



Fuel Quality Monitoring Programme

Test Results 2013–14

TRADING STANDARDS



**Ministry of Business,
Innovation & Employment**

New Zealand Government

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Executive Summary

New Zealand is highly reliant on motorised road transport for its social and commercial wellbeing. To put this reliance in perspective, in 2013 New Zealanders spent approximately \$11.5 billion on petrol and diesel. It is important that there is certainty in relation to the quality of the fuels used to ensure their safe and effective usage and to minimise negative environmental impacts.

This certainty is provided by the Fuel Quality Monitoring Programme (**the Programme**) administered by the Trading Standards unit of the Ministry of Business, Innovation and Employment. This programme samples and assesses the quality of retail fuel in New Zealand and monitors its compliance with the specifications set out in the Engine Fuel Specifications Regulations 2011 (**the Regulations**)¹.

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 and constituents of 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 point of sale.

This report is intended to give an overview of the results of the Programme from 1 July 2013 to 30 June 2014. During this period retail fuel samples were collected and tested from 100 of the approximately 1,200 fuel service stations in New Zealand.

This report also includes 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 fuel 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 relevant 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.

A small number of samples of biodiesel intended for non-retail sale were found to be potentially non-compliant when tested before supply to customers. None of this potentially non-compliant biofuel entered the retail fuel supply chain and it was subject to remedial action by the producers. The suspect non-compliant properties are discussed in the biofuel section of this report.

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



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

It provides technical detail and comment that is intended to be relevant and useful for fuel industry experts, researchers and stakeholders.

For further explanation or to comment on the reported results please contact Trading Standards at:

Tel: 0508 627 774 or

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Introduction

Trading Standards is an operational unit within the Market Services Group of the Ministry of Business, Innovation and Employment which 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;**
- **Registration of Auctioneers;**
- **Registration of Motor Vehicle Traders;** and
- **Fuel Quality Monitoring (*the focus of this report*)** – 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 Trading Standards’ 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; and
- 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 New Zealand and internationally; and
- 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 1989².

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.

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



This report sets out the results of the Programme from 1 July 2013 to 30 June 2014. It provides technical detail and comment that is intended to be relevant and useful for fuel industry experts, researchers and stakeholders. Consumer enquires or requests for non-technical explanations of the detail in this report can be directed to Trading Standards at: Tel: 0508 627 774 or Email: tradingstandards@mbie.govt.nz

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 site³ or in previous FQM Programme annual reports for the period from 2008 to 2013.

Collection of fuel samples during this period was carried out by SGS New Zealand Ltd under the direction of Trading Standards. The collected 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, 100 sample sets were collected from retail sites and each set included samples of regular and premium grade petrol and a sample of diesel.

The number of 'sample sets' collected and tested this year were similar to the previous year despite increased prices for testing services in the second half of the financial year.

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.

Two 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

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

has allowed Trading Standards to estimate the fraction 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 into account it was concluded that no increase in the total number of routine samples is needed compared to that in the previous three 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 4259:2006⁴ 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 identified a number of areas for improvement of the quality of biodiesel. This information has been provided directly to the relevant industry stakeholders.

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

In 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.

Terminal/Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Whangarei	0	0	0	0	0	0	0	0	1	2	0	1	4
Auckland	2	2	3	2	3	2	2	2	3	1	2	1	25
Mt Maunganui	1	3	1	0	1	2	3	1	0	1	2	1	16
New Plymouth	0	0	0	0	2	0	1	1	0	0	0	0	4
Napier	0	0	0	1	2	1	0	0	0	0	1	1	6
Wellington	1	2	1	1	1	1	2	2	2	1	0	0	14
Nelson	1	0	1	0	0	1	0	0	1	0	0	1	5
Lyttelton	2	2	1	1	0	1	0	1	0	3	1	0	12
Timaru	0	0	0	1	0	1	0	0	1	1	1	0	5
Dunedin	2	0	1	1	0	0	0	0	1	0	0	0	5
Bluff	0	0	0	1	0	0	1	2	0	0	0	0	4
Total	9	9	8	8	9	9	9	9	9	9	7	5	100

⁴ 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)

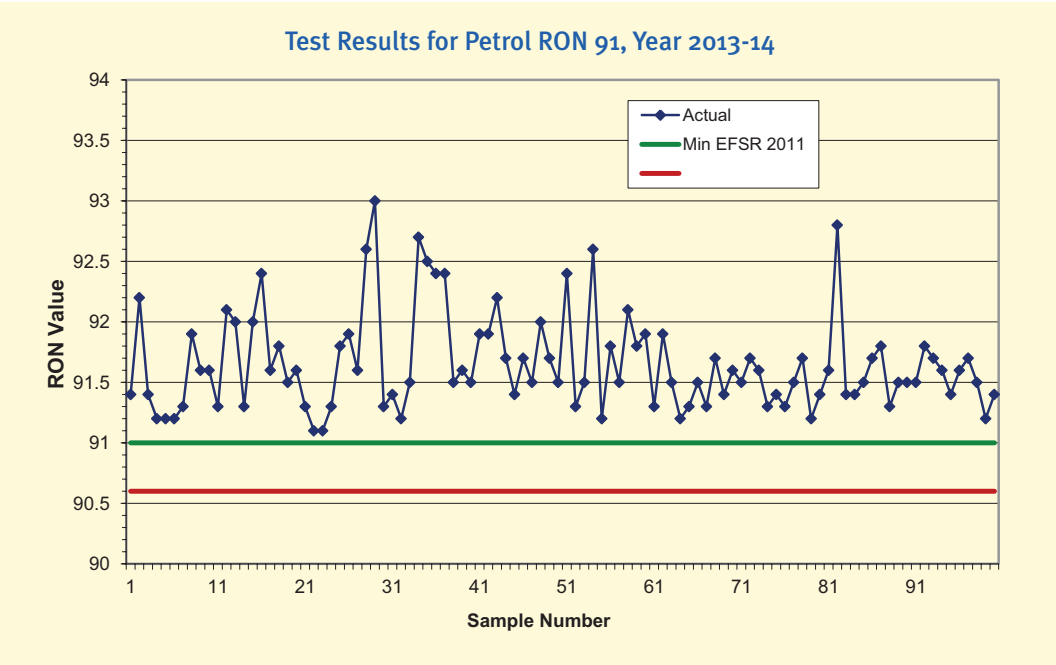
RON 91

In total, 100 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 legend ‘EFSR’ means the specification limit prescribed in the Regulations; each result is independent from others although they are connected in the graphs for convenience to follow.

