



# Fuel Quality Monitoring Programme

**Test Results 2014–15**

TRADING STANDARDS



**Ministry of Business,  
Innovation & Employment**

New Zealand Government

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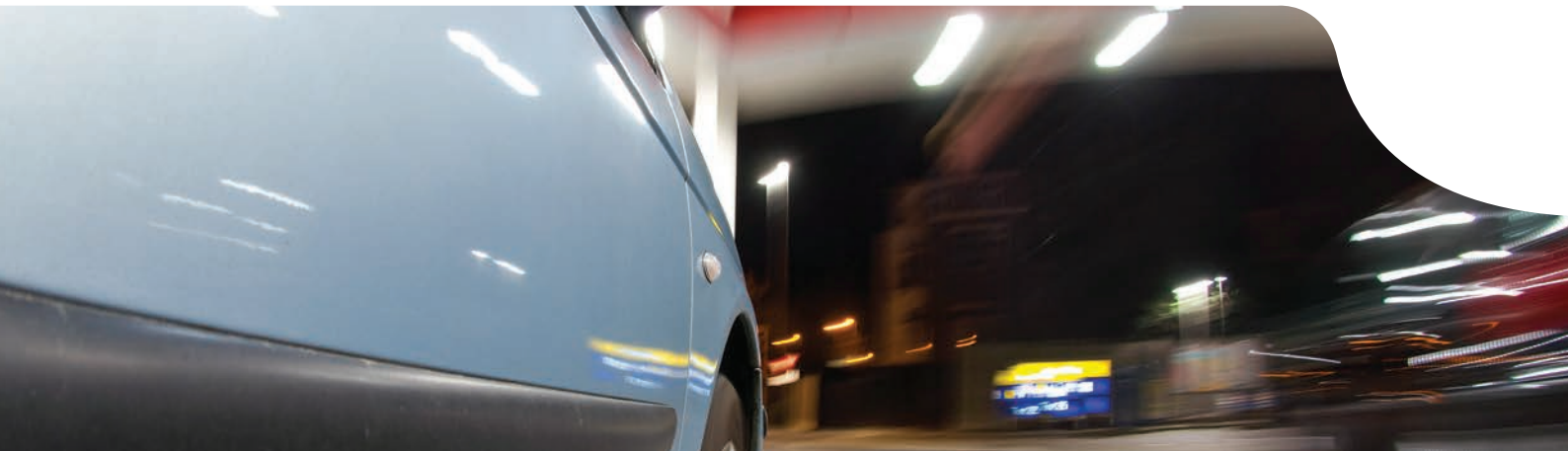


## Fuel Quality Monitoring Programme TEST RESULTS 2014-15

Executive Summary.....	3	Existent Gum (solvent washed).....	34
Introduction .....	5	<i>RON 91</i> .....	34
Petrol .....	9	<i>RON 95 &amp; 98</i> .....	35
Research Octane Number (RON)		Other Specification Parameter Testing.....	35
and Motor Octane Number (MON) .....	9	Summary for Petrol Test Results .....	36
<i>RON 91</i> .....	9		
<i>RON 95</i> .....	11	Diesel.....	37
<i>RON 98</i> .....	12	Density.....	37
Evaporation Percentage .....	14	Distillation .....	38
<i>RON 91</i> .....	14	Cetane Index.....	39
<i>RON 95 &amp; 98</i> .....	16	Water .....	40
Final Boiling Point.....	19	Total Contamination.....	41
Residue .....	21	Sulphur .....	42
Dry Vapour Pressure Equivalent.....	22	Cloud Point .....	43
<i>RON 91</i> .....	23	Cold Filter Plugging Point.....	44
<i>RON 95 &amp; 98</i> .....	24	Polycyclic Aromatic Hydrocarbons .....	44
Flexible Volatility Index .....	25	Filter Blocking Tendency .....	45
<i>RON 91</i> .....	25	Lubricity.....	46
<i>RON 95 &amp; 98</i> .....	26	Flash Point .....	47
Sulphur .....	27	Viscosity.....	48
<i>RON 91</i> .....	27	Summary for Diesel Test Results.....	49
<i>RON 95 &amp; 98</i> .....	28		
Benzene and Total Aromatics.....	29	Biofuels .....	51
<i>RON 91</i> .....	29	Summary of Testing .....	51
<i>RON 95 and 98</i> .....	30	Retail Fuel Sampling and Testing .....	51
Olefins.....	32	Non-Retail Fuel Sampling and Testing.....	52
<i>RON 91</i> .....	32		
<i>RON 95 &amp; 98</i> .....	33		







## Executive Summary

The Fuel Quality Monitoring Programme (**the Programme**) is administered by the Trading Standards unit of the Ministry of Business, Innovation and Employment. Trading Standards has continued the programme of sampling and assessing the quality of retail fuel in New Zealand and monitoring its compliance with the specifications set out in the relevant Engine Fuel Specifications Regulations (**the Regulations**). Currently, the Regulations of 2011 are in force<sup>1</sup>.

Primarily, the Programme has been established to monitor the quality of the fuel sold by fuel retail companies nationwide. It employs a statistically-based sampling scheme to ensure an acceptable probability of detecting non-compliance is maintained. The Regulations specify limits on a number of properties for premium and regular petrol grades, diesel and biofuels such as biodiesel and ethanol.

The main focus of the Programme is to sample and test the quality of fuels as they are sold to consumers, *i.e.* sampling is done from dispenser nozzles at the retail point of sale.

This report is intended to give an overview of the results of the Programme from 1 July 2014 to 30 June 2015. During this period retail fuel samples were collected and tested from 99 of the approximately 1,200 fuel service stations in New Zealand.

This report also covers the results of sampling and testing of fuel from the emerging market for biofuel. Biofuel testing at retail sites was focussed on specific monitoring of changes to the fuels parameters which can be influenced by

the introduction of biofuel components, for example enhanced dry vapour pressure in ethanol blended petrol.

Analysis of sampling and testing conducted during the period of this report has confirmed that on the whole, fuel sold in New Zealand was of good quality and compliant with specifications prescribed in the Regulations. In some instances samples were initially found to be marginally outside specifications but on subsequent investigation and analysis of the results they were found to be within established tolerance limits.

One marginally non-compliant sample detected during the period of this report related to diesel where the sulphur content on investigation was found to be 11.7 mg/kg relative to the maximum specified limit of 10.0 mg/kg.

Some biodiesel samples intended for non-retail sale were initially found to be non-compliant before supply to customers. None of the potentially non-compliant fuels identified by sampling and testing biofuels entered the retail fuel supply chain and they were subject to remedial action by the producers. The suspect non-compliant properties are discussed in the biofuel section of this report.

This report summarises the results of sampling and testing during the period covered.

For further explanation or to comment on the reported results please contact the Ministry:  
Tel: 0508 627 774 or Email: [tradingstandards@mbie.govt.nz](mailto:tradingstandards@mbie.govt.nz)

<sup>1</sup> <http://www.legislation.govt.nz/regulation/public/2011/0352/latest/DLM4044701.html>





## Introduction

Trading Standards is an operational unit within the Market Services Group of the Ministry of Business, Innovation and Employment (MBIE). MBIE has national responsibility for a number of infrastructure areas that are fundamental to consumer safety, supporting consumer and business confidence and facilitating domestic and international trade. These areas are:

- **Legal Metrology (Trade Measurement)**
- **Consumer Product Safety**
- **Auctioneers Register**
- **Motor Vehicle Traders Register** and
- **Fuel Quality Monitoring (FQM)** – maintaining and administering a programme to monitor and ensure the quality and compliance of New Zealand's retail fuel supply with the Engine Fuel Specifications Regulations.

In the fuel quality monitoring area activities include:

- Sampling, testing and analysing fuel quality including: routine samples taken in accordance with a statistical sampling plan and samples taken as part of targeted projects or in response to complaints or emerging issues;
- Investigating consumer and trader complaints and responding to enquiries;
- Advising on and facilitating improvement of fuel industry 'best practice';

- Developing and conducting projects in response to emerging issues;
- Contributing to work on regular amendments and updates to the Engine Fuel Specifications Regulations;
- Maintaining strong and effective relationships (as regulator) with fuel company technical managers, fuel retailers, industry associations and stakeholders within NZ and internationally;
- Representing New Zealand on international standards committees relating to fuel quality.

These activities and the Programme are funded from a proportion of the *Petroleum or engine fuel monitoring levy* of 0.045 cents for each litre of petroleum or engine fuel that is supplied in accordance with Section 24 of the Engine (Fuels, Levies, and References) Act 1989<sup>2</sup>.

The main focus of the Programme is to sample and test the quality of fuels as they are sold to consumers, *i.e.* sampling is done from dispenser nozzles at the point of sale. Trading Standards employs a statistically-based sampling scheme to ensure an acceptable probability of detecting non-compliance is maintained. The Regulations specify limits for a number of critical properties of premium and regular petrol grades, diesel and biofuels such as biodiesel and ethanol blends.

<sup>2</sup> <http://www.legislation.govt.nz/act/public/1989/0140/latest/DLM194754.html>



This report sets out the results of the Programme from 1 July 2014 to 30 June 2015.

The key principles and structure of the Programme remain the same as in previous years. References to legislation related to engine fuel quality may be found on the Ministry web site<sup>3</sup> or in previous FQM Programme annual reports for the period from 2008 to 2014.

Collection of fuel samples during this period was carried out by SGS New Zealand Ltd under the direction of Trading Standards. The samples were then tested by Independent Petroleum Laboratory Ltd and the results subsequently analysed by Trading Standards.

Any non-compliance or abnormalities identified through testing were subject to analysis and follow-up investigation by Trading Standards. The focus of any investigation is to confirm the validity of the results, identify any potential issues and implement an appropriate and timely response if required. Attention is also given to ensuring the underlying cause of any non-compliance is understood and remedied to prevent recurrence.

The samples were collected from 11 designated regional areas nationwide (see following Table) serviced by specific fuel supply terminals. The samples were taken from various fuel service stations according to a plan based on a statistical model which takes into account each retail fuel company's market share in that area.

In total, 99 sample sets were collected from retail sites and, as a rule, each set included samples of regular and premium grade petrol and a sample of diesel. At two sites premium petrol wasn't available at the time of sampling.

The number of samples collected and tested this year was similar to the previous years.

Additional resources were also allocated to small projects focused on investigating specific issues. In particular, a project focused on dry vapour pressure in petrol was continued in response to detection of several non-compliant samples during previous years.

A limited number of additional tests were added to the routine list of tests conducted. This included a test on appearance for diesel which is not specified in the Regulations but was completed in the routine list of diesel properties tested to enhance the confidence that water in bulk and/or other contamination, if present, were detected and categorised.

Four retail sites in New Zealand offer ethanol blended petrol with an ethanol content from 75 to 85% labelled as E85. This fuel is mainly used for motor vehicle racing. While fuel for motor racing is exempt from the Regulations there are flexible fuel vehicles available in New Zealand which are able to use E85. Since E85 dispensers at these sites are accessible to the public, and therefore the product available to retail customers, it was deemed prudent to test its properties.

As a result of collaborative work with the industry, the rate of suspect non-compliances has further decreased this year compared to the previous one.

Statistical analysis of the Programme data from previous years with regard to estimating the proportion of non-compliance detected has allowed Trading Standards to estimate the proportion of potentially suspect non-compliant samples that would be found if all batches of fuel in the retail sector were tested.

The key assumption in this analysis was that the true proportion of suspect non-compliances can be taken as constant across terminals and brands. Taking this assumption

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<sup>3</sup> <http://www.mbie.govt.nz/tradingstandards>



into account it was concluded that no increase in the total number of routine samples is needed compared to that in the previous three to four years to retain an appropriate level of confidence.

The seasonal and regional distribution of fuel ‘sample sets’ is shown in the table below.

The results of subsequent testing of these ‘sample sets’, have been reported in accordance to their relevant specification limits set out in the Regulations. Testing tolerance limits were derived according to the ISO Standard 4259:2006<sup>4</sup> as described in previous annual test result reports. Accordingly, the tolerance limit for each property is derived through the calculated tolerance margin. Further, the ‘corrected tolerance limit’ in this report is defined for two test results under the repeatability conditions (Section 7.2.3, EN ISO 4259:2006).

## Conclusion

The Programme has confirmed that throughout the year the retail fuel supplied in New Zealand was of good quality, fit for purpose and compliant with the performance and quality specifications prescribed in the Regulations.

In this report, the anonymity of the source of the samples is maintained due to the commercial sensitivity of this information.

Terminal/Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Whangarei	1	0	1	0	0	2	0	0	1	2	0	0	7
Auckland	4	4	0	4	2	2	1	2	2	2	2	0	25
Mt Maunganui	1	3	3	1	1	0	1	1	1	3	1	1	17
New Plymouth	0	1	0	1	0	1	0	0	0	0	0	0	3
Napier	1	0	0	2	0	1	0	1	0	0	0	1	6
Wellington	0	1	2	1	0	1	0	0	2	0	1	1	9
Nelson	1	0	0	0	2	2	1	1	1	0	0	0	8
Lyttelton	0	2	0	1	2	1	1	2	0	0	0	2	11
Timaru	1	1	0	0	1	0	0	0	0	0	0	0	3
Dunedin	1	0	1	0	2	0	1	0	0	0	1	0	6
Bluff	0	0	1	0	0	0	2	0	0	0	1	0	4
<b>Total</b>	<b>10</b>	<b>12</b>	<b>8</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>6</b>	<b>5</b>	<b>99</b>

<sup>4</sup> BS EN ISO 4259:2006, BS 2000-367:2006 *Petroleum products – Determination and application of precision data in relation to methods of test.*





# Petrol

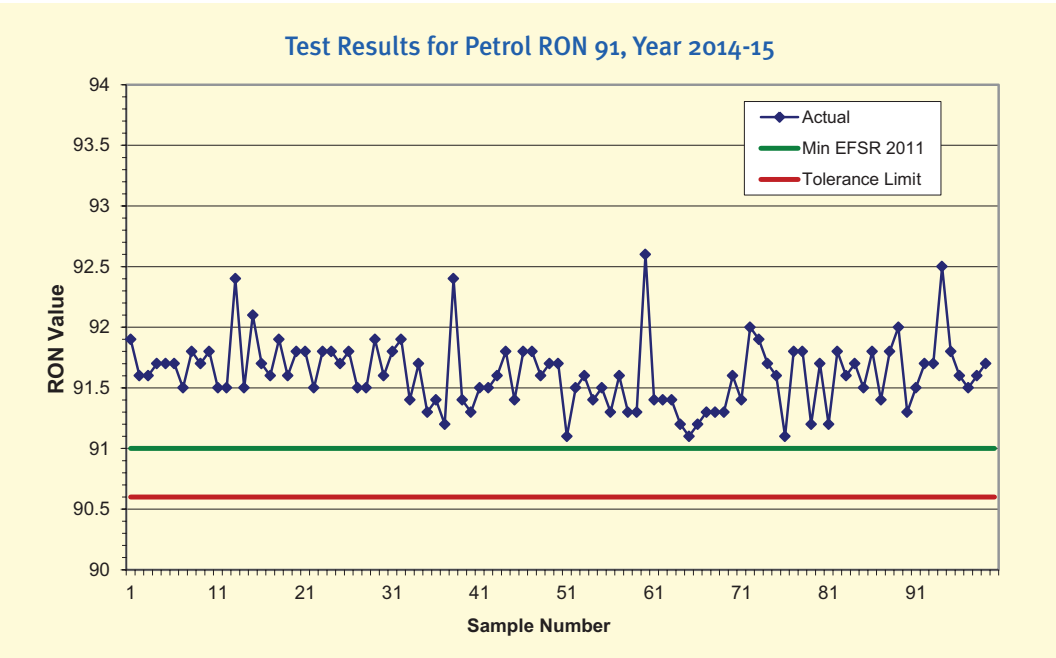
## Research Octane Number (RON) and Motor Octane Number (MON)

### RON 91

In total, 99 samples of regular petrol were collected and tested. Fig. 1a and 1b below show the testing results for RON and MON respectively.

All samples were found to be above the minimum specification limit of 91.0 for RON.

Fig. 1a



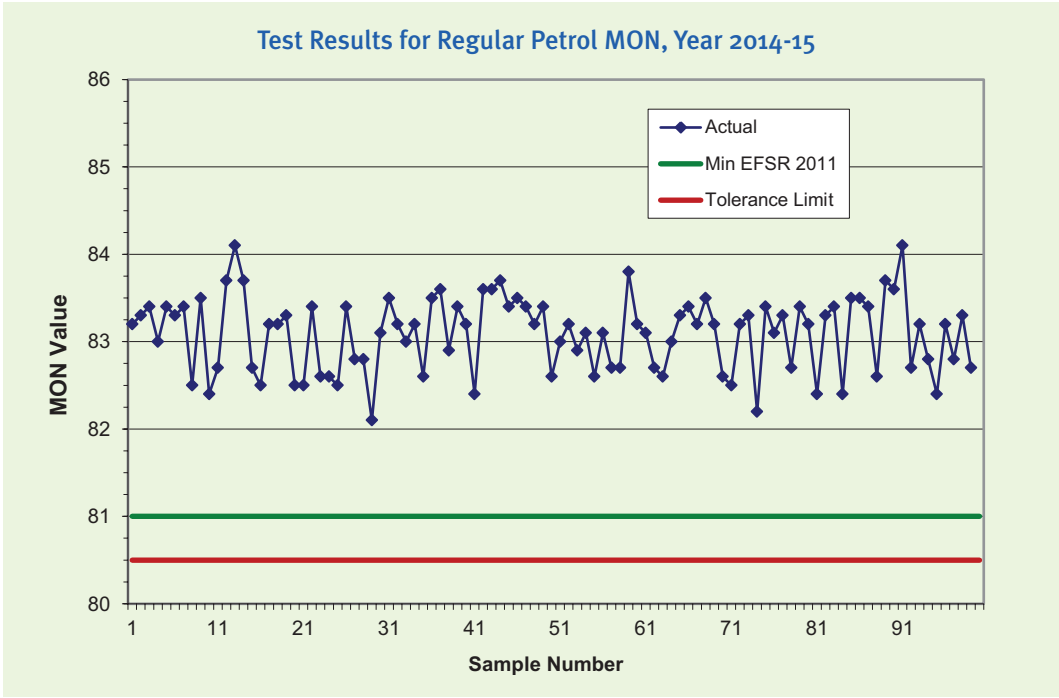
Here and below: The abbreviation ‘EFSR’ stands for the specification limit prescribed in the Regulations. Each individual result is independent from others although they are connected in the graphs for the ease of interpretation.



