MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

ENERGY MARKETS & TRADING STANDARDS

Unclassified

Reviewing Aspects of the Engine Fuel Specifications Regulations 2011

Discussion Paper

September 2015

New Zealand Government

Ministry of Business, Innovation and Employment
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Making a submission

We are seeking comments on this discussion paper by **30 October 2015.** We have included some questions to assist you, but your general comments are also welcome. Where we have asked for comments on an issue, we are particularly interested in your views on the costs, benefits and risks of each proposal. Where possible and appropriate, please provide quantified estimates of these costs, benefits and risks.

When making a submission, please include your name, your organisation's name (if applicable), and your address (postal and/or email).

To send us your comments, you can either:

- email them, preferably in an attached Microsoft Word document, to fuelspecs@mbie.govt.nz, or
- mail a hard copy to: Energy Markets Team
Ministry of Business, Innovation and Employment
PO Box 1473
Wellington 6140

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Please clearly indicate in your submission if you do not want your name to be included in any summary of submissions that we might publish.

1. Introduction

1.1. Background

1. The Ministry of Business, Innovation and Employment (**MBIE**) is responsible for administering the *Engine Fuel Specifications Regulations 2011* (this paper will sometimes refer to them as simply **the Regulations** or **EFSR**). The Regulations provide comprehensive fuel specifications for petrol, petrol/ethanol blends, diesel, biodiesel, and diesel/biodiesel blends.

2. Most of the diesel used in New Zealand and over half of the petrol is supplied by New Zealand's sole refinery at Marsden Point near Whangarei, with the remainder imported from refineries around the Asia-Pacific. Most biofuels used are domestically produced.

3. The Regulations set out minimum standards that affect the performance of fuel, enabling consumers to buy petrol and diesel to a quality standard appropriate for New Zealand's vehicle fleet and climatic conditions. The minimum standards also limit components that could be harmful to the environment or public health.

4. The current specifications are mainly the result of a major review carried out in 2001/02 of the then-Regulations, the *Petroleum Products Specifications Regulations 1998.* The outcomes of that review and of a subsequent review of sulphur levels were implemented between 2002 and 2009. In 2008, biofuels were added to the specifications and the Regulations were renamed the *'Engine Fuel Specifications Regulations'* to reflect their broader scope. The Regulations were amended again in 2011 to relax unnecessarily restrictive fuel parameters, to reflect technological advances, to align New Zealand with overseas specifications, and to future-proof the regime. That was the last time the Regulations were reviewed.

5. The specifications in the Regulations reflect a continual balancing of costs and benefits and have been developed in step with international developments in vehicle technology and fuel supply. While there is significant alignment among international fuel specifications, there is no international consensus on many parameters.

6. The tightening of fuel specifications over the last 13 years has reduced harmful emissions from vehicles and allowed the newest and cleanest vehicle technologies to be adopted. Fuel that meets these tighter fuel specifications is however more difficult to produce, and only some refineries in the Asia-Pacific can consistently achieve the specifications.

1.2. Scope of this review

7. The Regulations need to be reviewed every three to four years so that they stay current with developments in technology, in particular with test methods. As well as allowing for test methods to be updated or replaced, reviewing the Regulations gives an opportunity to look at other parameters to make sure New Zealand continues to be aligned with overseas specifications and technological advances.

8. Other options, such as incentives or tax differentials, have not been explored because the Ministry does not consider that such an approach would provide consumers or vehicle suppliers with any certainty that fuel being supplied would meet certain minimum specifications.

9. This review focuses on the following specific issues and parameters:

   9.1. sulphur limits for petrol

   9.2. whether to introduce total oxygen content limits to restrain the presence of oxygenates in petrol blends

   9.3. biodiesel blend limits in diesel

   9.4. whether to add a new parameter of cold soak filterability for biodiesel

   9.5. whether to introduce a fuel specification for the E85 blend known as ‘flex-fuel’

   9.6. how pool averages for aromatics in petrol are defined and measured.

2. Summary of proposed changes

Petrol

- **Sulphur levels** – Reducing the maximum sulphur level from 50 mg/kg to 10 mg/kg
- **Oxygen content** – Introducing oxygen content limits of 2.7% for petrol/ethanol blends containing up to 5.0% ethanol volume, and 3.7% for petrol/ethanol blends containing up to 10% ethanol volume
- **Tests for lead** – Introducing a modified test method ASTM D5185 and the test method ASTM 5059 as alternatives alongside the current prescribed test method for lead, IP 224
- **Tests for manganese** – Prescribing ASTM D5185 as the test method for manganese in place of the current prescribed method, ASTM D3831
- **Tests for olefins** – Prescribing ASTM D6839 as the test method for olefins as an alternative alongside the current prescribed method, ASTM D1319
- **Pool averages for aromatics** – Clarifying that pool averages for aromatics should apply to each period of six consecutive months.

Diesel

- **Limits for FAME** – Increasing the maximum for fatty acid methyl esters (FAME) from 5.0% to 7.0% volume
- **Tests for total contamination** – Replacing the IP 440 test method for total contamination with EN 12662 and ASTM D7321 for biodiesel blends and ASTM D6217 for pure mineral diesel.

Biodiesel

- **Tests for total contamination** – Replacing the IP 440 test method for total contamination with two alternatives, EN 12662 and ASTM D7321
- **Tests for density** – Adding the test method ASTM D4052 as an alternative alongside the current test method ASTM D1298 for density
- **Tests for oxidation stability** – Adding the test method EN 15751 as an alternative alongside the current EN 14112 for oxidation stability
- **Tests for carbon residue** – Removing the test method EN IS0 10370 as the prescribed test method for carbon residue (on 10% distillation residue) in biodiesel, and replacing it with the test method ASTM D4530, which is currently used to test the carbon residue (on 100% of distillation residue) in biodiesel
- **Cold soak filterability** – Adding a new requirement for cold soak filterability with a maximum limit of 200 seconds. The test method ASTM D7501 is proposed for this new requirement
- **Tests for phosphorous** – Adding the test method EN 16294 as an alternative alongside the current prescribed test method of EN 14107 for testing for phosphorous
- **Tests for Group 1 metals** – Adding the test method EN 14538 for Group 1 metals as an alternative alongside the current prescribed test methods, EN14108 and EN14109.

Ethanol

- **New ethanol specification** – Introducing a new fuel specification for ethanol blends of 85% volume (that is, up to 85% ethanol and minimum 15% petrol)
- **Testing water content** – Adding the test method IP 438 as an alternative alongside the current test method ASTM E203 for testing water content in ethanol.

3. Petrol

3.1. Sulphur limit

3.1.1. Why is sulphur important?

10. Sulphur occurs naturally in crude oils and must be reduced to an acceptable level during the refining process, as it promotes corrosion and affects the performance of vehicle control equipment. Specifically, sulphur reduces the conversion efficiency for carbon monoxide, hydrocarbons and oxides of nitrogen in vehicles fitted with three-way catalysts, and this accelerates catalyst ageing and reduces fuel efficiency.

11. Reducing sulphur levels from 50 parts per million (ppm) to 10 parts per million would result in the following:

    11.1. reductions of between 1% and 5% in CO_2 emissions from Euro 4 cars.[1] Cars registered to a vehicle emission standard of at least Euro 4 (which is broadly equivalent to the Japan 2005 standard) make up approximately 17% of the light petrol vehicle fleet in New Zealand.[2]

    11.2. reductions of at least 10% NOx and HC emissions from vehicles registered to an emissions standard pre-Euro 4.[3] In New Zealand, this represents approximately half of the country's light petrol vehicle fleet.[4]

    11.3. reductions in CO, SOx and PM emissions from existing petrol vehicles.

    11.4. increased uptake of the latest technology improvements in new vehicles (specifically vehicles designed for Euro 5 and Euro 6 emissions standards). Those improvements provide higher fuel efficiency and offer more substantial reductions in CO, NOx, SOx, PM and HC emissions.

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1 Directorate-General Environment. 2001. *The Costs and Benefits of Lowering the Sulphur Content of Petrol & Diesel to Less than 10 ppm.* Brussels: European Commission. Available at: http://ec.europa.eu/environment/archives/sulphur/cbloweringsulphurcontent.pdf

2 Ministry of Transport. New Zealand vehicle fleet statistics, 2013 data. Available at: www.transport.govt.nz/research/newzealandvehiclefleetstatistics/

3 *The Costs and Benefits of Lowering the Sulphur Content of Petrol & Diesel to Less than 10 ppm*.

4 New Zealand vehicle fleet statistics, 2013 data.

3.1.2. What is the current specification?

12. The *Engine Fuel Specifications Regulations 2011* specify a maximum limit of 50 mg/kg, equivalent to 50 ppm.

Standard/Specification document	Maximum sulphur content[5]
New Zealand (EFSR 2011)	50 mg/kg
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	150 mg/kg regular petrol 50 mg/kg premium petrol
Japan (JIS K 2202:2012)	0.001% mass fraction (equivalent to 10 mg/kg)
Europe (EN 228:2012)	10 mg/kg
United States (D4814 – 14b)	30 ppm annual average maximum with a per-gallon cap at 80 ppm
Worldwide Fuel Charter 2013 (Category 3)	30 mg/kg
Worldwide Fuel Charter 2013 (Categories 4 and 5)	10 mg/kg

13. The limit in New Zealand has been reduced in increments, from 500 ppm in 2002, to 50 ppm on 1 January 2008.

3.1.3. What is the issue?

14. Since the major review of fuel specifications in 2001/02, there has been a clear expectation that sulphur levels would be periodically reduced, to an ultimate end-point of near-zero sulphur petrol (defined as 10 ppm).

15. The ultimate goal of 10 ppm was set out in a footnote in the Regulations through various amendments up to 2011. The footnote (to Schedule 1) read: “Eventually, the requirement will be for ‘sulphur-free’ petrol of 10 ppm maximum sulphur content.” In 2011 it was decided to remove this statement since it did not specify when this ultimate requirement would be introduced.

16. The issue was formally discussed in a review by the Ministry of Economic Development in May 2005,[6] where 2010 was suggested as a likely time for New Zealand to move to 10 ppm. At the time of that review, the Auckland Regional Council, Environment Waikato, the Motor Industry Association, the Ministry of Health, and the Automobile Association supported introducing 10 ppm petrol by 2010 or even earlier. However, BP, Caltex, the Consumers’ Institute, Gull, Mobil, and Shell said that it was too early to commit to a date for moving to 10 ppm, given concerns about security of supply and cost, as well as what they argued would be the relatively modest reductions in vehicle emissions that would be achieved within the existing vehicle fleet.

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[5] Sulphur limits are set out in the relevant regulations or standards, usually in mg/kg. However, it is typical in industry to refer to the limit in “parts per million”, or “ppm”. A level of 50 mg/kg = 50 ppm. This discussion paper will refer simply to “ppm” across different fuel standards.

[6] Ministry of Economic Development. 2005. *Review of Permitted Sulphur Levels Beyond 2006 under the Petroleum Products Specifications Regulations*, Discussion Paper.

17. The principal reason for not moving to 10 ppm petrol has been concerns around security of supply, with relatively few refineries in the Asia-Pacific region capable of producing petrol to this standard.

18. There has not been a detailed review of moving to 10 ppm petrol since 2005.

Potential health and environmental benefits

19. During the combustion process, vehicles emit a range of gases that can result in adverse health and environmental effects. It is difficult to quantify the potential reduction in these gases that would be achieved by reducing the sulphur level in petrol from 50 ppm to 10 ppm in New Zealand's existing vehicle fleet. International studies are not necessarily applicable to New Zealand given the unique characteristics of our petrol specifications, vehicle fleet and climate. However, notwithstanding these limitations, it is clear that reductions across the vehicle fleet can be expected for almost all of the main pollutants.

The main pollutants and their effects

20. Below is a brief summary of each of the main pollutants, including the health and environmental concerns of each one, and the projected reductions of these pollutants resulting from a drop in sulphur levels.

CO_2 emissions

21. Carbon dioxide is the main greenhouse gas responsible for climate change. The European Commission estimated that the potential CO_2 reduction of moving from 50 ppm to 10 ppm would be in the order of 1% to 5% (with a base assumption of 3%) for vehicles registered to a Euro 4 emissions standard.

22. If a 3% base-case assumption is applied to New Zealand vehicles registered to at least a Euro 4 emissions standard (note that the Japan 2005[7] standard is considered broadly equivalent to Euro 4 and for the purposes of simplicity, this report refers to Euro 4 and Japan 2005 as Euro 4), this would mean an immediate reduction in emissions of 15,000 to 20,000 tonnes of CO_2 per year (0.03 X 562,000).

23. Applying the 2014 average New Zealand emissions cost for CO_2 of $3.40 per tonne, this would mean total economy-wide savings of $51,000 to $68,000 for the year.

24. These figures could be expected to increase substantially over time as the number of vehicles registered to a Euro 4 emissions standard increases and if the cost of carbon increases.

NOx emissions

25. Nitrogen dioxide is a respiratory irritant, and chronic exposure to elevated levels can lead to increased incidence of acute respiratory disease in children and lower resistance to respiratory infections in adults. NO_2 also absorbs blue light, resulting in a visible brown tint to polluted air.

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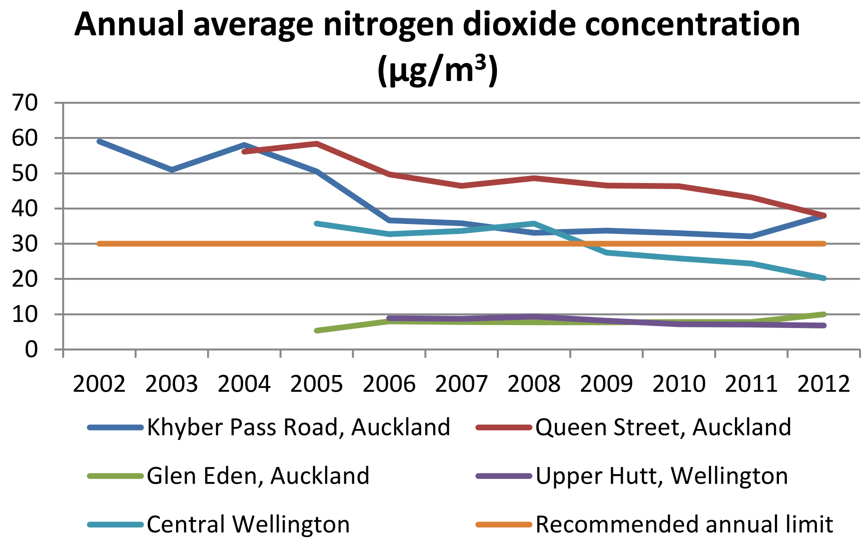
[7] New vehicles are usually declared to meet European (Euro) standards while used vehicles are usually declared to meet Japanese domestic standards, which are referred to by the year they were adopted in Japan.

