lubricating oil. The least amount of deposit formation was from highly refined or fully synthetic lubricating oil.

Impact on Operation

Biodiesel has less specific energy content than conventional diesel. This results in a slightly higher fuel consumption and power loss relative to conventional diesel. For B20 this loss is about 3% and for the most part may go unnoticed by the operator[35]. Detailed analysis of maintenance cost shows a slight increase for biodiesel[36].

Fuel Distribution System

As noted above biodiesel has a greater solvating and detergent power than normal diesel and this can result in the freeing of deposits in tanks and lines when biodiesel is introduced into a diesel distribution system[37]. This is pertinent to refinery storage tanks and pipelines as well as the fuel systems of vehicles. The consequence is a greater tendency to cause blocked filters when a user first switches to biodiesel.

Storage and Long Term Stability

The high olefin content of biodiesel leads to long term instability. For effective use a B20 blend would have to be stable for up to six months. One method of increasing the storage life and long term stability has been proposed[38] whereby impurities, which do not in themselves prevent the biodiesel attaining the B100 standard, are removed by a subsequent wash step using strong acids and complexing agents. This particularly removes phosphorus compounds that act as crystallisation nuclei when the biodiesel is stored for long periods.

Another claim is to add BHT (2,4-di-tert-butylhydroxytoluene) as a stabilising agent[39]. In a literature review concerning the nature and oxidative stability of biodiesel, workers at the SwRI found that BHT performed poorly relative to some other anti-oxidants such as TBHQ (Tertiary butyl hydroxyquinone)[40].

Another issue is contamination with water. Biodiesel (and hence B20) has a stronger affinity for water than diesel due to the increase in solvating power of the ester groups. On storage the B20 blend should not materially absorb water from the surroundings either via air absorption or from condensation within a tank.

Testing for Stability

One of the aims of current overseas research is to find a test that adequately tests for the oxidative and long-term stability of biodiesel. A wide range of analytical methods (17) that could be used to determine the long-term stability of biodiesel blends have been critically compared by Stavinoha and Howell[41]. The recommended methods were:

- A modified version of ASTM D2274
- A modified version of the test for high temperature stability (F-21, thermal stability test)
- A modified version of ASTM D4625

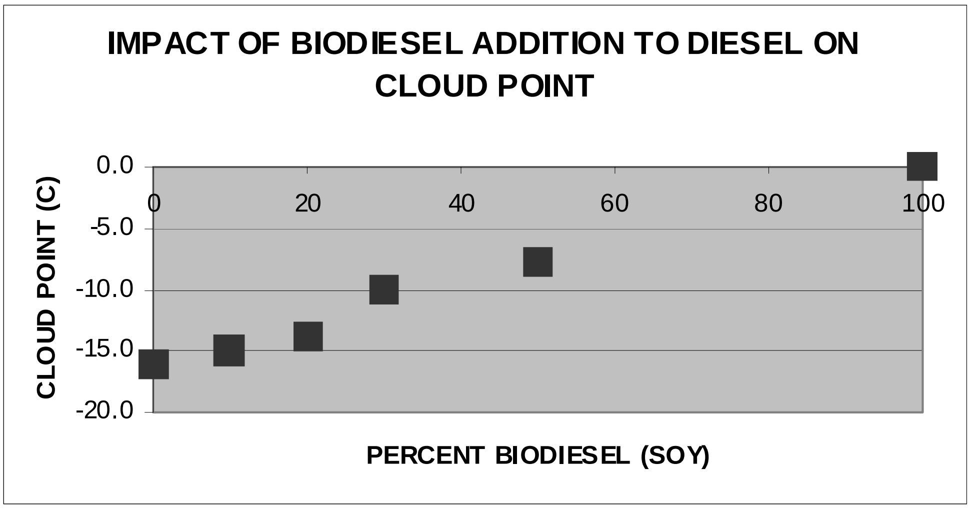
Recent work in the field has focussed on the modification of the ASTM D2274 and the European Racimate Test EN14112[42].

Cold Weather Operation and Cold Flow Properties

Biodiesel and diesel do not blend well at cold (0^oC) ambient temperatures. A study conducted by the National Biodiesel Board[43] for the production of B2 (2% biodiesel) showed that to produce homogeneous blends, the biodiesel has to be stored at least 10^oF (6^oC) above its cloud point to successfully blend with diesel in cold climates. This can be solved by heating the biodiesel and adding the diesel in stages[44] but at additional cost to the distribution system in Australia.

Addition of biodiesel (soy) to diesel results in degrading the cold flow properties of the blend, Figure 1.

Figure 1



(Data adapted from “Cold Flow Impacts” National Biodiesel Board)

The figure illustrates that within the errors of this type of determination, the effect is almost linear. Thus for soy based B20 there may be little practical consequence[45].

It is claimed that the cold flow properties of a biodiesel can be improved by the addition of glycerol ethers, which can be produced from the glycerol by-product of the biodiesel manufacturing process[46] The production of glyercol ethers requires the availability of a suitable olefin such as isobutene.

Cold flow properties of rapeseed biodiesel are claimed to be improved using polymers based on methacrylates[47] or vinyl carboxylate terpolymers[48].

Addition of ethanol to the mix also improves the cold flow properties of a biodiesel-diesel mixture[49]. However, this is likely to seriously degrade the flash point and increase the likelihood of water absorption.

Treatment of the biodiesel with ozone is also said to improve the cold flow properties of biodiesel[50]. However, in a study of the impact of oxidation on fuel properties, Terry[51] showed that oxidation raises the cloud point and degrades several other properties of the biodiesel such as viscosity and flash point.

In Australia a common method is adjust the cold flow properties of diesel by adding a lighter, freer flowing petroleum fraction such as kerosene or heating oil. This is method is discussed extensively in Australian Standard AS3750-1998 which gives practical guidance for reducing the cloud point by blending. This can also be applied to biodiesel blends with the concomitant reduction in the XX value of a BXX blend.

Discussions with Australian Stakeholders

In preparation of this report discussions were held with a number of stakeholders in the biodiesel, oil refining and additive supply industries. These were:

- Biodiesel Association
- Australian Renewable Fuels
- Australian Biodiesel Group
- Biodiesel Industries of Australia
- South Australian Farmers Fuels
- Natural Fuels
- BeBioEnergy
- Garner Smith Pty Ltd
- Victorian Chemicals Company
- Axiom Energy
- Gull Petroleum Ltd.
- Biodiesel Australia

- Caltex Australia
- Shell Australia
- BP Australia
- ExxonMobil
- Clariant Australia
- Lubrizol Australia
- Petrofin

Interactions Matrix

The objective is to identify the areas of diesel and biodiesel B20 blends for which there is a lack of data or operating experience that might lead to operational problems in Australia.

Range of Diesel Fuels

The current diesel fuels of interest can be characterised by density. Australian diesel fuels have typical densities in the region of about 840kg/m^3. However, the import of fuels and blend stock would make other diesel types available to the industry. High densities (850kg/m^3 and over) correspond to diesel fuel with a high level of aromatics and usually a high level of sulphur. However, some high-density low sulphur streams are produced in refineries of the Far East. Densities of 0.85 are typical of many of the B20 studies conducted in the US using their D2 fuel grade. Recent changes to the sulphur specification require extensive hydrogenation of the high sulphur streams and this also has the side benefit of reducing the diesel density. Reduced aromatic low sulphur diesel (as per Californian regulations) has densities of about 0.83. Diesel produced by high temperature, high pressure hydro-cracking operations (such as those from New Zealand) can have densities below 0.83. Such diesel is also characterised by a low level of aromatics and a high level of paraffins. Lower density, zero aromatic diesel is produced by the Fischer-Tropsch process. This process generally produces a high level of linear paraffins conferring a relatively high cloud point (5^{o}C). However, hydrotreatment results in some isomerisation that can significantly reduce the cold flow properties of the diesel.

Biodiesel

Biodiesel can be characterised by iodine number. For the most part the extremes are tallow (iodine number about. 40), which is a preferred feedstock by many producers in Australia and by soy (>120) the preferred feedstock in the USA. Rape (Canola) and palm olein have iodine values of about 100. Palm oil itself has an iodine value of about 50. At about 80 are many of the other potential oils and "yellow grease" used in many of the US studies. Coconut is lower in iodine number than tallow and has a lower molecular weight. There is a paucity of data for blending B20 with coconut. The referenced Philippine study was for B5.

Matrix

The Matrix below summarises the state of knowledge on B20 blends. There is a lot of data for rape and soy, which are well characterised (known in the Matrix). The more saturated biodiesel products (tallow etc) are well characterised for typical commercial diesel. Data for lighter diesel with densities of about 0.83 can be inferred in most cases. There is a paucity of information on low iodine number biodiesel with low density diesel (unknown). There is a paucity of information on coconut at the B20 level (unknown) but its blending with higher density diesel can be inferred.

MATRIX 1

State of Knowledge of Diesel/Biodiesel Blends

	TYPE	COCONUT	TALLOW	PALM	YELL GREASE	PALM OLEIN	RAPE	SOY
	Iodine No.	<20	40	48	79	96	107	130
DIESEL	DENSITY							
Fischer Tropsch	<0.8	**unknown**	**Unknown**	**unknown**	**inferred**	**Inferred**	**known**	**known**
	0.81	**unknown**	**Unknown**	**unknown**	**inferred**	**Inferred**	**inferred**	**known**
Hydrocracked	0.82	**unknown**	**Unknown**	**unknown**	**inferred**	**Inferred**	**known**	**known**
10% aromatic	0.83	**unknown**	**Inferred**	**inferred**	**known**	**Known**	**known**	**known**
Typical Australian	0.84	**inferred**	**Known**	**known**	**known**	**Known**	**known**	**known**
Typical US D2	0.85	**inferred**	**Known**	**known**	**known**	**Known**	**known**	**known**

Diesel and Biodiesel Fuel Additives

Nature of Additive Addition

Diesel fuel typically contains a suit of performance additives of varying chemical composition. These include:

- Detergents to maintain injector spray patterns by removing carbon deposits from the injectors.
- Anti-rust additives are used to protect the fuel distribution system from water that may be present in the fuel.
- Anti-foam agents are used to suppress foaming during tank filling operations.
- Fuel stabilizers are added to improve the thermal and oxidative stability. Oxidation results in fuel darkening, deposits and filter blockages.
- Demulsifiers are used to prevent the formation of water/fuel emulsions, especially if the fuel contains polar molecules (eg. FAME).
- Cetane improvers are used to improve combustion characteristics such as cold starting and maximising power.
- De-icers are used to protect the system in cold weather when the fuel may be contaminated with water.
- Lubricity improvers are required for low sulphur fuels. This role is often provided by biodiesel based additives.
- Cold flow improvers are used when ambient conditions are below the cloud point of the fuel. They suppress wax formation.

Most of these additives are used in small (<0.1%) amounts and would not present a problem. From the literature survey presented above, four types of additive are pertinent to the production of biodiesel and a B20 blend. These are demulsifiers, ignition (cetane) improvers, anti-oxidants and cold flow improvers.

Demulsifiers

Since any distribution is likely to be wet (from condensation if no other cause) there would be a tendency for B20 to absorb water. To prevent this, a higher level of demulsifiers would probably be required.

Ignition (Cetane) Improvers

Although biodiesel usually has sufficient cetane it may be considered necessary to use cetane improvers to limit the NOx emissions (see above). Typical commercial improvers are based on ethylhexylnitrate (EHN). Cetane improves are generally used in the 100-500 ppm range. This type of commercially available based cetane improver is applicable to all fuels types and there should be no adverse effects from their use.

Some other cetane or combustion improvers are being marketed based on iron (ferrocene) or other metal additives. Although they may be effective in reducing NOx, they increase particulate emission and may have adverse impact on vehicle parts.

Anti-Oxidants

From the above it is evident that high iodine number biodiesel or B20 will require anti-oxidants to achieve the necessary long-term stability. These are chemicals typically based on substituted phenols (BHT and the like). These materials are unlikely to materially affect the blend except in the intended manner.

Cold Flow Improvers

Cold flow improvers are widely used for commercial diesel but this is not a dominant practice in Australia. Here the general practice is to “cut” the diesel with kerosene or heating oil to the flash points specification.

There is extensive research into improving the cold flow of biodiesel and biodiesel blends using cold flow improvers. There is no obvious solution and several workers have reported significant differences according to the source of the biodiesel (eg tallow versus soy). Tallow (the main problem source) seems particularly unresponsive to cold flow improvement via additives.

Data provided by Lubrizol[52] illustrate the issues, which are:

- The addition of biodiesel into diesel rapidly degrades the cold flow properties of the blend.
- Mixing biodiesel from different sources affects the cold flow properties of the resulting biodiesel blend. The effect is approximately linear.

- Additives to B20 blends (soy) improve cold flow but there is a marked dependency on the base diesel composition.
- Lubrizol found that for their additives for B20 (soy) there was no harm with traditional CFI additives in the diesel. However, Lubriozol caution that some diesel additives can cause negative effects and the user needs to perform appropriate tests.
- The base biodiesel affects the choice and treat rate of the additive. Lubrizol has developed an additive to treat rapeseed B100. This is used in concentration up to 6000ppm. However, the impact of the additive is dependent on the source of the rapeseed.