All samples were found to be above the minimum specification limits of 81.0 for MON.

All samples were found to be compliant with the Regulations.

Fig. 1b





RON 95

In total, 79 samples of premium grade petrol with RON 95, were collected and tested. Fig. 2a and 2b below show the testing results for RON and MON respectively.

All samples were found to be above or on the minimum specification limit of 95.0 for RON.

Samples 37, 62, and 64 were found to be on the specification limit.

All samples were found to have MON on or above the minimum specification limit of 85.0 for premium petrol. Samples 28 and 70 were found to be on the specification limit.

Fig. 2a

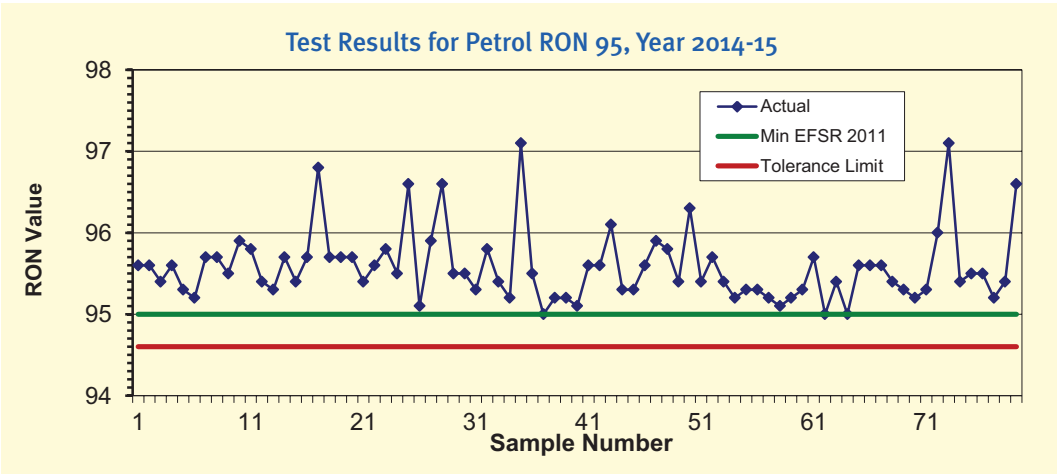
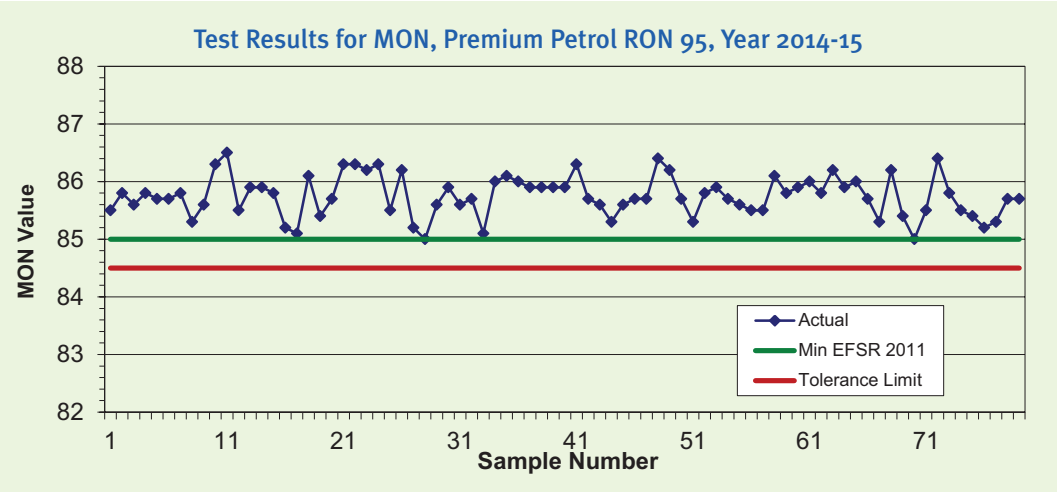


Fig. 2b





## RON 98

No minimum value is specified in the Regulations for premium petrol with RON 98. This fuel is advertised as having properties that are superior or in addition to the regulated limits. In particular, with an “advertised RON 98 minimum” which is referred to in Fig. 3a, it must conform, according to Section 11 of the Regulations, to those advertised properties when tested using the test methods specified in Schedule 1 in the Regulations.

This advertised limit is also enforceable under the provisions of the Fair Trading Act 1986 in relation to mis-description. Under this approach it is also deemed that the actual figures of RON must not be lower than 98.

For premium petrol with RON 98, a minimum limit for MON is neither specified in the Regulations nor advertised. In the absence of a specified minimum limit for MON the limit for premium petrol has been used as a benchmark.

In total, 16 samples of petrol with RON 98 were collected and tested. Fig. 3a and 3b below show the testing results for RON and MON respectively.

All samples with the advertised RON of 98 were found to be above the advertised minimum limit.

All samples were found to have MON above the specification limit of 85 for premium petrol.

Fig. 3a

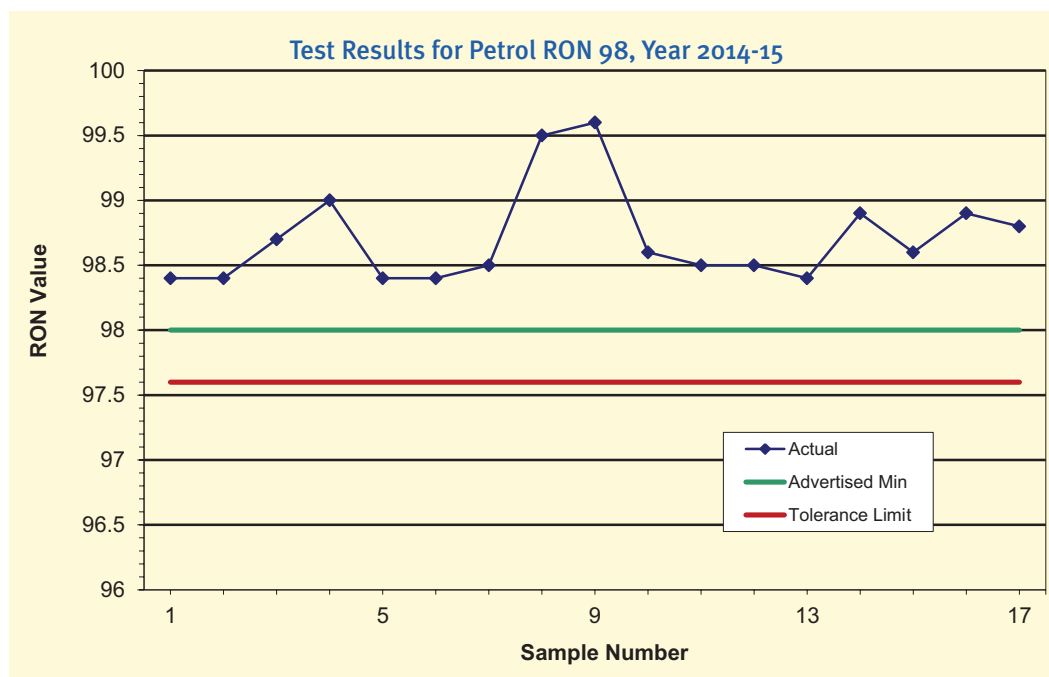
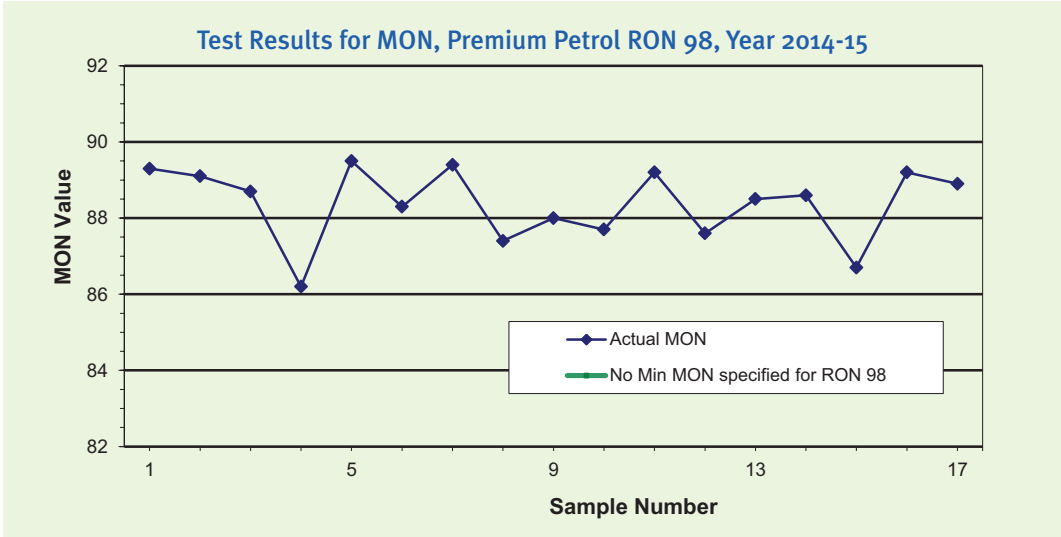


Fig. 3b





## Evaporation Percentage

The test method ASTM D86<sup>5</sup> is prescribed in the Regulations for definition of the volume percentage of evaporated petrol at the three fixed temperatures: at 70°C, 100°C and 150°C. Respectively, there are three categories for evaporation percentage limits in the Regulations: E70, E100 and E150. These categories are analysed below separately for regular petrol (RON 91) and for premium petrol (RON 98 data is included with RON 95 data).

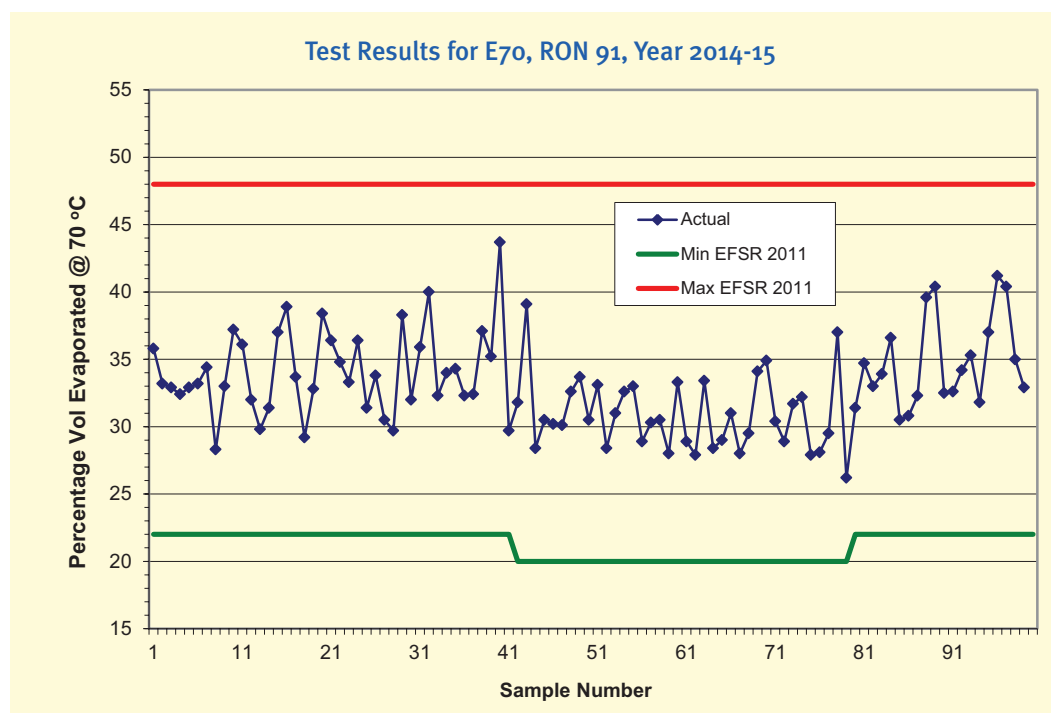
## RON 91

### Percentage Volume Evaporated @ 70°C

For petrol not containing ethanol, the minimum specification limit is 22% (a minimum of 20% E70 permitted for the summer season – see Footnote 1 in Schedule 1, the Regulations) and maximum specification limit is 48% while the relevant minimum tolerance limits are 20.5% (18.5% in summer) and 49.2% respectively.

All samples were found to be within the prescribed specification limits above the minimum limit of 22% at all seasons including the summer period when the specified minimum limit for E70 is permitted to be 20% (see Fig. 4a).

Fig. 4a



<sup>5</sup> ASTM D86-12 *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure.*

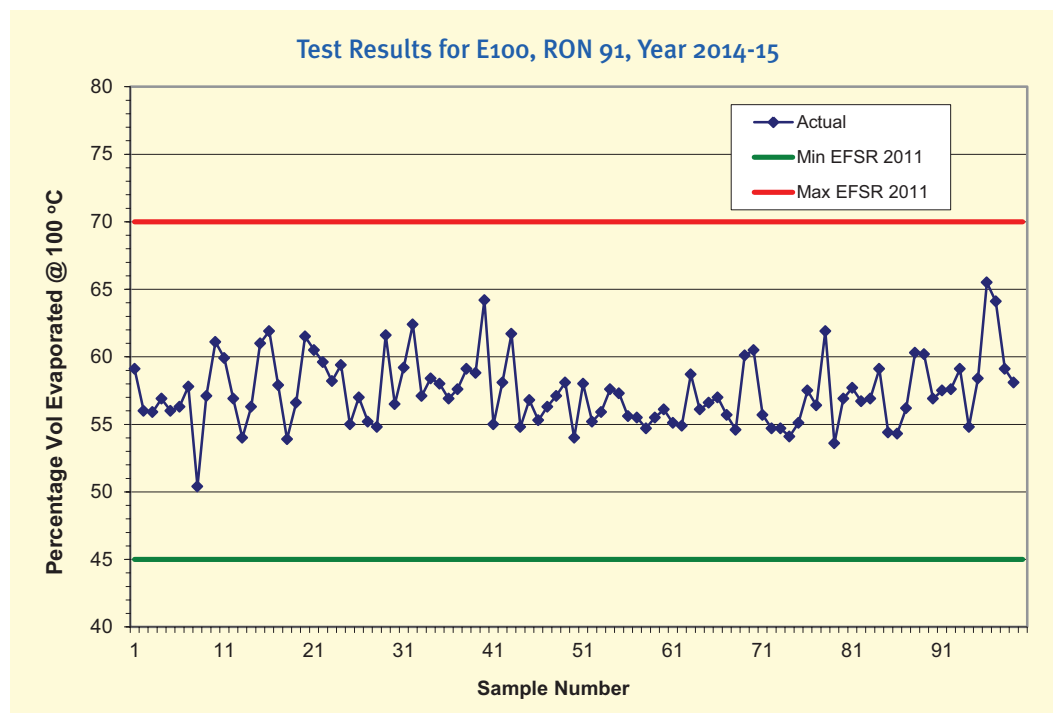


### Percentage Volume Evaporated @ 100°C

All samples were found to be well within the specification limits from 45% to 70%.

The minimum tolerance limit is 43.8% and maximum tolerance limit is 70.9%.

Fig. 4b



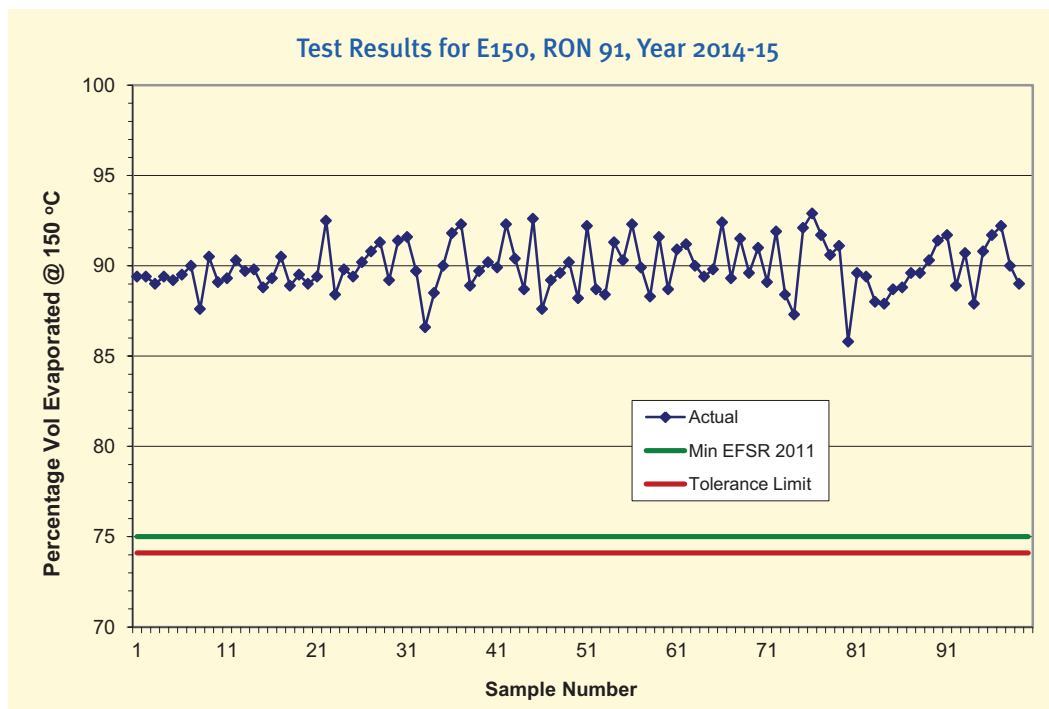


### Percentage Volume Evaporated @ 150°C

All samples were found to be above the minimum specification limit of 75%. The minimum tolerance limit is 74.1%.

No maximum is prescribed by the Regulations for this parameter.

Fig. 4c



## RON 95 & 98

### Percentage Volume Evaporated @ 70°C

For premium petrol not containing ethanol, as in case of regular petrol, the minimum specification limit is 22% (a minimum of 20% E70 permitted for the summer season – see Footnote 1 in Schedule 1, the Regulations) and maximum specification limit is 48% while the minimum tolerance limit is 20.5% (18.5% in summer) and maximum tolerance limit is 49.2%.