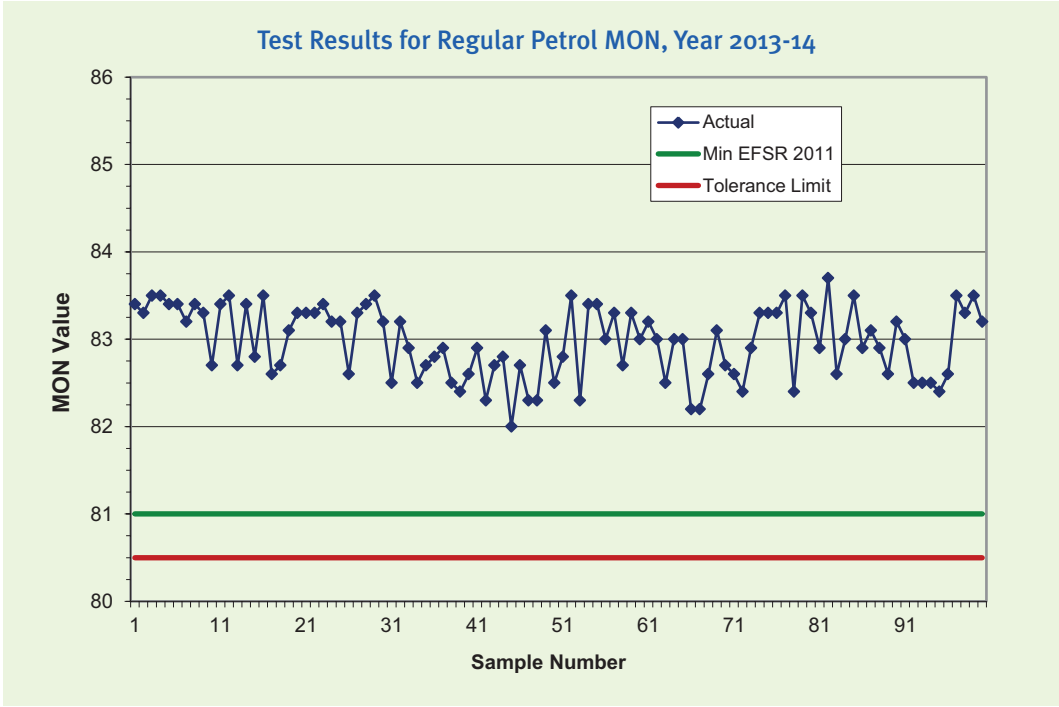




All samples were found to be above the minimum specification limits of 81.0 for MON.

To sum-up, all samples were found to be compliant with the Regulations.

Fig. 1b



RON 95

In total, 83 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. Only sample 7 was 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 47, 57, 74

and 77 were found to be on the specification limit.

An exception was Sample 59 which was initially found to be 84.9, *i.e.* below the specification limit of 85.0 although within the test tolerance limit *i.e.* above 84.5. The repeated test returned the same figure of 84.9, with the reproducibility condition obviously satisfied, $R=0.9$. Therefore Sample 59 was interpreted as compliant. The relevant figure for RON was above the minimum limit.

Fig. 2a

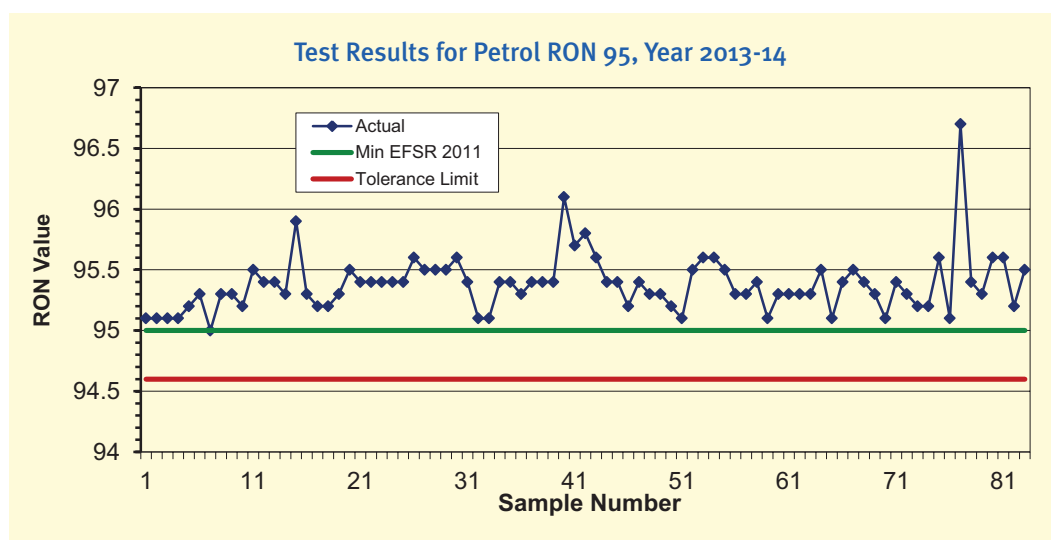
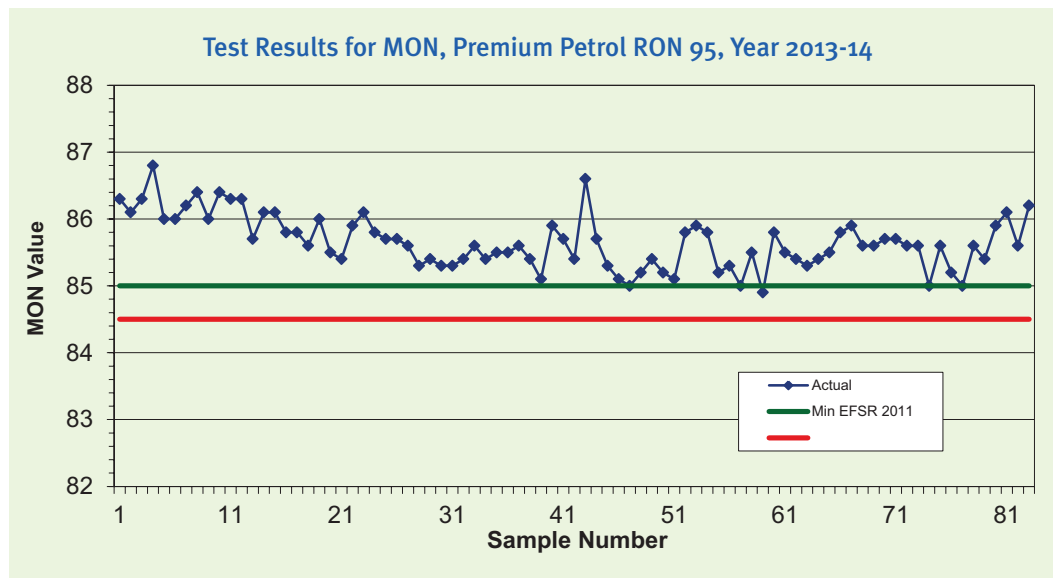




Fig. 2b



RON 98

No minimum value is specified in the Regulations for premium petrol with RON 98. In this circumstance, fuel that 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, must conform, according to Section 11 of the Regulations, to those advertised properties when tested by 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 misdescription. 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