26. The World Health Organization recommends a long-term (annual) guideline of 40 µg/m^3, which was met in 121 of the 124 monitoring sites in New Zealand in 2012.[8] In five selected locations (see the following graph) the annual averages for 2012 were below this limit, although in two of them – Khyber Pass Road and Queen Street in Auckland – they exceeded 30 µg/m^3 annually, which is considered a critical level for protecting ecosystems and is not a health-based guideline.[9]



Source: Auckland Council, Wellington Regional Council, used in the 2014 Air Domain Report

27. The European Commission assumed that reducing the sulphur content in petrol from 50 ppm to 10 ppm would reduce average NOx reductions from pre-Euro 4 vehicles by 10%.[10] The European Commission made no assumptions for vehicles at or above the Euro 4 standard. The Worldwide Fuel Charter provides a range of estimates depending on the study, the vehicle technology, and the reduction in sulphur levels.[11] The Environmental Protection Authority (EPA) in the United States found that the impact of moving from 30 ppm to 10 ppm in Tier 2 vehicles (broadly equivalent to the Japan 2009 standard) resulted in a 16% reduction in NOx emissions[12].

28. For the purposes of this discussion paper, a standard 10% reduction in NOx emissions has been applied for petrol vehicles ranging from Euro 1/JP 00 to Euro 4/JP 05. Based

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8 Ministry for the Environment and Statistics New Zealand. 2014. *New Zealand's Environmental Reporting Series: 2014 Air Domain Report*, page 32. Available at: www.mfe.govt.nz/sites/default/files/air-domain-report-final.pdf

9 NZ Transport Agency. *Ambient Air Quality (Nitrogen Dioxide) Monitoring Network – Annual Report 2007 to 2013*, page 12. Available at: www.nzta.govt.nz/resources/air-quality-monitoring/docs/air-quality-monitoring-report-2007-2013.pdf

10 *The Costs and Benefits of Lowering the Sulphur Content of Petrol & Diesel to Less than 10 ppm*, page 4, Table 1.

11 Worldwide Fuel Charter, 5th ed, September 2013, pages 23–27. Available at: www.acea.be/uploads/publications/Worldwide_Fuel_Charter_5ed_2013.pdf

12 *Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule – Regulatory Impact Analysis,* Pages 1–18 and 7–45. Available at: www.epa.gov/oms/documents/tier3/420r14005.pdf

on the vehicle emissions model developed by Dr Gerda Kuschel (see "Social benefits", below at page 22), NOx emissions could be reduced by 26.8 kilotonnes from 2015 to 2030 as a result of moving from 50 to 10 ppm petrol.

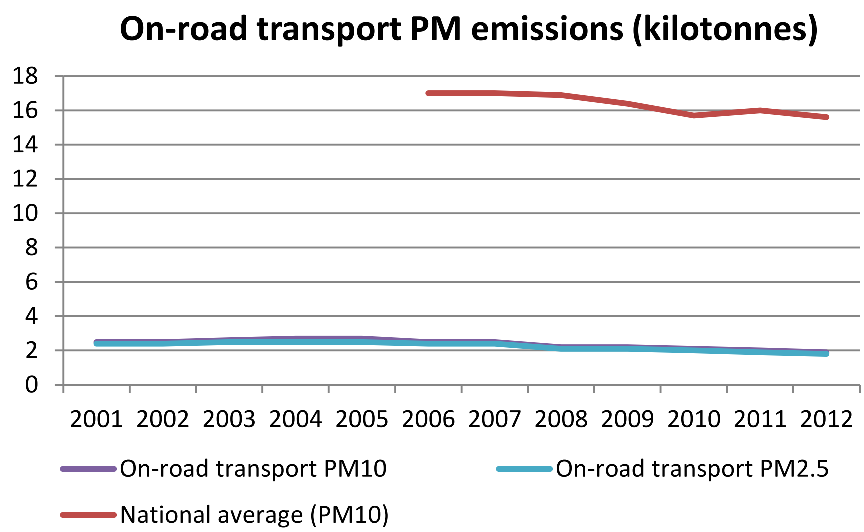
29. Of note, successive emissions standards in Europe have failed to deliver expected reductions in NOx.[13] It is expected that Euro 6 will go some way to address this problem with 10 ppm petrol a prerequisite for introduction of Euro 6.

Particulate matter

30. 'Particulate matter' (PM) is the term for microscopic particles and liquid droplets suspended in the air. The pollutant comes in a variety of sizes and can be composed of many types of materials and chemicals. However, particulate matter is typically referred to in two different size categories: PM_{10} (particles less than 10 micrometres in size) and $PM_{2.5}$ (particles less than 2.5 micrometres in size).

31. The major effects of concern with airborne particles are increased mortality, aggravation of existing respiratory disease, increased hospital admissions, and lost work days.

32. The most recent study in New Zealand is the Updated Health and Air Pollution in New Zealand Study of 2012.14 The report put the total social costs of PM10 attributable to motor vehicles in 2006 at $934 million (measured in NZ$ as at June 2010). This included: 255 premature deaths of adults over 30; 142 hospital admissions; and 352,300 restricted activity days.



Source: Regional Councils, NIWA - drawn from data used in the 2014 Air Domain Report

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13 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Clean Air Programme for Europe*. Available at: http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=9JB1JFTJVwPpxGm7BGzJLBXV1hT2rPGXn8BvtnVgCg21Hvxn98hp!1125658998?uri=CELEX:52013DC0918.

14 Gerda Kuschel. 2012. *Updated Health and Air Pollution in New Zealand Study, Volume 1: Summary report*. Available at: www.hapinz.org.nz/HAPINZ%20Update_Vol%201%20Summary%20Report.pdf

33. The European Commission's 2001 study assumed no reductions in particulates from Euro 4 or pre-Euro 4 vehicles.[15] Similar conclusions were drawn from the more recent regulatory impact analysis on Tier 3 air pollution and fuel quality standards by the US Environmental Protection Agency. The EPA concluded that there were relatively modest $PM_{2.5}$ reductions of 0.1% to 0.4% from the new emissions standards, but no reductions as a result of reducing sulphur levels from 30 ppm to 10 ppm in petrol.

34. MBIE has not assumed any PM reductions from reducing sulphur from 50 ppm to 10 ppm.

Hydrocarbons

35. Hydrocarbons emissions result from incomplete combustion and from fuel evaporation. Hydrocarbons combine with nitrogen oxides in heat and sunshine to form ground-level ozone.

36. There are a variety of health outcomes possible from exposure to ozone, including effects on mortality, hospital admissions, respiratory symptoms and lung function.

37. The US EPA's regulatory impact analysis found reductions of total hydrocarbon emissions of between 5.9% and 43.3% as a result of moving to 28 ppm to 5 ppm from in-use Tier 2 vehicles.[16] The European Commission assumed that reducing the sulphur content in petrol from 50 ppm to 10 ppm would reduce average hydrocarbons from pre-Euro 4 vehicles by 10%, but would result in no reduction in hydrocarbons from Euro 5 vehicles.[17]

Sulphur oxides

38. Sulphur oxides are gaseous emissions formed by the oxidation of fuel during the combustion process. Sulphur dioxide is the main form of sulphur oxide and is a potent respiratory irritant when inhaled. Ambient levels of SO_2 have been associated with increases in daily mortality, hospital admissions for respiratory and cardiovascular disease, increases in respiratory symptoms, and decreases in lung function.

39. The US EPA found significant reductions of over 50% in SO_2 from reducing sulphur levels from 30 ppm to 10 ppm.[18]

40. There are only nine sites that monitor sulphur dioxide in New Zealand. The *2014 Air Domain Report* notes that three of these nine sites exceeded the World Health Organization's guideline limit of 20 µg/m^3 in 2012. In the case of Mt Maunganui and Woolston in Christchurch, the high levels recorded were due to industrial emissions, while at the Auckland waterfront they were due to shipping.[19]

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15 *The Costs and Benefits of Lowering the Sulphur Content of Petrol & Diesel to Less than 10 ppm*, page 4, Table 1.

16 Table 1-6. Available at: http://www.epa.gov/oms/documents/tier3/420r14005.pdf

17 *The Costs and Benefits of Lowering the Sulphur Content of Petrol & Diesel to Less than 10 ppm*, page 4, Table 1.

18 Table 7-39. Available at: www.epa.gov/oms/documents/tier3/420r14005.pdf

19 Ministry for the Environment and Statistics New Zealand. 2014. *New Zealand's Environmental Reporting Series: 2014 Air Domain Report*, page 38. Available at: www.mfe.govt.nz/sites/default/files/air-domain-report-final.pdf

41. Reducing the sulphur level in petrol is likely to result in ongoing reductions in sulphur dioxide levels throughout the country, although it is difficult to quantify by just how much.

Carbon monoxide

42. Carbon monoxide is a poisonous gas formed from incomplete (or partial) combustion. Carbon monoxide affects human health by reducing the amount of oxygen that can be carried in the blood to the body tissues.

43. Transport is the main source of carbon monoxide emissions in New Zealand. In 2006, transport accounted for 85% of the annual carbon monoxide emissions in Auckland.[20] In 2012, there were no reported breaches of the national standard for carbon monoxide at the 20 sites where it is monitored, and 17 of the 20 sites had concentrations of less than half the national standard.[21]

44. The Worldwide Fuel Charter cites the results of a range of studies on the percentage reduction of carbon monoxide. Of most relevance is the Alliance/Ajam study of a reduction from 30 ppm to 1 ppm for LEV/ULEV vehicles, where the reduction in carbon monoxide was 12%.[22] Meanwhile, the US EPA found reductions of between 6.7% and 15.9% of carbon monoxide emissions as a result of reducing sulphur from 28 to 5 ppm for in-use Tier 2 vehicles.[23]

45. This discussion paper has assumed a reduction of 10% in carbon monoxide emissions from vehicles registered to a Japan 2005 standard or better. No reductions have been applied to vehicles registered to a pre-Japan 2005 standard, although some reductions are in fact likely.

46. In 2012 the level of on-road carbon monoxide emissions was 177,000 tonnes.[24] Petrol vehicles emit more carbon monoxide than equivalent-sized diesel vehicles. In 2013 there were approximately 450,000 light passenger petrol vehicles registered to a Japan 2005 standard or better, out of a total vehicle fleet of 3.36 million.[25] Simply applying a straight proportion implies that the total potential carbon monoxide savings to be achieved by reducing sulphur from 50 to 10 ppm would be over 2,300 tonnes (450,132 / 3,364,948 X 177,000 X 0.07). In reality, however, this is likely to be a conservative estimate, and the expected reduction is likely to increase over time as newer vehicles enter the market.

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[20] Ministry for the Environment. 2007. *Environment New Zealand 2007,* page 168. Available at: www.mfe.govt.nz/sites/default/files/environment-nz07-dec07.pdf

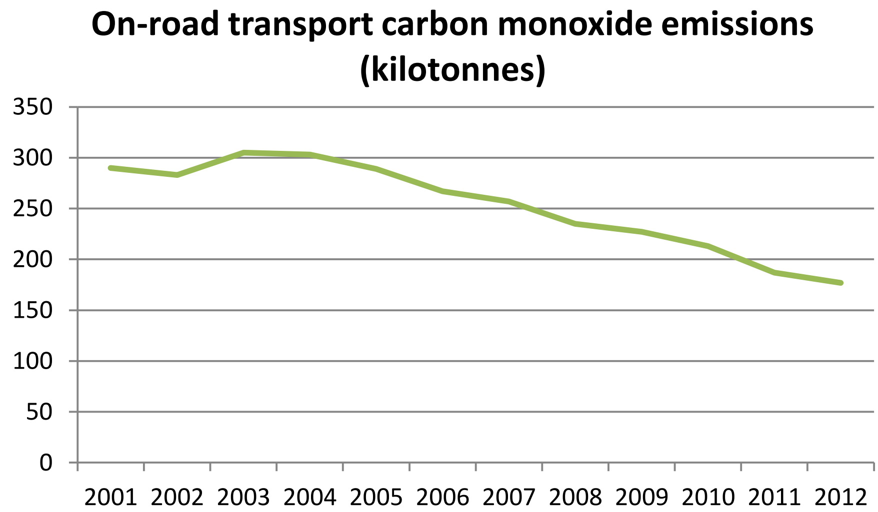
[21] *2014 Air Domain Report*, page 38.

[22] Worldwide Fuel Charter, 5th ed, September 2013, page 24. Available at: www.acea.be/uploads/publications/Worldwide_Fuel_Charter_5ed_2013.pdf

[23] Table 1-6. Available at: www.epa.gov/oms/documents/tier3/420r14005.pdf

[24] Ministry for the Environment. Data files used in 2014 Air domain report, Table 15. Available at: www.mfe.govt.nz/more/environmental-reporting/air/air-domain-report-2014/data-and-supporting-information/data-files

[25] Ministry of Transport. New Zealand vehicle fleet statistics, 2013 data, Tables 9.11 and 1.1, 1.2. Available at: www.transport.govt.nz/research/newzealandvehiclefleetstatistics/



Source: NIWA, used in the 2014 Air Domain Report

Alignment with vehicle emissions standards

47. New Zealand's vehicle emissions standards are set out in Table 2.2 of the *Land Transport Rule: Vehicle Exhaust Emissions 2007*.[26] Since 1 January 2012, the prescribed standard for all newly registered light-duty used vehicles is the Japan 2005 emissions standard, which is broadly equivalent to the Euro 4 emissions standard. In Europe, the Euro 4 emissions standard was introduced at the same time as the Euro 4 fuel quality standard (EN 228:2004), which required petrol with a maximum sulphur limit of 50 ppm (that is, the same as New Zealand currently requires).

48. The *Land Transport Rule: Vehicle Exhaust Emissions 2007* requires new petrol vehicles manufactured on or after 1 January 2014 to meet the Japan 2009 emission standard, which is broadly equivalent to the Euro 5 emissions standard. For Japan 2009 and Euro 5, Japan and Europe both introduced a maximum sulphur level of 10 ppm for petrol, to maximise the potential health and environmental benefits.

49. There is currently no timeframe for moving to the equivalent of the Euro 6 vehicle emissions standard but for these vehicles 10 ppm petrol is preferred over 50 ppm petrol.[27] The Ministry of Transport has said it will review the need for adoption of Euro 6 standards in 2016 as part of a wider review of emissions standards to be conducted at that time. Any decision on timing of adoption of Euro 6 will need to consider the timing of introduction in Australia, where dates for adoption have not been set either[28]. The Ministry of Transport is especially interested in the introduction of Euro 6 as previous emissions standards have not delivered sufficient reductions in levels of NOx.