Impact on the Risk Matrix

The use of additives in B20 blends is being extensively researched for soy and rape products. For cold flow improvers there is a marked variation depending not only on the oil seed used but also on the source of that seed. There is also a marked dependency on the diesel composition. Data can probably be inferred for some similar biodiesel sources. However there is a paucity of data for tallow and the like. Since this is a major challenge for the industry, the lack of data could be interpreted as there being significant problems with treating tallow- based product with conventional additives.

MATRIX 2

Impacts of Cold Flow Additives on B20

	TYPE	Coconut	TALLOW	PALM	YELL G	PALM OLEIN	RAPE	SOY
	Iodine No.	<20	40	48	79	96	107	130
DIESEL	DENSITY							
Fischer Tropsch	<0.8	**Unknown**	**unknown**	**unknown**	Inferred	inferred	inferred	Inferred
	0.81	**Unknown**	**unknown**	**unknown**	Inferred	inferred	inferred	Inferred
Hydrocracked	0.82	**Unknown**	**unknown**	**unknown**	Inferred	inferred	known	Known
10% aromatic	0.83	**Unknown**	**unknown**	**unknown**	Inferred	inferred	known	Known
Typical Australian	0.84	**Unknown**	**unknown**	**unknown**	Inferred	inferred	known	Known
Typical US D2	0.85	**Unknown**	**unknown**	**unknown**	Inferred	inferred	known	Known

Quality Analysis and Test Methods

ASTM Test Methods: Application to B20

For effective regulation of B20 there must exist acceptable test methods for each of the parameters in any specification. Specifications and test methods exist for B100 and diesel that may serve as the basis for any B20 specification. Attachment 1 gives an indication of the current use of ASTM testing methods in Australia and their potential use for B20.

Discussion: ASTM Evaluation Teams

There are several issues with the analysis of biodiesel that are undergoing development or are controversial in some respect.

ASTM Working Group WK 7852 on B20 Standards (Steve Howell)

The ASTM subgroup on the standardisation of B20 blends has been working towards producing a US biodiesel B20 standard. The issue will be discussed and may be resolved in December 2006. However, this has to pass the main diesel fuel quality committee of the ASTM in September 2006. A key point is the establishment of a stability specification in the Biodiesel B100 D6751 standard which is still subject to debate.

Distillation

The standard distillation procedure for distillate fuels is D86. However, biodiesel (B100), especially biodiesel high in olefins, thermally decomposes at the higher temperatures of the distillation process. The test should not therefore be applied to determine with significance the higher distillation points of biodiesel or biodiesel blends, namely the T90, T95, end points and residue. Distillation under vacuum will solve this problem (D1160), however, the algorithms described in the method used to compute the atmospheric equivalent temperatures are only applicable to hydrocarbons. The values can be computed using published data for FAME volatility but the accuracy of these is unknown.

Sulphur

New fuel standards call for a very low detection limit for sulphur, typically in the range 7 –50 ppm. Many of the older methods are inapplicable to this range. Further the precision of the Methods at these levels of sulphur is difficult to determine and there is ignorance as to how suitable methods cross correlate with each other. A sub-committee of the ASTM has, and still is, working on these issues. In a 2000 paper by Nadkarni[53] reported the following estimated limits for quantification of sulphur.

Table 3 - Limits to Sulphur Detection by Various ASTM Methods

Method	Name	Estimated Limit (ppm)
D1266-98	Lamp Method	10 – 20
D2622-98	WDXRF	10 – 15
D3120-96	Oxidative Microcoulometry	10 – 20
D4045-96	Hydrogenolysis and Rateometric Calorimetry	1
D5453-93	UV Fluorescence	1
D4294-98	EDXRF	150
D6445-99	EDXRF	48

These results led to the dropping of the EDXRF methods as routine methods of analysis for low sulphur fuels. Further D2622 and D5453 were cross-correlated and give good agreement. It was found that the D5453 Method gave better precision below 50ppm and was hence the recommended method. Work continues on an inter-laboratory cross checking program, with methods D2622, D3120, D4553, D6920 and D7039 being used in different laboratories on standard samples.

Lubricity

Two methods are used: The Scuffing Load Ball on Cylinder Lubricity Evaluator (SLBOCLE), D6078 and the High Frequency Reciprocating Rig (HFRR), D6079. Both have large repeatability and reproducibility limits making enforcement difficult. The correlation between the two methods is not considered to be perfect. The methods are not as sensitive to lubricity additives as desired. Different regulatory authorities prefer one or other of the tests. The EU is generally to favour HFRR which seems to be becoming the preferred test method in the US as well. Further, there is debate within the ASTM working group (WK2571, WK3615) as to the desired maximum value for HFRR with most voting for a 520mm value for the US. The EU value is 460mm which is preferred in the EMA recent B20 specification. A value of 520 micron in the HFRR test corresponds to approximately 3100g in the SLBOCLE test (ASTM WK842).

Cold Flow Properties: Cloud and Cold Filter Plugging Point.

The cloud point (CP) has traditionally represented the cold flow properties of diesel fuel. This measures the temperature at which wax crystals are first observed to form. Nowadays the cold filter plugging point (CFPP) is used more frequently. This measures the temperature at which filtration stops in a 45 micron filter. This temperature is below the cloud point and roughly corresponds to the failure temperature in practice when the wax in the diesel blocks the fuel filter.

The difference between CP and CFPP is usually several degrees, typically 3^{o}C. A difference in excess of 12^{o}C is taken to indicate other fuel problems and generally invalidates the results.

Non ASTM Methods of Interest

Determination of the Biodiesel Blend Level

It is of obvious interest to determine the amount of B100 in a BXX blend. This can be done by either mid infra-red spectroscopy or nuclear magnetic resonance spectroscopy[54]. An ASTM working group (WK10753) is developing a method for determining the FAME content of biodiesel using mid infra-red technology.

Areas of Certainty and Doubt in the Formation of B20 Blends

Before summarising the findings it is worthwhile to discuss the US experience with B20.

US Experience with B20

The United States has been the most active region for developing B20. This blend is widely used. The US Army have produced a B20 discussion paper and purchase description for B20[55]. The following observations on the army's experience with B20 were:

- Water content of the biodiesel increased on storage
- The acid number increases with time
- Separate tankage for biodiesel storage was required
- B20 may clean the fuel system out of deposits: A higher level of filter change may be required.

The purchase description for B20 fuel has been written relying on the existing specifications for B100 and diesel, but placing some additional requirements on the B20 blend:

1. To be used within six months of delivery
2. Fuels of TAN >0.25 mg KOH/kg are not recommended.

The use of B20 has been the subject of quality and stability surveys during 2004[56]. The principal findings of this survey as they related to B20 were:

1. 18 out of 50 samples were not nominally B20. This was put down to ineffective splash blending of the B100 and the diesel.
2. B20 samples show high levels of peroxides, reinforcing the need for an oxidation stability requirement for B100 and possibly B20.
3. B20 samples shown low level of water interfacial tension indicating that water separators on engine systems would not work as intended. The high peroxide levels may have contributed to this.

Probably in light of these findings, the US Engine Manufacturers Association has proposed a B20 specification that is tougher than the US B100 specification. The various specifications for fuels of interest are shown in the Table 4 below.

Table 4 - Comparison of Diesel and Biodiesel Specifications of Interest

PROPERTY		AUS DIESEL (a)	AUS B100 (b)	US D2 S15	US B100 S15	EMA D2	EMA B20
Flash Point (C) minimum	D93	61.5	120	52	130	52	52
Water, ppm max	D1744					200	
Sediment ppm max	D2276					10	
	D5452					10	
Water and Sediment (vol. %)	D2709	0.050	0.050	0.050	0.050		0.050
Distillation T90 (C max)	D86			338			343
	D1160		360		360		
Distilation T95 (C max)	D86	360				355	
Viscosity (40C)	D445	2.0 - 4.5	3.5 - 5.0	1.9 - 4.1	1.9 - 6.0	1.9 - 4.1	1.9 - 4.1
Ash, (mg//kg, ppm)	D482	100		100		100	100
Sulphated Ash (ppm)	D874		200		200		
PAH (%mass, max)	IP 391	11					
Aromaticity (%vol max)	D1319			35			
Copper Corrosion max	D130	1	1	3	3	3	3
Cetane Number, min	D613		51	40	47	50	43
Cetane Index, min	D976			40			
	D4737	46					
Ramsbottom Carbon, 10% residue (%max)	D524			0.35		0.15	0.35
Carbon, 10% residue (%max)	D4530	0.2	0.3		0.05		
API gravity (max)	D287					39	
Density kg/cm (max)	D1298		890				
	D4052	850					
Conductivity (pS/m, min)	D2624	50					
Lubricity g.min	D6078					3100	
Lubricity (micron, max)	IP 450	460		520			460
Oxidation Stability, mg/L max	D2274	25				15	10
Oxidative stability induction time (h, min)	EN14112						6
Sulphur (mg/kg)	D2622	50				500	
	D5453	50	10	15			15
Ester content (% min)	EN14103		96.5				
Phosphorus (ppm)	D4951		10		10		10
Detergency -L10 injector, CRC rating						<10	
Depositing test %flow loss						<6	
Low temperature flow (C)	IP387	2			report		
Cloud Point (C max)	D2500					3	as regulation
CFPP (C max)	D4539					3	

Microbial growth						4	
Acid Value (mgKOH/kg max)	D664		0.8		0.8		0.3
Total Contamination (ppm)	D5452		24				
Free Glycerol (% mass max)	D6584		0.02		0.02		
Total Gylcerol (% mass max)	D6584		0.25		0.24		
Alkali Metals (ppm max)	EN14108		5				not detected
Alkaline Metals (ppm max)	EN14538		5				not detected
Methanol content (% mass, max)	EN14110		0.2				
Blend fraction	EN14078						+/-2%

(a) Fuel Standard (Automotive Diesel) Determination 2001; (b) Fuel Standard (Biodiesel) Determination 2003

The data in the table gives an overview of the complexity when comparing so-called harmonised standards between different regulatory bodies, as each chooses its own preferred test requirement, method of analysis and value. The principal point is the proposal by EMA for a very tight B20 specification. Naturally from an engine manufacturer's standpoint the preference will be for the tightest standards. However, the proposed EMA specification for the T90 distillation point using the D86 method could seriously limit the types of FAME used to formulate the B100 used in the blend, because it is well known that many FAMEs decompose on distillation or have higher boiling points than the 343^{o}C proposed.

The other point of concern is the stability of the B20. The EMA specification proposes tighter levels of compliance than for the US B100 specification by requiring tests for both thermal and oxidative stability. This together with the very tight acid value parallels the US army's purchase description discussed above and represents the concern for the storage stability for B20 (especially one using the common US starting material of soy).

Knowns and Unknowns regarding the formation of B20

Positives

- Using soy or rapeseed (Canola) as the source of biodiesel (B100) a B20 blend can be formed with the range of conventional diesel available in Australia.
- The properties of such a blend are predictable.
- Such as B20 is responsive to the types of additives used in the control of properties for diesel.

- The operating performance of such a blend is well known. The emissions of particulate matter and carbon monoxide are significantly lower than conventional diesel. There is a small loss in efficiency.
- There is extensive field demonstrations and trials for B20 made from soy in the US and for rape in the EU.
- Using sources for biodiesel other than soy or rape can produce a biodiesel with predictable properties and a B20 blend with currently available conventional diesel.
- There is a reasonable amount of evidence to suggest that B20 made from palm oil olein would be similar to rapeseed derived B20.
- Apart from NOx emissions, the use of B20 has no increased adverse affects on human health relative to conventional diesel.
- Provided a blend is made from suitable feed stocks and stored in a suitable manner, B20 is compatible with components in modern engines.

Negatives and Solutions

<u>B20 from any source biodiesel</u>

- B20 is a stronger solvent than conventional diesel. This results in B20 mobilising deposits in the supply chain and leading to filter blockages. Solutions to this are:
  - Increasing the rate of filter change on engines
  - Placing filters at strategic places in the supply chain, (eg. retail pump)
  - Using a thoroughly cleaned or new and dedicated supply chain for B20 or one previously used for B100.
- B20 causes a small increase in NOx emissions. This can be ameliorated by blending with low aromatic diesel or by using cetane enhancers. The use of cetane improvers can compromise some of the ASTM test methods (eg D4530 Carbon Residue).
- B20 is more hygroscopic than conventional diesel and absorbs water from the atmosphere or within tanks on storage. This can be ameliorated to some extent by using demulsifying additives. This impact of using large amounts of these additives is unknown.

Blends containing High Levels of Olefins

- High levels of olefins in the oil lead to oxidative instability. This is especially true for soy based B20. However, this can be controlled to some extent by anti-oxidants.
- This oxidative instability leads to long term storage problems and degrading of the properties including increasing water content, increase in acid number (TAN) and an increase in degradation of elastomers.

Blends Containing Tallow or Coconut Biodiesel

- There is a paucity of detailed and sound technical information regarding the properties and performance of B20 made from high levels of tallow.
- There is a paucity of information regarding the formation of B20 from coconut oil
- For the typical conventional diesel currently in use the properties can be predicted but the properties of a B20 made from tallow and a low aromatic diesel may have unacceptable cold flow properties.
- Tallow has higher oxidative stability than vegetable oil products such as rape or soy, but this comes at the cost of poorer cold flow properties. Blending from different sources to trade off good and bad properties is well known and practiced.
- B20 made with tallow component does not respond well to the conventional range of cold flow additive improvers.