The majority of results were found to be within the specification limits of 22% to 48% with the exception of a number of ethanol blends. According to the Regulations (Footnote 2 in Schedule 1), the maximum percentage of volume evaporation at 70°C (E70) is increased by 1% per each 1% volume ethanol in the blend.

All results for samples with ethanol<sup>6</sup>, are set out in a Table 1 below. Two of them were found to be within the prescribed limit for ethanol blends while Sample 57 was tested for ethanol content twice, with 10.09% being the average of two identical results by the same operator at the testing tolerance limit of 10.49%.

As in the case with regular petrol (see above), all samples were found to be within the prescribed specification limits with the minimum limit of 22% at all seasons including the summer period when the specified minimum limit for E70 is permitted to be 20%.

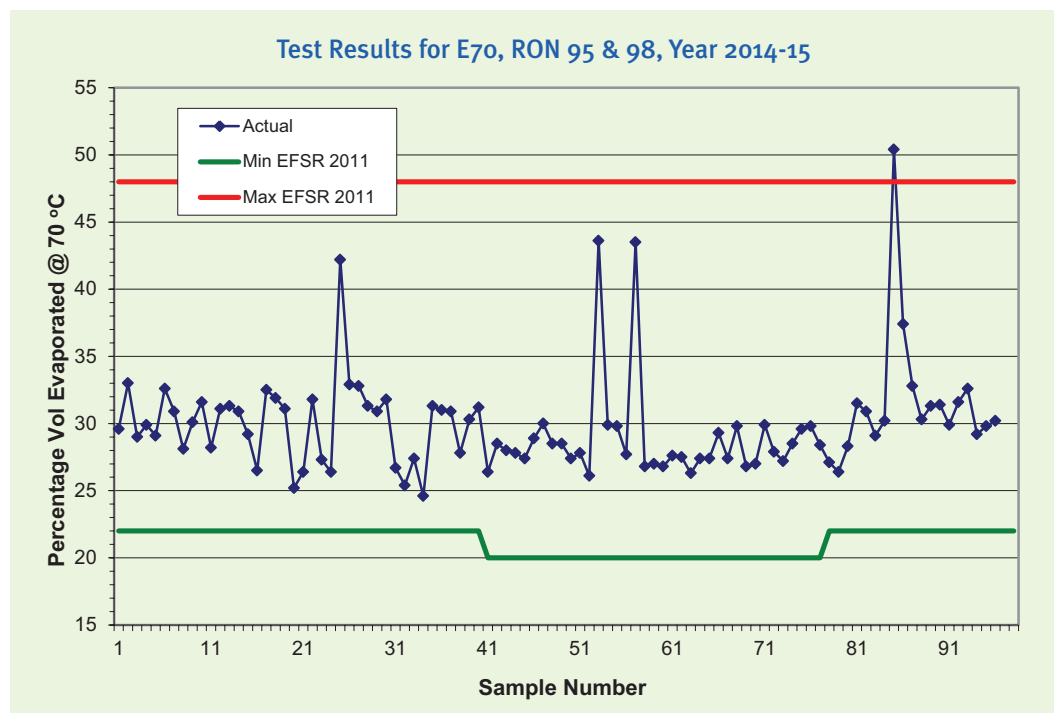
**Table 1**

Sample	Ethanol Content, % Vol	Limit for Ethanol Blend, % Vol	Percentage Volume Evaporated @ 70°C
25	10.00*)	58	42.2
53	9.75	58	43.6
57	10.09	58	43.5
85	9.45	57	50.4
86	1.05	49	37.4

\*) As advertised. Ethanol content was not tested.

The maximum specification limit for Sample 85 is 57% so the result is within the specification (see Table 1 above).

**Fig. 5a**



<sup>6</sup> ASTM D4815-15a Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C1 to C4 Alcohols in Gasoline by Gas Chromatography.

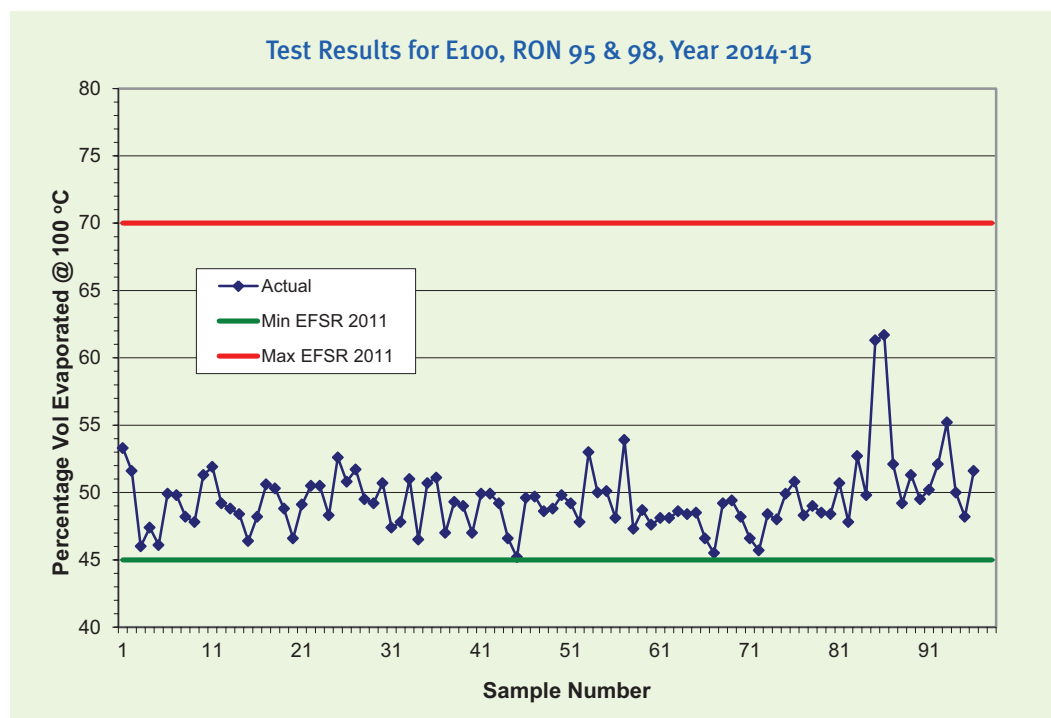


### Percentage Volume Evaporated @ 100°C

All samples were found to be within the specification limits from the minimum of 45% to the maximum of 70%. Sample 45 was found to be the lowest, 45.2%.

As in case of regular petrol, the tolerance limits are 43.8% and 70.9% respectively.

Fig. 5b





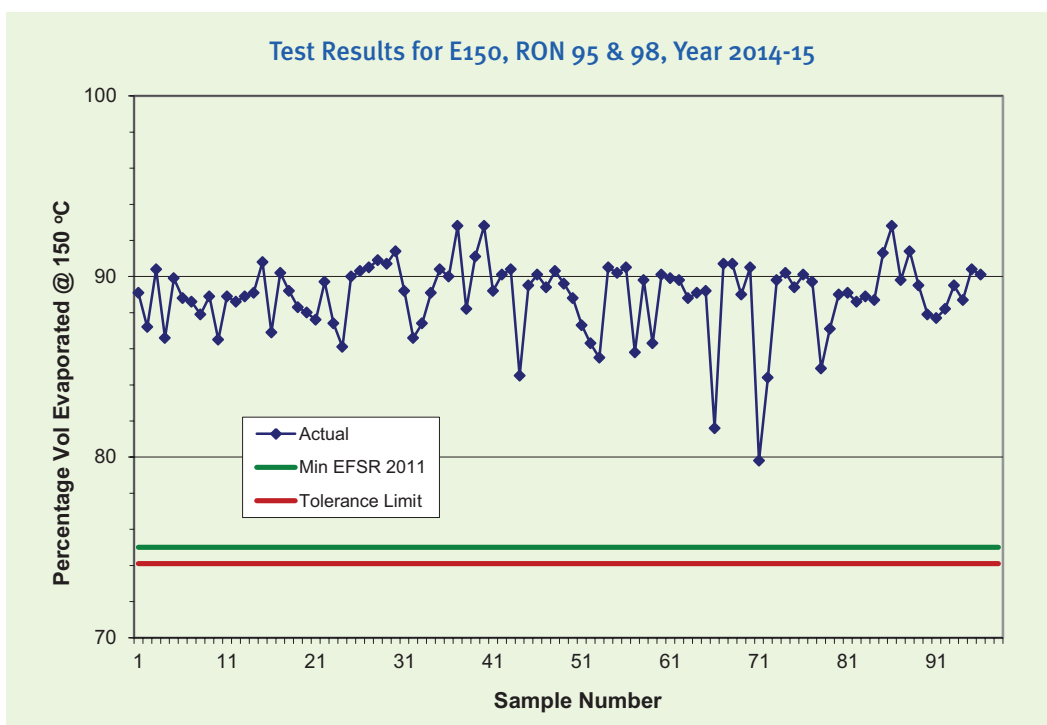
### Percentage Volume Evaporated @ 150°C

All samples were found to be above the minimum specification limit of 75%.

As in case of regular petrol, the minimum tolerance limit is 74.1%.

No maximum is prescribed by the Regulations for this parameter. All samples except one were found to be above 80% (Fig. 5c). The lowest figure of 79.8% was found for Sample 71.

Fig. 5c



### Final Boiling Point

The test method ASTM D86<sup>7</sup> is prescribed in the Regulations for distillation end point (or 'final boiling point') in petrol.

All samples were found to be within the specification maximum limit of 210°C for both regular and premium grades (Fig.6). The tolerance limit is 214°C.

The largest final boiling point figure for regular petrol of 206.2°C was found for Sample 52.

The largest figure for final boiling point of 205.0°C was found for Sample 1 of premium petrol.

<sup>7</sup> ASTM D86-12 *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.



Fig. 6a

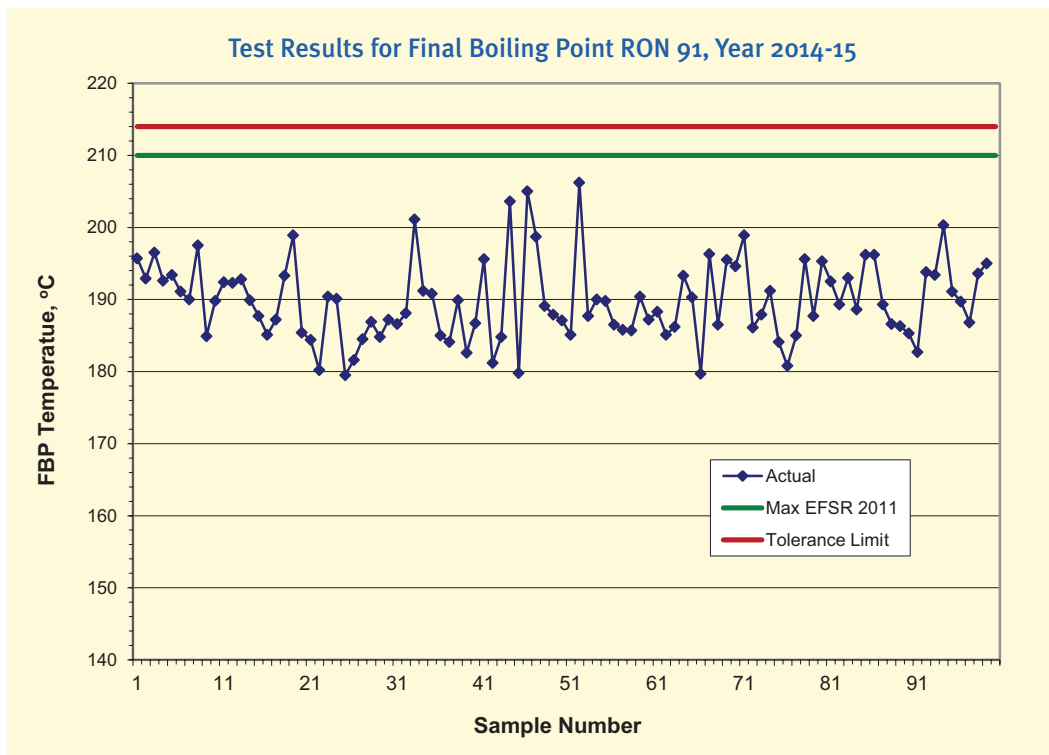
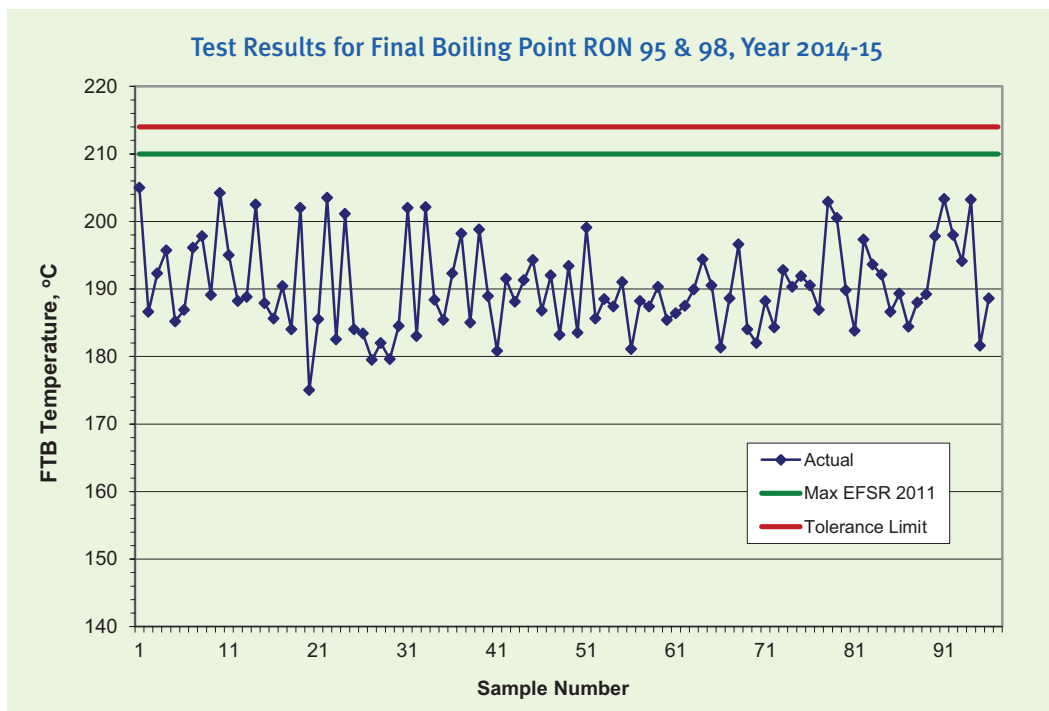


Fig. 6b



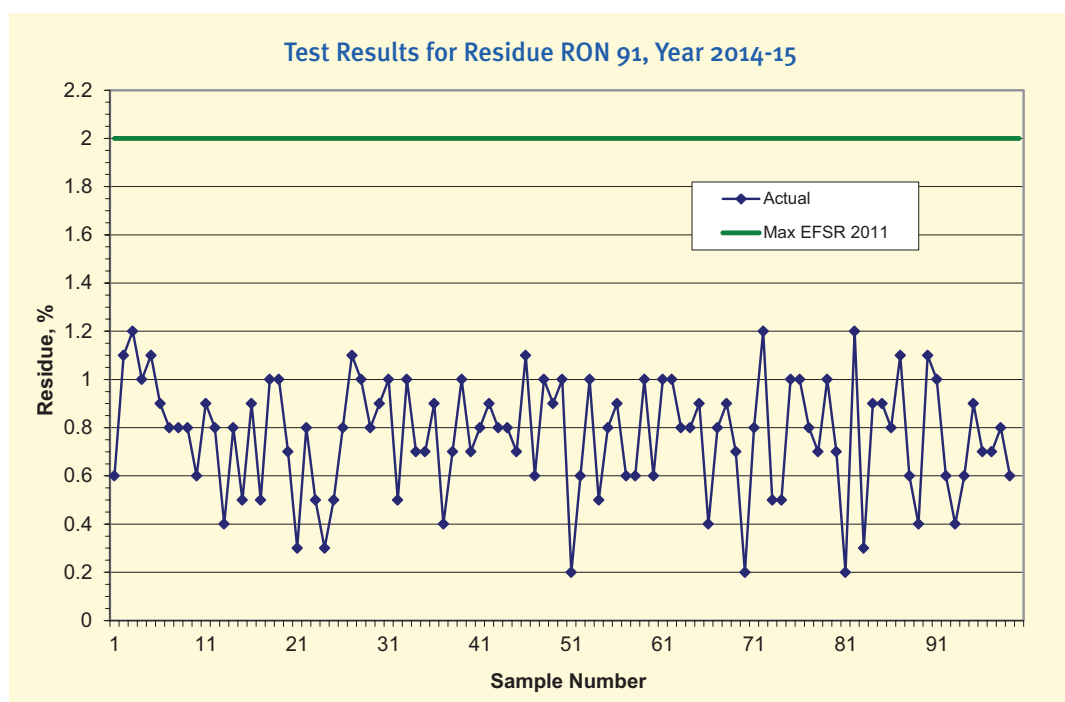
## Residue

All samples were found to be well within the limits for both regular and premium grades (Fig. 7).

No tolerance limit for residue could be defined due to the lack of data for the reproducibility of this parameter in ASTM D86<sup>8</sup>. Fortunately,

residue content was found to be well below the specified maximum limit of 2% volume. The largest figure for residue of 1.2% was found for a number of samples of both regular and premium petrol.