50. Data from the Ministry of Transport shows an increasing proportion of new light vehicles registered to the Euro 5 and Euro 6 emissions standards. This comes from a

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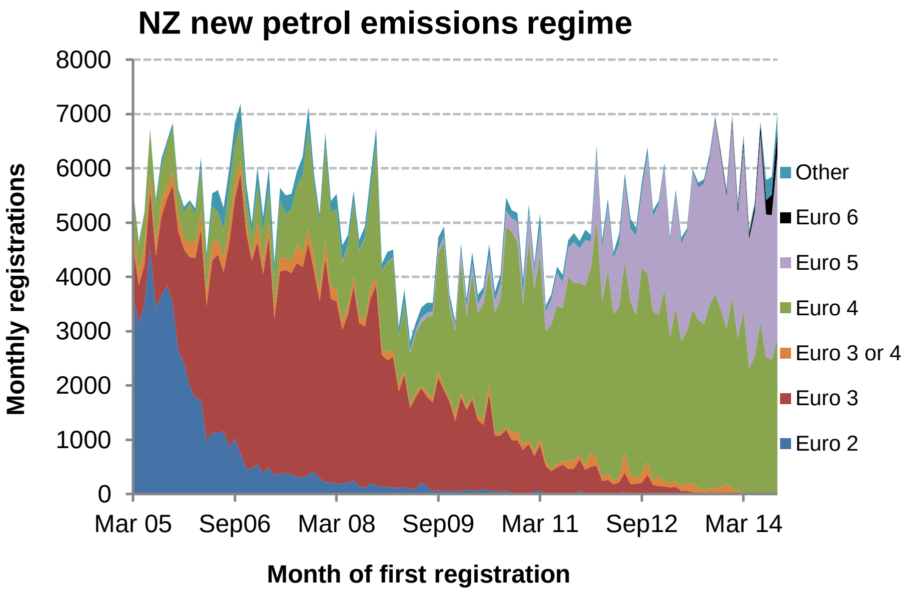
[26] Available at: http://nzta.thomsonreuters.co.nz/DLEG-NZL-LTSA-T.LTR-33001 2.pdf

[27] Meeting with the Australian Department of the Environment on 13 November 2014. The conclusion that 10 ppm petrol is preferable to 50 ppm petrol for Euro VI comes from a study undertaken by Orbital on behalf of the Department of the Environment but which was not shared with MBIE.

[28] http://www.transport.govt.nz/ourwork/vehicleemissions/

relatively low base. As at the end of December 2014, there were 95,194 Euro 5 and Euro 6 registered light vehicles, out of a total light vehicle fleet of 3.39 million.

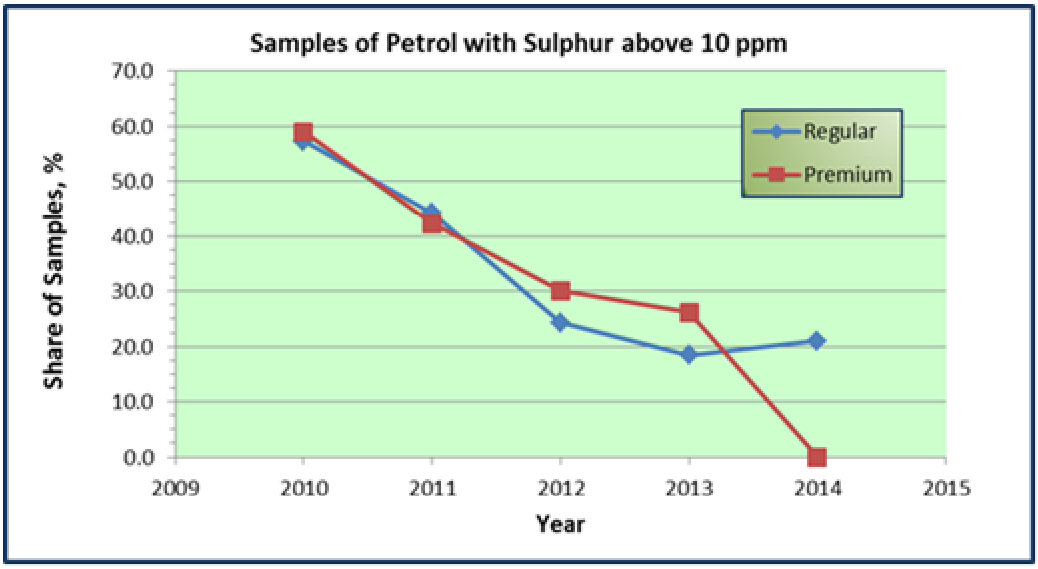


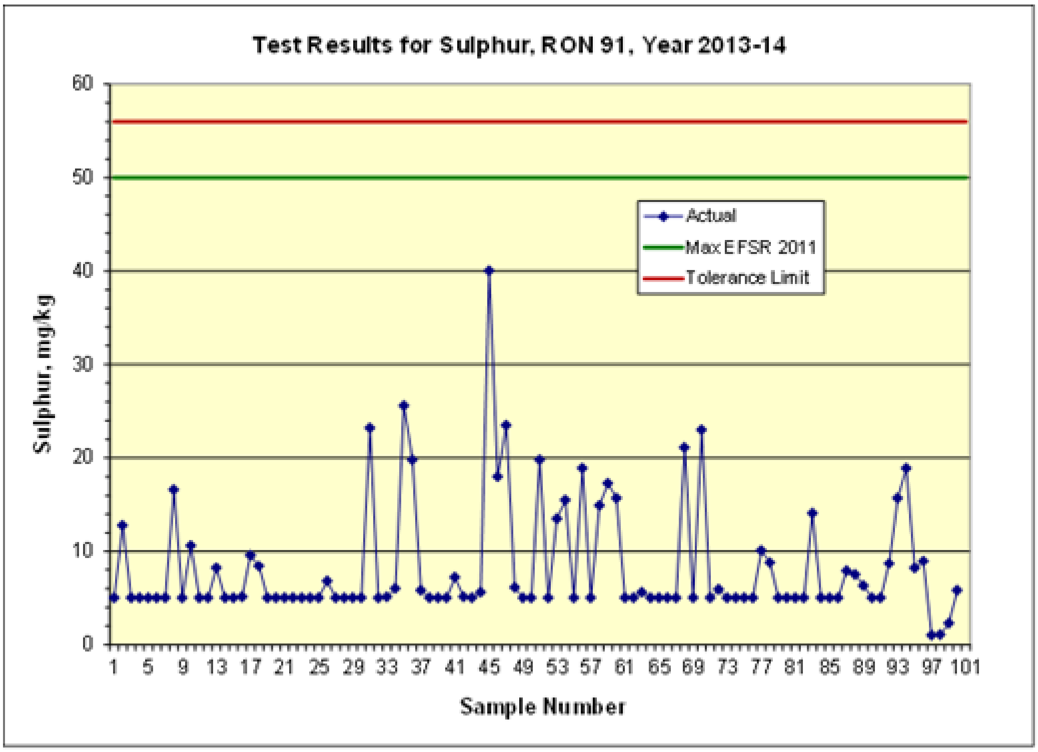
Source: NZ Vehicle Fleet Statistics, Ministry of Transport

51. MBIE concludes from this information that a move to 10 ppm petrol will have a relatively modest immediate impact on emissions from the existing vehicle fleet, but that the impact will increase over time. It is likely that requiring 10 ppm petrol will increase the rate of uptake of newer vehicles designed for higher emissions standards. The move to 10 ppm would also provide the preconditions needed to enable Euro 6-equivalent vehicle emissions standards to be introduced.

Implications for Refining New Zealand

52. MBIE understands that there are no difficulties in supplying 10 ppm petrol from New Zealand's sole refinery at Marsden Point, as the refinery already meets this standard. Twenty percent of samples tested in 2014 exceeded 10 ppm, and MBIE concluded (after consulting with the Independent Petroleum Laboratory) that all of those samples exceeding 10 ppm probably related to imported regular grade. Of those samples, only one exceeded 30 ppm, while five samples exceeded 20 ppm.


Samples of Petrol with Sulphur above 10 ppm
Share of Samples, %
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2009
2010
2011
2012
2013
2014
2015
Year
Regular
Premium


Test Results for Sulphur, RON 91, Year 2013-14
Sulphur, mg/kg
60
50
40
30
20
10
0
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101
Sample Number
Actual
Max EFSR 2011
Tolerance Limit

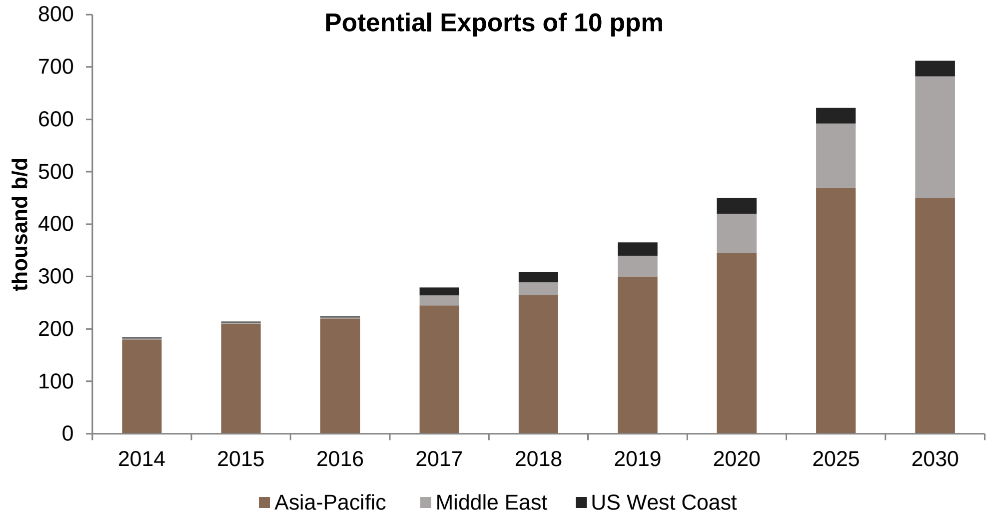
Security of supply

53. In 2005 one of the main concerns about moving to lower sulphur levels for petrol, and particularly to 10 ppm petrol, was around security of supply. Each of the oil companies expressed concerns about moving ahead of other Asia-Pacific jurisdictions.

54. MBIE engaged Stratas Advisors, a Hart Energy Company, to carry out a stocktake of current and future supply of 10 ppm petrol in the Asia-Pacific region. Its report is published separately alongside this discussion paper.

55. At present, only Japan, South Korea and Taiwan require 10 ppm petrol. China (2017/18), Singapore (2017), and Vietnam (2021) have confirmed plans to move to 10 ppm petrol, while India proposes to move to this level by 2020. Elsewhere, the United Arab Emirates (2015), Saudi Arabia (2016), Kuwait (2018) and the United States (2017) all have confirmed moves to 10 ppm petrol.

56. Based on a detailed refinery-by-refinery analysis and supply/demand forecast, Stratas concludes that the total export capability of 10 ppm petrol in the broader Asia-Pacific region was 184 tb/d (thousand barrels per day) in 2014, and that this will rise rapidly after 2017 to 450 tb/d in 2020 and to 712 tb/d in 2030 (as shown in the graph below).



57. Export capability is not the same as a forecast of actual 10 ppm petrol exports. Stratas forecasts 10 ppm petrol exports in the broader Asia-Pacific region of 55 tb/d in 2017, rising to 110 tb/d in 2020 and to 445 tb/d in 2030.

58. Refining New Zealand is set to meet 65% of the country's petrol requirements by December 2015. Based on demand levels for 2014, this leaves an import requirement of approximately 18 tb/d. MBIE's reference forecast sees a gradual decline in petrol demand from 2015 to 2040 as a result of ongoing efficiency improvements in an already very mature market.[29]

59. MBIE concludes from this analysis that moving from 50 to 10 ppm petrol raises few concerns around security of supply, particularly from 2017 when China, Singapore, the UAE, Saudi Arabia and the US will all have moved to 10 ppm.

[29] *New Zealand Energy Outlook: Reference Scenario*. Available at: www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/new-zealands-energy-outlook-reference-scenario

Alignment with Australia

60. In the past, Australia has been an important source of imported oil products to New Zealand. Ensuring that New Zealand's fuel quality standards are aligned with those of Australia has therefore been an important consideration in past reviews of New Zealand's fuel specifications.

61. The Australian Government has given no indications of when it will look to move to 10 ppm petrol, although the issue was highlighted in a recently published Issues Paper.[30]

62. The last recorded import parcel of petrol from Australia was in April 2012.[31] In 2012, Shell closed the 85 tb/d Clyde refinery in Sydney. This has been followed by announcements from BP that it would close its 102 tb/d Bulwer Island refinery in Brisbane by mid-2015,[32] and from Caltex that it would begin closing its 124.5 tb/d Kurnell refinery in Sydney in October 2014.[33]

63. Australia is now an increasingly large net importer of petrol, and it is therefore unlikely that New Zealand will look to source petrol from Australia in future. MBIE's view is that New Zealand does not need to rely on Australia moving to 10 ppm petrol before New Zealand does.

Cost implications

64. MBIE commissioned Hale & Twomey to carry out a review of the potential cost implications of moving from 50 ppm to 10 ppm petrol. A copy of this review has been released alongside this discussion paper.

65. Hale & Twomey developed a petrol blending model that allows various components to be mixed together to make a petrol blend. Using that model (with 2014 prices), they estimated that the cost impact of moving from 50 ppm to 10 ppm petrol would be around 35 to 50 US cents per barrel, with the low end of that cost range more closely aligned with high-octane petrol and the high end more closely aligned to lower-octane petrol.

66. Based on total petrol demand for 2014, Hale & Twomey estimates that the total cost to New Zealand consumers would be between $7.8 and $17.3 million, or between 0.26 and 0.57 cents per litre.

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30 *Independent Review of the Fuel Quality Standards Act 2000*, *Issues Paper*, June 2015. Available at: http://duqm0dwvyjbvv.cloudfront.net/wp-content/uploads/2015/06/Fuel-Quality-Act-Review_Issues-Paper1.pdf.