Advantages and Disadvantages of the Two Approaches

We are asked to discriminate between the approach to the promotion and regulation of B20 by either:

1. Blending to B20 using certified B100 and certified diesel fuel.
2. Blending any source biodiesel and diesel and certifying the B20.

From the foregoing and the detail provided in Attachment 1, it is evident that certifying at the B20 level would be difficult in that the integrity of many of the test methods for diesel performance would be compromised if applied to a B20 fuel.

However, there is a significant variant on the other option of certifying at the B100 and diesel level to form a blend, namely the use of additional analysis specific to the B20 blend after blending from certified fuels has occurred. There seems to be a wide consensus for this type of approach in the US and seems to be preferred by the industry here.

However, one significant issue to be decided is why certify B20 rather than another blend level (B10, B15, B25, B30 etc.). In fact certification of a general BXX where XX is in a range 06 – 20 say may be more practical than certifying a B20. This would permit blenders to mix in more conventional diesel to produce a product with acceptable cold flow properties for instance. This is the current practice with some players in the industry.

This approach facilitates the use of a high tallow based B100 into the mix where say a high tallow B20 could be diluted as required to maintain cold flow properties without trying to use additives of dubious effectiveness. We should recall that Australia has a relatively high level of tallow source material.

If this approach is adopted there will be some other issues of relevance to blend which should be tested post blending such as biodiesel content, flash point, water and solids, and cold filter plugging point.

Other Issues

NOx Emissions

The intention of the *Fuel Quality Standards Act 2000* is foster the introduction of cleaner burning fuels. B20 will produce less particulate emission and carbon monoxide emission than conventional diesel, but on the evidence gathered above, there will be a slight rise in NOx emissions.

The choice is to either (1) ignore the increase in NOx (and regard it as a partial trade off for the significant reduction in other pollutants), or (2) insist that a NOx neutral fuel be produced, that is a B20 which as the same NOx emission of conventional diesel.

Refiners and blenders can produce a NOx neutral fuel by either selection of low aromatic diesel streams or by adding cetane improvers. At this stage the latter seems the most cost effective and is generally applicable to a wider range of biodiesel producers and blenders. However, the use of organometallic additives such as ferrocene should be discouraged.

Density

The latest Australian specification limits the density of the diesel to 850 kg/m^3). It is worth noting that there is no specified limit in the US specification. Australia does not have the strict limits on aromatics content that apply elsewhere and as a consequence many refinery streams and finished diesel has a density close to this limit (eg. >840 kg/m^3). Other parts of the world, including New Zealand regularly produce diesel near to the low end of the limit, namely 820 kg/m^3. Biodiesel density is typically >860 kg/m^3 and the B100 specification allows B100 in the range 860 to 890 kg/m^3.

Clearly a B20 blend made from a relatively dense Australian diesel and B100 would have a final density over the Australian diesel density limit of 850 kg/m^3. Intertek has demonstrated this[57].

The options are (1) lift or remain silent on the density specification for a B20 or (2) maintain the limit at 850 kg/m^3.

In the latter case it will be necessary to blend low-density diesel streams with B100 to produce the B20. This may have the added benefit of reducing the NOx emissions. However, since tallow is a significant biodiesel feedstock in Australia, this takes the resulting B20 into the unknown (riskier) part of the Matrix discussed above. Excluding tallow and the like from the B100 could mitigate this risk.

Of the various options to minimise barriers for B20 entry, the first is preferred.

Water Content

The presence of water causes corrosion in the diesel engine, particularly in fuel injector systems. The water content of petroleum diesel is usually quite low since the hydrocarbons are generally hydrophobic. Fatty acid esters, on the other hand, are hygroscopic and will contain a high water content by merely being exposed to moist air during storage.

Blends formed from wet FAME and dry diesel would be expected to result in precipitation of excess water. This may be evident in the fuel as cloudiness or haze in the fuel blend. It is important to ensure that the biodiesel is as dry as possible, at least as dry as the petroleum diesel when forming a B20 blend and the resulting blend is stored under dry conditions.

Cold Flow Properties

The CFPP is not specified for the B100 standard. Cloud point and CFPP are extensively discussed in AS 3570-1998 (Automotive Diesel Fuel). The range of permitted CFPP ranges according to season and geographic district is illustrated in the following Table 5 taken from the 1988 version of the standard.

Table 5 - Maximum Limits for Cloud and Cold Filter Plugging Points - Australia

Zone	Winter 16 March-15 September		Summer 16 September–15March	
	CP (^oC)	CFPP (^oC)	CP (^oC)	CFPP (^oC)
North	+7	+4	+15	+12
West	0	-3	+6	+3
East	-1	-4	+4	+1
South	-4	-7	-4	-7

Clearly shown is a very wide geographic variation. Considering the fuel may be in storage for up to six months the lower (winter limits) will generally apply.

Although the standard for B100 does not specify a limit for CP or CFPP, in practice any B100 sold to a refiner for blending into B5 has to be supplied to these or similar industry imposed values.

Since we are concerned with the promotion of B20 to a wider user group, perhaps there should be some consideration to specifying the CP and CFPP for B20.

Recommended Approach

That a BXX (where XX ranges from 06 to 20) blend be regulated to be made from certified B100 and certified diesel fuel with the following additional test for BXX certification:

- Flash point - to maintain safety and that nothing as being added to help homogenise the blend but would compromise safety (such as ethanol)
- Oxidative stability and TAN value to indicate potentially a reasonable storage life.
- Water, sediment and solids to maintain the quality of the blending process.
- CFPP to advise the user of the likely operating minimum ambient temperature.
- Biodiesel content (+/- 2%) for consumer information and to ensure that the content is within the regulated range (05 to 20 say).
- Phosphorus and trace metals to help improve blend stability.

Industry Code of Practice

It is important to back up the certification of a BXX fuel with an industry code of practice for the handling and use of a BXX blend where XX is greater than 05. Such an industry code should at a minimum recommend:

- In order to achieve homogeneity and consistency, the blending of certified B100 and diesel should be performed with mechanical agitation rather than splash blending.
- BXX should be stored and transported in new or cleaned tanks and pipelines to ensure minimum pick-up of sediment. This should be backed by, as appropriate, in-line filters in the delivery system.
- The storage and use of BXX should be less than six months from its date of blending and certification.
- The user be advised that the biodiesel blend should be used within a specified period (eg within one month of purchase).
- The user to be advised to check with the engine manufacturer of the suitability of a BXX blend for the owner’s vehicle.

- The user of BXX to be advised of the propensity of the fuel to pick-up extraneous matter and to change filters regularly.
- The user be advised of the minimum operability temperature of the blend.

STAGE 2

Background and Approach to Stage 2

From the discussion provided in Stage 1 of this Study it is evident that biodiesel and petroleum derived diesel differ in certain fundamental properties. These differences impact on the properties of biodiesel-diesel blends.

Conventional wisdom and industry experience indicates that these differences do not materially influence blends with biodiesel levels of 5% or less. At this level the properties of the blend hardly change that of the conventional diesel in the blend. In fact biodiesel can be used as an additive at these levels to improve the lubricity of low sulphur diesel fuels, which generally have low levels of lubricity. The use of biodiesel at 5% or less in conventional diesel is widespread. Further, the incorporation of biodiesel at these low levels is generally not noted in the labeling of the fuel.

However, it is generally understood that levels of biodiesel higher than 5% can detrimentally impact on the properties of the blend.
Biodiesel and petroleum diesel differ fundamentally as a result of:

1. Biodiesel comprises fatty acid methyl esters (FAMEs) and the ester group imparts higher solvating powers than the hydrocarbons of the hydrocarbons of petroleum diesel, particularly low sulphur, paraffinic diesel fuel.
2. Biodiesel has generally a higher level of olefinic components than petroleum diesel, and in particular poly-olefinic compounds (poly-unsaturates) which are very susceptible to oxidation. These oxidation products (peroxides and acids) are very corrosive and can attack metals and elastomers resulting not only in erosion of parts but also the formation of deposits within the engine.
3. Biodiesel, unlike petroleum diesel, is not distilled during the production, and as a consequence heavy, high boiling materials are present in higher concentrations than found in conventional diesel. These heavier materials are susceptible to cracking in the hotter engine parts and subsequent coke and varnish lay-down within the engine.

All of the issues that confront the adoption of higher blends of biodiesel can be traced to these differences.

From the standpoint of the biodiesel producer, these problems can be ameliorated by careful selection of the types of feedstock used to make the biodiesel and hence the composition and properties of the FAMEs used. Thus selection of lower olefinic feed stock particularly lower poly-unsaturated feedstock, will ultimately produce a blend of higher stability than would otherwise be the case.

One point of note is the regional variation in the feedstock being used to produce biodiesel. European biodiesel is dominated by rapeseed biodiesel, US biodiesel is dominated by soy based biodiesel and Malaysian biodiesel is dominated by palm oil derivative biodiesel. However, for Australia the feedstock is likely to be all of these plus a large amount of animal tallow as a recycled waste from the meat processing industries.

The latter point leads to the opinion that for maximum flexibility it would be prudent to adopt standards here that do not, inadvertently or otherwise, proscribe the feedstock source.

Technical Parameters

The conclusion of the Stage 1 of this Study was that BXX (XX = 06 to 20) should be made from certified “on-specification” B100 biodiesel and certified “on specification” conventional diesel. A general discussion of the detail and reasoning for the technical parameters which relate to the B100 and petroleum diesel standards are beyond the scope of this work which relates to the standardizing of blends. However, certain of the parameters will impact on the standardization for a blend and these are discussed and repeat some of the key issues identified in Stage 1 with an expansion of the discussion to focus on the testing and regulation of the blends.

Sulphur

The limitation of sulphur to very low levels is necessary so that the new technologies for pollution control can be used on diesel engines, especially for the control of nitrogen oxide emissions. Sulphur content blends linearly so that the outcome for a BXX blend should be the weighted-average of the B100 and petroleum diesel components.

New fuel standards call for a very low detection limit for sulphur, typically less than 50 ppm. Many of the older methods are inapplicable to this range and it is necessary use an appropriated test method for the determination. In essence this means revising the method to be used as new information comes to hand from work in progress by the ASTM. However, since the recommendation is that the B100 and the petroleum diesel are to be specified there should be no need to determine the final sulphur for the blend and the issue of which method to use should be addressed within the specifications for the parent fuels.

At this time in order to determine the fuels are below 10mg/kg, the ASTM Method D5453 can be used.

Carbon Residue

Carbon residue gives a measure of the carbon forming tendency of the fuels. It is considered as indicative of the deposit forming tendency in fuel injectors.

The standard for B100 is higher than that for the petroleum diesel (eg. 0.3% mass versus 0.2% mass at the 10% distillation residue level). The carbon residue should blend linearly so that a BXX blend should have the weighted average of the B100 and the petroleum diesel value. Since it would be expected that the B100 value would be higher, the resulting BXX should have a lower value than that determined for the B100. There should be no need to determine separately the carbon residue for the blend provided the parent fuels meet the appropriate specifications.

Carbon residue with the 10% distillation residue method is determined by ASTM Method D4530. *Prima facie* the maximum value for a B20 blend should be 0.22% mass (weighted average of B100 and petroleum diesel). However, note that two decimal places is outside the precision for the method.

Water and Sediment, and Total Contamination

Water and sediment are regulated in the specifications for biodiesel and diesel at the same level of 0.05% by volume. Water contamination of fuels can result from the absorption of moisture from the air in storage tanks as well as condensation in tanks and pipelines. Water causes corrosion and hence the potential for blocked injectors.

Water also promotes biological growth in the fuel, which also results in blocked lines, filters and injectors. A marketing positive for biodiesel is its biodegradability relative to petroleum diesel. The converse is that biodiesel and biodiesel blends are good feedstock of microbiological growths so that it is important to minimise the level of water in biodiesel blends.

As noted previously in Stage 1, when biodiesel of high water content is mixed with petroleum diesel, water is precipitated causing cloudiness or haze in the fuel. In the extreme a free water layer may form. To protect against this the biodiesel should be as dry as possible prior to blending and the resultant blend should be stored under dry conditions.

Test method D2709 determines the level of free water in fuels. This is used for both B100 and petroleum diesel fuel. However, it may be necessary to introduce a test for *dissolved* water for the B100 fuel and the resulting blend.

Sediment generally consists of carbonaceous material, metals or other inorganic and insoluble materials. Fuel degradation (by oxidation) can contribute to sediment. Sediment blocks filters and causes deposits in injectors and within the engine itself.

Because of the solvation power of FAMEs, both biodiesel (B100) and its blends are more hygroscopic than petroleum diesel. Further, this higher solvation power mobilises sediment in the distribution system.

As detailed in Stage 1, US experience of blocked filters when using B20 is a consequence of this. Because of this it is important to carefully monitor the build up of water and sediment in a distribution system delivering a BXX blend. This should be as late as possible in the chain, preferably at the point of delivery to the final user.

The biodiesel standard for B100 sets a maximum value for particulate contamination at 24mg/kg measured using ASTM Method D5452. This method is primarily designed for aviation fuels rather than diesel.