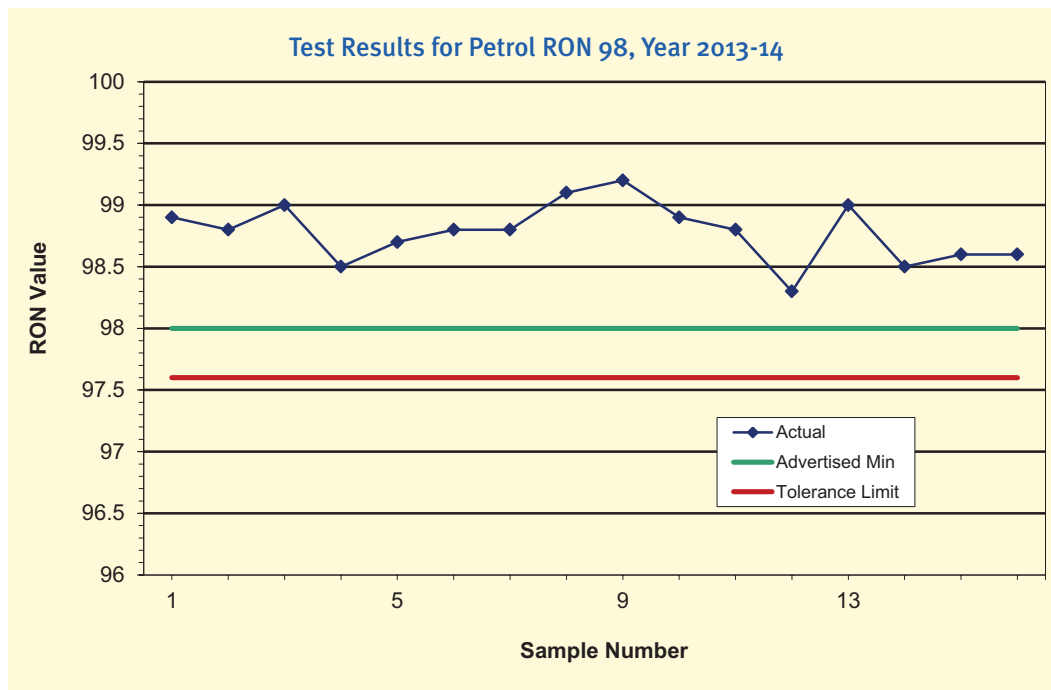
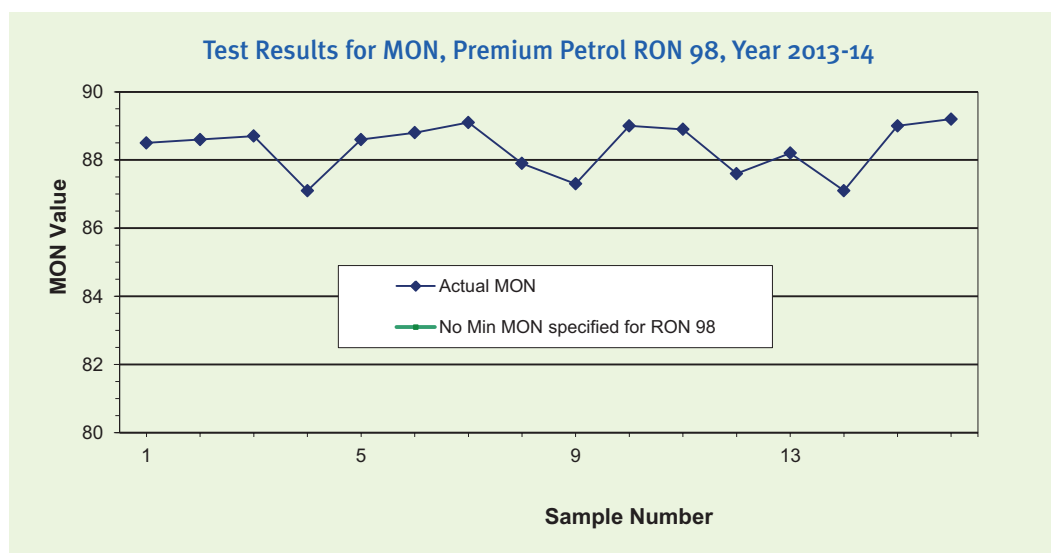


Fig. 3b





Evaporation Percentage

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 95 data include that with RON 98).

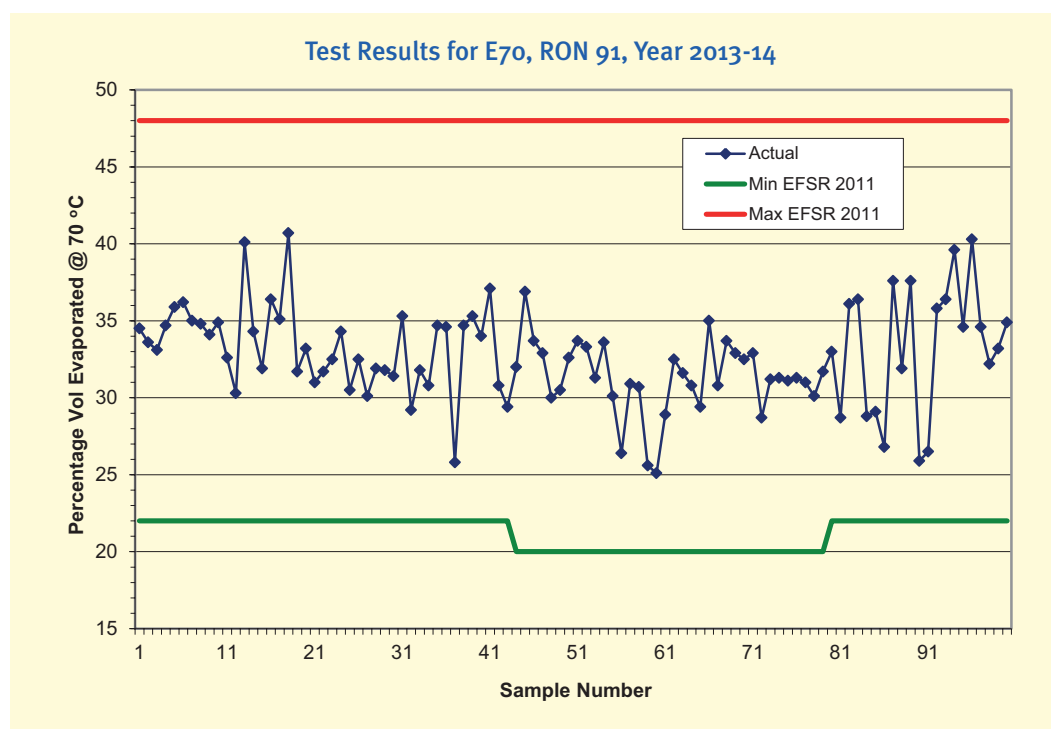
RON 91

Percentage Volume Evaporated @ 70°C

For petrol not containing ethanol, the minimum specification limit is 22% and maximum specification limit is 48% while the relevant minimum tolerance limits are 20.5% 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%, according to the Footnote 1 in the Regulations of 2011 (see Fig. 4a).