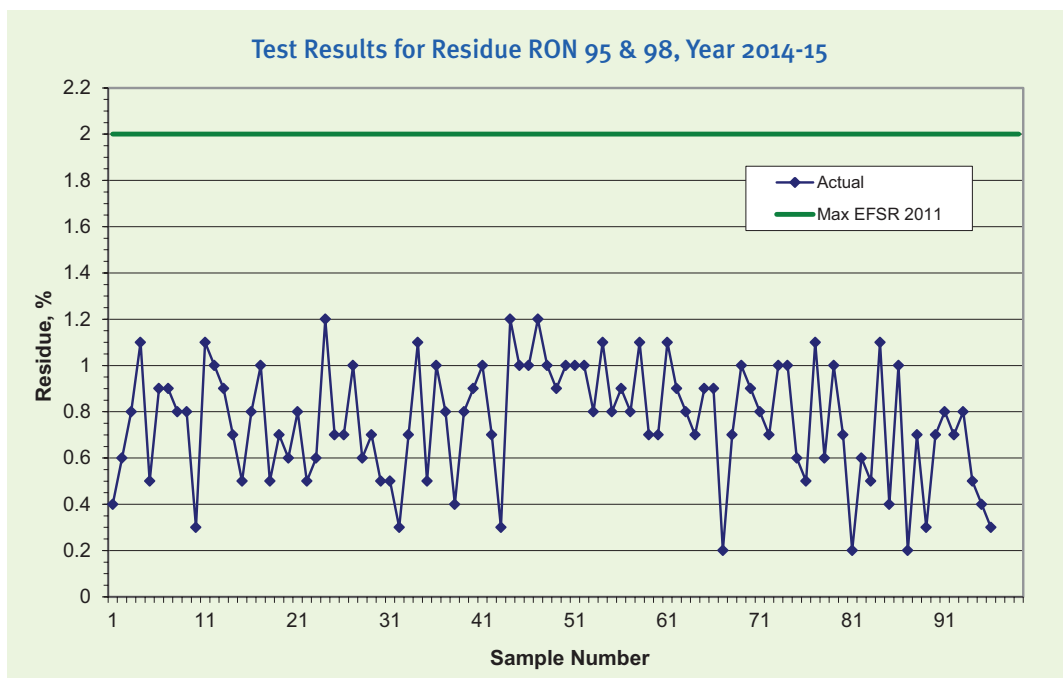
Fig. 7a



<sup>8</sup> ASTM D86-12 *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.



Fig. 7b



## Dry Vapour Pressure Equivalent

The test method ASTM D519<sup>9</sup> is prescribed in the Regulations for vapour pressure in petrol.

All samples tested for Dry Vapour Pressure Equivalent (DVPE) were found to be above the prescribed minimum limit of 45 kPa.

The cumulative results for the maximum limit are presented below in a simplified way by combining the lowest prescribed maximum limits for all seasons in one graph. Generally, if results were below the lowest maximum limit established for an area then they definitely complied with the Regulations in all other areas.

For the period of summer in Schedule 1 (season definitions in Section 5, the Regulations) from 1 December to 31 March inclusive, the lowest maximum limit of pressure 65 kPa is prescribed for Auckland and Northland. This is shown on the Fig. 8 by a square dip.

The top line before and after the dip, is the next lowest maximum, 80 kPa, which is prescribed for the North Island, for the autumn and spring periods.

The maximum limits prescribed for winter in all three designated regions are equal to or above 90 kPa and not shown in the graph.

<sup>9</sup> ASTM D5191-15 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)*.

Each sample within the relevant season which appeared to be above the lowest maximum limit line was individually analysed.

Tolerance limits related to the maximum specification limits are not shown since they are only approx. 2% above each relevant limit.

### RON 91

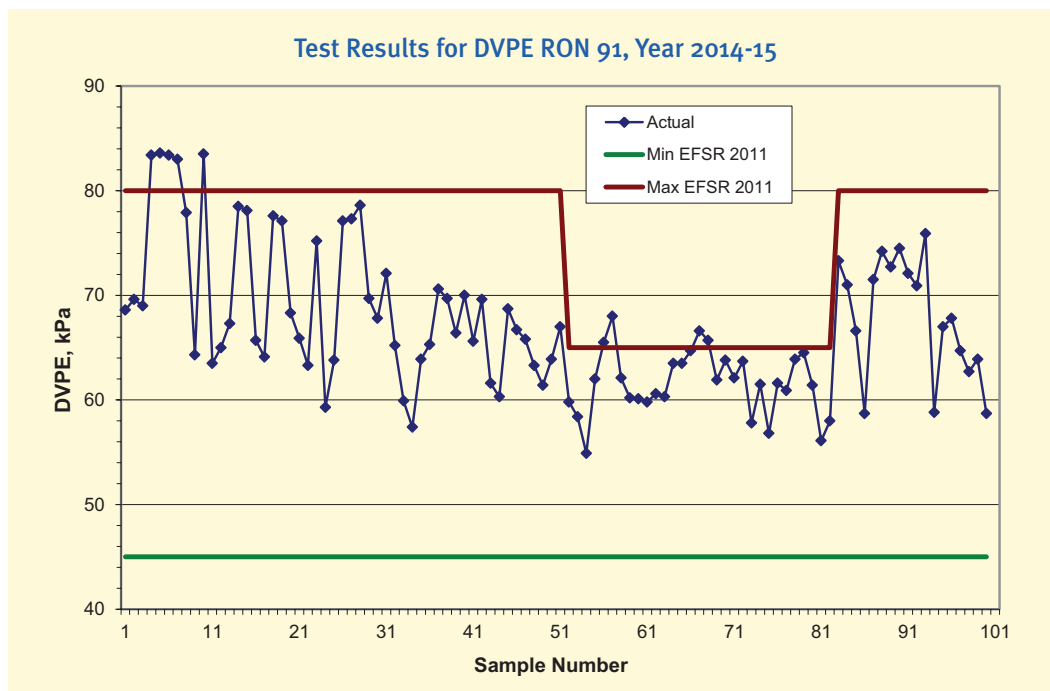
In various periods, several samples were initially found to be above the lowest maximum at the time. However, all they were found to be within the specification limits.

Of those, Samples: 4, 5, 6, 7, and 10, were found to be in the range from 83.0 kPa to 83.6 kPa *i.e.* well within<sup>10</sup> the maximum limit of 90 kPa for winter in the North Island.

There were also four samples found to be above the lowest maximum in the summer period.

Samples: 56, 57, 67, and 68, which were from the South Island, were found to be in the range from 65.5 kPa to 68.0 kPa, *i.e.* well within the maximum limit of 75 kPa for the region in the summer season.

Fig. 8a



<sup>10</sup> 'Well within the limit' in this Report means a compliant result which is away from the prescribed limit farther than three tolerance margins. Here, the limit is 75 kPa so that minus three tolerance margins gives 70.8 kPa.



### RON 95 & 98

All samples were found to be within the specification limits for premium petrol (Fig. 8b). However, as in case with regular petrol, in various periods, several samples were initially found to be above the lowest maximum at the time.

Of those, six samples: 4, 6, 9, 13, 14, and 17, which were found to be in the range from 80.5 kPa to 85.9 kPa, were well within the regional maximum limits for winter 90 kPa for the North Island. Sample 7 was well found to be within the regional maximum limit for winter 95 kPa for the South Island.

There were also five samples found to be above the lowest maximum in the summer period.

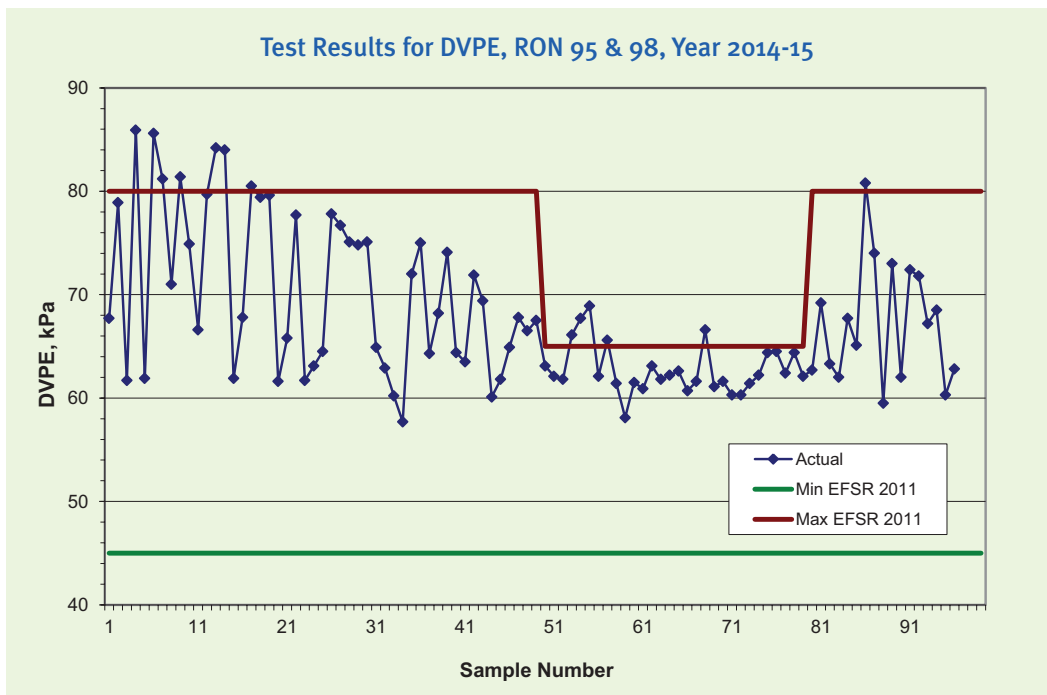
Samples: 54, and 55, which were found to be respectively 67.7 kPa and 68.9 kPa, were within the maximum limit of 75 kPa for the South Island in summer.

Sample 68 was found to be 66.6 kPa within the maximum limit of 70.0 kPa for the rest of the North Island, summer season.

Two other samples, 53, and 57, which were found to be, respectively, 66.1 and 65.6 kPa, were ethanol blends (see Table 1 above). They were found to be well within the seasonal maximum limits for 10% ethanol blends for the North Island.

Finally, Sample 86 was initially found to be 81.1 kPa at the tolerance limit of 81.4 kPa for a single test for the North Island in autumn. The tests repeated by the same operator returned the figure of 80.6 kPa with the repeatability condition of 1.4 kPa therefore being satisfied. A corrected tolerance limit for two results is 81.3 kPa. On investigation it was found that the average of 80.8 kPa was within testing tolerance limit so, according to the established policy, Sample 86 was deemed to be compliant.

Fig. 8b



## Flexible Volatility Index

The Flexible Volatility Index (FVI) is a derived parameter which is calculated from the measured value of DVPE (see above) and the value of E70, as

$$FVI = DVPE + (0.7 \times E70)$$

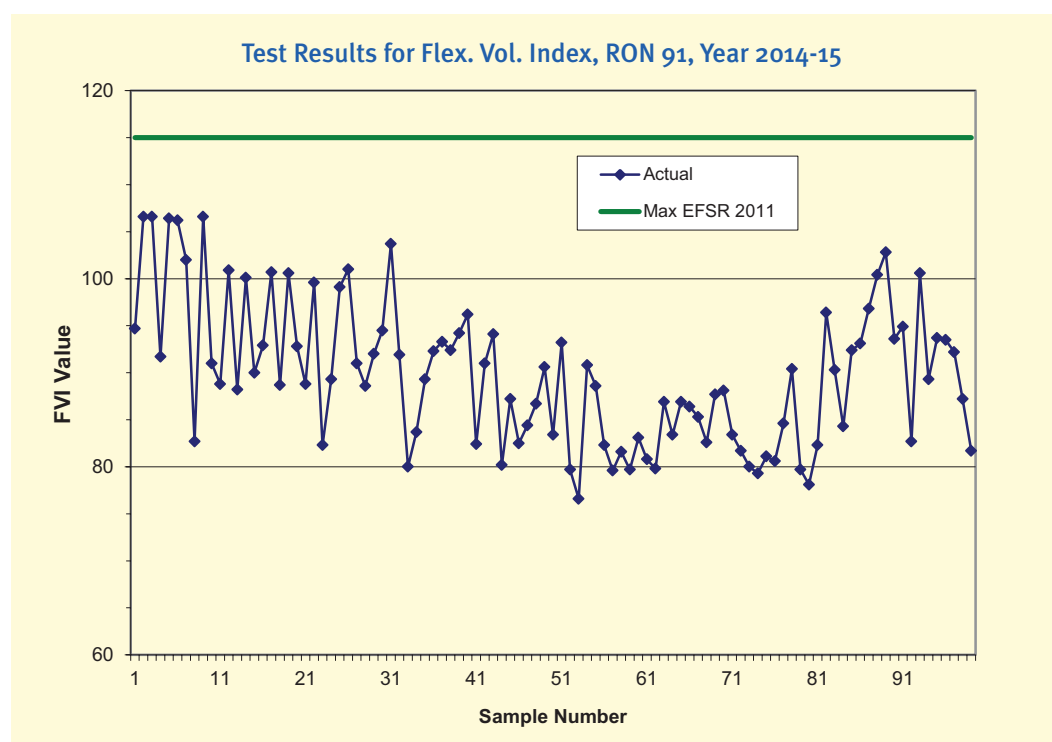
FVI serves as an indicator of the hot running performance (the tendency for vapour lock). No definition of the FVI value is given in the related ASTM Standards prescribed in the

Regulations (D86 and D5191<sup>11</sup>) and as a consequence no reproducibility value is identified. As a result of this the FVI serves only as a helpful indicator but cannot be used in a strict compliance analysis.

### RON 91

All samples were found to be within the specification maximum limit of 115.0.

Fig. 8c



<sup>11</sup> ASTM D5191-15 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)*.

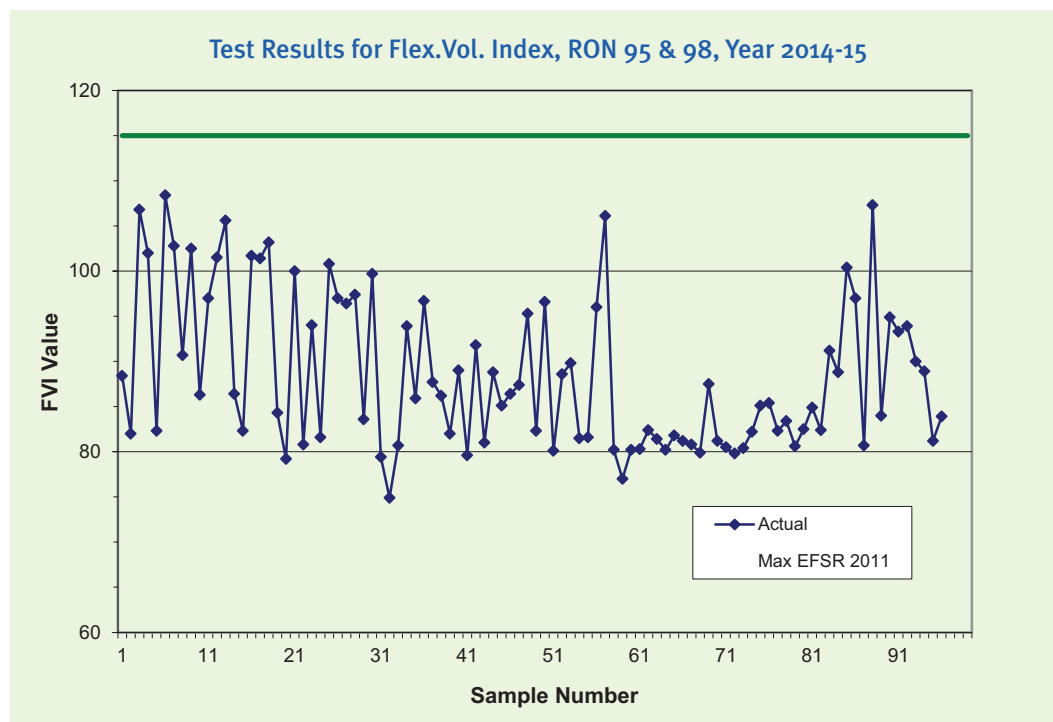




## RON 95 & 98

All samples were found to be within the prescribed maximum limit of 115.0.

Fig. 8d



## Sulphur

The scope of the test method IP 497<sup>12</sup> prescribed in the Regulations, is from 5 to 60 mg/kg. Accordingly, the lowest line of testing results by this method is 5 mg/kg where the actual figures were found to be on or below this indicative level at the specified maximum limit of 50 mg/kg.

The ASTM standard D5453<sup>13</sup> which is also prescribed in the Regulations along the

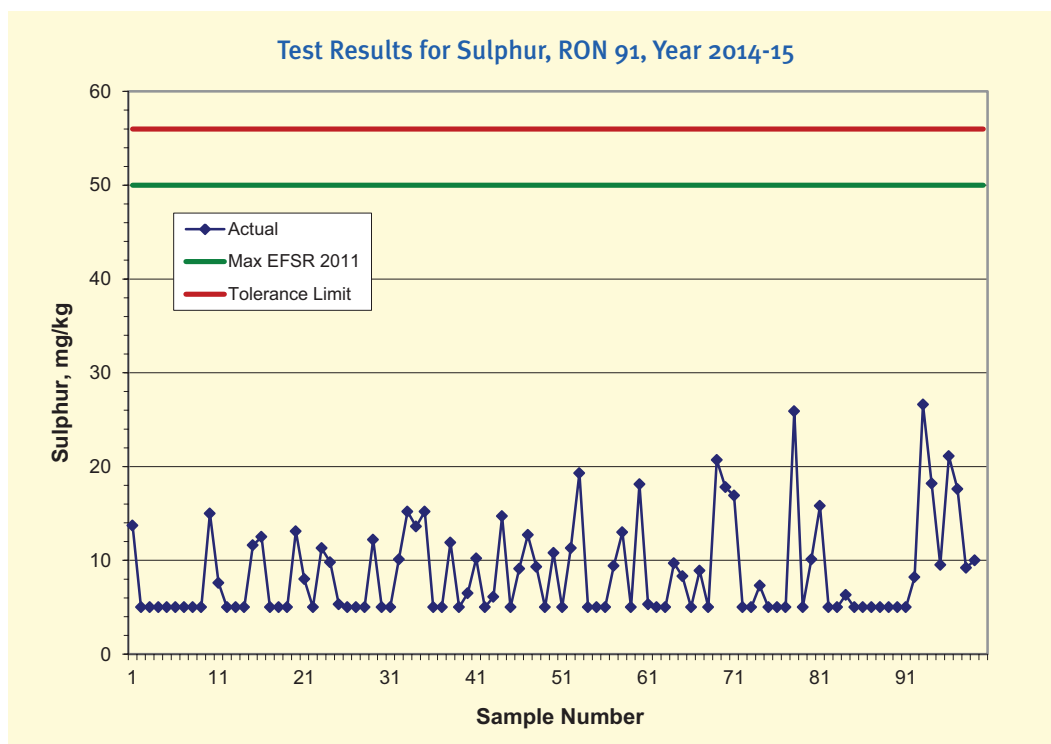
IP 497, give results down to a fraction of 1 mg/kg although it wasn't used by the testing laboratory this year.