The method used for determining water and sediment is D2709 and the level should be below less than 0.05% (by volume). As well as this method, D6217 or D6246 for sediment may usefully contribute. The method D6246 can be used in the field to check on filterability after storage.

However, there is some industry support for the use of filter blocking (plugging) tendency of fuels as a method for determining the cleanliness and possible the deterioration on storage of diesel fuels. These methods ASTM Method D 2068 or IP 387 would require the fuel to have values below 2 units.

Phosphorus

As discussed in Stage 1, phosphorus has been implicated in deposit formation in biodiesel (B100), especially on long term storage.

Phosphorus is regulated for biodiesel (B100) at a maximum level of 10mg/kg. This is the same level recommended by the EMA for B20.

Phosphorus is not regulated in petroleum diesel and the phosphorus content of diesel is unknown. Conventional wisdom would indicate that it should be absent in a distilled product such as diesel. It may be that there is not an issue with phosphorus contamination from the diesel. The method used for determining phosphorus is D4951 and the maximum level in the blend should be 10mg/kg.

The problems with long term storage of biodiesel blends indicates that it may be prudent to measure and report the phosphorus content of a BXX blend, at least when these are first being produced.

Glycerol (and glycerol esters)

These are regulated for biodiesel. Glycerol esters are the precursors to FAMEs and are poor quality diesel components generating deposits and varnishes within the engine.

Glycerol and its esters blend linearly so that the outcome for a BXX blend should be the weighted-average of the B100 and petroleum diesel components (for which they should be absent). It should not be necessary to redetermine this parameter.

Metals

Alkali and Alkaline earth metals are used in the biodiesel manufacturing process and can contaminate the final product. If present they can form engine deposits and are regulated in the biodiesel standard to a maximum level of 5mg/kg for each Group. They are not determined for petroleum diesel.

Metal contaminants blend linearly so that the outcome for a BXX blend should be the weighted average of the B100 and petroleum diesel components.

The method used is EN14108 and EN14538 and for a B20 blend should be well below the regulated B100 maximum value of 5mg/kg. Because of the ubiquitous nature they could enter the diesel stream at low levels (ppm) as contaminants or as additives. The impact of such contamination is unknown and it may be prudent to measure and report the level in a BXX blend, at least when these blends are first being produced.

Alcohols – Methanol and Ethanol

Alcohol contamination of biodiesel occurs from poor washing and final polishing processes. Methanol is the most likely alcohol. Methanol is very hygroscopic and corrosive to many parts within a conventional engine. It will also lower the flash point of the diesel.

Ethanol may also be used to form fatty acid esters. It has similar properties to methanol. Ethanol has also been proposed as a co-solvent to assist the blending operation. As well as increasing corrosion, ethanol will reduce the flash point of the blend.

Alcohols will blend linearly so the outcome for a BXX blend should be the weighted average of the B100 and the petroleum diesel components (the latter should be zero). Provided the parent biodiesel complies with the standard (maximum 0.2% mass by EN14110), and alcohols are not used as a co-solvent, there should be no necessity to determine the value for a BXX blend. Flashpoint may be appropriate surrogate test for the presence of alcohol.

Density

The density of petroleum diesel is important in determining the power delivery of the fuel. High density ensures high energy content per unit volume and therefore good fuel economy.

The latest Australian specification limits the density of the diesel to 850 kg/m^3. Australia does not have the strict limits on aromatics content that apply elsewhere and as a consequence many refinery streams and finished diesel has a density close to this limit (eg. >840 kg/m^3). Other parts of the world, including New Zealand regularly produce diesel near to the low end of the limit, namely 820 kg/m^3. Biodiesel density is typically > 860 kg/m^3 and the B100 specification allows B100 in the range 860 to 890 kg/m^3.

Clearly a B20 blend made from a relatively dense Australian diesel and B100 would have a final density over the Australian diesel density limit of 850 kg/m^3.
The options are:

(1) lift or remain silent on the density specification for a B20, or
(2) maintain the limit at 850 kg/m^3.

In the latter case it will be necessary to blend low-density diesel streams with B100 to produce the B20. This is the strategy used by some of the biodiesel. This may have the added benefit of reducing the NOx emissions. However, since tallow is a significant biodiesel feedstock in Australia, this takes the resulting B20 into the unknown (riskier) part of the Matrix discussed above in Stage 1. Excluding tallow and the like from the B100 could mitigate this risk.

Of the various options to minimise barriers for B20 entry, the first option is preferred.

Distillation

Conventional diesel fuel is specified using the high temperature distillation point T(90) or T(95). This is the temperature at which 90% or 95% (by volume) of the fuel has distilled

The correct distillation profile is essential for efficient combustion. Volatility characteristics affect the extent of smoke and odour. Low T90 values and end-point values tend to ensure low carbon residuals, minimum crankcase values and good vaporisation in cold weather.

The standard distillation procedure for distillate fuels is ASTM Method D86. However, biodiesel (B100), especially biodiesel high in olefins, thermally decomposes at the higher temperatures of the distillation process. The test should not therefore be applied to determine with significance the higher distillation points of biodiesel or biodiesel blends, namely the T90, T95, end points and residue. Distillation under vacuum will solve this problem (ASTM D1160), however, the algorithms described in the method used to compute the atmospheric equivalent temperatures are only applicable to hydrocarbons. The values can be computed using published data for FAME volatility but the accuracy of these is unknown. This would also require a knowledge of the breakdown of the FAMEs present, an analysis not required in certifying a B100 fuel.

Another point is that many of the normal boiling points of the fatty esters of interest lie above the typical T95 points of the petroleum diesel specification. *Prima facie* this limits the amount and type of biodiesel that could be blended. For example the T95 point in the Australian specification is 361^{o}C which is below the normal boiling points of C18:2 and C18:3 methyl esters which are common FAMEs. However, the benefit is that this may act to discriminate against these types of FAME which are known to have poor oxidative stability.

The high boiling points of FAMEs present a problem for the regulation of the fuels using distillation cut points. A preliminary proposal by Californian regulators suggests that a B20 blend should have cut points 10^{o}F higher than those in the US petroleum diesel specification D975. This is repeated in the latest EMA suggestion for B20 which lifts the specification for the T90 point from 338 to 342C.

In light of this it is suggested that the Australian standard for higher blends such as B20 should remain silent on the issue of distillation points, noting that these are is separately specified in the B100 and petroleum diesel specifications.

Viscosity

Viscosity affects the injection timing and therefore the optimisation of the pump setting. Viscosity values outside the range specified by the engine manufacturer will affect fuel delivery, the operation of advance units and governor mechanisms. Low viscosity can cause excessive wear in some injection pumps, impairment of combustion and cause restart problems. High viscosity can result in filter damage and pump drive line wear. It can also cause poor combustion (hence increased emissions) accompanied by power loss and loss of lubrication to the cylinder walls. There is also a risk of pump failure at start-up in cold conditions.

The Australian Standard for biodiesel (B100) specifies a range of 3.5 to 5.0 mm^2/s, and that for petroleum diesel in the range 2.0 to 4.5mm^2/s. Low sulphur petroleum diesel tends to be on the lower portion of this range.

Viscosity does not blend in a linear manner so that the viscosity of a BXX blend is unlikely to be the weighted average of the parent components. However, it is unlikely to be outside of the range 2.0 to 5.0mm^2/s provide the biodiesel and petroleum diesel comply with their respective standards.

Given this it is unnecessary to remeasure the viscosity for a BXX blend.

Flashpoint

The safe handling, storage and use of diesel is dependent on its relatively high flash point – for example in marine applications. It is often specified in fire regulations and insurance requirements.

The Australian Standard for biodiesel (B100) specifies a value of 120^oC and that for petroleum diesel at 61.5^oC. From the aspect of health and safety, flash point is a critical distinguishing feature between diesel and gasoline.

Flash point does not blend linearly and usually tends to the value of the lowest component, namely that of the petroleum diesel.

The danger is that the biodiesel is non-compliant containing excess alcohol or that alcohol is added to assist homogenising the blend, especially in cold weather. Either of these could radically reduce the flash point. Because of the importance to health and safety, it is recommended that after blending the flash point of a BXX be measured and reported by any of the recognised test methods such as ASTM Method D93 and shown to be more than the regulated limit for petroleum diesel (61.5^{o}C).

Copper Strip Corrosion

The copper corrosion test (ASTM Method D130) serves as a measure of possible corrosion of copper, brass or bronze parts within the fuel system. The copper strip corrosion test is designed to assess the relative degree of corrosivity of petroleum products. For petroleum products the results is related to the amount of sulphur present.

For compliant diesel, the Australian Standard calls for a maximum value of Class 1 whereas the corresponding biodiesel standards permits a higher level of corrosion at Class 3. The proposed EMA B20 biodiesel standard also calls for a Class 3 result.

Providing the B100 feedstock to the blend has a value of Class 3 or less, then there should be no necessity to test a BXX blend provided the petroleum diesel is also compliant with a value of Class 1.

Oxidation Stability

All diesel fuel oxidises on exposure to air and water, particularly if the fuel contains a high level of olefins. This is the case for biodiesel, especially biodiesel made from soybean.

Oxidation also increases with temperature and the presence of copper and zinc. Prolonged storage can result in oxidation and the formation of gums and sediment, which results in filter plugging, injector fouling and engine deposits. This increases engine wear.

Oxidation stability is measured by a modified ASTM Method D2274 or in the racimate test EN14112 in the Australian Biodiesel Standard and the EMA specification. Oxidation stability is specified in the recent Australian petroleum diesel standard ASTM D2274 at 25mg/L. Notre that some stakeholders express concern that D2274 is not relevant to biodiesel.

Because storage life is one of the main issues with biodiesel blends, it is recommended that the oxidative stability of a BXX blend be determined. The BXX blend should have the maximum value of 25mg/L by D2274 or a 6 hour stability by EN14112.

Acid Value

This is a general test for acid components in petroleum fluids. The use in the B100 specification is for quality control regarding the amount of free fatty acids and the like present. However, free acids are also formed as a result of oxidation of the biodiesel on storage.

The method used is D664 and the limit for B100 is set to a maximum of 0.80mg KOH/g (maximum). Since the acid value for the petroleum diesel is not measured, it would seem prudent to measure the acid value after blending to form a BXX blend.

The method could have application to BXX blends as a method of monitoring oxidation on storage which results in the formation of organic acids and hence and increasing acid number. Regular determination of the acid value of stored B20 is suggested by the EMA standard.

Cetane Number

This test method (ASTM Method D613) is used by engine manufacturers, petroleum refiners and marketers and in commerce as a primary specification measurement relating to matching fuels and engines. The biodiesel (B100) standard calls for a minimum value of 51.

The petroleum diesel standard calls for the fuel cetane to be determined by the index method (D976 or D4737) which must have a minimum value of 46. For petroleum diesel a good correlation exists between the cetane index and the cetane number as measured by D613. The accuracy is +/- 2 cetane numbers for most fuels. However, the method is unsuitable for biodiesel and biodiesel blends.

Prima facie the biodiesel (B100) should have a better cetane number than the petroleum diesel. These should be no need to determine the cetane number for a BXX blend provided both the parent fuels comply to their respective standards.

Lubricity

The Australian standard for petroleum diesel adopts the European value of 460mm using the HFRR ASTM Method D6079 (IP450). Since biodiesel has better lubricity properties than low sulphur petroleum diesel there should be no necessity to specify the lubricity for a BXX blend provided the petroleum diesel component of itself meets the specification.

Cold Flow Properties: Cloud and Cold Filter Plugging Point.

The cloud point (CP) has traditionally represented the cold flow properties of diesel fuel and measured by the ASTM Method D2500. This measures the temperature at which wax crystals are first observed to form. Nowadays the cold filter plugging point (CFPP) is used more frequently. This measures the temperature at which filtration stops in a 45 micron filter (ASTM Method D4539). This temperature is below the cloud point and roughly corresponds to the failure temperature in practice when the wax in the diesel blocks the fuel filter.

The difference between CP and CFPP is usually several degrees, typically 3^{o}C. A difference in excess of 12^{o}C is taken to indicate other fuel problems and generally invalidates the results.

The CFPP is not specified for the Australian B100 standard. However, cloud point and CFPP are extensively discussed in earlier versions of the diesel standard AS 3570-1998 (Automotive Diesel Fuel). The range of permitted CFPP ranges according to season and geographic district and a simplified version is illustrated in the following Table taken from the 1988 version of the standard.

Table 6 - Maximum Limits for Cloud and Cold Filter Plugging Points - Australia

Zone	Winter 16 March-15 September		Summer 16 September–15March	
	CP (^oC)	CFPP (^oC)	CP (^oC)	CFPP (^oC)
North	+7	+4	+15	+12
West	0	-3	+6	+3
East	-1	-4	+4	+1
South	-4	-7	-4	-7

Although the standard for B100 does not specify a limit for CP or CFPP, in practice any B100 sold to a refiner for blending into B5 has to be supplied to these or similar industry imposed values.

As B20 may be taken up by a wider user group, with new players entering the market and producing BXX blends, then it may prove wise to measure and report to the user. The CFPP should be measured according to the method D4539 (or similar) with the intention that the blend should have a CFPP value as detailed in the AS 3570-1998 specifications.