Fig. 4a

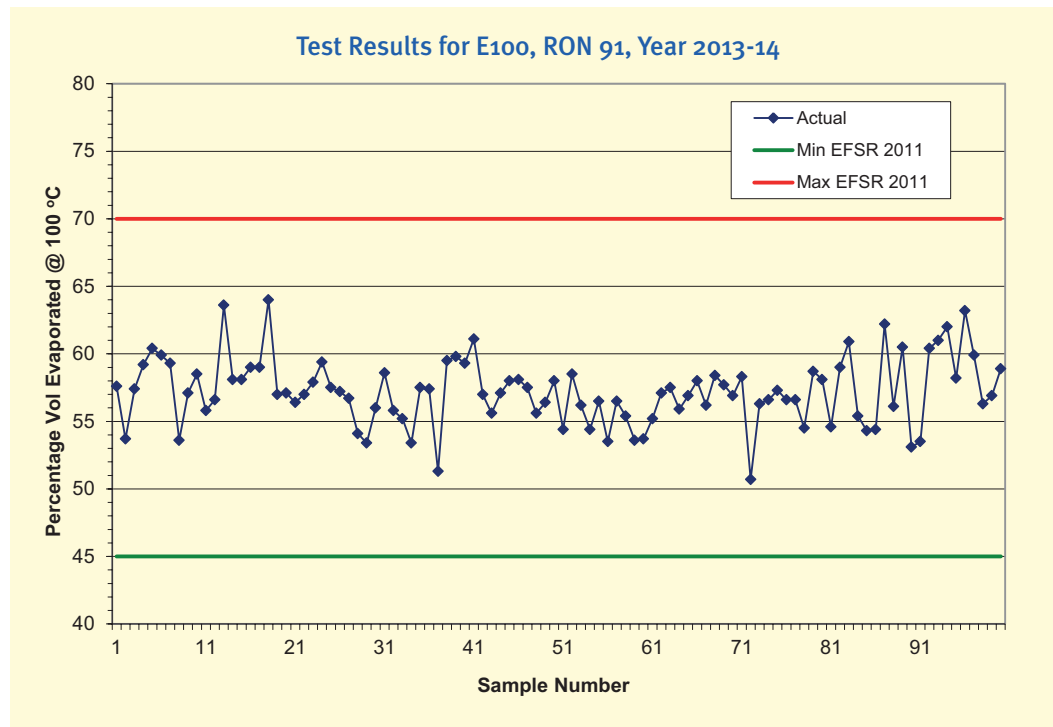


Percentage Volume Evaporated @ 100°C

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



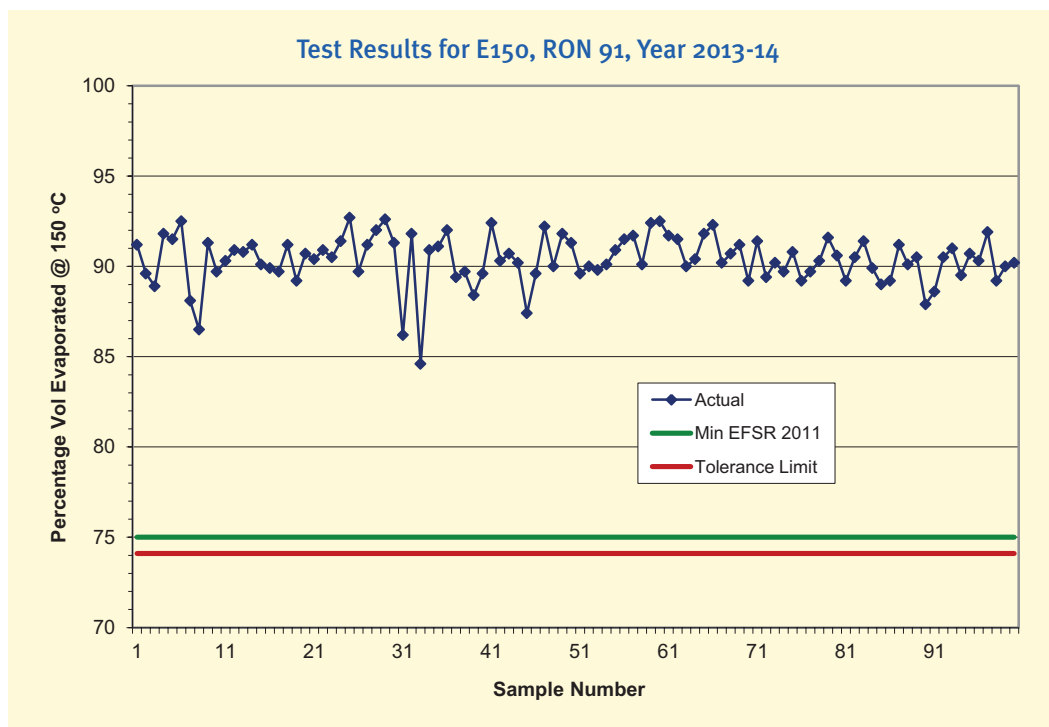


Percentage Volume Evaporated @ 150°C

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% and maximum specification limit is 48% while the minimum tolerance limit is 20.5% 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 1 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, are set out in a Table 1 below. They were all found to be within the prescribed limits for ethanol blends.

Table 1

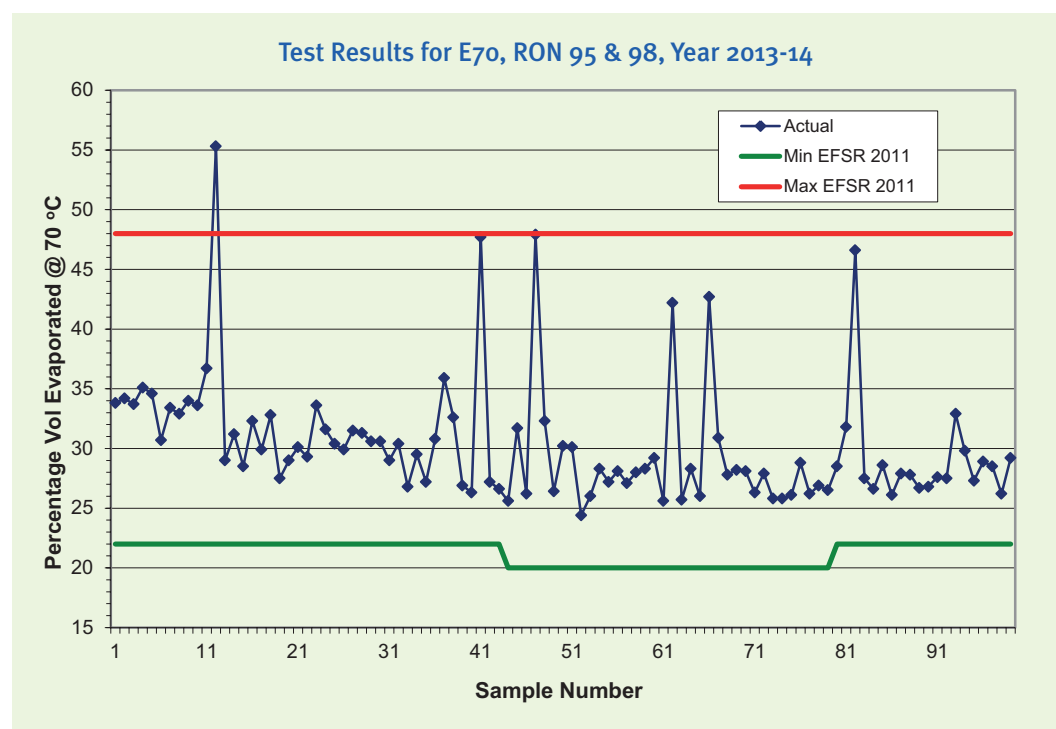
Sample	Ethanol Content, % Vol	Limit for Ethanol Blend, % Vol	Percentage Volume Evaporated @ 70°C
12	9.45	57	55.3
41	10.00*)	58	47.7
47	9.90	58	47.9
66	9.14	57	42.7
82	9.49	57	46.6

*) Ethanol content as advertised

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%, according to the Footnote 1 in the Regulations of 2011.

Fig. 5a



For Sample 12 see explanation in Table 1 above.