### RON 91

All samples for regular petrol were found to be within the prescribed maximum limit.

All results were between 5 and 30 mg/kg.

Fig. 9a



<sup>12</sup> IP497 EN ISO 20884:2011 *Petroleum products – Determination of sulfur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry.*

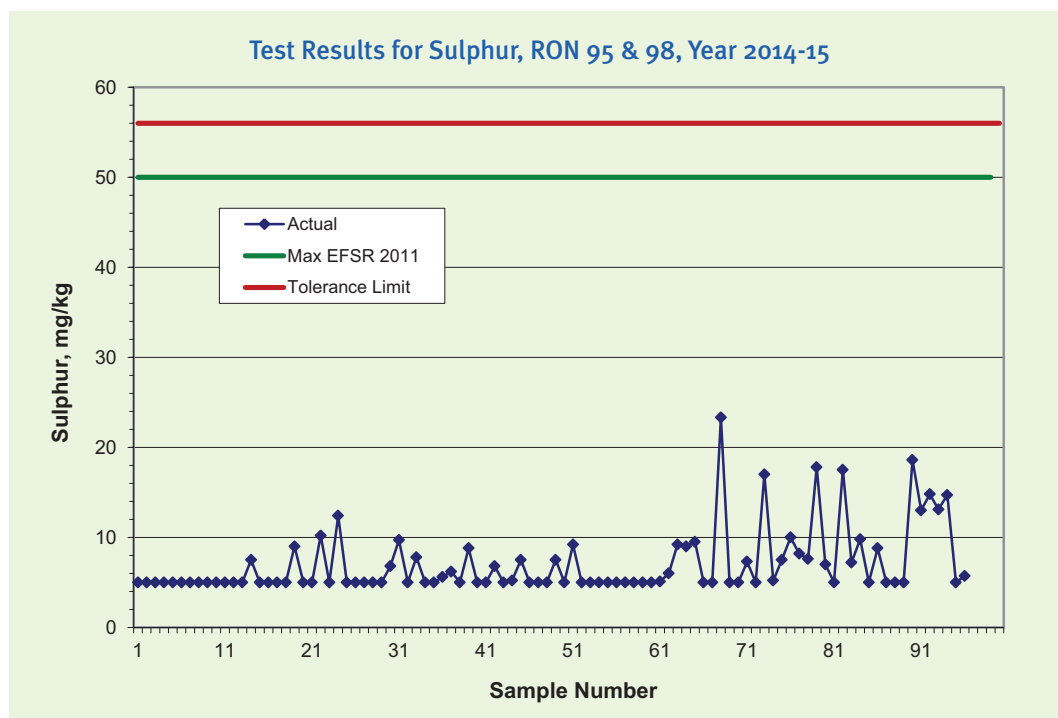
<sup>13</sup> ASTM D5453-12 *Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence.*



### RON 95 & 98

All results for premium petrol were found to be well within the prescribed maximum limit with only one result exceeding 20 mg/kg.

Fig. 9b



## Benzene and Total Aromatics

The test method ASTM D5580<sup>14</sup> is prescribed in the Regulations for aromatic compounds including benzene.

All samples were found to be within the prescribed maximum limits, for both benzene (maximum 1% vol) and total aromatic compounds (45% vol maximum cap) for regular as well as premium grade of petrol with the tolerance limits, respectively, of

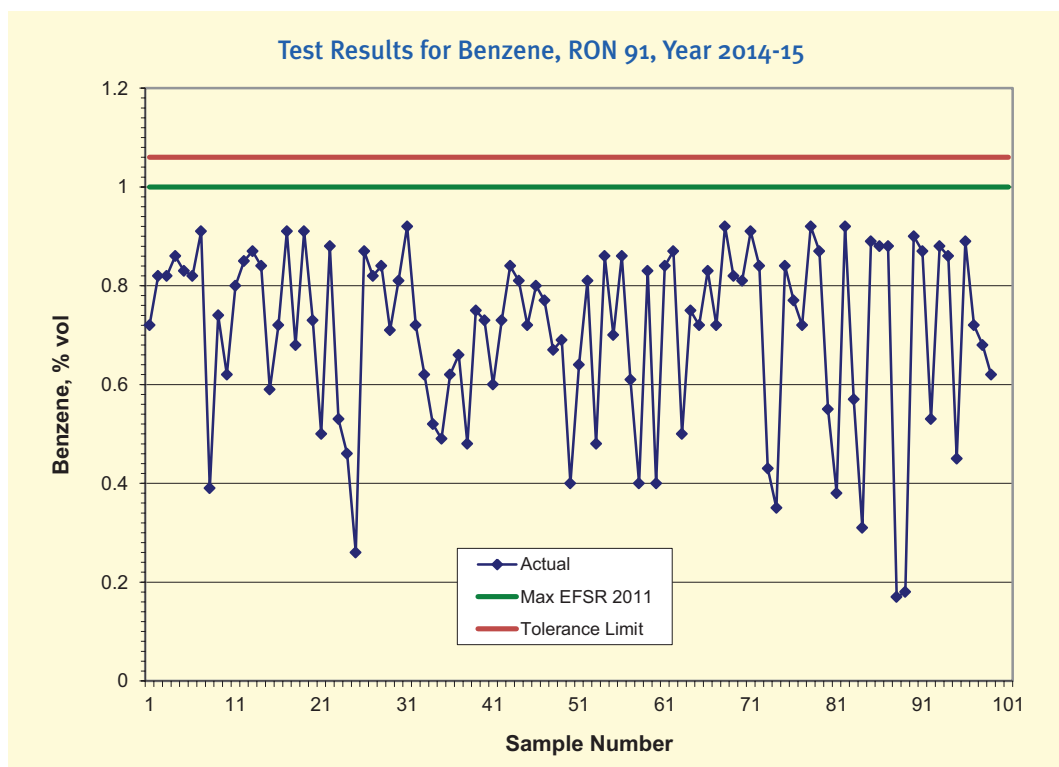
1.06% for benzene and of 46.03% for the maximum cap in total aromatics.

### RON 91

All results for benzene content in regular petrol were below 0.95% with the largest figure of 0.92% for Sample 31 (Fig.10a).

All results on total aromatics were found to be below 41% (Fig. 10b).

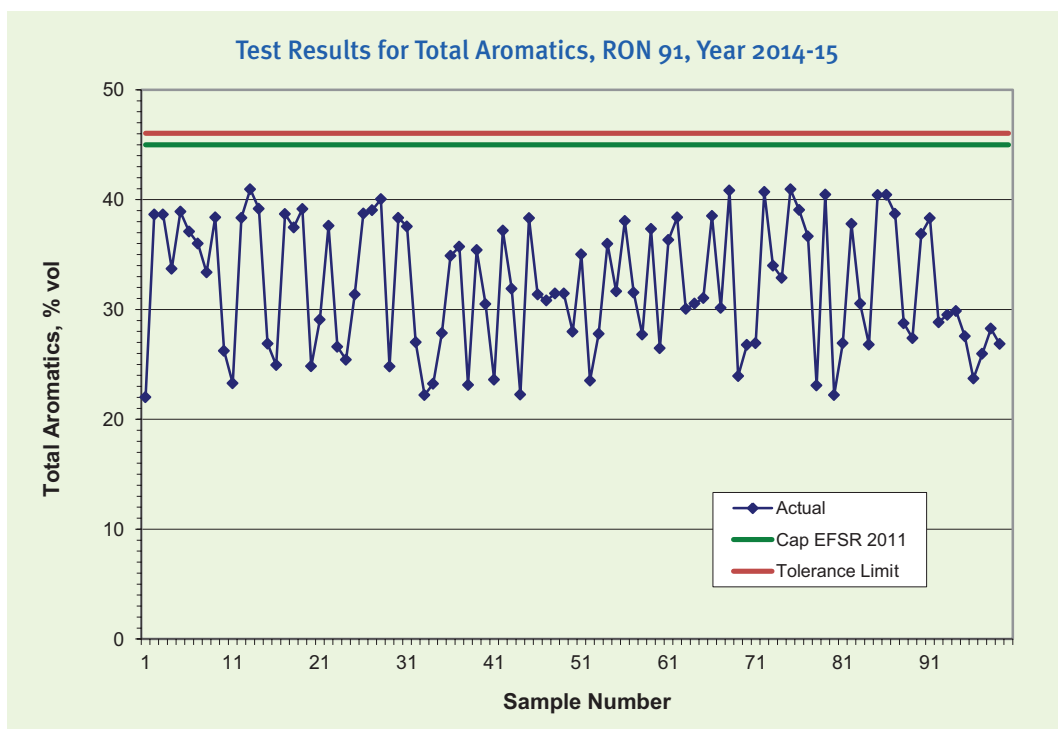
Fig. 10a



<sup>14</sup> ASTM D5580 – 13 Standard Test Method for Determination of Benzene, Toluene, Ethylbenzene, p/m-Xylene, o-Xylene, C<sub>9</sub> and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography.



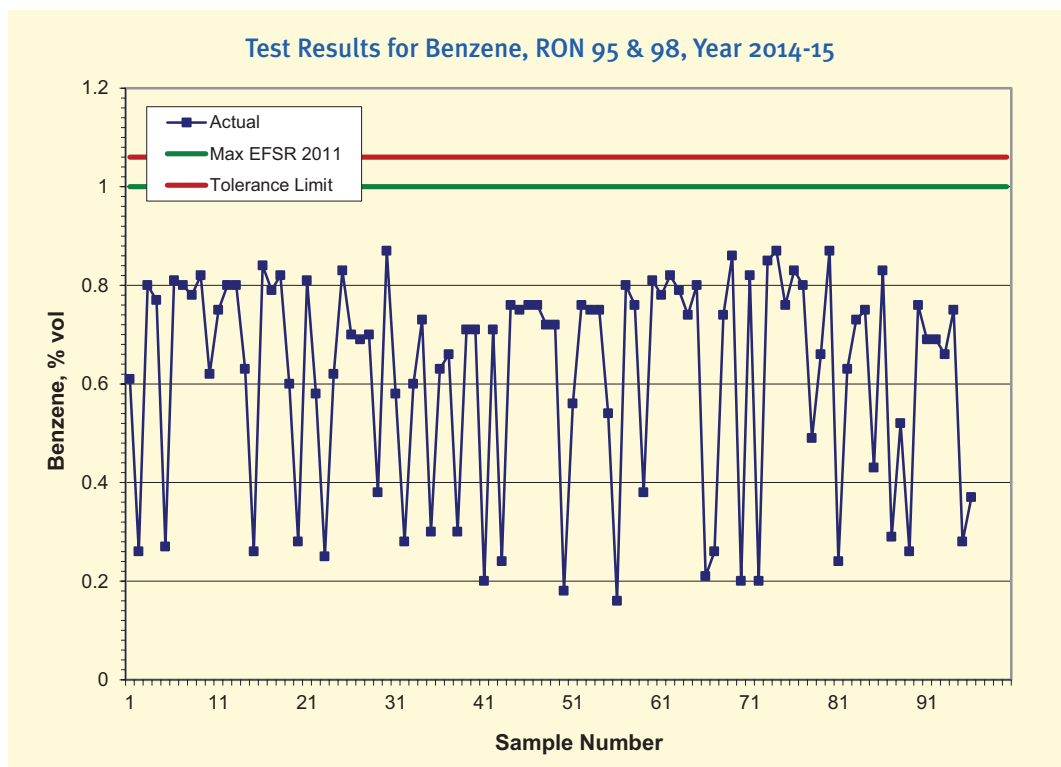
Fig. 10b



### RON 95 and 98

All samples of premium petrol were found to be well within the prescribed maximum limit for benzene with largest results not higher than 0.90%.

Fig. 10c

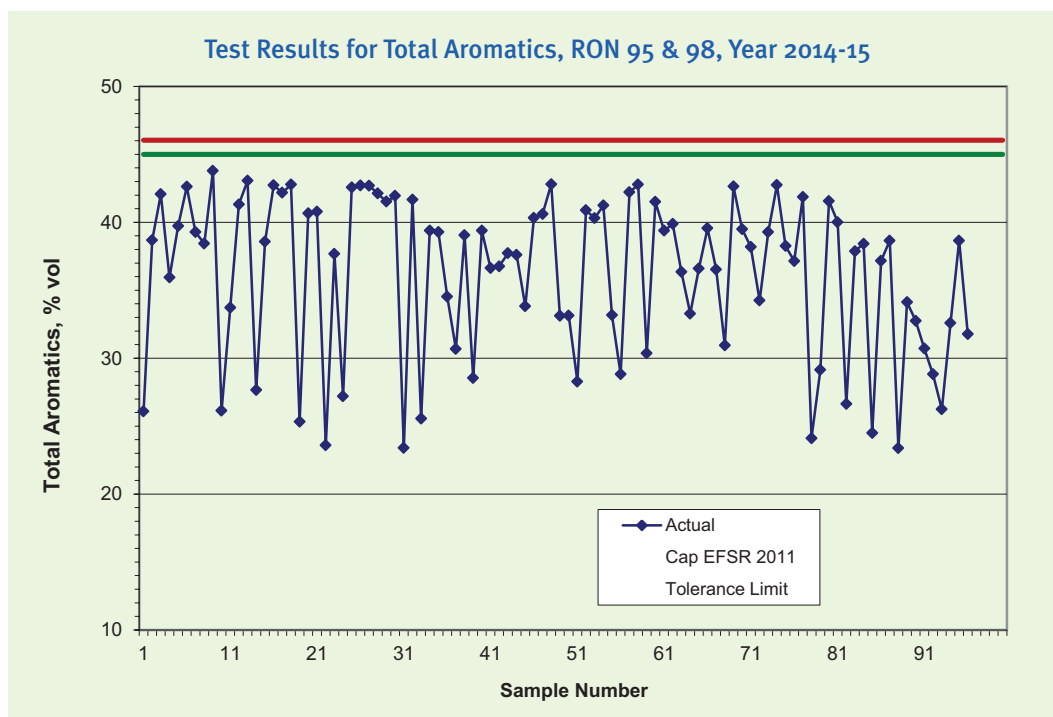


For premium petrol, all results on total aromatics were below 44% with the largest result on total aromatics was found to be 43.78% for Sample 9 (Fig. 10d).

According to Section 19 of the Regulations, actual amounts of petrol which were produced or imported, must be accounted, to calculate 'pool average' figures for the total aromatic compounds for each calendar month. The pool average specification for total aromatics is 42% vol maximum.

Data on 'pool average' was collected from four major fuel retail companies and from The New Zealand Refining Company Ltd for the one year period ending on 30 June 2015. The actual results were found to be within the required limits. Due to the commercial sensitivity of the calculation process, the actual results were not included in this report.

Fig. 10d





## Olefins

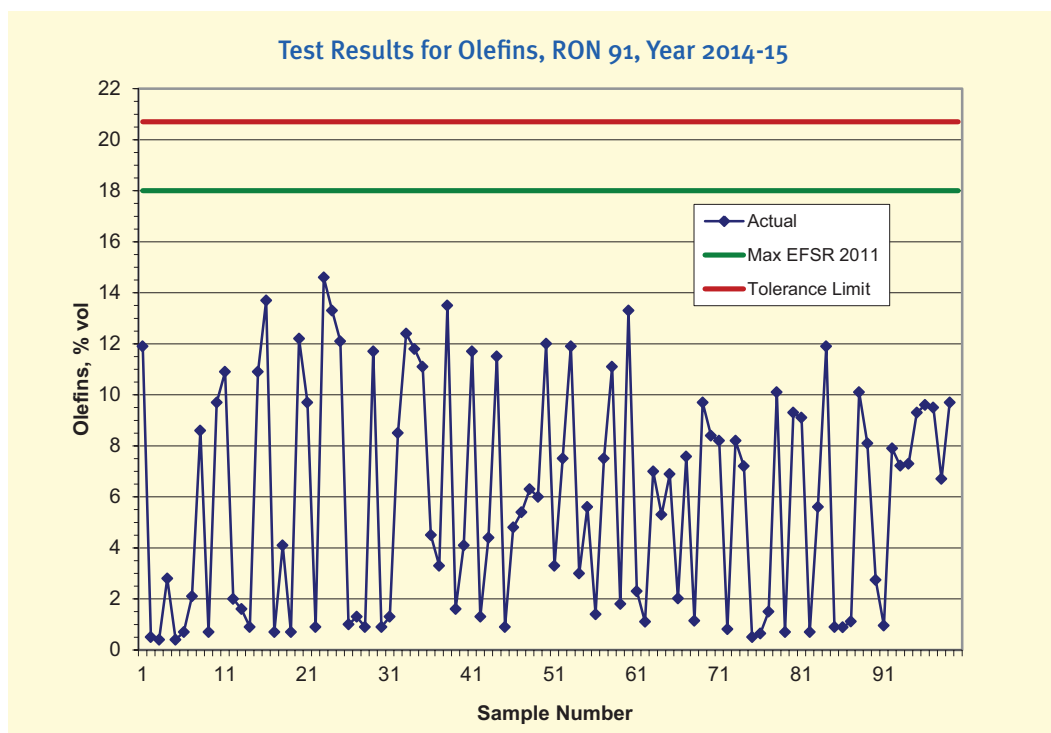
The test method ASTM D1319<sup>15</sup> is prescribed in the Regulations for olefins content.

All samples were found to be within the specification maximum limit of 18% vol.

### RON 91

For RON 91, all results except one were found to be below 14% (Fig. 11a). Only Sample 23 was found to exceed this figure with the result of 14.6%.