Determination of the Biodiesel Blend Level

It is of obvious interest to determine the amount of B100 in a BXX blend. This can be done by either mid infra-red spectroscopy or nuclear magnetic resonance spectroscopy. An ASTM working group (WK10753) is developing a method for determining the FAME content of biodiesel using mid infra-red technology. The recent EMA B20 standard calls for the measurement of biodiesel content to +/- 2% using method EN14078.

One of the problems found in the US sampling study discussed in Stage 1 of this report was that the wide variation in the biodiesel content for so-called B20 blends. The route cause of this was put down to poor splash blending practices.

It order to ensure that the BXX value required is being achieved it would seem prudent that the XX value should be measured and reported for customer information and to be done in a manner so as to ensure adequate mixing of the blend components have been achieved. If a standard for a BXX blend is to be issued then the XX value should be determined and reported using EN14078 or similar to a precision of +/-2% by volume.

Conductivity

A relatively high conductivity of diesel fuel is required to minimise the build up of static electricity in pumping and tank filling operations. Static electricity discharge acts as an ignition sources and cause of fires in the petroleum industry. The conductivity of petroleum diesel is set at a minimum of 50pS/m as measured by ASTM Method D2624. Biodiesel has a higher conductivity that petroleum diesel and is not specified in the B100 standard. Provide the petroleum diesel complies with the standard the formation of a BXX blend should not be detrimental to the conductivity limit.

Suggested Regulatory Values

Stage 1 suggested that the route to standardising a biodiesel blend of XX percent FAME in petroleum diesel should be done by making all blends from certified B100 and certified diesel. This should then be supplemented by further tests on the blends to verify quality of the blend. Since one of the main issues is contamination and deterioration in transport and storage, these tests should be performed on fuel obtained from the retail pump.

The suggested further tests, suggested test methods (which may be substituted with a similar method for determining the parameter) and the suggested limits are:

Table 7 - Suggested Post Blending Tests and Values

Parameter	Test Method	Value
Flash Point	ASTM D 93	61.5^{o}C (minimum)
Oxidative Stability	ASTM D 2274	25mg/L (maximum)
Total Acid Number	ASTM D664	0.80mg KOH/L (max)
Water, Sediment and Solids	ASTM D 2709	0.05 vol% (maximum)
Filter Blocking Tendency	IP 387	2 (maximum)
Cold Filter Plugging Point	ASTM D2500	Report value
Biodiesel Content	EN 14078	Report Value (20 max)
Phosphorus	D4951	10mg/kg (maximum)
Alkali Metals	EN 14108	5mg/kg (maximum)
Alkaline Metals	EN 14538	5mg/kg (maximum)

Vehicle and Engine Manufacturers Approach

Various groupings of automotive and engine manufacturers have come together and issued the World-Wide Fuel Charter. These groupings comprise:

ACEA - European Automobile Manufacturers Association

ALLIANCE – Alliance of Automobile Manufacturers

EMA – Engine Manufacturers Association

JAMA – Japan Automobile Manufacturers Association

Together these industry organisations cover the majority of the vehicle manufacturing industry.

In the December 2002 edition of the World-Wide Fuel Charter, these industry associations call for a maximum level of 5 vol.% of FAME present and that bowsers should be marked to indicate the presence of FAME. The Charter states that *"… at higher levels in diesel fuel, the vehicles need to be adapted to the fuel, and particular care is needed to avoid problems."*

The Charter goes on to state that FAME should not be used in high quality fuels markets (Category 4) which demand the use of sophisticated control equipment to limit nitrogen oxides and particulate matter.

Federal Chamber of Automotive Industries (FCAI)

The FCAI have provided the following statement:

"The Federal Chamber of Automotive Industries (FCAI) is the peak industry body that represents the majority of Australia's manufacturers and importers of passenger and light commercial vehicles, and motorcycles.

Australia is one of the most competitive automotive markets in the world with more than 50 brands, 350 models from 20 source countries.

The FCAI acknowledges the important role properly refined biofuels (ie those conforming to the national fuel standards) can play in the transport fuels equation. Particular reference is made to the Federal Government's 350 million litre biofuels target (for ethanol and other biofuels) and recognises the benefit of establishing such a target. The vehicle industry's perspective is that biofuels that conform to the national fuel standards are acceptable for those models identified by the manufacturer as being compatible with such fuels.

Steps to encourage the use of biodiesel must recognise the nature of the Australian automotive industry. New vehicle sales are approaching 1 million units annually. This however, still only represents less than 1% of the global market. Some 30% of new vehicles are manufactured locally and about 70% imported. ***All diesel engine vehicles are imported.***

FUTURE VEHICLE FLEET AND FUTURE EMISSION REQUIREMENTS

Australia has a policy to harmonise the Australian Design Rules (ADRs) with international standards as specified in the UN ECE Regulations. To that end, the current (ADR 79/01) and future (ADR 79/02) exhaust and evaporative emissions are harmonised with UNECE Regulation 83. New vehicles certified to these standards will increasingly use advanced emission control technologies and have therefore more stringent fuel quality requirements.

As a broad philosophy, steps to encourage the uptake of biofuels here in Australia should not undermine the environmental benefits foreshadowed to flow from these new vehicle standards. In other words, decisions on fuel quality should not compromise vehicle environmental performance or vehicle operability.

BIODIESEL BLENDS USING FAME

No limits for biodiesel exist in the National fuel standard for diesel fuel. However, Fatty Acid Methyl Esters (FAME) including vegetable derived esters (VDE) are generally acceptable when blended with conventional diesel fuel up to 5% (vol/vol) (so called B5). The FAME(s) on which the biodiesel is based must comply with either EN14214 or ASTM D6751 standards. The resultant biodiesel (B5) blend must conform to the national Diesel Standard, which is based on EN590. This is consistent with the World Wide Fuel Charter (WWFC).

When biodiesel is used, either as a pure fuel, or at higher levels in diesel fuel, vehicles need to be adapted to the fuel, and particular care is needed to avoid fuel system component and engine performance problems. In this application, rapeseed, sunflower, palm, soya, cooking oils and animal fats can be used for making FAMEs. Importantly, these blended diesel fuels need to be properly refined and produced to meet high quality standards and it is ***mandatory that all aspects of legislated national fuel quality standards for diesel and vehicle manufacturer recommendations are maintained at all times and locations.***

FCAI does not generally support the use of biodiesel blends greater than B5, including 100% biodiesel fuel (B100), in engines unless the manufacturer of such engines recommends it. Such engines would need to be specifically designed to use such fuels.

OXIDATION STABILITY

Research is being carried out in Japan and the USA regarding concerns over the oxidation stability of biodiesel blends. The formation of undesirable break-down products will have an adverse effect on the performance and durability of fuel system componentry.

The Engine Manufacturers' Association (EMA) has made recommendations to use ASTM D2274 (modified) and EN14112 as part of their test specification for biodiesel fuel to facilitate testing and evaluation of the performance of B20 biodiesel blends.

The FCAI believes that oxidation stability must be addressed as part of any standard on biodiesel blends, regardless of the percentage of biodiesel contained in the blend.

BIODIESEL BLENDS USING ETHANOL (E-DIESEL)

In line with the WWFC, FCAI is opposed to the addition of ethanol to diesel fuel (E-diesel) not only on the grounds of safety concerns but also vehicle operability issues. The minimum flashpoint of conventional diesel is 61.5^{o}C which classifies it as a "combustible material". However, the addition of ethanol (i.e. to produce E-diesel) which has an extremely low flashpoint of 13^{o}C, reduces the flashpoint of the blend to below 61^{o}C, which alters the blend's classification to a "flammable material". There are safety risks to engines, vehicles and fuel distribution facilities, which raises serious safety concerns (such as explosions) for fuel handling, storage and use. Vehicle and engine manufacturers are concerned that E-diesel may damage vehicle parts, especially fuel injectors, and cause other types of vehicle failure due to low lubricity. The fuel's compatibility with the vehicle in other ways, its impact on vehicle emissions and its health effects remain unknown. There is also the impact on fuel consumption because of the lower energy content of ethanol compared to diesel fuel. Therefore, until the many safety, performance and health concerns are resolved and sufficient peer-reviewed research is undertaken, FCAI does not support the practice of adding ethanol to any category of diesel fuel.

LABELLING

In addition to the technical points listed previously, labelling of fuels containing biodiesel is important for consumers, not only for personal choice and transparency but also to ensure that vehicle manufacturer recommendations are met. The exact nature of the labelling needs to be discussed and considered depending on the blend.

DISCUSSION

If biodiesel is to be widely utilised by the Australian motoring public, care needs to be exercised on how 'biodiesel' is viewed - whether it is a specific automotive fuel with its own properties and characteristics or whether it is simply a blended diesel product. The recent experience with ethanol in petrol is to be avoided if confidence in biodiesel is to be nurtured.

FCAI recommends that National Standards for FAME's and Biodiesel blends, based on the EN and/or ASTM standards, be developed concurrently with a study on the impact of biodiesel on vehicles.

Further, the development of an Australian biodiesel market should not undermine the emissions outcomes to be expected from new vehicle diesel technology and the foreshadowed improvements in national diesel fuel standards, both of which are implicit in the timetable of the new vehicle emission ADRs.

SUMMARY

FCAI's position regarding biodiesel is summarised as follows:

- *Fatty Acid Methyl Esters (FAME) including vegetable derived esters (VDE) are generally acceptable when blended with conventional diesel fuel up to 5% (vol/vol). The FAME(s) on which the biodiesel is based must comply with either EN14214 or ASTM D6751 standards.*
- *The resultant biodiesel B5 blend must conform to the national Diesel Standard, which is based on EN590. This is consistent with the World Wide Fuel Charter (WWFC).*
- *FCAI does not generally support use of 100% biodiesel fuel (B100).*
- *FCAI members will not warrant damage caused by using biodiesel blends greater than B5, unless such use is sanctioned by a manufacturer.*
- *FCAI members do not support the use of E-Diesel (Diesohol) and will not warrant damage caused by its use.*
- *Adoption of WWFC recommendations is particularly relevant in Australia where diesel engine technology comes entirely from overseas sources.*
- *FCAI recommends that National Standards for FAME's and Biodiesel blends, based on the EN and/or ASTM standards, be developed concurrently with a study on the impact of biodiesel on vehicles. This must include the issue of oxidation stability, regardless of the percentage of biodiesel contained in the blend.*
- *There needs to be a transparent process to allow consumers to make an informed choice on whether their vehicles can use biodiesel.*

End of FCAI Statement"

Small Vehicle Manufacturers

A recent article produced by the RAC WA in their *RoadPatrol* magazine (August/September 2006) give a list of manufacturers which support the use of biodiesel and those which do not. This is reproduced in the table below:

Manufacturer/Importer	**Company Policy**
BMW, Chrysler, Ford, Hyundai, Jaguar, Kia, Land Rover, Mercedes Benz, Volkswagen	Not recommended
Holden	Maximum 5% biodiesel
Holden Rodeo	Not recommended
Mazda	Maximum 5% subject to all other fuel standards being maintained
Mitsubishi	Use at owners risk
Nissan	Maximum 5% biodiesel
Peugeot	Acceptable with some models up to 30% biodiesel

Volkswagen

Volkswagen are currently promoting a diesel sedan in Australia. However the VW technical department in Australia confirmed that no blend of biodiesel was suitable for this vehicle, including B5.

Truck Industry Council (TIC)

The TIC have provided the following statement:

"…. last year the Truck Industry Council representing truck and diesel engine suppliers approved a fuel standards document. This document, with respect to Biodiesel allowed up to 5% (B5) to be sold at retail with identification.

For Biodiesel above that level we would be opposed to general retail. Blends such as the B 20 you have proposed, and agreed by the EMA should only be sold direct from supplier to end uses with the specifications made quite clear.

At the time Biodiesel is still in its infancy in Australia, and we are not convinced that all Biodiesel produced, meets the standards required by TIC, and contained in the EMA paper.

Caltex have recently advised that they will retail B2 in Queensland and N.S.W from October this year. We are comfortable with this approach.

The new exhaust emission standards being introduced in Australia over the next 3-4 years include low NOx limits that some North American engine manufacturers will find difficult to achieve. As you will be aware that the use of Biodiesel reduces/ remove particulate matter, the level of NOx is increased."

Caterpillar

The Caterpillar website has available a 54 page statement on the use of lubricants and fuels in Caterpillar engines. This contains a section on the use of biodiesel. The paper states:

"Warranty and the Use of Biodiesel in Caterpillar Engines

Capterpillar neither approves nor prohibits the use of biodiesel fuels. Caterpillar is not a position to evaluate the many variations of biodiesel and the long term effects on performance, durability or compliance to emissions standards for Caterpillar products. The use of biodiesel does not affect Caterpillar materials and the warranty for workmanship. ***Failures that result from the use of any fuel are not Caterpillar factory defects. Therefore the cost of repair would NOT be covered by a Caterpillar warranty."***

The paper goes on to list engines that may use biodiesel blends in any concentration of biodiesel provided the biodiesel meets the specification (ASTM D6751). The paper also lists those engines which should be limited to B5 or below.