31 Company returns to the then-Ministry of Economic Development.

32 BP Australia, 'BP Bulwer Island Refinery: processing to halt', 2 April 2014. Available at: www.bp.com/en_au/australia/media/media-releases/bulwer-island-refinery-processing-halt.html

33 Caltex Australia, 'Marketing & Distribution Growth Continues; Kurnell Refinery to Commence Shutdown in October', 25 August 2014. Available at: www.caltex.com.au/Media%20Items/25%20August%202014%20-%20Marketing%20and%20Distribution%20growth%20continues,%20Kurnell%20refinery%20to%20commence%20shut%20down%20in%20October.pdf

Social benefits

67. The most recent review of the social costs of vehicle emissions is the report *Updated Health and Air Pollution in New Zealand Study,* prepared in March 2012.[34] The report concluded that the total social cost in 2006 (measured in NZ$ as at June 2010) was $934 million. Most of this social cost can be attributed to the estimated 256 premature adult and baby mortalities per year. In addition, the study found that 142 hospital admissions and 352,300 restricted activity days could be attributed to vehicle emissions.

68. MBIE commissioned the author of that review, Dr Gerda Kuschel, to estimate the potential reduction in social costs resulting from a reduction from 50 ppm to 10 ppm petrol. Dr Kuschel concluded that the total non-discounted benefit to society through to 2030 from making this change would be $517 million (or over $30 million per year). This reduced to $401 million with a discount rate of 3% (used as a proxy for the Crown's social rate of time preference) or $275 million with a discount rate of 8% (used as a proxy for a commercial rate of return).

69. These estimates were made by determining the benefits per tonne of reductions in pollutants, and modelling reductions in total particulate matter, oxides of nitrogen, volatile organic compounds, and carbon dioxide. The model was based on the Ministry of Transport's Vehicle Emissions Prediction Model and international comparisons for the value of a life year for reductions against each of these pollutants. The model that was used and a short explanation of the assumptions and key outputs have been publicly released alongside this discussion paper.

70. MBIE concludes from that analysis that the social benefits of reducing sulphur levels from 50 ppm to 10 ppm exceed the potential increased costs to consumers by a factor of at least 2:1. The only issues associated with making the change are around timing and ensuring sufficient supply. MBIE proposes a staged process to align with moves in other major jurisdictions (particularly China) to reduce sulphur levels to 10 ppm, and also to give suppliers time to arrange alternative sources of supply if necessary. MBIE proposes to reduce the sulphur limit in petrol to 30 ppm from 1 July 2016 and then to 10 ppm from 1 July 2017.

Q1: Do you agree with moving to 30 ppm petrol by 1 July 2016, and to 10 ppm petrol by 1 July 2017? If not, why not?

3.2. Oxygen content and other oxygenate limits

3.2.1. What are oxygenates?

71. Oxygenates are organic compounds containing carbon, oxygen and hydrogen. They can be added to petrol as a blending component and to increase octane. Their use in petrol increases the available oxygen for combustion, which has the effect of reducing the formation of carbon monoxide and reducing hydrocarbon emissions.

34 Dr Gerda Kuschel. 2012. *Updated Health and Air Pollution in New Zealand Study, Volume 1: Summary report*. Available at: www.hapinz.org.nz/HAPINZ%20Update_Vol%201%20Summary%20Report.pdf

72. Oxygenate limits need to be set carefully, as blending oxygenates into petrol can increase the fuel's vapour pressure and significantly modify the volatility and distillation characteristics, resulting in increases in evaporative emissions.

3.2.2. What is the current specification for oxygen?

Standard/Specification document	Maximum oxygen content
New Zealand (EFSR 2011)	No prescribed limit
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	2.7% m/m maximum for all grades of petrol not containing ethanol 3.9% m/m maximum for all grades of petrol containing ethanol
Japan (JIS K 2202:2012)	1.3% m/m maximum for all grades of petrol containing a maximum 3% ethanol by volume 3.7% m/m maximum for all grades of petrol containing a maximum 10% ethanol by volume
Europe (EN 228:2012)	2.7% m/m maximum for all grades of petrol containing a maximum of 5% ethanol by volume 3.7% m/m maximum for all grades of petrol containing a maximum of 10% by volume
United States (D4814 – 14b)	2.0% m/m maximum except fuels containing aliphatic ethers and/or alcohols (excluding methanol) 2.7% m/m maximum including fuels containing aliphatic ethers and/or alcohols (excluding methanol) For examples of waivers, see this footnote[35]
Worldwide Fuel Charter 2013 (Category 3)	2.7% m/m maximum
Worldwide Fuel Charter 2013 (Categories 4 and 5)	2.7% m/m maximum

[35] One waiver relates to the gasoline-alcohol mix known as OCTAMIX, and applies if the resultant fuel is composed of a maximum 3.7% by weight fuel oxygen, a maximum of 5% by volume methanol, a minimum of 2.5% by volume co-solvents, and 42.7 milligrams per litre of Petrolite TOLAD MFA-10 corrosion inhibitor. On 23 March 2011 the US EPA authorised the use of TXCeed as an alternative corrosion inhibitor. See: www.epa.gov/oms/fuels/registrationfuels/documents/420f12020.pdf

3.2.3. What is the current specification for other oxygenates

Standard/Specification document	Maximum oxygenate limits
New Zealand (EFSR 2011)	Limit of 1% m/m for 'other oxygenates' and 10% maximum volume for ethanol
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	10% volume by volume (v/v) ethanol 1% v/v DIPE (di-isopropyl ether) 1% v/v MTBE (methyl tertiary-butyl ether) 0.5% v/v TBA (tertiary butyl-ether)
Japan (JIS K 2202:2012)	7% v/v MTBE 3% ethanol for total oxygen limit of 1.3% m/m 10% ethanol for total oxygen limit of 3.7%
Europe (EN 228:2012)	For all grades of petrol containing a maximum of 5% ethanol by volume: - methanol 3% v/v maximum - the volume blending restricted to 2.7% (m/m) maximum oxygen content for iso-propyl alcohol, iso-butyl alcohol, tert-butyl alcohol, ethers (5 or more C atoms), other oxygenates. For all grades of petrol containing a maximum of 10% by volume: - 3% v/v methanol maximum - 12% v/v iso-propyl alcohol maximum - 15% v/v iso-butyl alcohol maximum - 15% v/v tert-butyl alcohol maximum - 22% v/v ethers (5 or more C atoms) maximum - 15% v/v other oxygenates maximum.
United States (D4814 – 14b)	Oxygenates excluding aliphatic ethers and/or alcohols (and excluding methanol) up to a maximum oxygen limit of 2.0% m/m Oxygenates including aliphatic ethers and/or alcohols (and excluding methanol) up to a maximum oxygen limit of 2.7% m/m For examples of waivers, see this footnote[36]

[36] One waiver relates to the gasoline-alcohol mix known as OCTAMIX, and applies if the resultant fuel is composed of a maximum 3.7% by weight fuel oxygen, a maximum of 5% by volume methanol, a minimum of 2.5% by volume co-solvents, and 42.7 milligrams per litre of Petrolite TOLAD MFA-10 corrosion inhibitor. On 23 March 23 2011, the US EPA authorised the use of TXCeed as an alternative corrosion inhibitor. See: www.epa.gov/oms/fuels/registrationfuels/documents/420f12020.pdf .

Worldwide Fuel Charter 2013 (Category 3)	2.7% m/m. Where oxygenates are used, ethers are permitted. Methanol is not permitted. By exception, up to 10% by volume ethanol content is allowed if permitted by existing regulation.
Worldwide Fuel Charter 2013 (Categories 4 and 5)	2.7% m/m. Where oxygenates are used, ethers are permitted. Methanol is not permitted. By exception, up to 10% by volume ethanol content is allowed if permitted by existing regulation.

3.2.4. What is the issue?

73. New Zealand's specifications around oxygenates are quite different in the following ways from any of the other jurisdictions that New Zealand typically compares itself with:

    73.1. New Zealand does not specify a maximum limit for oxygen content, unlike all of the other jurisdictions and standards reviewed.

    73.2. New Zealand's specifications for oxygenates of up to 10% ethanol and 1% m/m 'other oxygenates' are much tighter than all of the other jurisdictions and standards reviewed.

74. New Zealand does not spell out what 'other oxygenates' may include. This contrasts with the European approach of stipulating different limits for different types of oxygenates.

Background on "other oxygenates" limit

75. The current specification for "other oxygenates" was introduced during the major review of fuel quality in 2001/02. At the time of that review, methyl tertiary-butyl ether (MTBE) had been raised as an issue in the UK and the US. MTBE has a strong affinity for water. While levels found in ground water in the UK and the US did not appear to pose a significant health risk as such, MTBE has a distinctive taste and smell and will taint groundwater supplies, even at very low concentrations.

76. The 2001/02 review concluded:

Two partial waivers have been made that taken together allow, but do not require, the introduction into commerce of petrol that contains greater than 10% volume ethanol and up to 15% volume ethanol (E15) for use in model year (MY) 2001 and newer light-duty motor vehicles, subject to certain conditions. On 13 October 2010, the EPA granted the first partial waiver (www.gpo.gov/fdsys/pkg/FR-2010-11-04/pdf/2010-27432.pdf) for E15 for use in MY2007 and newer light-duty motor vehicles (that is, cars, light-duty trucks and medium-duty passenger vehicles). On 21 January 2011, the EPA granted the second partial waiver for E15 for use in MY2001–2006 light-duty motor vehicles (www.gpo.gov/fdsys/pkg/FR-2011-01-26/html/2011-1646.htm). These decisions were based on test results provided by the US Department of Energy and other test data and information on the potential effect of E15 on vehicle emissions.

> "Given environmental concerns about contamination of groundwater in other jurisdictions, it is proposed that the use of MTBE and other ethers in petrol be banned until the environmental case is proven. This would be achieved by removing the exemption for MTBE from the oxygenates limit. This decision should be subject to review as more information becomes available, and may have an impact on the timetable and ultimate reduction of aromatic levels.
>
> "Given that MTBE is still in widespread use in some countries which are sources of imported petrol in New Zealand, maximum limits of 1.0% vol for MTBE and 0.1% vol for all other oxygenates would be included to allow for contamination from previous cargoes."[37]

77. Other than the inclusion of ethanol limits in 2008, there has been no formal review of oxygenate limits since 2001/02.

78. While MBIE notes that MTBE is widely used as an octane enhancer in other jurisdictions, notably in Europe and Asia, there is no desire to relax the current effective limit of 1% volume MTBE. The limit of 1% volume MTBE was introduced in 2001/02 to accommodate trace elements of MTBE but the policy intent from this time has always been that no MTBE should be supplied into New Zealand.

79. One of the public policy objectives for fuel specifications is to provide as much flexibility as possible to fuel suppliers within minimum environmental, public health and consumer protection constraints. This flexibility will enhance security of supply as fuel can be sourced from a wider range of refineries and minimise costs to consumers as the premium paid by fuel suppliers relative to the international benchmark is likely to be lower if there is a wider potential supply pool.

80. New Zealand's specifications appear unnecessarily stringent and restrictive compared to all the jurisdictions and standards that New Zealand typically benchmarks itself against. This may add costs for consumers where cheaper fuel options are available, and restrict potential sources of supply. For some refineries in the Asia-Pacific that can supply New Zealand, a special batch must be produced that can meet all of New Zealand's specifications. This means that the petrol bought by fuel suppliers for sale to New Zealand is priced at a premium to the internationally traded benchmark petrol price in Singapore. This premium in 2015 is estimated at US$3 per barrel (NZ 2.56 cents per litre). The Ministry does not know the exact proportion of this premium that can be ascribed to New Zealand's specification limit for oxygenates but considers that it is likely to be reasonably significant (possibly one-third). If it were to be one-third, this would represent approximately $26 million in additional costs to consumers (0.0256 / 3 x 3.023 billion litres of petrol sold in 2014).

81. The potential costs to consumers may in fact be greater than this if one includes other potential alcohols and ethers that could be blended into petrol. By way of example, the maximum allowable methanol content under the proposal would be 3% if prescriptive limits for individual types of alcohols and ethers were adopted. Using average benchmark petrol and methanol pricing for 2014, the average 2014 US$/NZ$ exchange rate, the relative energy content of methanol to petrol, and assumptions

[37] Ministry of Economic Development. 2001. *Petrol and Diesel Resource Document: A Review of the Petroleum Products Specifications Regulations,* page 68.

around the potential efficiency gains of methanol relative to pure mineral petrol, the total maximum potential savings to consumers in 2014 would be $37 million.[38]

82. There does not appear to be any justification for this restrictiveness, given the vast experience built up in other jurisdictions.

83. MBIE proposes to adopt an approach that is broadly similar to the European Standard, but is open as to whether the *Engine Fuel Specifications Regulations* should prescribe limits for individual types of alcohols and ethers (as is done in EN 228:2012 (E)), or whether total oxygenate limits are sufficient. In either option, a clarification would be provided that MTBE would be restricted to either the current effective limit of 1% volume, or possibly a tighter limit of 0.5% volume to reflect the policy intent that fuel suppliers should not supply MTBE to the New Zealand market. MBIE is interested in gauging the views of stakeholders as to whether to retain the current effective MTBE limit of 1% volume or whether to restrict it further to 0.5% volume.

84. If the regulations are amended, petrol containing oxygenates other than ethanol would not be able to be sold in New Zealand until such time that a new approval is given by the Environmental Protection Authority under the Hazardous Substances and New Organisms Act 1996 (HSNO). Approvals are required under the HSNO regime for the importation, manufacture, containment, and handling for hazardous substances. A new approval was required for petrol/ethanol blends when ethanol was introduced into the market in 2008 and the same process would be required in this instance.

Q2: Do you agree with removing the property 'other oxygenates', and the 1% volume maximum limit, from the Regulations and replacing it with one of the following two options:

a) Specifying total oxygenate limits of 2.7% mass for petrol blends with a maximum ethanol content of 5.0%, and 3.7% mass for petrol blends with a maximum ethanol content of 10.0%. MTBE volumes would be restricted to the current limit of 1% volume (or possibly 0.5% volume).

b) Specifying the total oxygenate limits in option a) above, <u>and</u> also specifying the following individual oxygenate limits in the case of petrol blends with a maximum ethanol content of 10.0% and a maximum oxygen content of 3.7% mass:

i) 3.0% volume methanol

ii) 12.0% volume iso-propyl alcohol

iii) 15.0% volume iso-butyl alcohol

iv) 15.0% volume tert-butyl alcohol

v) 22.0% volume ethers (5 or more C atoms)*

vi) 15.0% volume other oxygenates (defined as oxygenates that are not alcohols or ethers, and that have a final boiling point no higher than

[38] Key assumptions as follows: average retail petrol price excluding taxes and levies of $0.901 per litre, methanol price of US$472 per tonne, methanol blending/storage cost of 10%, assumed retail methanol cost excluding taxes and levies of $0.495 per litre, energy conversion factor of 2.079 GJ per litre of petrol per GJ of methanol, 15% thermal efficiency gain using methanol, US$/NZ$ exchange rate of 0.83, average petrol consumption of 8 litres per 100 km, average consumption using a 3% methanol/petrol blend of 8.11 litres per 100 km, total km travelled of 40.87 billion km.