Fig. 11a



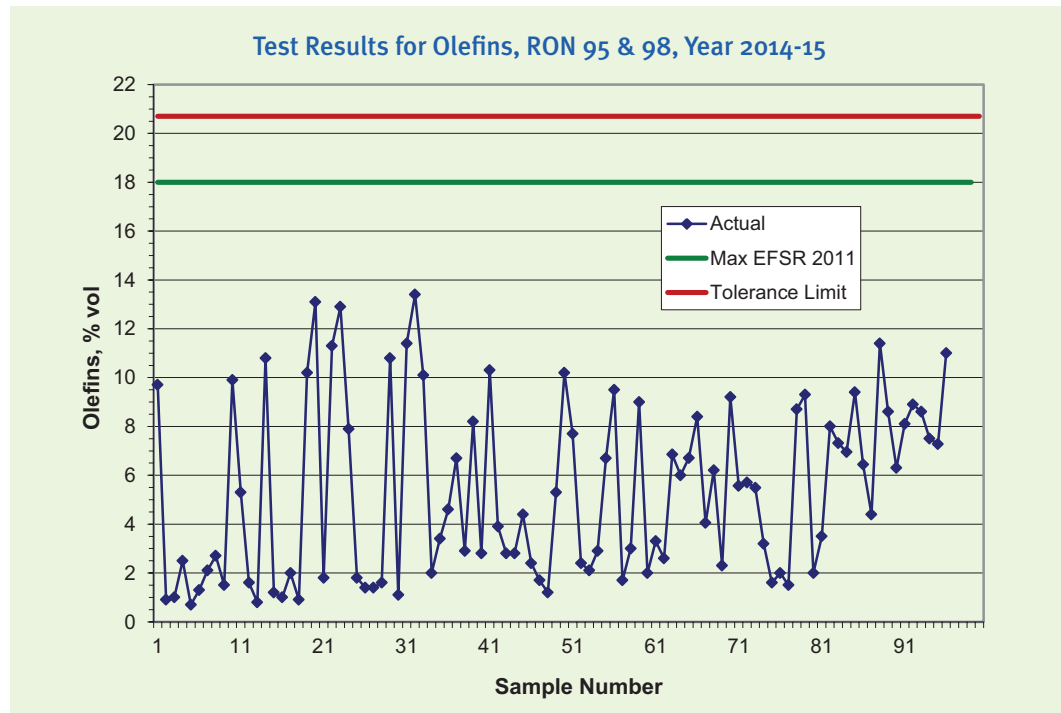
<sup>15</sup> ASTM D1319-14 Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption.



### RON 95 & 98

For premium petrol, all results were found to be below 14% (Fig. 11b).

Fig. 11b





## Existent Gum (solvent washed)

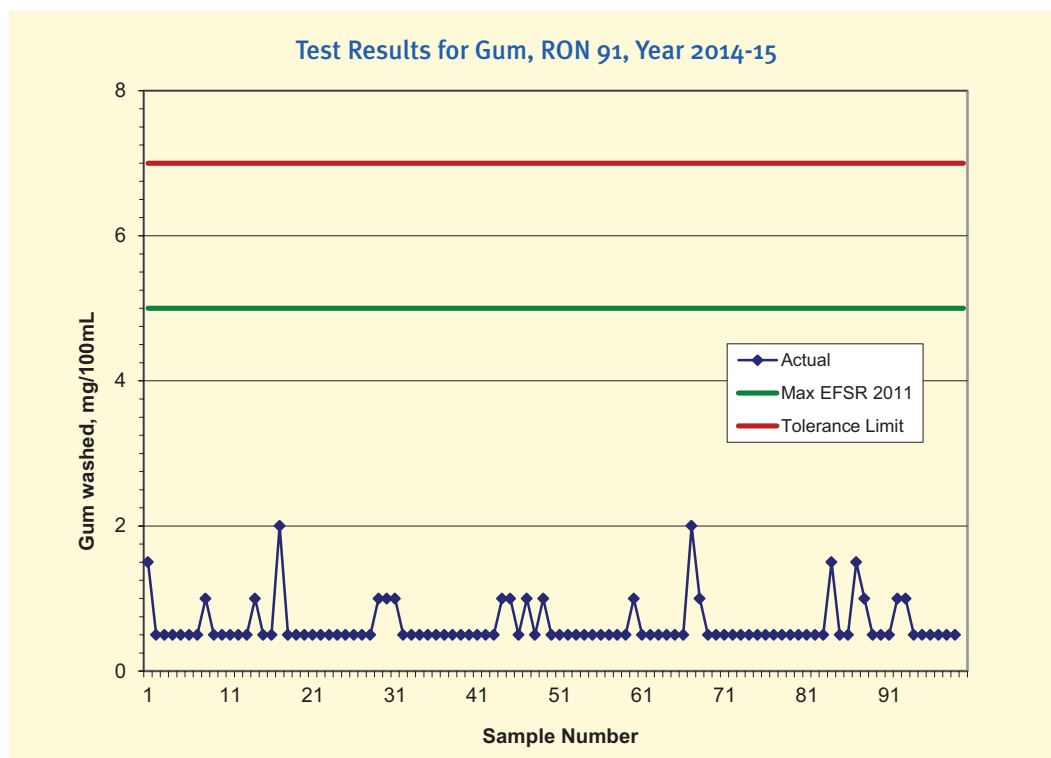
The threshold of the test method ASTM D381<sup>16</sup> prescribed in the Regulations, is 0.5 mg/100mL. Accordingly, the lowest line of testing results as prescribed by this method is 0.5 mg/100mL where the actual figures were found to be on or below this indicative level at the specified

maximum limit of 5 mg/100mL. The tolerance limit is 7 mg/100mL.

For both regular and premium petrol, all results were found to be not higher than 2.5 mg/100mL which is well below the specification maximum limit (Fig. 12).

## RON 91

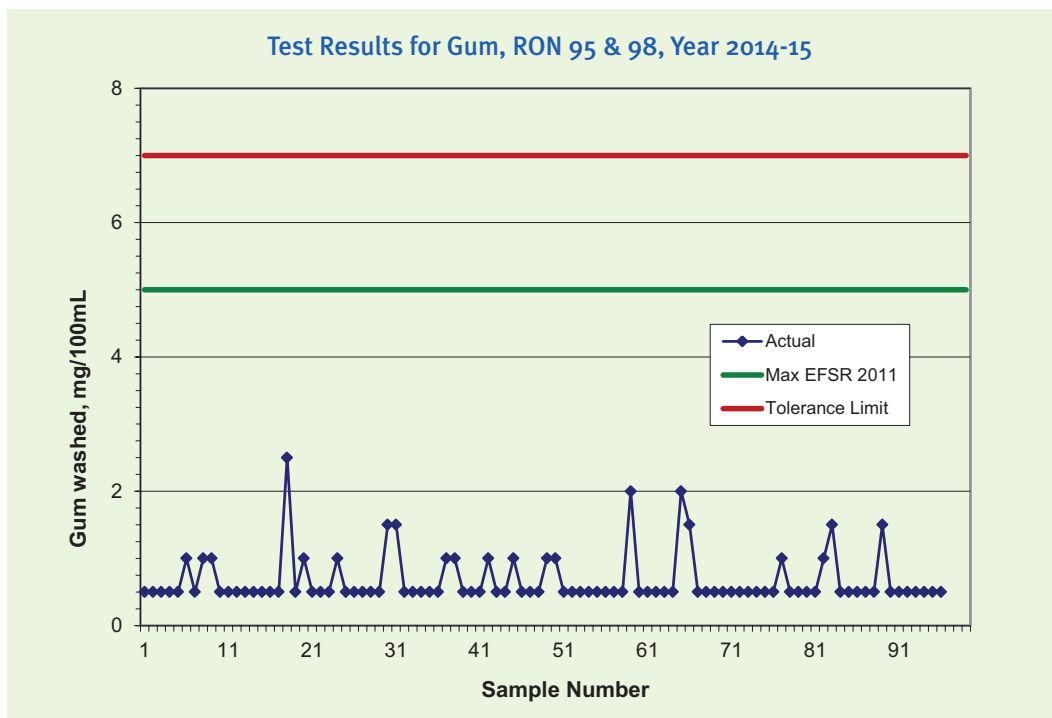
Fig. 12a



<sup>16</sup> ASTM D381-12 Standard Test Method for Gum Content in Fuels by Jet Evaporation.

## RON 95 & 98

Fig. 12b



## Other Specification Parameter Testing

Testing and analysis, at a lower frequency, was also conducted on other parameters and properties prescribed in the Regulations. This included screening for the content of contaminants which are not expected to be present in fuel: lead, manganese and phosphorus. This is done by means of an initial identification of their presence on the threshold of resolution by each relevant method. These tests' results have not been included in this report as they were usually found to be below the threshold and well within the specification limits.

Testing for oxidation stability has not been usually done due to the relatively short periods of storing fuel by the retail industry. The test was added since January 2014 to the regular list of tests with a special testing frequency of approx. two tests per month. All results were found to invariably exceed the specified induction period of 360 minutes, *i.e.* tests were usually stopped when the induction time period would exceed the tolerance limit of 381 minutes.

The ethanol content in petrol blends was also tested, as it is shown above, and found to be within the testing tolerance limit.

## Summary for Petrol Test Results

There were only two suspected non-compliance case and there were no repeated cases of non-compliance identified.

One suspect non-compliant sample detected related to a sample of premium petrol where the vapour pressure on investigation was found to be above the specified limit of 80.0 kPa with an actual figure of 81.1 kPa. This sample was found to be outside specification after subsequent additional testing and analysis however the average was within the testing tolerance limit of 81.3 kPa therefore the product was deemed to be compliant.

Another suspect non-compliant sample related to a sample of premium petrol where the ethanol content on investigation was found to be above the specified limit of 10% with an actual figure of 10.09%. This sample was found to be outside specification after subsequent additional testing and analysis however the average was within the testing tolerance limit of 10.49% therefore the product was also deemed to be compliant.



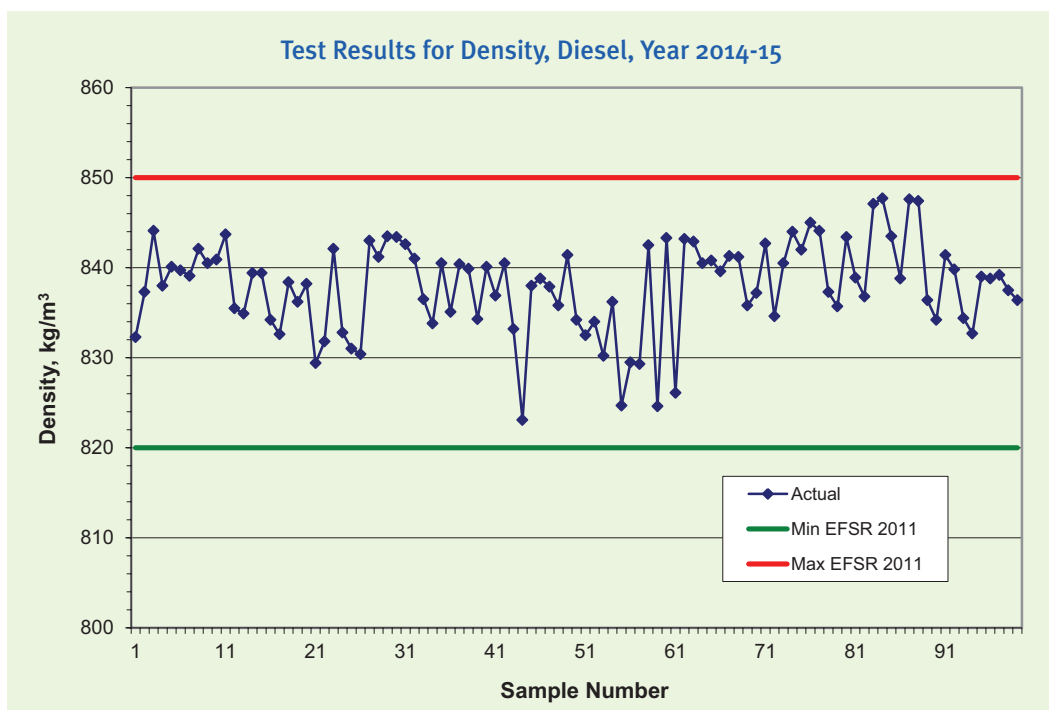
# Diesel

## Density

Density of diesel at 15°C can be tested according to ASTM D1298<sup>17</sup> or ASTM D4052<sup>18</sup> prescribed in the Regulations. Respectively, there are two pairs of tolerance limits identified using the two methods for the minimum limit of 820 kg/m<sup>3</sup> and for the maximum limit of 850 kg/m<sup>3</sup>.

All results were found to be well within the specification limits with the minimum figure of 823.1 kg/m<sup>3</sup> at the minimum tolerance limit of 819.3 kg/m<sup>3</sup> and the maximum figure of 847.7 kg/m<sup>3</sup> at the maximum tolerance limit of 850.7 kg/m<sup>3</sup>.

Fig. 13



<sup>17</sup> ASTM D1298-12b *Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.*

<sup>18</sup> ASTM D4052-11 *Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter.*



## Distillation

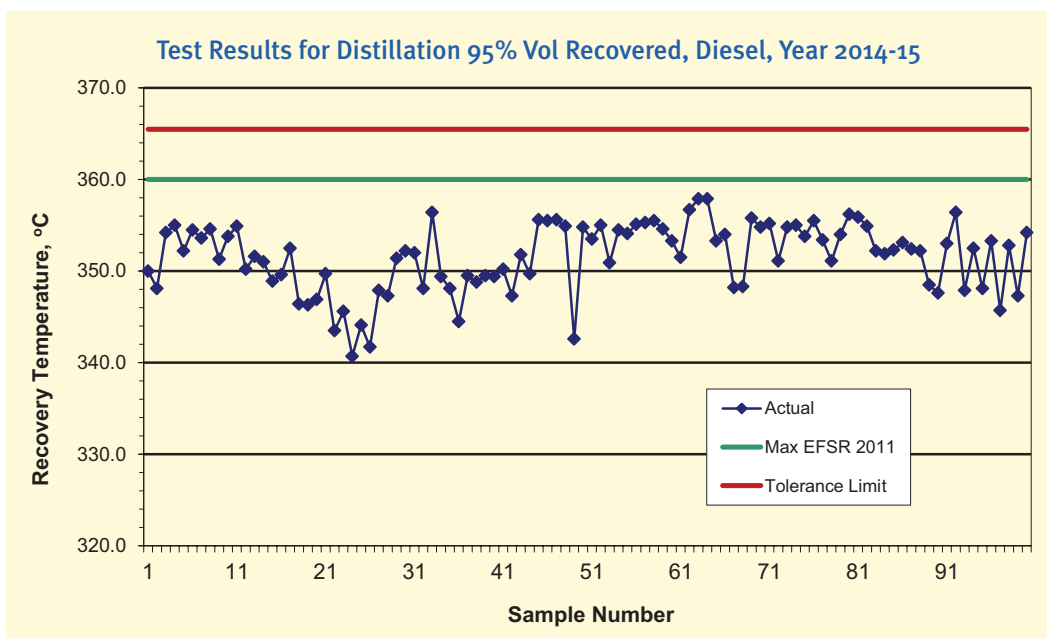
The Distillation test means definition of temperature (°C) at which 95% volume recovered. The temperature should be tested by ASTM D86<sup>19</sup> prescribed in the Regulations.

All samples were found to be below the specification maximum limit of 360°C for distillation at 95% volume recovered (T<sub>95</sub>).

Samples 63 and 64 were found to be the closest to the limit with the actual result of 357.9°C (Fig. 14). The tolerance limit is 365.5°C.

Sample 24 was found to be the lowest with the actual figure of 340.7°C although there is no prescribed minimum limit for this property.

Fig. 14



<sup>19</sup> ASTM D86-12 Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure.

## Cetane Index

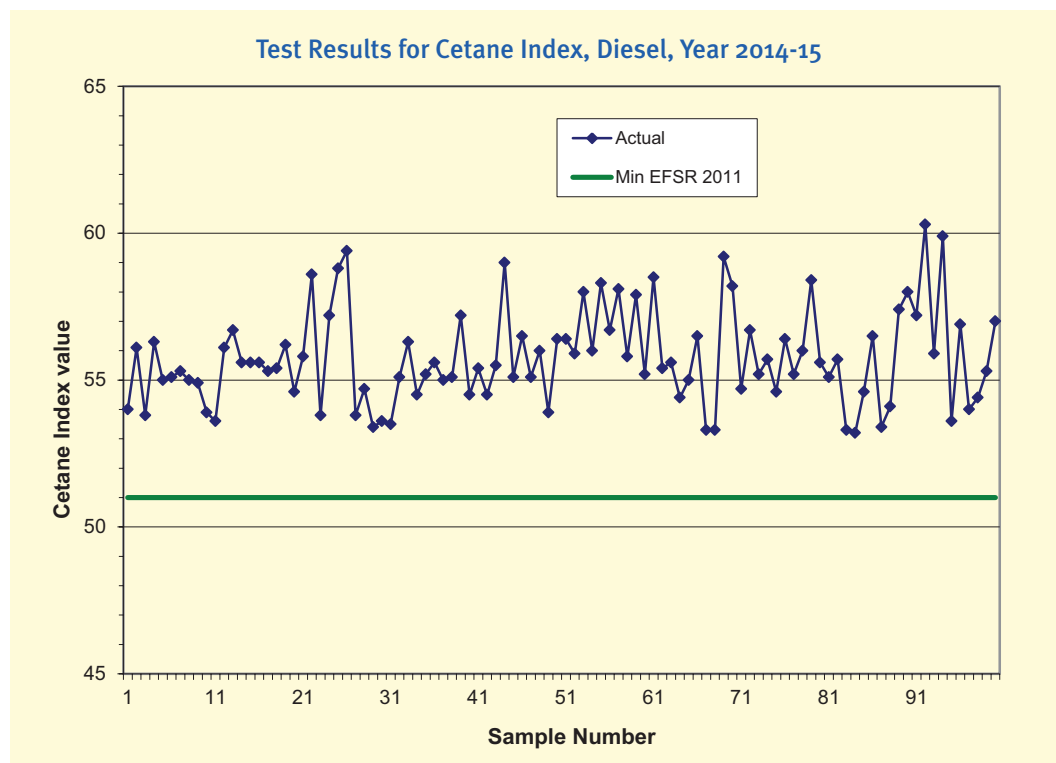
The cetane index, according to ASTM D4737<sup>20</sup> prescribed in the Regulations, is not tested for but calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine for determining cetane number is not available and/or cetane improvers are not used.

All samples were found to be above the minimum limit of 51 (Fig.15).

Samples 67, 68 and 83 were found to be the lowest with the actual figure of 53.3.

Since the reproducibility for cetane index is not defined in the ASTM D4737, it is impossible to exactly define a tolerance limit. However, the Standard specifies that 'the expected error of prediction of Procedure A will be less than  $\pm 2$  cetane numbers for 65% of the distillate fuels evaluated'. On these grounds, an estimate for the tolerance limit would be derived as 49.8.

Fig. 15



<sup>20</sup> ASTM D4737-10 Standard Method for Calculated Index by Four Variable Equation.