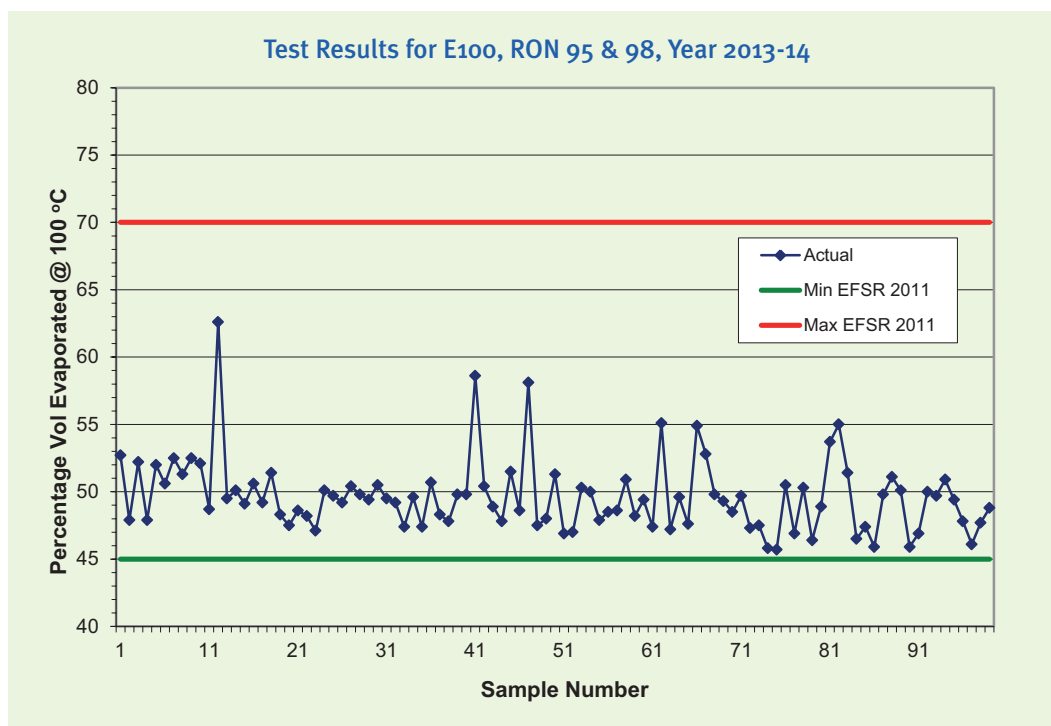


Percentage Volume Evaporated @ 100°C

All samples were found to be within the specification limits from the minimum of 45% to the maximum of 70%. Sample 75 was found to be the lowest, 45.7%.

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

Fig. 5b



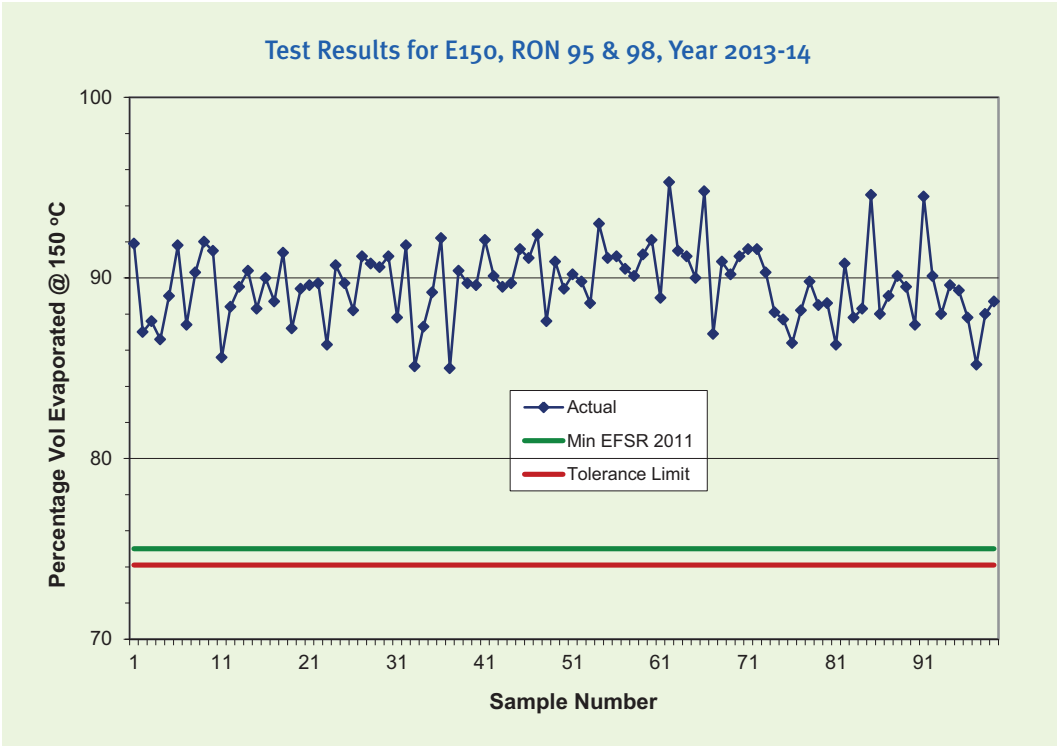
Percentage Volume Evaporated @ 150°C

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 were found to be well above 80% (Fig. 5c).

Fig. 5c





Final Boiling Point

All samples were found to be within the specification maximum limits for both regular and premium grades (Fig.6).

The largest figure for final boiling point of 204.9°C was found for Sample 8 of regular petrol.

Fig. 6a

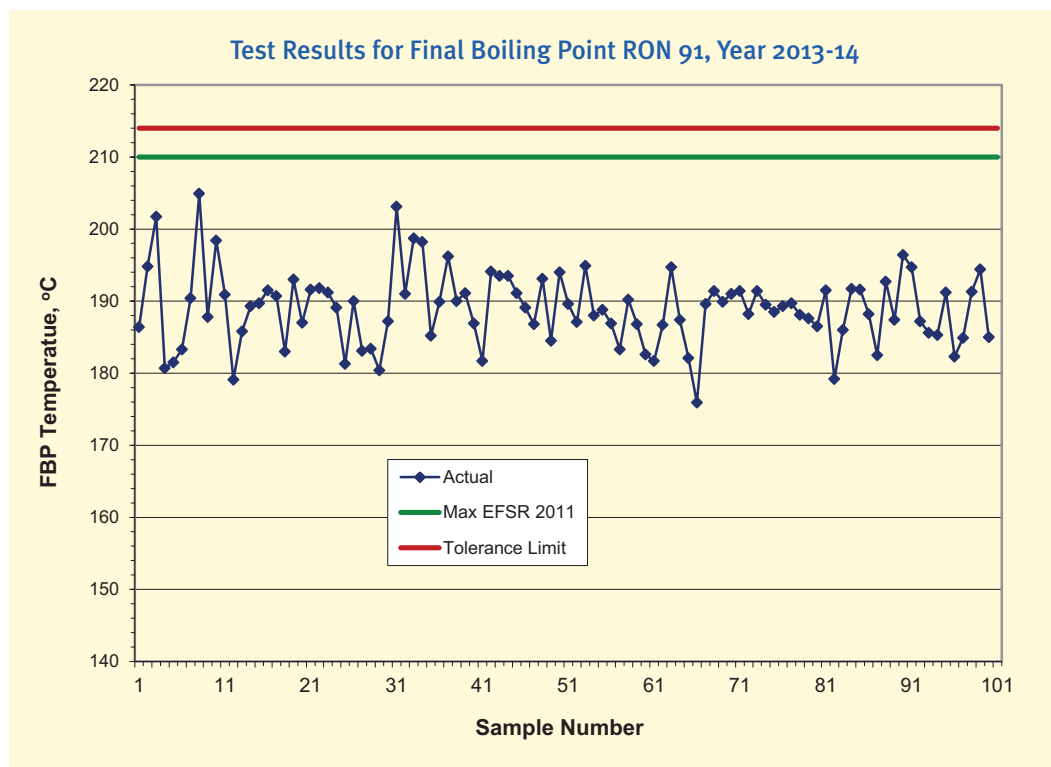
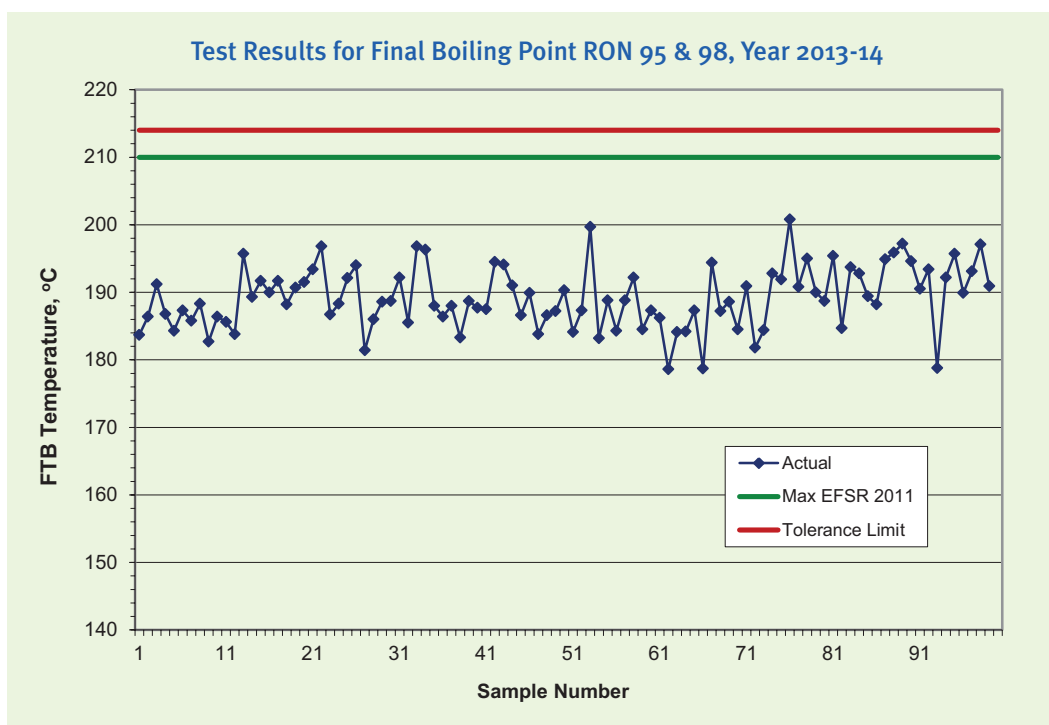