Several recommendations to the user covering:

- Monitoring lubricating oil and the oil change interval
- Warning not to change engine ratings
- Monitoring of elastomers
- Low ambient temperature issues
- Fuel oxidation especially in electronic fuel systems
- Microbial contamination
- Water contamination

John Deere

The John Deere website (www.deere.com) contains a statement on biodiesel "*Biodiesel Fuel in John Deere Tractors*". This states:
"Biodiesel blend up to B5 (5% biodiesel mixed with regular petrodiesel by volume) can be used in John Deere diesel engines, provided that the neat biodiesel or B100 meets ASTM D 6751 (USA) or EN 14214 (Europe) specification.

Biodiesel blend above B5 could have increasingly more performance related issues. The higher the biodiesel concentration, the more likely the risk associated with its *negative aspects. There is no industry standard to regulate the quality & performance of biodiesel blend at this time. In particular, certain properties of biodiesel blend may deviate significantly from its B100 and petrodiesel characteristics. For this reason, higher biodiesel blends over B5 can have increasingly negative effect in diesel engines."*

The following shall be observed during routine practice:

Fuel quality assurance

- Ensure the quality of B100 and biodiesel blend (right concentration, uniform mixture)
- One-time splash blending in an immobile tank is inadequate for homogeneous mixing
- Recommend in-line (or proportional) blending to achieve good mixture
- B100 should be kept warm prior to blending in the winter to preclude wax formation
- Keep storage & vehicle tanks as full as possible to minimize moisture condensation
- Monitor water content and microbial growth of the biodiesel fuels regularly
- Sampling fuel periodically to confirm the % level of biodiesel is consistent
- Limit the storage tanks from extreme temperature exposure (direct sun or frost)
- Storage life should be reduced accordingly (one year for B2, six months for B20, etc.)

The paper lists problems occurring when the biodiesel blend is higher than 5% concentration (B5) and recommends for higher concentrations regular checking of the oil and changing the oil if necessary. The user should also monitor the cloud point.

The paper also states:
"Our product warranty only covers defects in material and workmanship as manufactured and sold by John Deere. Failures caused by the use of poor quality aftermarket fuels, be that biodiesel or regular petroleum diesel, are not defects of material and/or workmanship as supplied by John Deere, hence cannot be

compensated under our warranty. On the other hand, using higher biodiesel blends above B5 does not automatically void warranty. Users of John Deere emission certified engines are responsible for obtaining the proper local, state, and national exemptions required for the use of biodiesel."

Iveco

Iveco require the biodiesel content of fuels to be limited to a maximum of 5% (B5). They have a particular concern with higher values causing a series of problems. Vehicles subject to warranty claims are examined for fuel induced damage, this involves a check list for deposits and wear in vehicle parts. Damage induced by fuel is not covered.

Cummins

Cummins position on biodiesel is B5, with the expectation that this is the same as diesel when tested to the test specs. Cummins is evaluating B20 and higher blends, unfortunately, at this stage, this is still being worked on.

The Cummins website (www.cummins.com) has a page position paper on biodiesel fuel "*What is Cummins'position on the use of Biodiesel fuel in Cummins engines*?"

This position raises many of the issues raised in Stage 1 of this report and states: "*Cummins certifies its engines using the prescribed EPAQ and European Certification Fuels, Cummins does not certify engines on any other fuel. It is the user's responsibility to use the correct fuel as recommended by the manufacturer and allowed by EPA or other regulatory agencies...*" and "*Cummins neither approves or disapproves of the use of biodiesel fuel. Cummins is not in a position to evaluate the many variations of biodiesel fuels or other additives and their long term effects on performance, durability or emissions compliance of Cummins products. The use of biodiesel fuel does not effect Cummins Material and Workmanship warranty. Failures caused by the use of biodiesel fuels or other fuels additives are NOT defects of workmanship and/material as supplied by Cummins Inc. and CANNOT be compensated under the Cummins warranty*."

Scania

The Scania website indicates that some of their vehicles are built capable of using B100.

"Scania permits a mix of 5 per cent RME (rapeseed methyl ester) in diesel fuel and our newest engines, with unit injectors, can handle 100% RME."

However, Scania in Australia don't recommend the use of biodiesel blends.

Mack Trucks

Since 2001 Mack has received enquiries from customers regarding the possible use of alternative fuels with their Mack engines. These enquiries have increased as escalating diesel prices have encouraged the use of less expensive alternatives and, in particular, organically based products like Biodiesel. Mack Trucks policy is:

"Biodiesel can be made from a number of sources - from soybeans (which can be good), to rendered animal fat (of dubious quality). Supply sources and quality standards vary considerably with these products. There are certainly potential product issues including filter blocking and unconfirmed emission effects - which have been widely publicized and documented by industry sources and engine suppliers.

Mack has worked with Bosch and several other fuel system suppliers to review their positions and recommendations. We are now able to reconfirm that the use of Biodiesel can only be approved to a level of 5% maximum (otherwise known as B5). Higher blends - of up to 20% - are available in the marketplace, so it is important that operators are sure of the mix being considered or offered.

Powertrain investigations are continuing with alternative fuels but, for the foreseeable future, the Mack approved use of biodesel blends will be limited to B5 or less".

Fuel Injection Equipment Manufacturers

In June 2004, the fuel injection equipment manufacturers, Delphi, Stanadyne, Denso and Bosch, issued a "Joint FIE manufacturers common position statement concerning biodiesel. This sets out the concerns of these manufacturers. Amongst the concers of the FIE manufacturers are the following fuel characteristics:

- Free methanol
- Water
- Free glycerine
- Mono, di- and tri-glycerides
- Free fatty acids
- Total solid impurity level
- Alkali/alkaline earth metals
- Oxidation stability

The FIE Manufacturers position is:

"FIE manufacturers encourage the development of renewable compression ignition fuels. Experience to date with Rapeseed Methyl Ester fuels in Europe suggests that fuels conforming to the European standard EN 14214 at the point of sale used in mixtures up to 5% volume with mineral diesel fuel complying with the EN590 diesel fuel standard should not give end-users any serious problems. ***The currently agreed position of all FIE manufacturers undersigned is to limit release of injection equipment for admixtures up to a maximum of 5% FAME (meeting the EN 14214 standard) with unadulterated diesel fuel (meeting the EN590 standard). The final product B5 must comply with EN 590.***

The required quality of the FAME fuel is defined in European standard EN 14214, which covers relevant impurities and tramp chemicals from the processing. Suppliers of FAME fuels must be able to demonstrate compliance to this standard at the filling station. There are several risks associated with possible supply chains.

For the FIE manufacturers a key property of any FAME fuel is the resistance to oxidation. Aged or poor quality FAME contains organic acids like formic acid and *acetic acids and acids of higher molecular weight as well and polymerisation products which attack many components, drastically reducing the service life of the FIE. A list of issues which have been witnessed in service is detailed in the attachment to this document.*

The ASTM specification for FAME fuel (D6751) does not to date contain a requirement for oxidation stability. The ASTM diesel fuel specification (D975) makes no provision for the inclusion of FAME, although there are currently proposals to define a specification for blends up to B20. The FIE manufacturers are concerned both with the missing oxidation stability in the specification and the lack of sufficient safeguards against blend quality.

The FIE manufacturers can accept no legal liability for failure attributable to operating their products with fuels for which the products were not designed, and no warranties or representations are made as to the possible effects of running these products with such fuels.

Non-compliance of the fuel to Standards agreed by the FIE manufacturers, whether being evident by appearance of the known degradation products of these fuels, or their known effects within the fuel injection equipment (see attached list of known issues) will render the FIE Manufacturers guarantee null & void."

Attachment

Fuel Injection Equipment –Potential Problems with FAME (non-exhaustive list)

Fuel Characteristic	Effect	Failure Mode
Fatty acid methyl esters (general)$	Softening, welling or hardening and cracking of some elastomers including nitrile rubbers (physical effects depend upon elastomer composition). Displacement of deposits from diesel operation	Fuel Leakage Filter plugging
Free methanol in FAME	Corrosion of aluminium and zinc Low flash point	Corrosion of FIE
FAME process chemicals	Entry of potassium & sodium and water hardness (alkaline earth metals). Entry of free acids hastens the corrosion of non ferrous metals,	Filter plugging Corrosion of FIE

	e.g. zinc. Salt formation with organic acids (soaps) Sedimentation	Filter plugging Sticking of moving parts
Free water	Reversion (hydrolysis) of FAME to fatty acid and methanol Corrosion Sustainment of bacterial growth Increase of electrical conductivity of the fuel	Corrosion of FIE Filter plugging
Free glycerine	Corrodes non ferrous metals Soaking of cellulose filters Sediment on moving parts and lacquering	Filter clogging Injector coking
Mono – D- and Tri-gylceride	Similar to glycerine	Injector coking
Free fatty acid	Provides electrolyte and hastens the corrosion of zinc. Salts formed	Corrosion of FIE Filter plugging Sediment on parts
High modulus of elasticity	Increases injection pressure	Potential of reduced service life
High viscosity at low temperatures	Generations excessive heat locally heat in rotary type distributor pumps. Higher stressed components	Fuel delivery problems Pump seizures Early life failures Poor nozzle spray atomisation
Solid impurities	Potential lubricity problems	Reduces service life Nozzle seat wear. Blocked nozzles
Ageing Products		
Corrosive acids (formic & acetic)	Corrosion of all metal parts – may form a simple cell	Corrosion of FIE
High molecular organic acids	Similar to fatty acid	
Polymerisation products	Deposits, precipitation especially from fuel mixes	Filter plugging Lacquer formation by soluble polymers in hot areas

<u>Bosch Australia Ltd</u>.

Mr Bob Tait of Bosch Australia provided the following position statement:

“Bosch does not support the use of Bio Fuels in its products and does not provide warranty for damage resulting from its use”.

The National Biodiesel Board (NBB)

The US National Biodiesel Board has issued a paper “OEM Warranty Statements and Use of Biodiesel Blends over 5% (B5)”. This paper states that the Board , diesel engine, fuel injection and vehicle companies have formed a B20 evaluation team. This team has set a list of recommendations for users who wish to use B20 in their existing fleet. A summary of the most significant recommendations are given in the Table below. The advice would apply to all blends in the range B5 to B20.

Technical Recommendations for B20 Fleet Use on Existing Data - B20 Evaluation Team: June 2005

Ensure the biodiesel meets the ASTM specification for pure biodiesel (ASTM D 6751) before blending with petrodiesel. Purchase only from companies that have been registered under the BQ-9000 fuel quality program
Ensure the B20 blend meets the properties for ASTM D975, Standard Specification for Diesel Fuel Oils or the ASTM specification for B20 once it is approved.
Ensure your B20 supplier provides a homogeneous product.
Avoid Long term storage of B20 to prevent degradation. Biodiesel should be used within six months.
Prior to transitioning to B20, it is recommended that tanks be cleaned and free from sediment and water. Check for water and drain regularly if needed. Monitor for microbial growth and treat with biocides as recommended by the biocide manufacturer.
Fuel filters on the vehicles delivery system may need to be changed more frequently upon initial B20 use. Biodiesel and biodiesel blends have excellent cleaning properties. The use of B20 can dissolve sediments in the fuel system and result in the need to change filters more frequently when first using biodiesel until the whole system has been cleaned of deposits left by petrodiesel.
Be aware of B20's cold weather properties and take appropriate precautions. When operating in winter climates, use winter blended diesel fuel. If B20 is to be used in winter months, make sure the B20 cloud point is adequate for the geographical region and time of year the fuel will be used.
Perform regularly scheduled maintenance as dictated by the engine operation and maintenance manual. If using B20 in seasonal operations where fuel is not used within six months, consider storage enhancing additives or flushing with diesel fuel prior to storage.
These recommendations on the use of B20 are preliminary and are not provided to extend or supplant warranty limitation provided by an individual engine or equipment supplier. Use of B20 blends is solely at the discretion and risk of the ïcustyomer and any harm effect caused by the use of B20 are not the responsibility of the engine or equipment maker.

Labelling

The task is " to suggest appropriate labelling for B20 and B100 including a rationale for proposed approach cognisant of the current simplified approach to labelling to ensure the labels do not inadvertently act as a warning."

Before recommendations are made for the appropriate labelling of biodiesel fuels it is worthwhile reviewing and discussing the principal issues as they impact on the possible labelling of the product.

Stage 1 of this report recommended that rather than standardise a B20 (20% biodiesel in petroleum diesel) it may be a better option to standardise a BXX blend where XX ranges from 06 to 20 (say). This would align the standard with the practice of some in the industry of producing grades to meet cold point specifications by adding more diesel (kerosene or heating oil) to the mix resulting in a B13 (say) blend.

If this is an acceptable approach then a question to be put is:

What should be the upper limit?

Up to this point it has been assumed that B20 would be the limit. This essentially follows the practice in the USA but for Australia the picking of 20% blend is somewhat arbitrary. There is little if any difference between a B20 and B23.

One answer to this is that the upper limit should be any value provided the blend meets the current Australian Standard for diesel fuel. Some in the industry effectively practice this because of the interaction with the *Fuel Tax Act 2006* which is not part of this Study.

One consequence of this approach is that the petroleum diesel has to be selected from the range of diesel blend stocks available so that the final BXX blend complies with the maximum density specification of the diesel standard (<850 kg/m^3). The use of light diesel blend stock, which tends to be lower in aromatics, also gets around the issue of increased NOx emissions (see Stage 1).