## Water

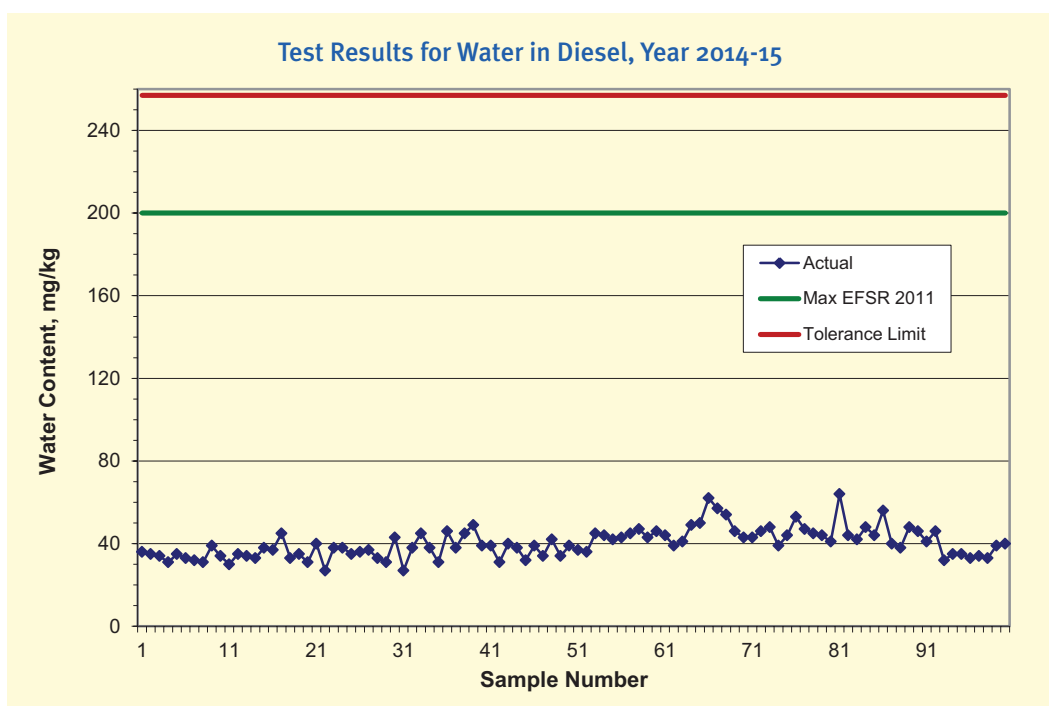
The test for water content is done according to IP 438,<sup>21</sup> which determines the total water present in the diesel sample (either in solution or in solution and free water).

Water is soluble to some extent in hydrocarbons. The amount of water that is held in solution will be dependent on the temperature and the composition of the hydrocarbon. At typical ambient temperatures

in New Zealand the expected concentration of water dissolved in diesel, is around 30 to 40 mg/kg.

The water content in all the tested samples was found to be well within the specification limit of 200 mg/kg with actual testing results not exceeding 80 mg/kg. Sample 81 was found to be the largest with the results of 64 mg/kg.

Fig. 16



<sup>21</sup> BS EN ISO 12937:2001, BS 2000-438:2001. *Petroleum products. Determination of content. Coulometric Karl Fischer titration method.*

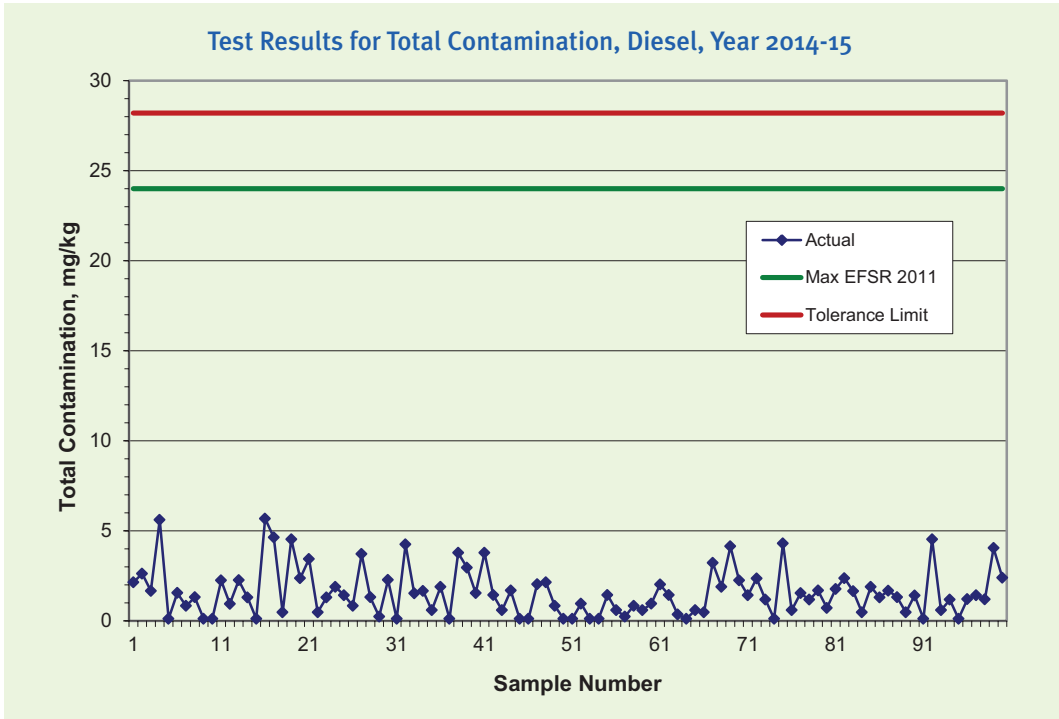
# Total Contamination

The Total Contamination should be tested by IP440<sup>22</sup> prescribed in the Regulations.

Regulations (Fig. 17). The tolerance limit is 28.5 mg/kg.

All samples were found to be well below the maximum limit of 24 mg/kg specified in the

Fig. 17



<sup>22</sup> BS EN 12662:2014, BS 2000-440:2014. *Liquid petroleum products. Determination of total contamination in middle distillates, diesel fuels and fatty acid methyl esters.*



## Sulphur

Sulphur content can be tested according to IP 497<sup>23</sup> or ASTM D5453<sup>24</sup> prescribed in the Regulations. Respectively, there are two slightly different tolerance limits identified for the two methods: 11.8 mg/kg for IP497:2011 and 11.9 mg/kg for D5453-12.

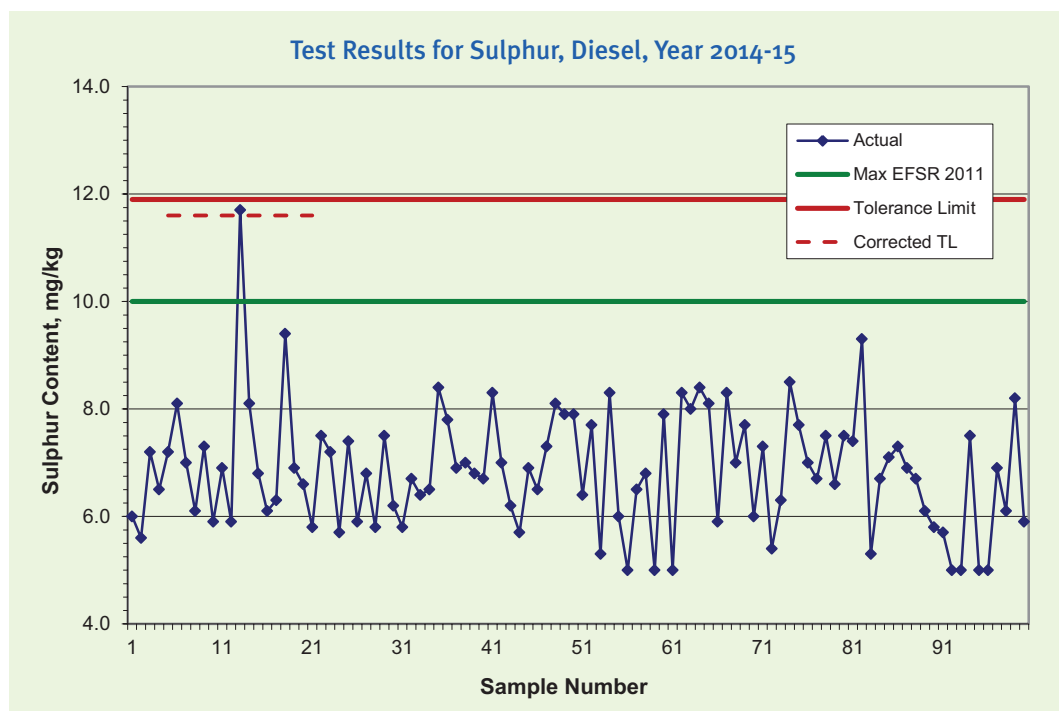
All samples except one were found to be below the maximum limit of 10 mg/kg specified in the Regulations (Fig. 18).

Sample 13 was tested by IP497 and was initially found to be 12.5 mg/kg at the tolerance limit of 11.8 mg/kg for a single test.

The tests repeated by the same operator returned the figure of 10.9 mg/kg with the repeatability condition satisfied,  $r=1.9$  mg/kg. A corrected tolerance limit for two results is 11.6 mg/kg. On investigation it was found that the average of 11.7 mg/kg was marginally above the testing tolerance limit so, according to the established policy, Sample 13 was deemed to be marginally non-compliant.

Although no further action was undertaken, it has been recognised that in such cases further testing is required, preferably, by both methods and by different operators.

Fig. 18



<sup>23</sup> IP 497 ISO 20884:2011: *Petroleum products — Determination of sulfur content of automotive fuels — Wavelength-dispersive X-ray fluorescence spectrometry.*

<sup>24</sup> ASTM D5453-12 *Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence.*

## Cloud Point

Cloud point of diesel should be tested according to ASTM D5773<sup>25</sup> prescribed in the Regulations.

The cumulative results for Cloud Point (CP) are presented below by combining the lowest prescribed maximum limits for each season in one graph (Fig.19). Generally, if results were below the lowest maximum limit established for an area they definitely complied with the Regulations in all other areas.

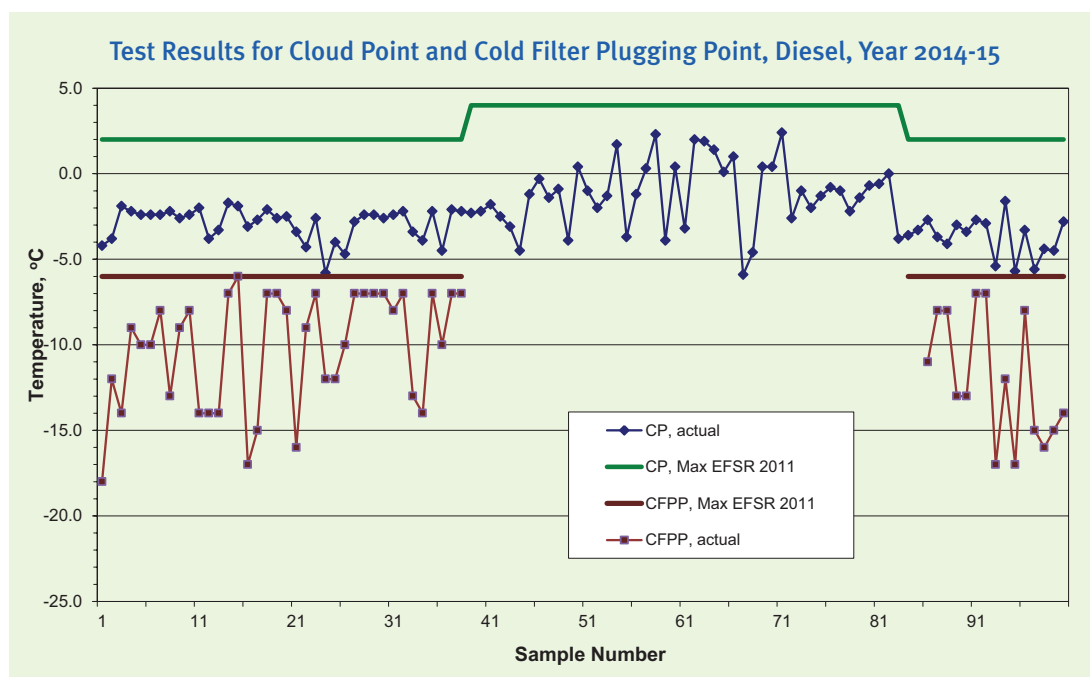
For the period of summer in Schedule 2 (season definitions in Section 5, the Regulations) from 15 October to 14 April inclusive, the lowest maximum limit of CP +4°C is prescribed for all New Zealand excluding Auckland and Northland.

The bottom line before and after the pedestal, is the next lowest maximum, +2°C, which is prescribed for all New Zealand in winter, from 15 April to 14 October inclusive. The maximum limit prescribed for summer in Auckland and Northland, is +6°C and not shown in the graph. All tolerance limits are 0.5°C above each specified limit.

All samples within the relevant seasons appeared to be below the lowest maximum limit. Sample 71 returned the highest testing result for summer, +2.4°C, at the maximum limit of +4°C.

The lowest figure for CP was found to be -5.9°C for Sample 67 from the South Island.

Fig. 19



<sup>25</sup> ASTM D5773-15 Standard TTest Method for Cloud Point of Petroleum Products (Constant Cooling Rate Method).



## Cold Filter Plugging Point

Cold filter plugging point of diesel should be tested according to IP309<sup>26</sup> prescribed in the Regulations.

The test results for Cold Filter Plugging Point (CFPP) are set out on the same graph as that for CP (Fig.19). This gives an advantage to see the data 'at glance' and compare the two sets where necessary.

CFPP is defined only for the winter season with maximum limit of  $-6^{\circ}\text{C}$ .

All samples except one were found to be below the maximum limit specified in the Regulations for the winter season. Sample 15 was found to be on the limit. Sample 1 was found to have the lowest CFPP of  $-18^{\circ}\text{C}$  with a result for CP of  $-4.2^{\circ}\text{C}$ .

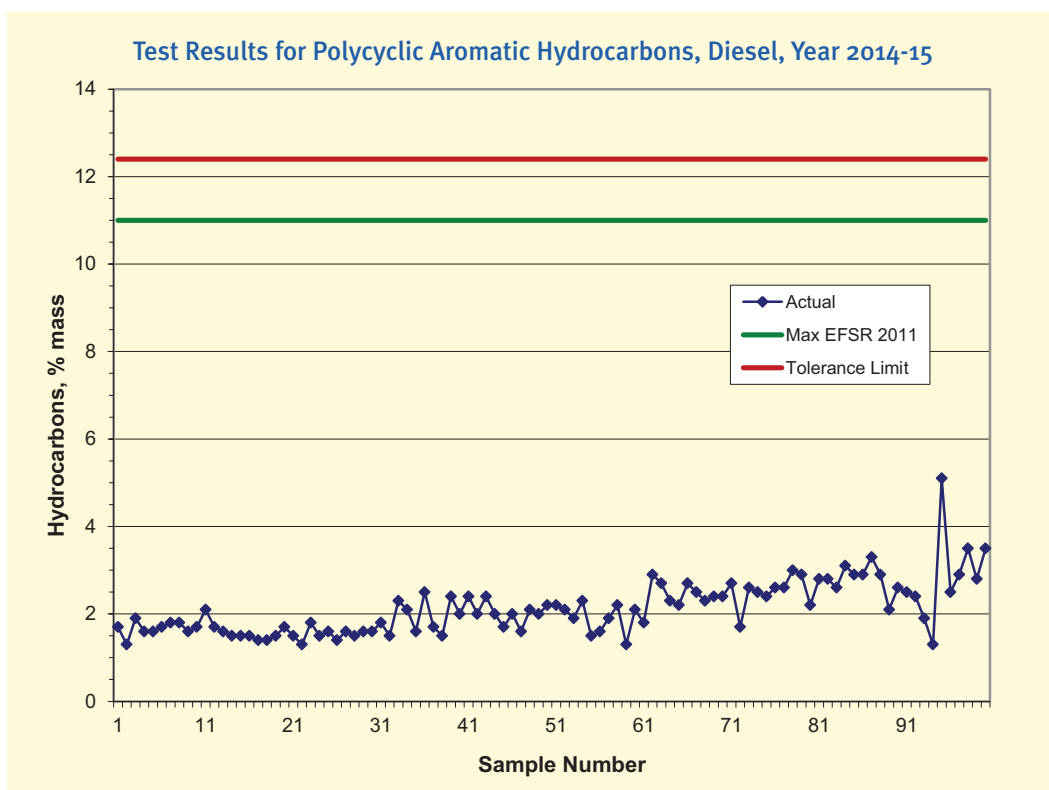
The tolerance limit is  $-4.2^{\circ}\text{C}$ .

## Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons should be tested by IP391<sup>27</sup> prescribed in the Regulations. All samples were found to be well below the maximum limit of 11% specified in the Regulations.

All testing results were found to be below 5% except one of 5.1%. The tolerance limit is 12.4%.