210^{0}C).

- **MTBE volumes would be restricted to the current limit of 1% volume (or possibly 0.5% volume).**

3.3. Test method for lead

3.3.1. Why is lead important?

85. Historically lead was added to petrol to improve the octane rating. It does not affect engine performance as such, but lead accumulates in catalytic converters and poisons the catalyst. This effect is cumulative and irreversible.

86. Concerns over effects on human health resulted in the phasing out of petrol additives containing lead during 2002.

3.3.2. What is the current test method?

Standard/Specification document	Test method for lead
New Zealand (EFSR 2011)	IP 224
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	ASTM D3237
Japan (JIS K 2202:2012)	JIS K 2255
Europe (EN 228:2012)	EN 237
United States (D4814 – 14b)	ASTM D3237 or ASTM D5059
Worldwide Fuel Charter 2013	ASTM D3237, JIS K 2255, EN 237

87. The prescribed limit for lead is 5.0 mg/litre. There is a certain level of variance in the test results from the current test method IP 224, and therefore a tolerance limit of 6.0 mg/L is applied.

3.3.3. What is the issue?

88. The current test method for testing lead under the Regulations is *IP 224:2002, Determination of Low Lead Content of Light Petroleum Distillates by Dithizone Extraction and Calorimetric Determination* (reapproved in 2014). The method includes the use of a cyanide solution, which is extremely toxic.

89. Since early 2012, MBIE has agreed to the temporary use of a modified test method ASTM D5185 *(ASTM D5185-13e1 Mod B, Standard Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)1)*. This followed a formal request for this by the Independent Petroleum Laboratory (IPL) in 2008. The request was accompanied by a precision validation report, which showed better repeatability and reproducibility than for the unmodified ASTM D5185 test method, which is specified for lead in concentrations above 10 mg/L. The modified test method used by IPL is accurate down to 0.4 mg/L. The validation procedure conducted by IPL allows

them to conclude that the method ASTM D5185 Mod B is more precise than IP 224 for the determination of lead down to a concentration of 1 mg/L.

90. MBIE notes that the test method for lead prescribed in Australia and the US, and recommended in the Worldwide Fuel Charter, is ASTM D3237. This is an Atomic Absorption Spectrometry (AAS) method that has been superseded by Inductively Coupled Plasma (ICP) technology. The Independent Petroleum Laboratory has replaced the AAS facility with ICP technology for safety and accuracy reasons. Specifically, AAS uses highly flammable nitrous oxide and acetylene gases to combust the sample on a burner located on top of the instrument. This can create a safety hazard, and has caused fires and explosions in other laboratories where one of the equipment safety interlocks has failed. In contrast, the ICP technology uses a non-flammable gas (argon) ignited with a high voltage coil inside the instrument. This creates a much safer environment for the technician and the laboratory.

91. In addition, Inductively Coupled Plasma technology has similar or better repeatability and reproducibility compared to Atomic Absorption Spectrometry methods. ASTM International noted that the main advantages of ICP technology over AAS are its “wide dynamic range, simultaneous elemental capability, and extremely low detection limits.”[39]

92. For these reasons, MBIE proposes not to use ASTM D3237, the test method used in Australia and the US and recommended in the Worldwide Fuel Charter. MBIE proposes to formalise the current arrangement by adding the modified test method ASTM D5185 alongside the current test method of IP 224. MBIE also proposes to include the test method ASTM D5059: this test method would ultimately replace IP 224 for concentrations of lead below 10 mg/L, but IPL needs to formally validate ASTM D5059 before IP 224 can be completely replaced.

Q3: Do you agree with adding the test methods ASTM D5185 and ASTM D5059 alongside the current test method of IP 224 for lead? If not, why not?

3.4. Test method for manganese

3.4.1. What is it and why is it important?

93. Methylcyclopentadienyl manganese tricarbonyl (MMT) is a manganese-based compound used as an octane-enhancing fuel additive for petrol (typically in concentrations up to 18 mg/litre).

94. While MMT is allowed to be sold in petrol sold in the United States and Canada it is opposed by engine manufacturers, with the Worldwide Fuel Charter explicitly excluding it. The Charter states:

> “Studies have shown that most of the MMT-derived manganese in the fuel remains within the engine, catalyst and exhaust system. The oxidized manganese coats exposed surfaces throughout the system, including spark plugs, oxygen sensors and

[39] *Significance of Tests for Petroleum Products,* 8th edition, Rand Salvatore, 2010, page 294.

inside the cells of the catalytic converter. These effects result in higher emissions and lower fuel economy. The effect is irreversible and cumulative."[40]

3.4.2. What is the current test method?

Standard/Specification document	Test method for manganese
New Zealand (EFSR 2011)	ASTM D3831
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	Not tested
Japan (JIS K 2202:2012)	Not tested
Europe (EN 228:2012)	EN 16135 and EN 16136
United States (D4814 – 14b)	Not tested
Worldwide Fuel Charter 2013	Not tested, as manganese is explicitly banned from petrol.

95. The prescribed limit for manganese in New Zealand is 2.0 mg/litre.

3.4.3. What is the issue?

96. The current test method is *ASTM D3831-12, Standard Test Method for Manganese in Gasoline by Atomic Absorption Spectroscopy*. As noted above, the Atomic Absorption Spectroscopy (AAS) method is a relatively old technology and the Independent Petroleum Laboratory (IPL), which does all the testing of oil products in New Zealand, no longer has an AAS facility.

97. Since at least 2008, IPL has in practice been using the modified test method ASTM D5185 (*ASTM D5185-13e1 Mod B, Standard Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)1).* IPL has argued that the Regulations need to be updated to reflect current best industry practice.

98. MBIE proposes to replace the current test method for manganese, ASTM D383, with the modified test method ASTM D5185, to reflect that current best practice.

Q4: Do you agree with replacing the ASTM D3831 test method for manganese with the modified test method ASTM D5185? If not, why not?

3.5. Test method for olefins

[40] *Worldwide Fuel Charter*, 5th edition, September 2013, page 28. Available at: www.acea.be/uploads/publications/Worldwide_Fuel_Charter_5ed_2013.pdf

3.5.1. What are olefins and why are they important?

99. Alkenes and cycloalkenes are referred to as 'olefins'. They have double bonds (that is, they are unsaturated) and are not normally present in crude oil, but are created during cracking and other refinery processing.

100. Olefins are good octane components, although at very high levels they can cause both engine damage and environmental concerns. Specifically, at very high levels olefins can affect some of the elastomers used in seals and gaskets in pumps and fuel lines, while their evaporation into the atmosphere has been established as contributing to the formation of ozone. The combustion products form toxic dienes such as 1,3-butadiene.

3.5.2. What is the current test method?

Standard/Specification document	Test method for olefins
New Zealand (EFSR 2011)	ASTM D1319
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	ASTM D1319
Japan (JIS K 2202:2012)	JIS K 2536
Europe (EN 228:2012)	EN 15553 and EN ISO 22854
United States (D4814 – 14b)	ASTM D3237 or ASTM D5059
Worldwide Fuel Charter 2013 (Category 3)	ASTM D237, JIS K 2255, EN 237

3.5.3. What is the issue?

101. The current test method is *ASTM D1319-14, Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption.*[41] This an older packed glass column method. It includes a number of warnings in relation to safety and toxicity, and may require calibration using mercury.

102. To that current test method MBIE proposes to add *ASTM D6839-13, Standard Test Method for Hydrocarbon Types, Oxygenated Compounds and Benzene in Spark Ignition Engine Fuels by Gas Chromotography.* ASTM D6839 compares well to the current ASTM D1319 across most ranges, but it does not give comparable results if the oxygenate content is greater than 0.3% volume.

103. The ASTM D6839 method is considered more accurate, repeatable and precise than ASTM D1319, the older packed glass column method. As well as being quicker and easier to use than ASTM D1319, ASTM D6839 is also safer, as the silica gel used to pack the ASTM D1319 columns can cause respiratory diseases. ASTM D6839 is used in other countries as a release method, and some petrol imported into New Zealand has only that method reported on its Certificate of Quality.

Q5: Do you agree with adding the test method ASTM D6839 alongside the current test method ASTM D1319 for olefins? If not, why not?

41 Available at: https://law.resource.org/pub/us/cfr/ibr/003/astm.d1319.2003.pdf

3.6. Calculation of pool average for aromatics

3.6.1. What are aromatics?

104. Aromatics are fuel molecules that contain at least one benzene ring. They occur naturally in crude oil and are also produced as part of the refining process. Aromatics are used in the refining process to increase the petrol's octane rating, which is a measure of petrol's resistance to auto-ignition.

105. The octane-enhancing qualities of aromatics are balanced by the following factors:

105.1. Heavy aromatics have been linked to the formation of engine deposits, particularly combustion chamber deposits. These increase tailpipe emissions, including hydrocarbons and oxides of nitrogen.

105.2. Combustion of aromatics can lead to the formation of carcinogenic benzene in exhaust gas. Lowering aromatic levels significantly reduces toxic emissions.

3.6.2. What is the current specification?

Standard/Specification document	Total aromatics
New Zealand (EFSR 2011)	42% volume by volume (v/v) pool average and 45% v/v cap
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	42% v/v pool average over 6 months and 45% v/v
Japan (JIS K 2202:2012)	Not specified
Europe (EN 228:2012)	35% v/v
United States (D4814 – 14b)	Not specified
Worldwide Fuel Charter 2013 (Category 3)	35% v/v

106. The standard in New Zealand and Australia is less stringent than the standard that applies in Europe and that is recommended by the Worldwide Fuel Charter, both in terms of the maximum limit allowable and also in the allowance of pool averages. The use of pool averages gives some flexibility for 'overs and unders' from one month to the next.

107. The rules for calculating pool averages are set out in the *Engine Fuel Specifications Regulations* (reg 19). Regulations 19(8) and (9) state:

19(8) Debits must be offset with an equal number of credits within 5 months following the end of the month in which the debits are calculated.

19(9) Credits may be used within 5 months following the end of the month in which the credits were accumulated to offset future debits. Credits expire and may not be used after this time period.

3.6.3. What is the issue?

108. The use of pool averages in Australia and New Zealand is justified by considerations of geography and security of supply. Europe, with its densely populated urban centres and greater number of supply options, can apply stricter limitations.

109. As in Australia, the intention of regulation 19 is that the pool average over any six-month period should be compliant.

110. However, the very prescriptive wording of regulation 19(8) and (9) has not achieved this intention. It is possible to have a six-month period that does not meet the 42% volume limit but yet technically still complies with the Regulations. This can occur if the first-month debit is offset by a credit from the previous five months, and then the next five months are also debits. This occurred in one company's reported pool averages between November 2010 and April 2011.

111. MBIE proposes to replace the current regulation 19(8) and (9) with a new 19(8) that is aimed at better capturing the original intent. It would read something along the following lines:

> 19(8) In each period of six consecutive months, the sum of debits and credits must not be negative.

Q6: Do you agree with amending the definition of 'pool average' to clarify that, for each period of six consecutive months, the sum of debits and credits must not be negative?

4. Diesel

4.1. Biodiesel limit

4.1.1. What is biodiesel?

112. Biodiesel refers to fatty acid methyl esters (FAME). Biodiesel esters are usually made in a transesterification process from vegetable oils, such as soy, canola (also called 'rapeseed'), and sunflower. In New Zealand, tallow and canola are the main feedstocks used for biodiesel. Fossil methanol is typically used as an alcohol in the process, and sodium or potassium hydroxide is used as a catalyst. The side-product of the process is glycerol. The transesterification process is basically limited to oils and fats as feedstocks, and the product is always an ester.

113. Biodiesel is blended into diesel up to a maximum of 5% by volume.

114. FAME biodiesel generally reduces CO, HC, and PM emissions, but increases NOx emissions.

4.1.2. What is the biodiesel limit?

Standard/Specification document	Biodiesel limit
New Zealand (EFSR 2011)	5% v/v maximum
Australia (Fuel Standard (Diesel) Determination 2001, as amended)	5% v/v maximum
Japan (JIS K 2390:2008)	5% m/m maximum
Europe (EN 509:2009)	7% v/v maximum
United States (D975-14)	5% v/v maximum
Worldwide Fuel Charter 2013 (Category 3)	5% v/v maximum

4.1.3. What is the issue?

115. As part of its broader aim of reducing energy-related greenhouse gas emissions, the Government supports policies that increase the use of biofuels where this is commercially viable and has no negative impacts on fuel quality or vehicle operability.

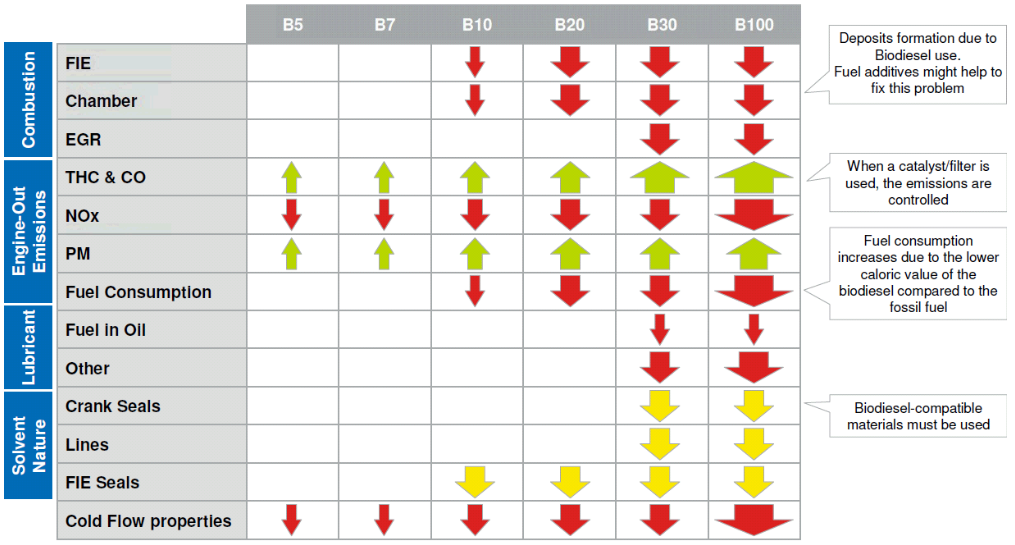
116. The main concerns around biodiesel are as follows:

- deterioration of oil quality
- clogging of particulate filters
- dissolving of materials
- poor injection performance and cold-start properties
- challenges for storage stability.