Some diesel blend stocks (eg. Fischer-Tropsch products) have very low density (eg. 780 kg/m^3). Using this as a blend stock in theory with a typical B100 biodiesel of density 880 kg/m^3, ignoring volume effects on mixing, this could deliver a B70 which was compliant with the specification for density of the Australian Standard. This would be even higher for a lower density B100 biodiesel such as that from coconut oil.

Of course as it stands at the moment Fischer-Tropsch diesel will not comply with the Australian Diesel Standard which requires a minimum density of 820 kg/m^3. Nevertheless it is worth noting that severe hydrogenation of gas oil to achieve the low sulphur specifications reduce the density of the diesel below 820 kg/m^3 and several refining companies have received exemptions to produce diesel to a density of 800 kg/m^3. Using the same biodiesel blend stock with a density of 880 kg/m^3 could be used to make the biodiesel blends as indicated in the following table:

Diesel density (kg/m^3)	Maximum BXX
780	B70
800	B62
820	B50

The conclusion is that using the compliance to the Australian diesel standard as a yardstick may result in very high blends with essentially little or no difference to B100 being compliant with a BXX standard.

At this point we have to recognise that high levels of biodiesel (B50 and higher) have a generally greater impact on engine components than lower content biodiesel.

At this stage it would appear that the upper limit for an intermediate blend would be in the range of B20 to B30 (some vehicle manufacturers allow B30) but the choice of B20 or B30 as a maximum would appear arbitrary.

The foregoing discussion illustrates that the compliance with the Australian Diesel Standard may be insufficient to qualify a product for retail sale. How the issues of oxidative stability and cold weather properties impact on the quality control and the product are now discussed.

What are the Issues with Oxidative Stability?

As illustrated by the common position paper put out by the fuel injection manufacturers, a main concern is the oxidation of biodiesel products on storage. Oxidation stability can be measured during the manufacturing, in the distribution system and at the point of sale. This is not the problem, rather it is the slow deterioration of the fuel on storage in vehicle tanks *after* the point of sale.

Given that fuel may remain in tanks for several months the oxidation of fuel presents the user with an unknown problem of how long to keep biodiesel in the fuel tank and how the vehicle system could be flushed.

Oxidation reactions of the type often involve free radicle processes. As a consequence the fuel would not be expected to deteriorate in a linear (even) manner.

Generally oxidation processes involve a slow initiation stage followed by a rapid oxidation stage. The initiation stage may take many weeks or months and involves the slow build up of critical intermediates. These intermediates (often peroxides) are present in very small amounts so that the fuel would remain within the specification over this period. At some point the oxidation takes-off and the fuel rapidly deteriorates. This means that the fuel may be in storage (in the vehicle tank) for many months and then deteriorate within a few days or a week. A similar effect is often observed in the deterioration of lubricating oils.

It would thus be prudent to ensure that the biodiesel was sold with the expectation of a very long (six months) storage life at the point of sale. A recommendation would be that biodiesel users should use the fuel within a designated period. However, since some fuel remains in the tank, this could contaminate the new fuel coming in (reducing the initiation time in the oxidation process).

If a B20 user regularly refills when the tank is 10% full (say) and then refills with B20, then 10% of the total FAME present will be “old” FAME from the first fill. If the fuels thoroughly mix in the tank and the refill process is repeated, then on the third filling, the tank will contain 1% of FAME from the first fill, 9% from the second and the rest the new FAME. How, or if, the 1% old FAME influences the stability of the fuel in the tank is moot and unfortunately unknown.

This suggests that a limit to the BXX value should take into consideration of this point and an upper limit of 20% may be apt.

Cold Weather Properties

Both the current Australian Diesel Standard and the Biodiesel Standard (B100) are silent on the issue of cold weather properties (cloud point and cold filter plugging point). Reintroducing these parameters (as the AS 3570-1998) to a biodiesel BXX blend would have the impact of discriminating against the more oxidatively stable tallow FAME, especially in the southern states in the winter months. However, it may also force the producers to dilute the biodiesel blend so as to better achieve the required cold weather properties.

Labels

In approaching the issue of labelling at the retail level it is quite evident from the above that it would be tempting to insist on an extensive labelling regime for a BXX blend. This is unlikely to help the industry because some users would be put off by extensive warnings or be informative to the user since wordy documentation is likely to be ignored.

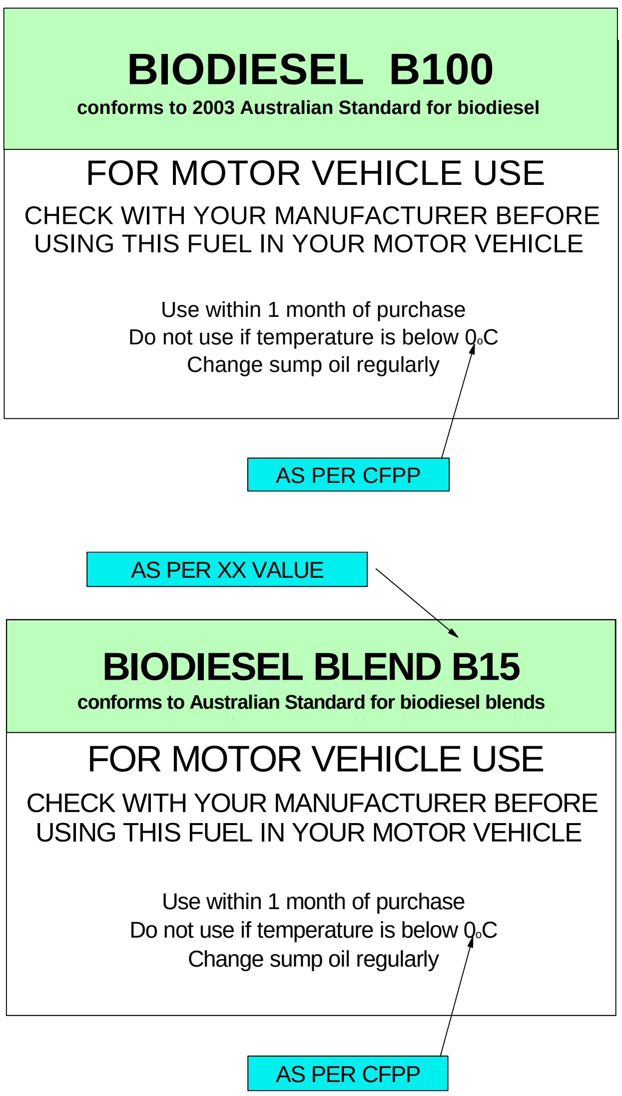
At this stage it would seem that several things MUST be included on the label:

1. That Biodiesel FAME are present
2. The concentration of the FAME (XX value of BXX)
3. That the Blend Meets a BXX standard
4. That the purchaser of the fuel should take cognizance of advice from the OEM on the use or otherwise of the fuel.

There then follow several other advisory pieces of information:

1. That the fuel should be used within a specified time (eg 1 month of purchase)
2. That the use of the fuel may require more frequent sump oil changes.
3. The CFPP of the blend

This could be condensed into a label as illustrated:



Attachment -1

Quality Analysis and Test Methods

ASTM Test Methods: Application to B20

For effective regulation of B20 there must exist acceptable test methods for each of the parameters in any specification. Specifications and test methods exist for B100 and diesel that may serve as the basis for any B20 specification. The following is a list of ASTM Methods in numerical order. The list gives an indication of the current use in Australia and the potential for use in B20.

D 86 - DISTILLATION OF PETROLEUM PRODUCTS AT ATMOSPHERIC PRESSURE

Used in Australian Standard for Diesel but not for B100

The standard distillation test for petroleum products. Generally biodiesel (B100) decomposes before the final fractions are distilled and the test is therefore not used for biodiesel. It would not be generally applicable for B20.

D 93-02a (IP34/99) - FLASH POINT BY PENSKY-MARTENS CLOSED CUP TESTER

Used in Australian Standards for Diesel and B100

The method is generally applicable to all fuels, although interestingly the Method does not refer to biodiesel. There should be no issue with its use for a B20.

D 130-04 (IP 154/93) - CORROSIVENESS TO COPPER FROM PETROLEUM PRODUCTS BY COPPER STRIP TEST

Used in Australian Standards for Diesel and B100

The method is generally applicable to all fuels, although interestingly the Method does not refer to biodiesel. The main aim is to test for corrosion from sulphur compounds, which are generally absent in biodiesel. There should be no issue with its use for B20.

D 189-01 (IP 13/94) - CONRADSON CARBON RESIDUE OF PETROLEUM PRODUCTS

Not used in the latest Australian diesel and B100

The Method correlates well with D4530, which is used in the Australian diesel specification. Biodiesel is not a distilled product and may by its nature contain non-volatile materials that may form coke. Another complication is that nitrates cause erroneous results. These may be used as cetane improvers to suppress NOx in B20. This Method would not be applicable to B20.

D 445-04 (IP 71/1/97) - KINEMATIC VISCOSITY OF TRANSPARENT AND OPAQUE LIQUIDS

Used in Australian Standards for Diesel and B100

The method is generally applicable to all fuels. There should be no issue with its use for a B20.

D 482-00 (IP 4/96) - ASH FROM PETROLEUM PRODUCTS

Used in Australian Standard for Diesel but not B100

The test is generally used to determine ash forming materials in petroleum fluids free of ash forming additives and phosphorus compounds. This method could be used for B20; see also Method D874

D 524-04 (IP 14/94) - RAMSBOTTOM CARBON RESIDUE OF PETROLEUM PRODUCTS

Not used in the latest Australian Diesel and B100 specifications

The Method correlates with D4530, which is used in the Australian diesel specification. Biodiesel is not a distilled product and may by its nature contain non-volatile materials that may form coke. The method is used for petroleum fuels that decompose on distillation, such as biodiesel. Another complication is that nitrates cause erroneous results. These may be used as cetane improvers to suppress NOx in B20. This Method would not be useful in defining B20.

D 613-05 (IP 41/2000) - CETANE NUMBER OF DIESEL FUEL OIL

Used in the Australian B100 specification but not for Diesel

As stated in the Method at 5.2): “This test method is used by engine manufacturers, petroleum refiners and marketers and in commerce as a primary specification measurement relating to matching fuels and engines.” and 5.4 “This test method may be used for unconventional fuels such as synthetics, vegetable oils, and the like.

However, the relationship to the performance of such materials in full scale engines is not completely understood."

The B100 specification requires a minimum cetane number of 51.0 set by this method. Although the use of the method for the B100 specification is required, it is not required for the Australian diesel standard. The method is applicable to all diesel fuels including B20.

D 664-04 (IP 177/96) - ACID NUMBER OF PETROLEUM PRODUCTS BY POTENTIOMETRIC TITRATION

Used in the Australian B100 specification but not for diesel

This is a general test for acid components in petroleum fluids, particularly lubricating oils. The use in the B100 specification is for quality control regarding the amount of free fatty acids and the like present. There is no correlation between acid number and the corrosion of metals. The Method could have application to B20, possibly as a method of monitoring oxidation on storage.

D 874-00 (IP 163/96) - SULPHATED ASH FROM LUBRICATING OILS AND ADDITIVES

Used in the Australian B100 specification but not for Diesel

The primary aim of the test is to determine the level of metals in additives. Phosphorus, which may be a contaminant of B100 interferes and the method, which carries the warning "sulfated ash requirement generally should not be used in product specifications without a clear understanding between a buyer and a seller of the unreliability of an ash value as an indicator of the total metallic compound content." Given this caveat this test may be recommended for B20. See also Method D482.

D 974-04 (IP 139/98) - ACID AND BASE NUMBER BY COLOR-INDICATOR TITRATION

Not used in the Australian Standard for either Diesel or B100

This method is broadly similar to Method D664 with similar caveats. It is generally applicable to monitor degradation of fuels, particularly lubricating oils. The Method could have application to B20, possibly as a method of monitoring oxidation on storage.

D 976-04 - CALCULATED CETANE INDEX OF PETROLEUM FUELS

Used in Australian Standard for Diesel but not B100

Note that Cetane Index is a supplement to Cetane Number (D613) not a replacement of it. The Method is primarily used for refinery intermediates and is probably not applicable to diesel containing esters. The Method has been replaced from ASTM standpoint by D4737 but is still used by US regulatory authorities (EPA). It would not be useful for B20.

D 1160-03 - DISTILLATION OF PETROLEUM PRODUCTS AT REDUCED PRESSURE

Used in the Australian B100 specification but not for Diesel

The Method is used to specify the Distillation T90 point in the Australian B100 specification. Diesel boiling points are specified using Method D86. Biodiesel can decompose at relatively low temperatures hence the attraction of using a reduced pressure method. The T(90) point of the specification (360^{o}C) is presumably the Atmospheric Pressure Equivalent Temperature although this is not stated in the specification. Further, the estimation of this temperature by the algorithms in the Method presumes hydrocarbon fluids of known Watson K-factor. These equations may not apply to biodiesel. The method would not be applicable to B20.

D 1266-98 (IP 107/86) - SULFUR IN PETROLEUM PRODUCTS (LAMP METHOD)

Used in Australian Standards for Diesel but not B100

Generally for higher sulphur levels of hydrocarbon fuels but can be adapted to determine levels as low as 5ppm. There may be interference from acids produced from the combustion of FAMEs. Would not be used for B20.