Fig. 6b



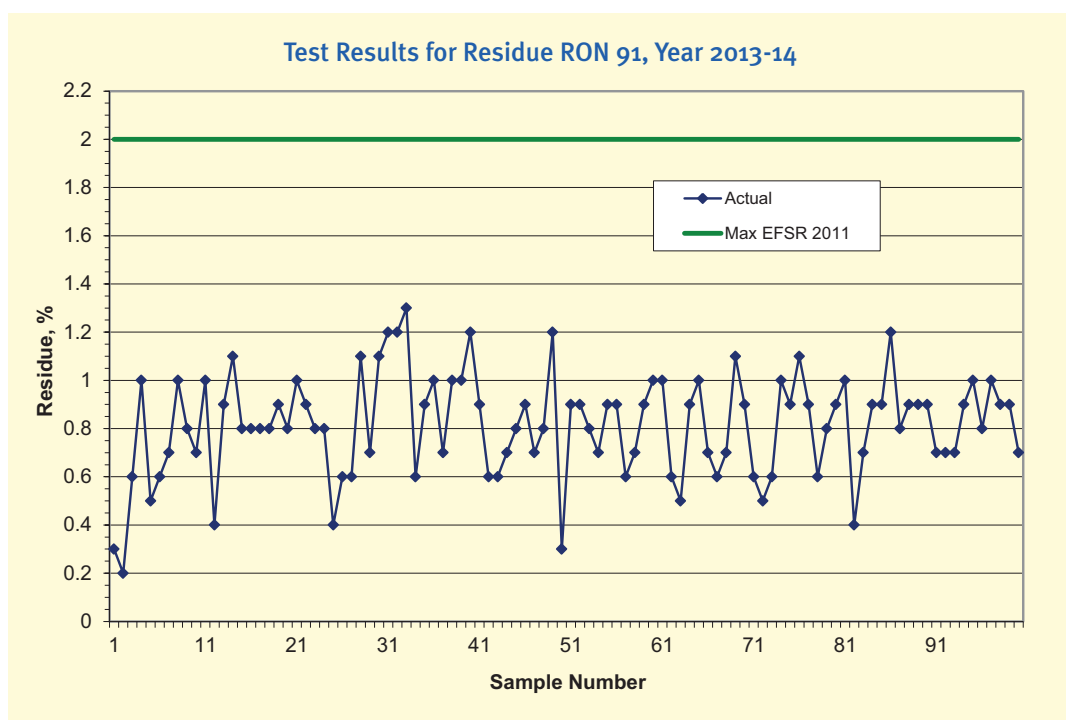
Residue

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 D86⁵.

Fortunately, residue content was found to be well below the specified maximum limit of 2% volume. The largest figure for residue of 1.3% was found for Sample 33 of regular petrol.

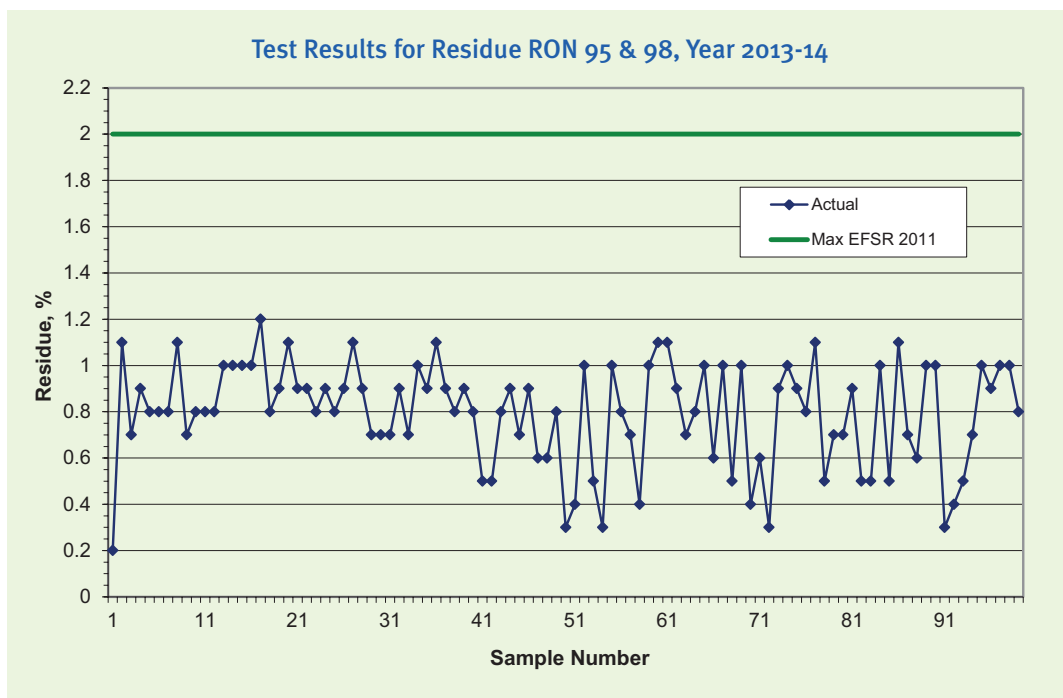
Fig. 7a



⁵ ASTM D86 - 12 Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure



Fig. 7b



Dry Vapour Pressure Equivalent

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.