117. European fuel standards are the benchmark internationally, although New Zealand also looks to the Australian, Japanese and US standards as points of reference. In 2009, the European Standard EN 590:2009 lifted the allowable level of FAME biodiesel in diesel from 5% volume to 7% after the European Commission satisfied itself that each of the concerns that had been raised were manageable.

118. The tables below show the effects of different biodiesel blends on light and heavy-duty diesel vehicles with and without a diesel particulate filter (DPF).[42] By way of reference, the Euro 4 vehicle emissions standard is broadly equivalent to the Japanese 2005 vehicle emissions standard, which is the minimum standard for all newly imported new and used diesel vehicles in New Zealand.

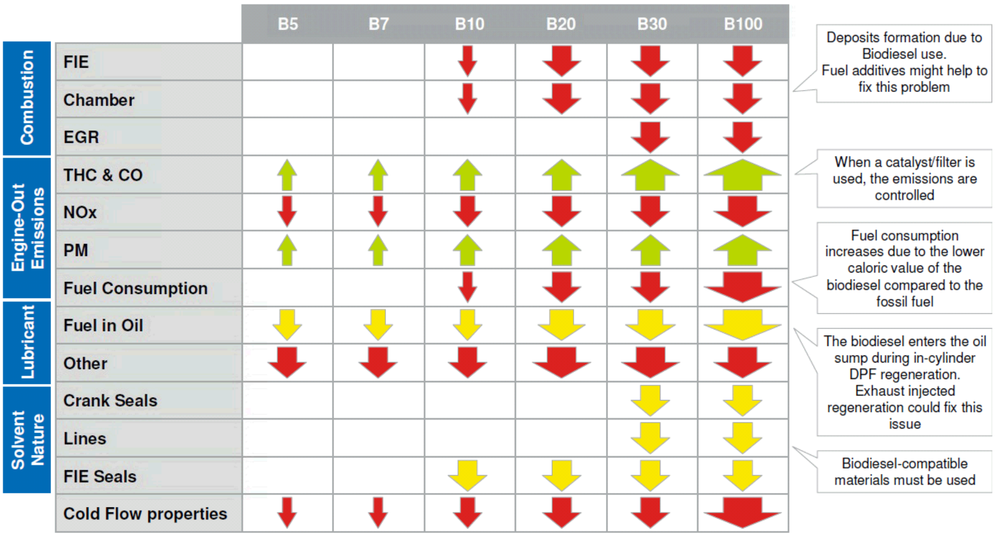
Biofuel blend impact table – Light-duty diesel Euro 4 (no DPF)



Source: Ricardo

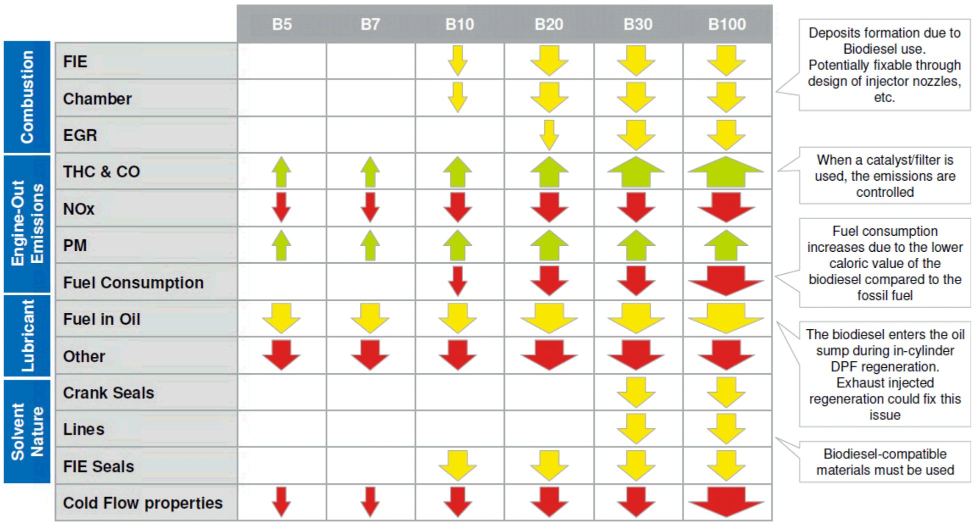
42 European Commission. 2010. *Impact of the Use of Biofuels on Oil Refining and Fuels Specifications*, section 7.6.1. Available at: http://ec.europa.eu/energy/sites/ener/files/documents/2011_06_impact_biofuels_0.pdf

Biofuel blend impact table – Light duty diesel Euro 5 (no DPF)



Source: Ricardo

Biofuel blend impact table – Light duty diesel Euro 6 (DPF + NOx Control)

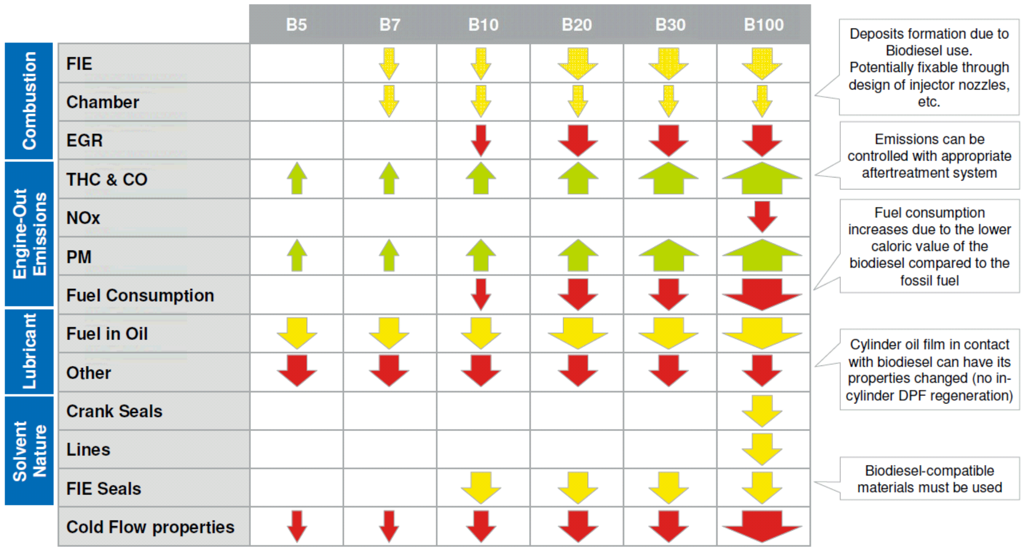


Source: Ricardo

Biofuel blend impact table – Heavy duty diesel Euro 4 (no DPF) and Euro 5 (no DPF, with SCR)

Source: Ricardo

Biofuel blend impact table – Heavy duty diesel Euro VI (DPF + SCR)



Source: Ricardo

119. The European Commission concluded from this analysis that for biodiesel blends up to 7% volume, the effects were relatively minor. As the blend ratio increases to 10% volume and above, the effects appear to become more significant.

120. In July 2013, the European Commission reiterated its view that "up to B7 there are no significant engine issues or impact on pollutant emissions."[43]

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43 CE Delft. 2013. *Bringing Biofuels on the Market: Options to increase EU blending biofuels volumes beyond current blending limits*, page 181. Available at: http://ec.europa.eu/energy/sites/ener/files/documents/2013_11_bringing_biofuels_on_the_market.pdf

121. B7 blends complying with the European Standard EN 590:2009 have also been endorsed by diesel fuel injection equipment manufacturers[44] and for all Toyota vehicles sold in Europe.[45]

122. MBIE's view is that there is sufficient evidence to support the increase in biodiesel levels from the current limit of 5% volume to 7%. MBIE notes that fuel standards and associated vehicles are still being worked on internationally, notably in Europe, to raise biodiesel levels to 10% or higher, but that this work has yet to be finalised. We therefore do not currently propose to raise the biodiesel limit any higher than 7% volume.

123. At present, there is only one biodiesel supplier in New Zealand, with a second due to commence later in 2015. In 2013 the greenhouse gas emissions from diesel in transport use stood at 5,616 kt CO2-e. Were the entire diesel fleet to operate on B5, then New Zealand would emit an estimated 281 kt CO2-e (5% x 5,616) less than what it would if the entire fleet operated on pure mineral diesel. This increases to 393 kt CO2-e for B7 blends (7% x 5,616). The maximum potential benefit from this proposal is emissions abatement of 112 kt CO2-e. This represents 0.35% of total energy sector emissions in 2013.

Q7: Do you agree with raising the maximum level of fatty acid methyl esters (biodiesel) in diesel from 5% volume to 7% volume? If not, why not?

4.2. Test method for total contamination in diesel

4.2.1. What is total contamination?

124. 'Total contamination' refers to sediment or particulate levels in diesel. Individual contaminants may include calcium, copper, sodium, manganese, potassium, phosphorous, zinc and chlorine. Contaminants can cause significant harm to the powertrain, fuel, exhaust and emission control systems.

125. The term 'total contamination' is used in the European Standards for diesel (EN 590:2009) and biodiesel (BS EN 14214:2012), while the Worldwide Fuel Charter refers to 'particulate contamination'. In Australia and the US the idea is picked up in references to 'water and sediment', but MBIE's view is that that term is out of date and not suitable for detailed elemental analysis.

126. The current limit is 24 mg/kg and is the same as in the European Union.

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[44] "The agreed position of all FIE manufacturers undersigned is to limit release of injection equipment for admixtures up to a maximum 7% FAME (meeting EN 14214:2009) with the resulting blend meeting the EN 590:2009 standard": *Fuel Requirements for Diesel Fuel Injection Systems – Diesel Fuel Injection Equipment Manufacturers Common Position Statement*, 2009. Available at: www.globaldenso.com/en/topics/091012-01/documents/common_position_paper.pdf

[45] Toyota, 'Our Stance on Biofuels'. Available at: www.toyota.eu/green_technologies/Pages/biofuels.aspx

4.2.2. What is the current test method?

Standard/Specification document	Test method for total contamination
New Zealand (EFSR 2011)	IP 440
Australia (Fuel Standard (Diesel) Determination 2001, as amended)	ASTM D2709
Japan (JIS K 2204:2007)	Not specified
Europe (EN 590:2009)	EN 12662
United States (D975-14)	ASTM D2709 (water and sediment), ASTM D6217 (insoluble fuel contaminants)
Worldwide Fuel Charter 2013 (Category 3)	ASTM D6217 (FAME-free), ASTM D7321 (with FAME), EN 12662

4.2.3. What is the issue?

127. The current test method IP 440 is practically identical to the test method EN 12662 Standard used in Europe (the latter has a double title that includes BS 2000 440:2014). As EN 12662 Standard is more readily recognised by industry as the test method for total contamination in diesel, MBIE proposes to replace IP 440 with EN 12662. In reality, this is little more than a name change.

128. Further, the Independent Petroleum Laboratory is keen to add the test method *ASTM D6217, Standard Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration*. ASTM D6217 has not been validated for testing biodiesel or biodiesel blends, but for pure mineral diesel it is capable of detecting microscopic particulates. This test method is considered to be significantly more accurate than the test method ASTM D2709, which is the prescribed standard for water and sediment in Australia and the US.

129. The tolerance limit for ASTM D6217 is 27.2 mg/kg, while the tolerance limit for the EN 12662 Standard is 28.8 mg/kg.

Q8: Do you agree with replacing IP 440, the current test method for total contamination in diesel, with EN 12662 and ASTM D7321 for biodiesel blends and ASTM D6217 for pure mineral diesel? If not, why not?

5. Biodiesel

5.1. Test method for total contamination

5.1.1. What is total contamination?

130. 'Total contamination' refers to sediment or particulate levels in diesel. Contaminants can cause significant harm to the powertrain, fuel, exhaust and emission control systems.

131. The current limit is 24 mg/kg. This is the same as the limit in Japan, Australia and the European Union and the limit recommended in the Worldwide Fuel Charter's biodiesel guidelines.

5.1.2. What is the current test method for total contamination?

Standard/Specification document	Test method for total contamination
New Zealand (EFSR 2011)	IP 440
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	EN 12662
Japan (JIS K 2390:2008)	EN 12662
Europe (EN 14214:2012)	EN 12662
United States (D6751 – 15)	ASTM D2709 (water and sediment)
Worldwide Fuel Charter 2009 – Biodiesel guidelines	EN 12662, ASTM D2276, ASTM D5452, ASTM D6217

5.1.3. What is the issue?

132. The current test method IP 440 is practically identical to the test method EN 12662 Standard used in Europe (the latter has a double title that includes BS 2000 440:2014). As EN 12662 Standard is more readily recognised by industry as the test method for total contamination in biodiesel, MBIE proposes to replace IP 440 with EN 12662. In reality, this is little more than a name change.

133. Although it is widely used, the EN 12662 test method can be confidently applied only to diesel containing up to 30% v/v biodiesel. CEN, the European Committee for Standardization, acknowledges that the method requires further development for pure biodiesel (B100) and in the interim advises that a 1998 version of EN 12662 standard should be used to test total contamination in B100 blends.

134. Notably, the Worldwide Fuel Charter's 2009 biodiesel guidelines recommend ASTM D6217. This contrasts with the 2013 version of the Charter, which recommends ASTM D7321 for biodiesel blends *(ASTM D7321-2014 Standard Test Method for Test Method for Particulate Contamination of Biodiesel B100 Blend Stock Biodiesel Esters and Biodiesel Blends by Laboratory Filtration)*. The two test methods are very similar, except for a few differences around control filters.

135. The question whether the test method ASTM D6217 is better or worse than ASTM D7321 is still being debated by professionals. However, as ASTM D7321 is the most recently recommended test method for 'particulate contamination' under the Worldwide Fuel Charter, MBIE proposes that this test method be adopted alongside the test method EN 12662.

136. MBIE's view is that it is important that both of the test methods EN 12662 and ASTM D7321 be adopted, as international professional development is advancing under both sets of Standards.

Q9: Do you agree with replacing IP 440, the current test method for total contamination in diesel, with EN 12662 and ASTM D7321? If not, why not?

5.2. Test method for biodiesel density

5.2.1. What is density?

137. Density is a measure of a fuel's mass per unit volume. It is temperature dependent and for diesel is normally referenced to 15^{0}C. Variations in density result in variations in engine power and, consequently, variations in engine emissions and fuel consumption.