Fig. 20



<sup>26</sup> BS EN 116:1998, BS 2000-309:1998 *Diesel and domestic heating fuels. Determination of cold filter plugging point.*

<sup>27</sup> BS EN 12916:2006, BS 2000-391:2006 *Petroleum products. Determination of aromatic hydrocarbon types in middle distillates. High performance liquid chromatography method with refractive index detection.*

## Filter Blocking Tendency

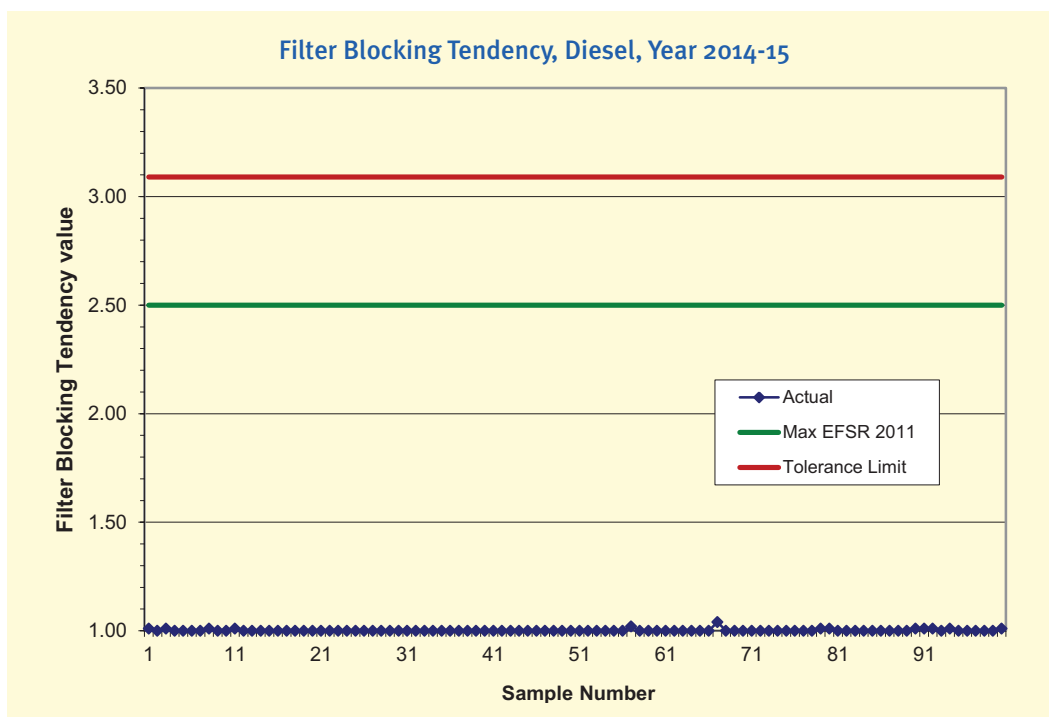
Filter blocking tendency can be tested by IP387<sup>28</sup> or ASTM D2068<sup>29</sup> prescribed in the Regulations.

All samples were found to be well within the specified maximum limit of 2.5 for filter

blocking tendency. Further, all actual figures were in the range from 1.00 to 1.05 which means practically perfect filtering of the product.

The tolerance limit is 3.09.

Fig. 21



<sup>28</sup> BIP 387:2014 Determination of filter blocking tendency.

<sup>29</sup> ASTM D2068-14 Standard Test Method for Determining Filter Blocking Tendency.



## Lubricity

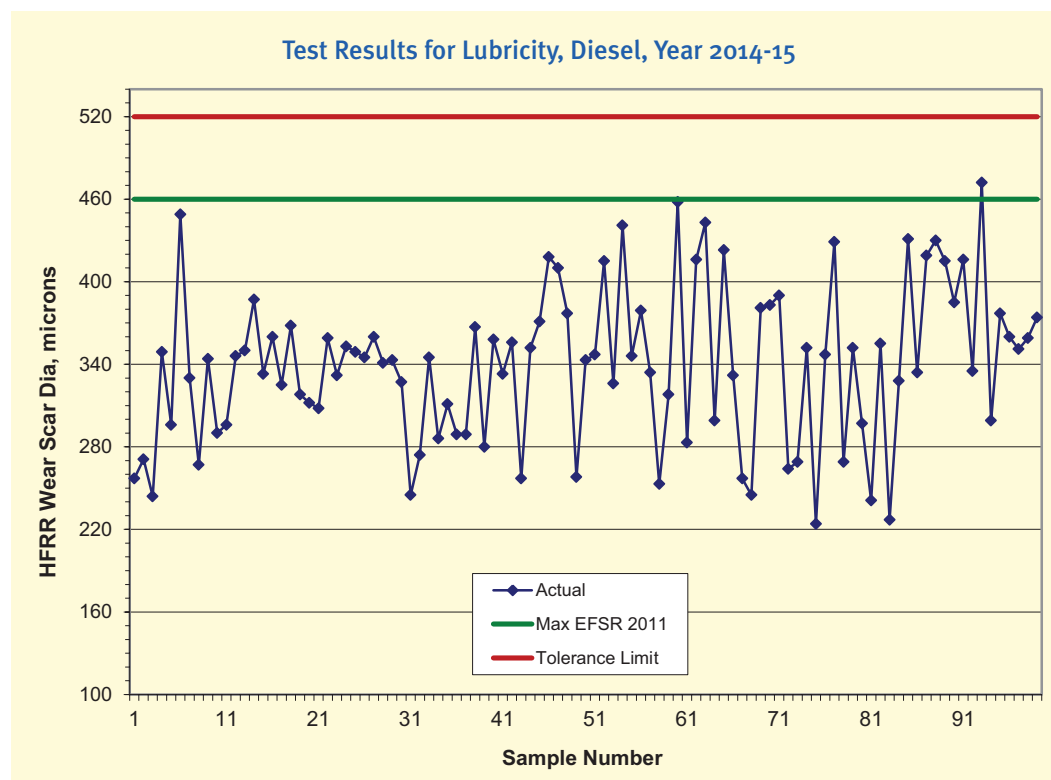
Lubricity should be tested by IP450<sup>30</sup> prescribed in the Regulations.

All samples except one were found to be below the specification maximum limit for the lubricity identified as a diameter of the wear scar produced on an oscillating ball from contact with a stationary plate immersed in the fluid. The diameter is usually measured in microns: the specification maximum limit is 460  $\mu\text{m}$ . The tolerance limit is 520  $\mu\text{m}$ .

An exception was Sample 93 which was initially found to be 469  $\mu\text{m}$ , *i.e.* above the specification limit although within the test tolerance limit *i.e.* well below 520  $\mu\text{m}$ . The repeated test returned the figure of 474  $\mu\text{m}$ , with the repeatability condition satisfied,  $r=63$   $\mu\text{m}$ , at the testing tolerance limit of 514  $\mu\text{m}$ . Therefore Sample 93 was interpreted as compliant.

Sample 60 was found to be close to the limit although within the specification: 458  $\mu\text{m}$ .

Fig. 22



<sup>30</sup> BS 2000-450:2000 *Methods of test for petroleum and its products. Diesel fuel. Assessment of lubricity using the high-frequency reciprocating rig (HFRR). Test method.*



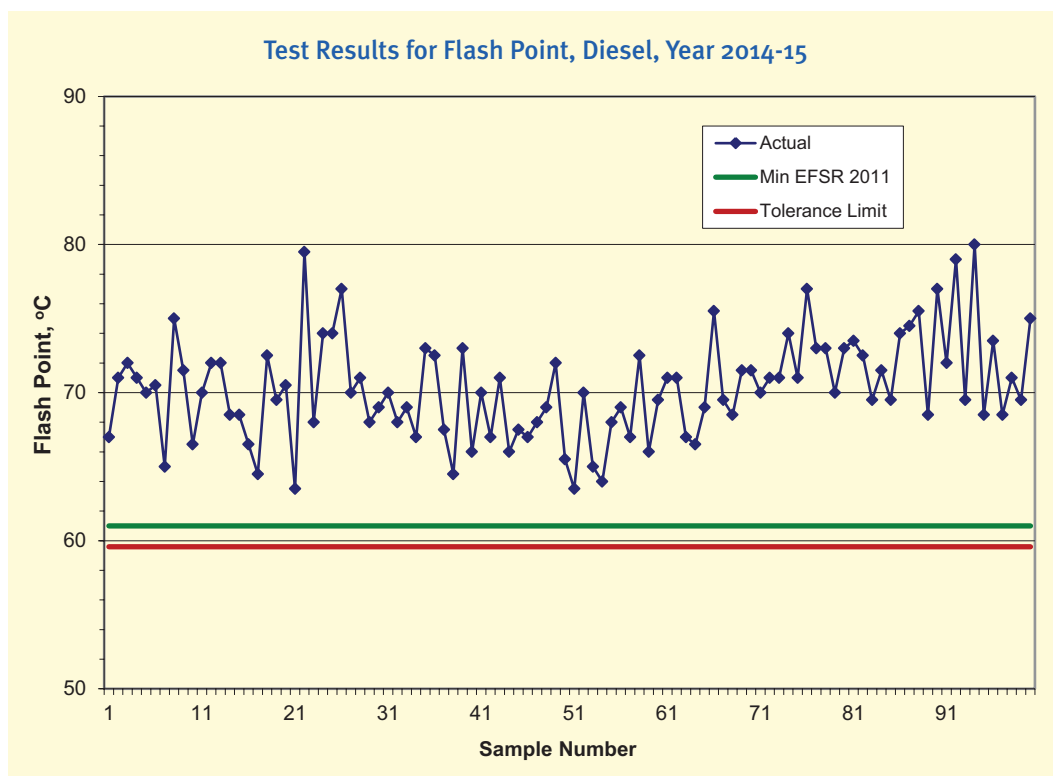
## Flash Point

Flash point should be tested by ASTM D93<sup>31</sup> prescribed in the Regulations.

All samples were found to be well above the specified minimum limit of 61°C for flash point of diesel.

The vast majority of the test results were in the range above 65°C with the minimum result of 63.5°C for Samples 21 and 51. The tolerance limit is 59.6°C.

Fig. 23



<sup>31</sup> ASTM D93-15a *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*.



## Viscosity

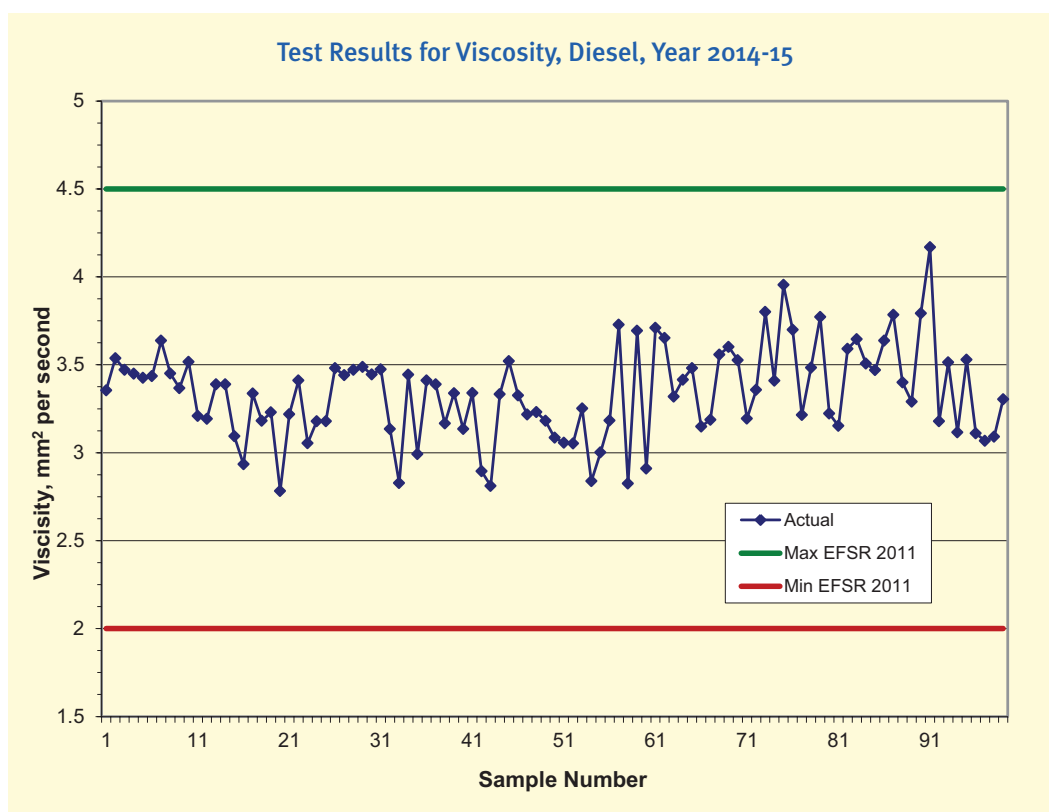
The viscosity should be tested at 40°C by ASTM D445<sup>32</sup> prescribed in the Regulations.

All samples were found to be well above the specified minimum limit of 2.0 mm<sup>2</sup> per second and below the specified maximum limit of 4.5 mm<sup>2</sup> per second for viscosity of diesel.

The vast majority of the test results were in the range between 3.0 and 4.0 mm<sup>2</sup> per second

with the minimum result of 2.782 mm<sup>2</sup> per second for Sample 20 and the maximum result of 4.168 mm<sup>2</sup> per second for Samples 91. The minimum tolerance limit is 1.974 mm<sup>2</sup> per second and the maximum tolerance limit is 4.559 mm<sup>2</sup> per second (not shown on Fig.24).

Fig. 24



<sup>32</sup> ASTM D445-15 *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)*.

## Summary for Diesel Test Results

There were two suspected non-compliance cases and there were no repeated cases of non-compliance identified.

One suspect non-compliant sample detected during the period of this report related to a sample of diesel where the sulphur content on investigation was initially found to be above the specified limit of 10 mg/kg with an actual figure of 12.5 mg/kg. This sample was found to be outside specification after subsequent additional testing and analysis with the average of 11.7 mg/kg above the corrected tolerance limit of 11.6 mg/kg therefore the product was deemed to be marginally non-compliant.

Another suspect non-compliant sample detected during the period of this report related to a sample of diesel where the lubricity on investigation was initially found to be above the specified limit of 460  $\mu\text{m}$  with an actual figure of 469  $\mu\text{m}$ . This sample was found to be outside specification after subsequent additional testing and analysis

however the average of 472  $\mu\text{m}$  was within the corrected tolerance limit of 514  $\mu\text{m}$  therefore the product was deemed to be compliant.

In the past, testing for oxidation stability of diesel has not been usually done as it is for petrol. This was due to the relatively short periods of storing diesel fuel by the retail industry. However, the test was added since early 2014 to the regular list of tests with a special testing frequency of approx. two tests per month and continued until the end of 2014. All results were found to be well within the maximum specified limit of 25 g/m<sup>3</sup>.

This year, testing diesel for appearance according to the ASTM standard D4176<sup>33</sup> which is not listed in the Regulations, was continued. This was done in order to maintain confidence that water in bulk and/or other contamination, if present, would be identified. No test results were found to be suspect on appearance.

<sup>33</sup> ASTM D4176-04(2014) *Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)*.





## Biofuels

### Summary of Testing

Various fuels such as biodiesel as well as ethanol blended petrol, were tested throughout the period of this report. As in previous annual reports, the actual results are not shown due to the commercial sensitivity of the data.

### Retail Fuel Sampling and Testing

#### *Biodiesel B5*

Like last year, this blend was tested 6 times throughout the year at retail sites. The product falls into the category of diesel by definition in the Regulations, with FAME (Fatty Acid Methyl Esters) content up to 5%. All samples were found compliant with the relevant specifications in the Regulations.

#### *Ethanol blended petrol E3 and E10*

This year, a project on ethanol blended petrol was continued with the intention to verify that blended petrol was within specifications. It was focussed on dry vapour pressure in particular because some samples had in the past been found outside specification. Seven samples of regular petrol blended with ethanol and labelled as E3 and eleven samples of premium petrol blended with ethanol and labelled as E10, were sampled and tested from the retail sites of two fuel retail companies.

The overall result of this project was that the dry vapour pressure was found within the prescribed specifications, for all the samples.

#### *Ethanol blended petrol E85*

Four retail sites in New Zealand now offer fuel ethanol *i.e.* blend with an ethanol content from 75 to 85% labelled as E85. This product is mainly intended for motor sport cars and its dispenser is distinctively labelled to differentiate the product from traditional retail fuels. Fuel for motor vehicle racing is exempt from the Regulations although there are flexible fuel vehicles available in New Zealand which are able to use E85.

Since the E85 dispensers at these sites are accessible to the public, and therefore the product available to retail customers, it was deemed prudent to test its properties.

Currently, parameters for E85 blends are not specified in the Regulations. However, this type of fuel is specified by the Standard ASTM D5798<sup>34</sup> which was chosen as a reference standard for the list of properties to be tested. Two samples taken during the report period were found to be within prescribed specifications according to ASTM D5798, with the ethanol content of 85.03% and 81.59%, with the tolerance limit of 85.64%.

The need to include into the Regulations specifications for fuel ethanol, is currently being considered by the Ministry.

<sup>34</sup> ASTM D5798 – 15 *Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines.*



## Non-Retail Fuel Sampling and Testing

This year, the Ministry continued sampling and testing biodiesel, in particular, B100 (pure biodiesel) and B10 (10% blend with mineral diesel). Biodiesel B100 was tested according to the requirements of Schedules 3 in the Regulations while B10 blend was tested according to the Regulation 17.

In total, eight samples of biodiesel were collected from production plants or non-retail refuelling sites and tested. These include four samples of B100 and four samples of B10.

### *Biodiesel B100*

Problems with accurate measurement of FAME content remained in the focus of the testing programme. The Ministry in collaboration with IPL continues to contribute to the on-going review of the standard by international standard committees such as CEN and ISO.

A few samples out of four were found to be below the specified minimum limit but within the tolerance limit.

In the recent past, water content had often been found above the specified maximum limit. After corrective actions implemented by the producer, this year the water level was found to be on specification in all four instances.

Further, total acid number was once found to be above the specified maximum limit. After Ministry's intervention the acidity was brought under the required limits.

Also, in the recent past, total contamination had often been found above the prescribed maximum limit. After corrective actions, this year the results were found to be within the specification.

### *Biodiesel B10*

This blend was considered to be a final product supplied to customers and therefore the properties listed in Regulation 17 were tested along with a few additional properties such as the filter blocking tendency. Filter blocking tendency is deemed to be an essential parameter for the product to be 'fit for purpose'.

Four samples of B10 were collected either at the plant dispenser or at the non-retail point of sale.

In two instances the FAME content was found to be slightly above the stated maximum of 10% with the actual figures of 13.4% and 12.5%, at the tolerance limit of 10.4%. These results indicate that there could possibly be a problem with homogeneity of the biodiesel mix. The filter blocking tendency for these samples was found to be, respectively, 1.00 and 1.01, at the maximum limit of 2.5. Although, the largest figure of filter blocking tendency which was found in another sample of B10, was found to be 1.47.

In all these cases, the remedial actions were undertaken by the producer with respect to the product at the plant so the product was not dispensed to customers.

All findings on suspect non-compliance however marginal they were discussed with the producers in detail and adjustments to the production processes were identified and implemented.

**NOTE:** It must be noted that none of the potentially non-compliant fuels identified by sampling and testing biofuels ever entered the retail fuel supply chain and they were subject to remedial action by the producers before subsequent release or disposal.

The specifications for properties of biofuels are still under review and development by the international standardisation committees (CEN and ASTM technical committees in particular).

The Ministry continues to monitor and contribute to this work to ensure New Zealand has sufficient technical knowledge in this area and our perspectives and issues are represented and considered internationally.