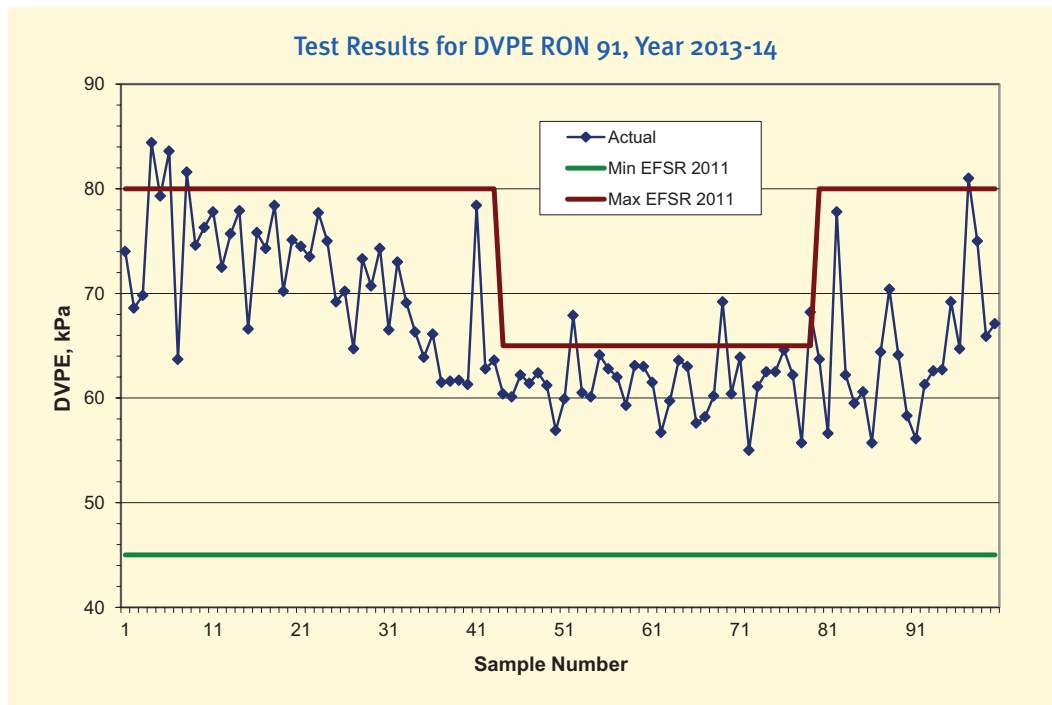
The top line before and after the dip, is the next lowest maximum, 80 kPa, which is prescribed for the North Island, for the autumn and spring periods.

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

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.

Fig. 8a



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, 6, 8, and 97, were well within the maximum limit of 90 kPa for winter in North Island.

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

Samples: 52, 69, and 79, which were drawn from South Island, were found to be in the range from 67.9 kPa to 68.2 kPa, *i.e.* well within the maximum limit of 75 kPa for the region in the summer season.



RON 95 & 98

To sum up, 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, ten samples: 1, 6, 8, 9, 10, 14, 16, 17, 18, and 97, which were found to be in the range from 80.8 kPa to 84.2 kPa, were well within the regional maximum limits for winter (90 kPa for North Island and 95 kPa for South Island).

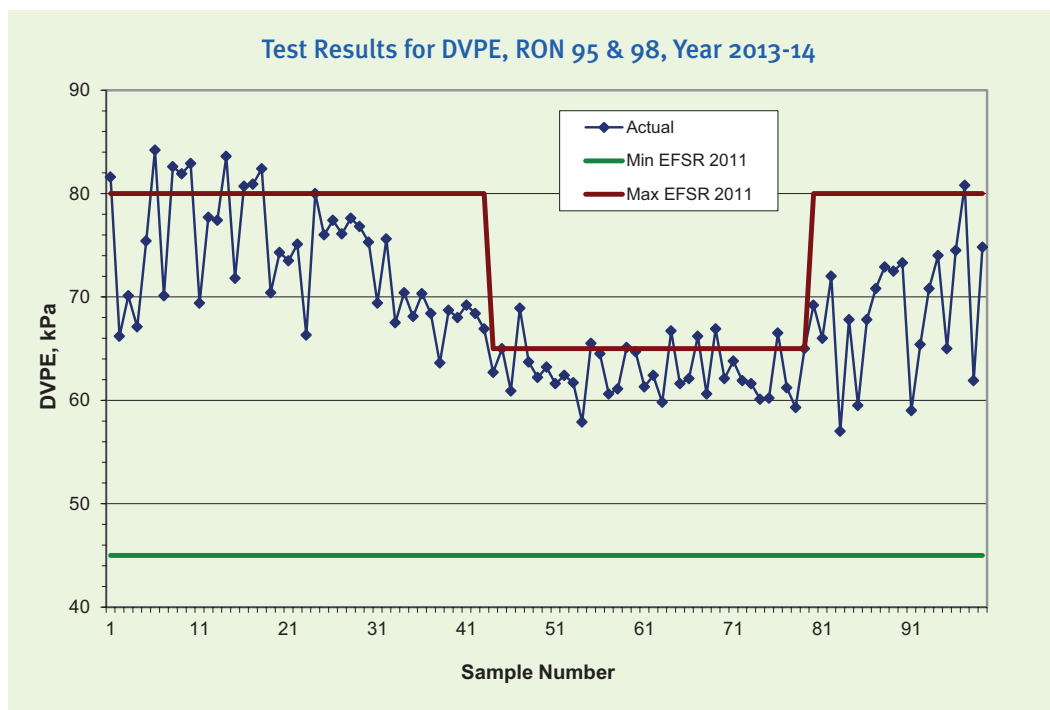
There were also nine samples found to be above the lowest maximum in the summer period.

Three samples: 45, 47, and 59, which were found to be in the range from 65.0 kPa to 68.9 kPa, were within the maximum limit of 70 kPa for the rest of North Island.

The remaining six samples in the summer season, which were found to be in the range from 65.0 kPa to 66.9 kPa, were from South Island. They were found to be well within the seasonal maximum limit of 75 kPa for the region.

Finally, Sample 24 was found to be on the maximum limit of 80.0 kPa for the North Island, spring season.