138. The current specification for density for diesel is a minimum of 820 kg/m^3 and a maximum of 850 kg/m^3, while for biodiesel the minimum is set at 860 kg/m^3 and the maximum is 900 kg/m^3.

5.2.2. What is the current test method for density?

Standard/Specification document	Test method for biodiesel density
New Zealand (EFSR 2011)	ASTM D1298
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	ASTM D1298
Japan (JIS K 2390:2008)	JIS K 2249
Europe (EN 14214:2012)	EN ISO 3675 or EN ISO 12185
United States (D6751 – 15)	Not prescribed
Worldwide Fuel Charter 2009 – Biodiesel guidelines	EN ISO 3675, ASTM D4052, JIS K2249, EN ISO 12185, ABNT NBR 7148/14065

5.2.3. What is the issue?

139. The current prescribed test method for density for biodiesel is *ASTM D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.*[46]

[46] Available at: https://law.resource.org/pub/us/cfr/ibr/003/astm.d1298.1999.pdf

140. By contrast with the single prescribed test method for biodiesel, both ASTM D1298 and ASTM D4052 are allowed for testing the density of diesel (see Schedule 2 of the *Engine Fuel Specifications Regulations*). The recommended test method in the Worldwide Fuel Charter is *ASTM D4052-11, Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter,*[47] and that is also the more common test method used across the petroleum industry.

141. MBIE proposes to align the prescribed test method for density for biodiesel with that prescribed for diesel by adding ASTM D4052 as an alternative to ASTM D1298.

Q10: Do you agree with adding test method ASTM D4052 alongside ASTM D1298 as a prescribed test method for density for biodiesel? If not, why not?

5.3. Test method for oxidation stability for biodiesel

5.3.1. What is oxidation stability?

142. Oxidation stability is a measure of the fuel's resistance to degradation by oxidation. Oxidation of diesel or biodiesel can result in the formation of gums and sediments, causing plugging of filters and engine deposits.

5.3.2. What is the current test method for oxidation stability for biodiesel?

Standard/Specification document	Test method for oxidation stability
New Zealand (EFSR 2011)	EN 14112
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	prEN 15751 or EN 14112
Japan (JIS K 2390:2008)	Not prescribed
Europe (EN 14214:2012)	EN ISO 14112 or EN ISO 15751
United States (D6751 – 15)	EN 15751
Worldwide Fuel Charter 2009 – Biodiesel guidelines	prEN 15751 or EN 14112 as alternative

5.3.3. What is the issue?

143. The current test method for oxidation stability in biodiesel is *EN 14112:2003, Fat and oil derivatives. Fatty acid methyl esters (FAME). Determination of oxidation stability (accelerated oxidation test)*.[48] The scope of this method does not extend to biodiesel blends.

144. MBIE is proposing a new test method, *BS EN 15751:2014, BS 2000-574:2014, Automotive fuels. Fatty acid methyl ester (FAME) fuel and blends with diesel fuel.*

[47] Available at: www.twa800.com/ntsb/8-15-00/docket/Ex_8H.pdf

[48] Available at: http://img1.chem17.com/5/2008/633550819477967500.pdf

Determination of oxidation stability by accelerated oxidation method. This method is based on, and is very similar to, EN 14112. It uses the same testing instruments, but its scope extends to biodiesel (FAME) and biodiesel blends with petroleum-based diesel containing a minimum of 2% v/v biodiesel.

145. The proposed new EN 15751 has tighter repeatability and reproducibility limits compared to the current EN 14112. However, for pure FAME samples the European Committee for Standardization (CEN/TC 307) recommends retaining EN 14112 for pure FAME samples.

146. MBIE proposes to add the test method EN 15751 as an alternative to EN 14112 for oxidation stability for biodiesel.

Q11: Do you agree with adding the test method EN 15751 alongside the current test method EN 14112 for oxidation stability for biodiesel? If not, why not?

5.4. Test method for carbon residue in biodiesel

5.4.1. What is carbon residue?

147. Carbon residue is a measure of the tendency of diesel to form carbonaceous deposits in engines, which can result in hot spots leading to stress, corrosion, or cracking of components. The deposits of most concern are those that build up in the nozzles of fuel injectors.

148. The test for carbon residue is typically performed on the residual volume after 90% of the fuel has been boiled off (10% residual), although some jurisdictions such as the US calculate it on the basis of all the diesel having been boiled off.

149. The current specification is set at 0.05% mass maximum on 100% distillation residue, or 0.30% mass maximum on 10% distillation residue.

5.4.2. What is the current test method?

Standard/Specification document	Test method for carbon residue
New Zealand (EFSR 2011)	ASTM D4530 for 0.05% maximum on 100% distillation residue ISO 10370 for 0.30% mass maximum on 10% distillation residue
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	ASTM D4530 for 0.30% mass maximum on 10% distillation residue
Japan (JIS K 2390:2008)	JIS K 2270 for 0.30% mass maximum on 10% distillation residue, provided that the preparation of 10% distillation residue is undertaken in accordance with the distillation determination method under reduced pressure specified in JIS K 2254

Europe (EN 14214:2012)	Not tested[49]
United States (D6751 – 15)	ASTM D4530 for 0.05% maximum on 100% distillation residue
Worldwide Fuel Charter 2009 – Biodiesel guidelines	ASTM D4530 for 0.05% maximum on 100% distillation residue

5.4.3. What is the issue?

150. The test method currently prescribed in the Regulations for carbon residue on 10% distillation residue is *BS EN ISO 10370, BS 2000-398:2014, Petroleum Products. Determination of carbon residue. Micro method.* This test requires an additional test by ASTM D1160 to obtain the 10% distillation residue. However, the Independent Petroleum Laboratory does not currently have the facilities to perform a vacuum distillation required by ASTM D1160, as the boiling point of the B100 is too high to recover 10% residual using the test method ASTM D86 for atmospheric distillation.

151. Investing in the facilities needed for testing to the ISO 10370 standard does not appear to be warranted, as the prescribed test method is very similar to the alternative test method ASTM D4530. The reproducibility of the two test methods is almost the same.

152. IPL recommends that only ASTM D4530 be retained in the Regulations as the prescribed test method for carbon residue for biodiesel. MBIE supports this recommendation.

Q12: Do you agree with removing the test method EN IS0 10370 as the prescribed test method for carbon residue (on 10% distillation residue) in biodiesel, and retaining the test method ASTM D4530 (on 100% of distillation residue), which is currently the only test used in New Zealand for carbon residue in biodiesel? If not, why not?

5.5. Cold soak filterability requirement

5.5.1. What is cold soak filterability?

153. Several components in biodiesel can lead to the unexpected clogging of filters, as components that appear to be soluble at room temperature may drop out of solution if cooled or left standing for an extended period of time.

154. The usual parameters used to test filterability are the cloud point[50] and the cold filter plugging point.[51] New Zealand also has a requirement to meet limits for filter blocking tendency,[52] which is also a requirement in Australia but not in Europe or the US.

49 This parameter was deleted in the 2012 version as it was considered unnecessary. Previous European Standards EN 14214:2008+A1:2009, EN 14213:2003 and EN 14213:2003/AC:2003 had a requirement to test for carbon residue.

155. However, biodiesels can develop a thermal memory leading to some B100 and biodiesel blends forming precipitates above the cloud point. These precipitates can clog filters. The cold soak filterability test is aimed at identifying this problem.

5.5.2. What is the current specification?

Standard/Specification document	Specification and test method for cold soak filterability
New Zealand (EFSR 2011)	Not prescribed
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	Not prescribed
Japan (JIS K 2390:2008)	Not prescribed
Europe (EN 14214:2012)	Not prescribed
United States (D6751-15)	Maximum limit of 200 seconds using test method ASTM D7501-12a
Worldwide Fuel Charter 2009 – Biodiesel guidelines	Not prescribed

5.5.3. What is the issue?

156. To identify precipitates that can form above the cloud point, a cold soak filtration test provides an accelerated means of determining whether the biodiesel would show precipitate formation when cooled to temperatures slightly above the cloud point.

157. At present, only the United States has a cold soak filterability test. Under that US test the requirement is set at 200 seconds using the test method *ASTM D7501-12a, Standard Test Method for Determination of Fuel Filter Blocking Potential of Biodiesel (B100) Blend Stock by Cold Soak Filtration Test*, when B100 is intended for blending into diesel fuels that are expected to give satisfactory vehicle performance for fuel temperatures at or below minus 12^{0}C (ASTM D6751-15, section 5.1.19).

158. This test method has been used by biodiesel producers in New Zealand, particularly those that use tallow as a feedstock, as an additional verification for cold flow properties. Tallow presents more difficulties than other feedstocks (such as canola/rapeseed or soy) in meeting cold flow and filterability requirements.

159. The difference in the feedstocks used may explain why the cold soak filterability test is not a requirement in Europe but is in the US. In Europe the main feedstock for biodiesel is canola/rapeseed, while in the US tallow is far more common.

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[50] The cloud point is the temperature at which wax crystals start to precipitate out and the fuel becomes cloudy.

[51] The cold filter plugging point is the lowest temperature at which the fuel can pass through a standard filter under standard conditions. The cold filter plugging point is more precise than the cloud point and is a better indication of fuel performance in an engine.

[52] The filter blocking tendency test measures the filterability of diesel.

160. MBIE proposes to add a new requirement that biodiesel have a cold soak filterability limit of no more than 200 seconds for fuel after the cold soak procedure at a temperature of 4.5^{0}C using the test method ASTM D7501. A tolerance limit of 280 seconds would be used for compliance purposes.

Q13: Do you agree with adding a new requirement for a cold soak filterability test for biodiesel with the maximum limit set at 200 seconds for fuel at a temperature at or below minus 12^{0}C using the test method ASTM D7501? If not, why not?

5.6. Phosphorous test method

5.6.1. Why are phosphorous levels important?

161. Phosphorous levels must be set at low levels, as they can damage catalytic converters used in emission control systems. The current prescribed limit is 4.0 mg/kg.

5.6.2. What is the current specification and test method?

Standard/Specification document	Specification and test method for phosphorous
New Zealand (EFSR 2011)	4.0 mg/kg using test method EN 14107
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	10.0 mg/kg using test method EN 14107
Japan (JIS K 2390:2008)	10.0 mg/kg using test method EN 14107
Europe (EN 14214:2012)	4.0 mg/kg using test methods EN 14107 or FprEN 16294
United States (D6751 – 15)	0.001% mass (equivalent to 10.0 mg/kg) using test method ASTM D4951
Worldwide Fuel Charter 2009 – Biodiesel guidelines	4.0 mg/kg using test method EN 14107, ASTM D4951 or ASTM D3231

5.6.3. What is the issue?

162. The current prescribed test method is *BS EN 14107:2003, Fat and oil derivatives. Fatty acid methyl esters (FAME). Determination of phosphorous content by inductively coupled plasma emission spectrometry.* The determination of phosphorous content by this method is for test results between 4.0 mg/kg and 20 mg/kg in FAME. The Independent Petroleum Laboratory can detect and report levels down to 1 mg/kg with the currently prescribed specification limit of 4.0 mg/kg. However, any samples with quantities below 4.0 mg/kg must be reported with a disclaimer that the result is beyond the scope of the method.

163. The European Standard for biodiesel prescribes the test method *BS EN 16294:2012, BS 2000-609:2012, Petroleum products and fat and oil derivatives. Determination of*

phosphorous content in fatty acid methyl esters (FAME). Optical emission spectral analysis with inductively coupled plasma (ICP OES).

164. The two test methods are very close but the European Standard method, EN 16294, is accurate for phosphorous content between 2.5 mg/kg to 8.0 mg/kg, which covers a range both below and above the current specification limit. IPL does not currently have the equipment to undertake this test method but it informs MBIE that the cost of setting it up would be minimal.

165. MBIE proposes to add the test method EN 16294 as an alternative to the existing method EN 14107 for phosphorous levels in biodiesel.

Q14: Do you agree with adding the test method EN 16294 as an alternative to the existing method EN 14107 for phosphorous levels in biodiesel? If not, why not?

5.7. Group 1 metals (Na + K) test method

5.7.1. What are group 1 metals?

166. Sodium (Na) and potassium (K) may be present in biodiesel as abrasive solids or soluble metallic soaps. Abrasive solids can contribute to injector, fuel pump, piston and ring wear, and also to engine deposits. Soluble metallic soaps have little effect on wear, but they may contribute to filter plugging and engine deposits. High levels of sodium or potassium compounds may also be collected in exhaust particulate removal devices and are not typically removed during passive or active regeneration; they can create increased back pressure and reduced period to service maintenance.

5.7.2. What is the current specification and test method?

Standard/Specification document	Specification and test method for group 1 metals
New Zealand (EFSR 2011)	5.0 mg/kg using test methods EN 14108 and EN 14109
Australia (Fuel Standard (Biodiesel) Determination 2003, as amended)	5.0 mg/kg using test method EN 14538
Japan (JIS K 2390:2008)	5.0 mg/kg using test methods EN 14108, EN 14109, or EN 14538
Europe (EN 14214:2012)	5.0 mg/kg using test methods EN 14108, EN 14109, or EN 14538
United States (D6751 – 15)	5 µg/g using test method EN 14538
Worldwide Fuel Charter 2009 – Biodiesel guidelines	5.0 mg/kg using test methods EN14108/EN14109 or EN 14538

5.7.3. What is the issue?

167. The two test methods currently prescribed in the EFSR are:

> *BS EN 14108:2003 Fat and oil derivatives. Fatty acid methyl esters (FAME). Determination of sodium content by atomic absorption spectrometry*; and
>
> *BS EN 14109:2003 Fat and oil derivatives. Fatty acid methyl esters (FAME). Determination of potassium content by atomic absorption spectrometry*.

168. Both EN 14108 and EN 14109 are Atomic Absorption Spectrometry (AAS) methods, and IPL does not have the capability to test by these methods. Instead, IPL uses the test method *BS EN 14538:2006, BS 2000-547:2006 Fat and oil derivatives. Fatty acid methyl esters (FAME). Determiantion of Ca, K, Mg and Na content by optical emission spectral analysis with inductively coupled plasma (ICEP OES).* This is the prescribed test method in Australia, Japan, Europe and the US. It is safer, more precise, and more efficient than the current prescribed methods. Specifically, it allows the operator to measure the limits of both metals at once, rather than using separate test methods for sodium and potassium.

Q15: Do you agree with replacing the current test methods EN 14108 and EN 14109 for group 1 metals with EN 14538? If not, why not?