D 1298-99 (IP 160/99) - DENSITY, RELATIVE DENSITY (SPECIFIC GRAVITY), OR API GRAVITY OF CRUDE PETROLEUM AND LIQUID PETROLEUM PRODUCTS BY HYDROMETER METHOD

Used in Australian Standards for Diesel and B100

This is the classical method for determining density of fluids and applicable to all liquid fuels, including B20. There are several variants on the method using different techniques that would also be applicable to B20. These are D4052 (digital density meter) and D5002 (digital density analyser).

D 1796-04 - WATER AND SEDIMENT IN FUEL OILS BY THE CENTRIFUGE METHOD

Not used in the Australian Standard for either Diesel or B100

This method is generally applied to high viscosity distillate fuels with viscosities over 4cSt (40^{o}C). The US specification D975 used this method only for heavy distillate fuel No. 4-D. It may have applicability for some B100 types but would not be recommended for B20.

D 2068 (Similar to IP 387) - FILTER PLUGGING TENDENCY OF DISTILLATE FUEL OILS

Not used in Australian Standard for B100.

The ASTM Method D 2068 is similar to the IP 387 Method (uses the same equipment) which is used for the Australian diesel specification. These method can be used to quantify particulate contamination of a batch of fuel or the degree of deterioration on storage. Applicable to all distillate fuels including B20.

D 2274-03 (IP 388/97) - OXIDATION STABILITY OF DISTILLATE FUEL OIL

Used in Australian Standards for Diesel and B100

The Method as written is not applicable to biodiesel (non petroleum fuels) but has been modified for this role (see above literature survey). The modified method could be used for B20.

D 2500-05 (IP 219/82) - CLOUD POINT OF PETROLEUM PRODUCTS

Not used in latest Australian Standard for Diesel nor B100

Although not used in the latest Australian Standards, cloud point is an important parameter in determining cold weather operation of diesel and biodiesel fuels. This issue is extensively discussed in an appendix to AS 3570. If not explicit in the standard the method and use is used widely by the industry and is of relevance to biodiesel fuels including B20. However, there is a general opinion that the cloud point is not as important as the cold filter plugging point. There are several variations on the determination of cloud point using slightly different techniques for which similar comments apply; these are D5772 (optical detection, stepped cooling method), D5772 (linear cooling rate method) and D5773 (constant cooling rate method).

D 2622 - SULFUR IN PETROLEUM PRODUCTS BY WAVELENGTH DISPERSIVE X-RAY FLORESCENCE SPECTROSCOPY

Used in Australian Standards for Diesel but not B100

Used to determine sulphur over a wide range of fuels and values (20ppm and upwards). Could be used for B20.

D 2709-96 - WATER AND SEDIMENT IN MIDDLE DISTILLATE FUELS BY CENTRIFUGE

Used in Australian Standards for Diesel and B100

This is the preferred method for fuels with a viscosity in the range 1.0 to 4.1 cSt @ 40^{o}C. This will generally be the case for B20 fuels.

D 3117-03 - WAX APPEARANCE POINT OF DISTILLATE FUELS

Not used in Australian Standards for Diesel nor B100

Test for wax formation in the range –26 to +2^{o}C. Could be used for B20.

D 3120-03 - TRACE QUANTITIES OF SULFUR IN LIGHT PETROLEUM HYDROCARBONS BY OXIDATIVE MICROCOULOMETRY

Not used in Australian Standards for Diesel nor B100

The Method detects sulphur in the range 3 to 1000ppm. Although designed for fuels boiling below 274^{o}C, the Method can be used for diesel and biodiesel. The Method could be used for B20.

D 3828-05 (IP 303/83) - FLASH POINT BY COSED CUP TESTER

Not used in Australian Standard for Diesel nor B100

This is an alternative to Method D93 but using a smaller sample. The test is universally applicable especially in the context of shipping product. Could be used for B20.

D 4294-03 - SULFUR IN PETROLEUM AND PETROLEUM PRODUCTS BY ENERGY DISPERSIVE X-RAY FLUORESCENCE SPECTROMETRY

Used in Australian Standard for Diesel but not B100

The applicable concentration range is 150 to 50,000ppm and is designed as a cheaper and rapid testing alternative to other methods. For the most part we are considering B20 with a sulphur content <150ppm and this Method would not be applicable.

D 4530-03 - DETERMINATION OF CARBON RESIDUE (MICRO METHOD)

Used in Australian Standards for Diesel and B100

The test Method gives results equivalent to D189 (Conradson Carbon) and is applicable to products that partially decompose on distillation at atmospheric pressure (biodiesel). Alkyl nitrates (cetane improvers) influence the result, which may be problematic if these are being used in a B20 to control NOx. Otherwise this Method could be used for B20.

D 4737-04 - CALCULATED CETANE INDEX BY FOUR VARIABLE EQUATION

Used in Australian Standard for Diesel but not B100

This Method is a supplementary tool for estimating cetane number when a result for Method D613 is unavailable and if a cetane improver is not used. Like D976 (which it replaces) it is only applicable to hydrocarbon stocks and requires results from atmospheric distillation Method D86, under which biodiesel decomposes. This Method would not give useful results for B20.

D 4951-02 - DETERMINATION OF ADDITIVE ELEMENTS IN LUBRICATING OILS BY INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROMETRY

Used in the Australian B100 specification but not for Diesel

The Method gives quantitative determination for barium, boron, calcium, copper, magnesium, phosphorus, sulfur and zinc. All elements are analysed, however, phosphorus is the one of interest for biodiesel. Note the method is primarily for lubricating oils and does not mention biodiesel specifically. However, the Method could be of use in B20 analysis.

D 5453-05 - DETERMINATION OF TOTAL SULFUR IN LIGHT HYDROCARBONS, SPARK IGNITION ENGINE FUELS, DIESEL ENGINE FUEL AND ENGINE OIL BY ULTRAVIOLET FLUORESCENCE

Used in Australian Standards for Diesel and B100

The method is universally applicable to fuels, including biodiesel and could be used for B20.

D 6078-04 - LUBRICITY OF FUELS BY THE SCUFFING LOAD BALL-ON-CYLINDER LUBRICITY EVALUATOR (SLBOCLE)

Not used in the Australian Standard for Diesel nor B100

The method is generally applicable to diesel fuels. The method would be suitable for B20. There is some concern on the outcome when various combinations of lubricity additive are used. Since FAMEs (B100) can be used as a lubricity additive this may affect the results. An ASTM working group is addressing this problem.

D 6079-01 - LUBRICITY OF DIESEL FUELS BY THE HIGH-FREQUENCY RECIPROCATING RIG (HFRR)

Not used in the Australian Standard for Diesel nor B100

The method is generally applicable to diesel fuels. The method would be suitable for B20. There is some concern on the outcome when various combinations of lubricity additive are used. Since FAMEs (B100) can be used as a lubricity additive this may affect the results. An ASTM working group is addressing this problem.

D 6217-98 (IP 415/98) - PARTICULATE CONTAMINATION IN MIDDLE DISTILLATE FUELS BY LABORATORY FILTRATION

Not used in Australian Standard for Diesel nor B100

The Method is used to quantify particulate contamination of a batch of fuel. Applicable to all distillate fuels including B20.

D 6371-05 - COLD FILTER PLUGGING PIONT OF DIESEL AND HEATING FUELS

Not used in Australian Standard for Diesel nor B100

This Method is equivalent to IP 309 and EN 116 which are used in AS 3570. In European experience with light trucks the CFPP point is close to the temperature of failure in service. This test could be used for B20

D 6450-05 - FLASH POINT BY CONTINUOUSLY CLOSED CUP TESTER

Not used in Australian Standard for Diesel nor B100

The method could be used for B20 but it should be noted that results from different flash point methods (D93, D3828) are not interchangeable.

D 6584-00 - DETERMINATION OF FREE AND TOTAL GYCERIN IN B100 BIODIESEL METHYL ESTERS BY GAS CHROMATOGRAPHY

Used in the Australian B100 specification but not for Diesel

The Method is for B100 fuels with the exception of lighter fatty acid esters derived from coconut or palm kernel oil. It is not clear if diesel hydrocarbons would materially interfere with the determination if used for B20.

D 6920-04 - TOTAL SULFUR IN NAPHTHAS, DISTILLATES, REFORMULATED GASOLINES, DIESELS, BIODIESELS AND MOTOR FUELS BY OXIDATIVE COMBUSTION AND ELECTROCHEMICAL DETECTION

Not used in Australian Standard for Diesel nor B100

A new method for the determination of sulphur at very low levels in motor fuels. The method or a variation of it is still under development by an ASTM working party. This would be applicable to B20.

D 7039-04 - SULFUR IN GASOLINE AND DIESEL FUEL BY MONOCHROMATIC WAVELENGTH DISPERSIVE X-RAY FLUORESCENCE SPECTROMETRY

Not used in Australian Standard for Diesel nor B100

This is a new method for determining sulphur at very low levels. This is designed as a rapid test for refinery blending streams. The test may be applicable to biodiesel.

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APPENDIX B

Engine Manufacturers Association – Position Statement – Test Specification for Biodiesel Fuel, May 31, 2006.

APPENDIX C

Background to fuel quality standards.

APPENDIX C - BACKGROUND TO FUEL QUALITY STANDARDS

Guiding principles

The principal drivers under the FQS Act for regulating fuel quality are for both environmental and vehicle operability reasons. Improvements to fuel quality are aimed at:

- reducing the environmental impacts of transport by providing fuels which facilitate the adoption of emerging vehicle engine and emission control technologies *and*

- enabling the effective operation of vehicles.

Regulating fuel quality can also serve to establish and maintain consumer confidence. This is particularly important for fuels that are new to the marketplace and depend on gaining consumer support.

The guiding principles for the development of fuel quality standards are:

1. Fuel standards are intended to manage those fuel qualities/parameters that are known to have the potential to impact adversely on the environment.

2. Fuel standards should be compatible with relevant international or internationally accepted standards in order not to impede competition and trade.

3. Fuel standards should not impede competition and favour one technology over another.

4. Fuel standards are intended to be mandated and implemented on a national basis. In particular, fuel standards that are technology enabling must apply nationally. Local environmental circumstances may, however, dictate variation within the national standard to achieve environmental outcomes (Department of Industry Science and Resources, 1999).

- Consideration will be given to state-by-state establishment of fuel standards that address airshed specific environmental conditions; however, in such cases a national standard may be determined as a default.

5. Fuel standards will apply to, and be enforced equally in respect of, imports as well as domestically produced fuels (Department of Industry Science and Resources, 1999).

- Fuel standards must not impede competition, either between Australian refiners, or with imported refined product.

6. Fuel standards that directly address environmental or health issues will be determined on the basis of Australian-specific requirements. In such instances, harmonisation with European specifications may be neither necessary nor desirable.

7. The timetable for the introduction of new fuel standards will be based on Australian requirements. Harmonisation, in terms of timing, will not be based on European or any other regional timetable, except where there is a previous policy decision to this effect or the standard is technology enabling and the need for such harmonisation is clearly demonstrated.

8. Consideration will be given to setting standards that provide, as far as possible, flexibility in terms of compliance, providing:

- flexibility provisions must not impede competition or trade *and*
- flexibility provisions must not add significantly to legislative/regulatory complexity or implementation/enforcement costs to Government.

Government policy – reducing vehicle emissions

The Australian Government has an ongoing programme of introducing new vehicle emission standards to ensure that the environmental benefits of evolving emission control and fuel efficiency technologies are realised in Australia. New vehicle emission standards are established as Australian Design Rules (ADRs) under the *Motor Vehicles Standards Act 1989* and are subject to regular review.

The 1997 Australian Academy of Technological Sciences and Engineering (AATSE) report, "Urban Air Pollution in Australia", identified transport activities as the most significant contributor to urban ambient air pollution in Australia, with road vehicles the dominant source of pollutants. The report also found that new vehicle emission standards were "the long term foundation for maintaining and improving air quality", and recommended that Australia should move to adopt European vehicle emission regulations.

The Prime Minister, in his 1997 statement *Safeguarding the Future - Australia's Response to Climate Change,* identified harmonisation with these international vehicle emission standards as a goal of the Australian Government and nominated a target date of 2006. In response to the Prime Minister's statement, the Government established new vehicle emission standards for petrol and diesel vehicles in December 1999, to help achieve reductions in emissions of significant pollutants. Fuel quality standards for petrol and diesel were also established from 1 January 2002 to support the new emissions standards.

Future fuel quality and vehicle emission standards

Vehicle emission and corresponding fuel quality standards will be tightened progressively in the future to align more closely with European standards. Standards have become increasingly stringent to address advancing vehicle and fuel refining technology, increasing vehicle fleet size and usage, and mounting concern about air pollution. Under the *Motor Vehicle Standards Act 1989*, diesel vehicle emissions standards equivalent to *Euro 4* (ADR 79/01) are mandated for 2006 and require fuel with a sulfur limit of 50 ppm. *Euro 4* emissions standards for light vehicles will be implemented in July 2008/2010 supported by a 50ppm sulfur petrol (95 & 98 RON) standard in January 2008. *Euro 5* emission standards for heavy vehicles will be implemented in January 2010/11 supported by 10ppm sulfur diesel standards in January 2009.