6. Ethanol

6.1. E85 fuel standard

6.1.1. What is E85?

170. E85 is a fuel blend that comprises 85% ethanol and 15% petrol.

6.1.2. What is the current specification and test method?

171. There is no currently prescribed standard for E85 in New Zealand. MBIE proposes a standard for E85 that has the parameters set out in the far-right column of the following table:

Parameter	Australia *(Fuel Standard (Ethanol E85) Determination 2012)*	Europe *(CEN/TS 15293:2011)*	United States *(ASTM D5798-13a)*	Proposed for New Zealand
Acidity (as acetic acid)	0.006% m/m maximum ASTM D1613	0.005% m/m maximum EN 15491	0.005% m/m maximum ASTM D1613 or ASTMD7795	0.006% m/m maximum ASTM D1613
Benzene	0.35% v/v maximum ASTM D5580	Not prescribed	Not prescribed	Hydrocarbon blendstock with maximum benzene limit of 1% ASTM D5580
Copper	0.10 mg/kg maximum EN 15837 (as modified in CEN/TS 15293)	0.10 mg/kg maximum EN 15488 or EN 15837	0.07 mg/kg maximum Modification of ASTM D1688	0.10 mg/kg maximum ASTM D1688A (as modified in ASTM D4806)
Copper strip corrosion (3 hours at 50^0C)	Not prescribed	Class 1 EN ISO 2160	No. 1 maximum ASTM D130	Not prescribed
Density (at 15^0C)	Not prescribed	760.0 kg/m^3 minimum 800.0 kg/m^3 maximum EN ISO 12185	Not prescribed	Not prescribed
Electrical conductivity	Not prescribed	1.5 µS/cm EN 15938	Not prescribed	Not prescribed

Parameter	**Australia** *(Fuel Standard (Ethanol E85) Determination 2012)*	**Europe** *(CEN/TS 15293:2011)*	**United States** *(ASTM D5798-13a)*	**Proposed for New Zealand**
Ethanol	70-85% v/v ASTM D5501	60-85% depending on climate EN 13016-1	51-83% ASTM D5501	70-85% v/v ASTM D5501
Ethers (5 or more C atoms)	1.0% v/v maximum ASTM D4815	11.0% v/v maximum EN 1601	Not prescribed	Not prescribed
Final boiling point (distillation)	210^{0}C maximum ASTM D86	Not prescribed	225^{0}C maximum ASTM D86	210^{0}C maximum ASTM D86
Higher alcohols	2.0% v/v maximum for C_3-C_8 ASTM D4815	6.0% v/v for C_3-C_5	Not prescribed	Not prescribed
Inorganic chloride	1 mg/kg maximum ASTM D7328	1.2 mg/kg maximum prEN 15492	1 mg/kg maximum ASTM D7319 or ASTM D7328	1 mg/kg maximum ASTM D7319 or ASTM D7328
Lead content	5 mg/L maximum ASTM D3237	Not prescribed	13 mg/L maximum	5 mg/L maximum ASTM D3237
Methanol	0.5% v/v maximum ASTM D5501	1.0 % v/v maximum EN 1601	0.5% v/v maximum ASTM D5501	Not prescribed
Motor octane number	87 minimum Test method not prescribed	88 minimum	Not prescribed	Not prescribed
Oxidation stability	360 minutes minimum ASTM D5252	360 minutes minimum EN ISO 7536	240 minutes minimum ASTM D525	360 minutes minimum ASTM D5252
pHe	6.5–9.0 ASTM D6423	Not prescribed	6.5–9.0 ASTM D6423	6.5–9.0 ASTM D6423
Phosphorous	1.3 mg/L maximum ASTM D3231	0.15 mg/L maximum EN 15487 or EN 15486	1.3 mg/L maximum	1.3 mg/L maximum ASTM D3231

Parameter	**Australia** *(Fuel Standard (Ethanol E85) Determination 2012)*	**Europe** *(CEN/TS 15293:2011)*	**United States** *(ASTM D5798-13a)*	**Proposed for New Zealand**
Research octane number	100 minimum Test method not prescribed	104 minimum	Not prescribed	Not prescribed
Silver strip corrosion	Not prescribed	Not prescribed	No. 1 maximum ASTM D7667 or ASTM D7671	Not prescribed
Solvent washed gum	5 mg/100 mL maximum ASTM D381	5 mg/100mL maximum EN ISO 6246	5 mg/mL maximum ASTM D381	5 mg/100 mL maximum ASTM D381
Sulfate	4.0 mg/kg maximum ASTM D7319	4.0 mg/kg maximum prEN 15492	Not prescribed	4.0 mg/kg maximum ASTM D7319
Sulphur	70 mg/kg maximum ASTM D5453	10.0 mg/kg maximum EN 15485 or EN 15486	80.0 mg/kg maximum ASTM D5453	50 mg/kg maximum up to 30 June 2016 30 mg/kg maximum up to 30 June 2017 10 mg/kg maximum from 1 July 2017 ASTM DD453 or IP 497
Unwashed gum content	Not prescribed	Not prescribed	20 mg/mL maximum ASTM D381	Not prescribed
Vapour pressure (DVPE)	38–65 kPa at 37.8^{0}C ASTM D5191	35.0–80.0 kPa depending on temperature class EN 13016-1	38–103 kPa depending on Class ASTM D4953, ASTM D1590 or ASTM D5191	35.0–80.0 kPa ASTM D5191
Water	1.0% m/m maximum ASTM E1064	0.4 % m/m maximum EN 15489 or EN 15692	1.0% m/m maximum ASTM E203 or ASTM E1064	1.0% m/m maximum ASTM E203

6.1.3. What is the issue?

172. All fuel sold by way of retail sale must comply with Part 2 of the *Engine Fuel Specifications Regulations*. MBIE is aware of three service stations, all located near racing tracks, that are selling E85. In the normal course of events, all fuel sold at service stations needs to be prescribed in the Regulations.

173. The regulatory approach to the sale of E85 has been that it is only being sold for racing purposes, which the Regulations provide an exemption for (Regulation 4). However, this is considered an awkward workaround as the service stations are open to the public.

Q16: Do you agree with prescribing an E85 standard that would have the parameters proposed in the table in section 6.1.2 of this paper? If not, why not?

6.2. Water content test method

6.2.1. What is water content?

174. Water in fuel can promote corrosion and microbial growth. Water can enter ethanol during production, and also through condensation while the fuel is being distributed and stored. If the water content is too high, there may be phase separation after the ethanol is blended with petrol. Undissolved water in fuel lines can cause vehicle engines to run unevenly or stall.

6.2.2. What is the current specification and test method?

Standard/Specification document	Specification and test method for water content
New Zealand (EFSR 2011)	1.0 % volume maximum using test method ASTM E203
Australia (Fuel Standard (Petrol) Determination 2001, as amended)	1.0% volume maximum using ASTM E203
Japan (JIS K 2190:2011)	0.4 m/m using test method JIS K8101
Europe (EN 15376:2014)	0.3% m/m using test methods EN 15489 or EN 15692
United States (D4806-13a)	1.0% m/m using test methods ASTM E203 or ASTM E1064
Worldwide Fuel Charter – Ethanol Guidelines (March 2009)	0.3% m/m using test methods, EN 15489, ASTM E203 or JIS K8101

6.2.3. What is the issue?

175. The current test method for water content in ethanol is *ASTM E203-08, Standard Test Method for Water Using Volumetric Karl Fischer Titration.* This test method is also prescribed in Australia and the United States and is one of the test methods recommended in the Worldwide Fuel Charter.

176. IPL is not currently equipped for volumetric KFT but is instead equipped for coulometric KFT methods such as ASTM D6304 (*ASTM D6304-07, Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration)* or IP 438 *(IP 438:2001 (Reapproved 2013) Petroleum Products – Determination of Water – Coulometric Karl Fisher Titration method)*. IPL has used these two methods for testing water content in methanol for several years. In case of any dispute, it is understood that ASTM E203 would be used as a test method. To date, there has been no dispute.

177. IPL considers that the coulometric KFT test method IP 438 is more accurate and repeatable and can measure water levels much lower than the currently prescribed volumetric method ASTM E203. ASTM E203 can report the percentage of water only to the nearest 0.01%, while IP 438 can report to the nearest 0.001%.

178. MBIE does not propose to replace the current test method ASTM E203, as it is widely recognised and used in other jurisdictions. However, MBIE does propose to add IP 438 as an alternative to ASTM E203.

Q17: Do you agree with adding the test method IP 438 for water content in ethanol alongside the existing test method ASTM E203? If not, why not?

7. Complete list of questions

Q1: Do you agree with moving to 30 ppm petrol by 1 July 2016, and to 10 ppm petrol by 1 July 2017? If not, why not?

Q2: Do you agree with removing the property 'other oxygenates', and the 1% volume maximum limit, from the Regulations and replacing it with one of the following two options:

a) Specifying total oxygenate limits of 2.7% mass for petrol blends with a maximum ethanol content of 5.0%, and 3.7% mass for petrol blends with a maximum ethanol content of 10.0%. MTBE would be restricted to the current limit of 1% volume (or possibly 0.5% volume).

b) Specifying the total oxygenate limits in option a) above, and also specifying the following individual oxygenate limits in the case of petrol blends with a maximum ethanol content of 10.0% and a maximum oxygen content of 3.7% mass:

i) 3.0% volume methanol

ii) 12.0% volume iso-propyl alcohol

iii) 15.0% volume iso-butyl alcohol

iv) 15.0% volume tert-butyl alcohol

v) 22.0% volume ethers (5 or more C atoms)*

vi) 15.0% volume other oxygenates (defined as oxygenates that are not alcohols or ethers, and that have a final boiling point no higher than 210^0C).

- MTBE would be restricted to the current limit of 1% volume (or possibly 0.5% volume).

Q3: Do you agree with adding the test methods ASTM D5185 and ASTM D5059 alongside the current test method of IP 224 for lead? If not, why not?

Q4: Do you agree with replacing the ASTM D3831 test method for manganese with the modified test method ASTM D5185? If not, why not?

Q5: Do you agree with adding the test method ASTM D6839 alongside the current test method ASTM D1319 for olefins? If not, why not?

Q6: Do you agree with amending the definition of 'pool average' to clarify that, for each period of six consecutive months, the sum of debits and credits must not be negative?

Q7: Do you agree with raising the maximum level of fatty acid methyl esters (biodiesel) in diesel from 5% volume to 7% volume? If not, why not?

Q8: Do you agree with replacing IP 440, the current test method for total contamination in diesel, with EN 12662 and ASTM D7321 for biodiesel blends and ASTM D6217 for pure mineral diesel? If not, why not?

Q9: Do you agree with replacing IP 440, the current test method for total contamination in diesel, with EN 12662 and ASTM D7321? If not, why not?

Q10: Do you agree with adding test method ASTM D4052 alongside ASTM D1298 as a prescribed test method for density for biodiesel? If not, why not?

Q11: Do you agree with adding the test method EN 15751 alongside the current test method EN 14112 for oxidation stability for biodiesel? If not, why not?

Q12: Do you agree with removing the test method EN IS0 10370 as the prescribed test method for carbon residue (on 10% distillation residue) in biodiesel, and retaining the test method ASTM D4530 (on 100% of distillation residue), which is currently the only test used in New Zealand for carbon residue in biodiesel? If not, why not?

Q13: Do you agree with adding a new requirement for a cold soak filterability test for biodiesel with the maximum limit set at 200 seconds for fuel at a temperature at or below minus 12^{0}C using the test method ASTM D7501? If not, why not?

Q14: Do you agree with adding the test method EN 16294 as an alternative to the existing method EN 14107 for phosphorous levels in biodiesel? If not, why not?

Q15: Do you agree with replacing the current test methods EN 14108 and EN 14109 for group 1 metals with EN 14538? If not, why not?

Q16: Do you agree with prescribing an E85 standard that would have the parameters proposed in the table in section 6.1.2 of this paper? If not, why not?

Q17: Do you agree with adding the test method IP 438 for water content in ethanol alongside the existing test method ASTM E203? If not, why not?

8. Abbreviations

AAS Atomic Absorption Spectrometry

ASTM American Society for Testing and Materials

CO Carbon monoxide

CO_2 Carbon dioxide

DPF Diesel particulate filter

EFSR Engine Fuels Specifications Regulations 2011

FAME Fatty acid methyl ester

FIE Fuel injection equipment

HC Hydrocarbon emissions

ICP Inductively Coupled Plasma

IPL Independent Petroleum Laboratory

K Potassium

LEV Low Emission Vehicle

m/m mass/mass

MBIE Ministry of Business, Innovation and Employment

MMT Methycyclopentadienyl manganese tricarbonyl (an octane enhancer)

MTBE Methyl tertiary butyl ether (an octane enhancer and petrol extender)

Na Sodium

NO_2 Nitrogen dioxide

NOx Oxides of nitrogen

PM_{10} Particulate matter of less than 10 µm diameter

$PM_{2.5}$ Particulate matter of less than 2.5 µm diameter

ppm Parts per million

SOx Oxides of sulphur

tb/d Thousands of barrels per day

THC Total hydrocarbons

ULEV Ultra Low Emission Vehicle

v/v volume/volume

9. Explanatory note on vehicle emissions standards

179. The Worldwide Fuel Charter recommends different fuel quality for petrol and diesel depending on the vehicle emissions standards that are applicable. These vehicle emissions standards have been grouped into five categories. New Zealand sits within Category 3. The categories are as follow:

Category 1

Markets with no or first level requirements for emission control; based primarily on fundamental vehicle/engine performance and protection of emission control systems – for example, markets requiring US Tier 0, EURO 1 or equivalent emissions standards.

Category 2

Markets with more stringent requirements for emission control or other market demands – for example, markets requiring US Tier 1, EURO 2/II, EURO 3/III or equivalent emission standards.

Category 3

Markets with more stringent requirements for emission control or other market demands – for example, markets requiring US LEV, California LEV or ULEV, EURO 4/IV (except lean burn gasoline engines), JP 2005 or equivalent emission standards.

Category 4

Markets with advanced requirements for emission control – for example, markets requiring US Tier 2, US Tier 3 (pending), US 2007/2010 Heavy Duty On-Highway, US Non-Road Tier 4, California LEV II, EURO 4/IV, EURO 5/V, EURO 6/VI, JP 2009 or equivalent emission standards. Category 4 fuels enable sophisticated NOx and particulate matter after-treatment technologies.

Category 5

Markets with highly advanced requirements for emission control and fuel efficiency – for example, those markets that require US 2017 light-duty fuel economy, US heavy-duty fuel economy, California LEV III or equivalent emission control and fuel efficiency standards in addition to Category 4-level emission control standards.