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

$$\text{FVI} = \text{DVPE} + (0.7 \times \text{E70})$$

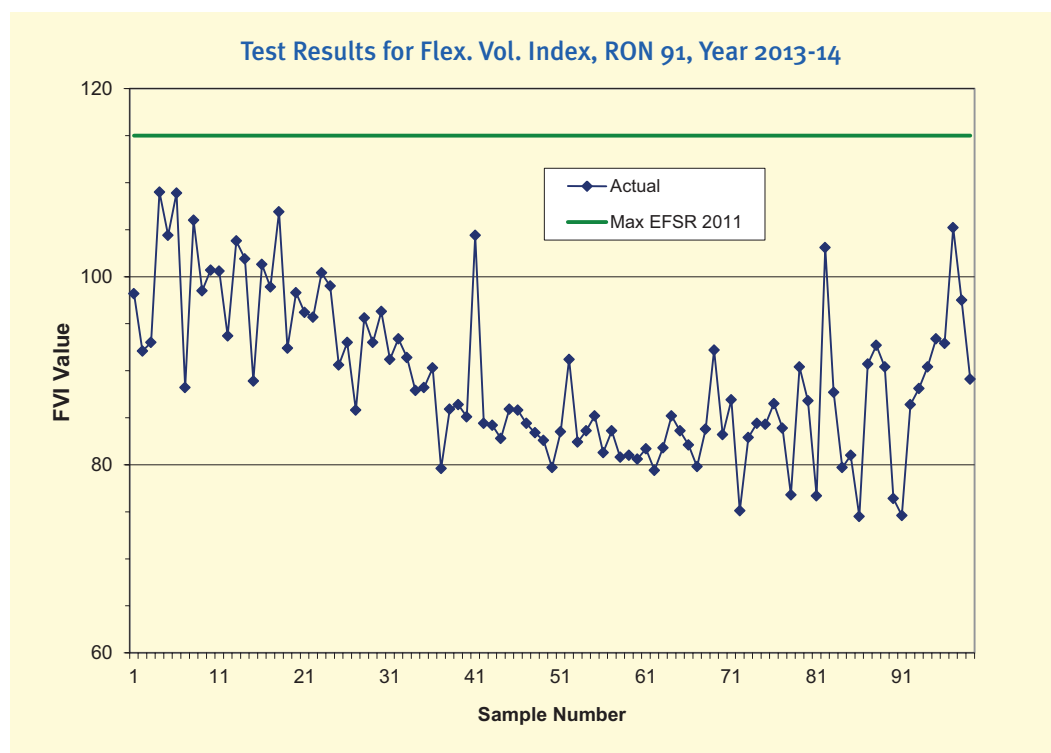
FVI serves as an indicator of hot running performance (the tendency for vapour lock). No definition of the FVI value is given in the related ASTM Standards prescribed in the

Regulations (D86 and D5191⁶) and 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



⁶ ASTM D5191 – 13 Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method).



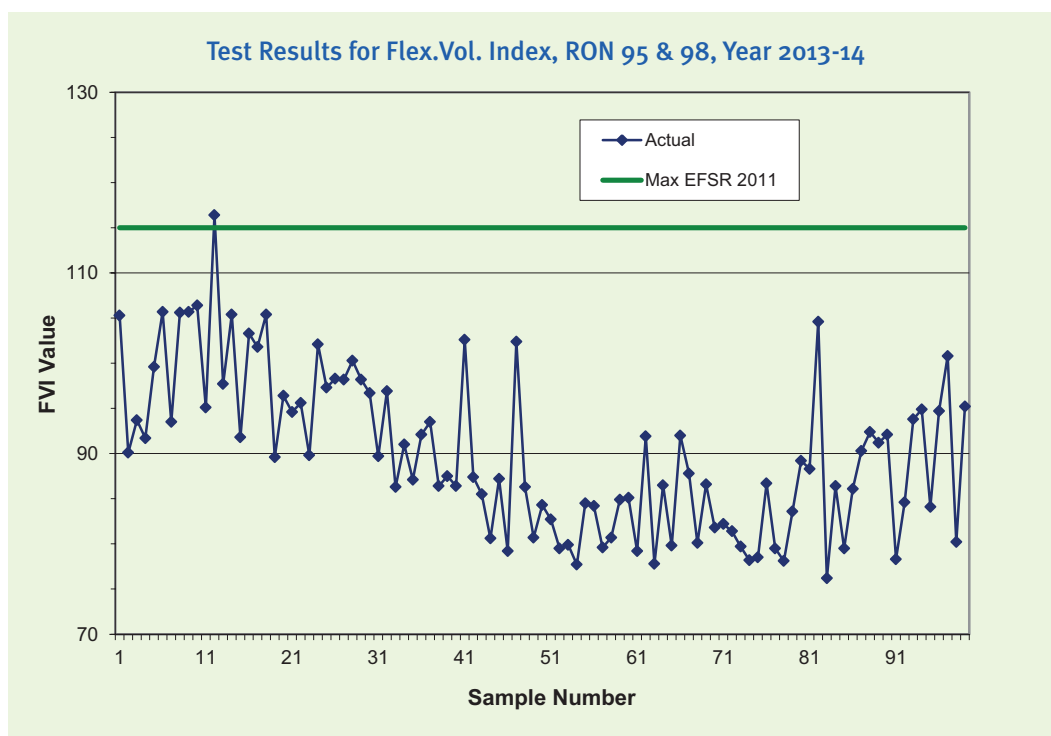
RON 95 & 98

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

Sample 12 was found to be well within the maximum limit of 130.0 specified for petrol

blended with ethanol (in this case, 9.45% blend) for winter (Footnote 3, Schedule 1), with the testing result of 116.4.

Fig. 8d



Sulphur

The scope of the test method IP 497⁷ 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.

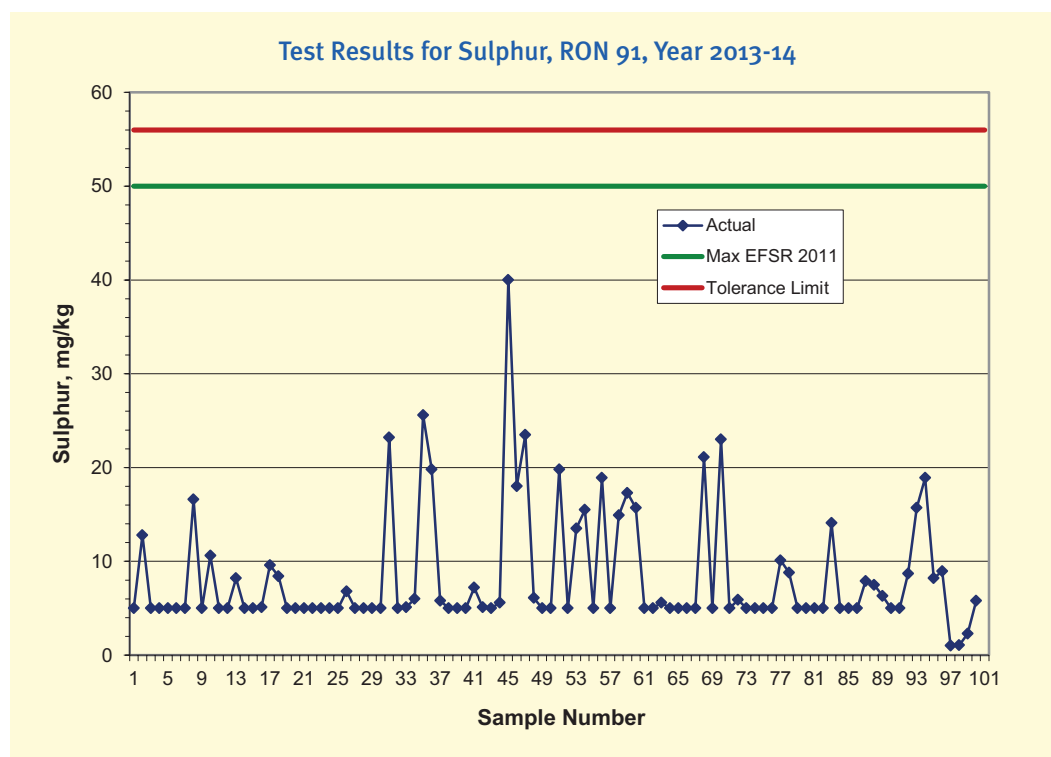
The ASTM standard D5453⁸ which is also prescribed in the Regulations along the IP 497, give results down to a fraction of 1 mg/kg although it was used by the testing laboratory for petrol just a few times this year.

RON 91

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

The majority of the results were between 5 and 30 mg/kg. Only Sample 45 was found to exceed 30 mg/kg with the actual figure of 40.0 mg/kg.

Fig. 9a



⁷ BS EN ISO 20884:2011, BS 2000-497:2011 *Petroleum products – Determination of sulphur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry.*

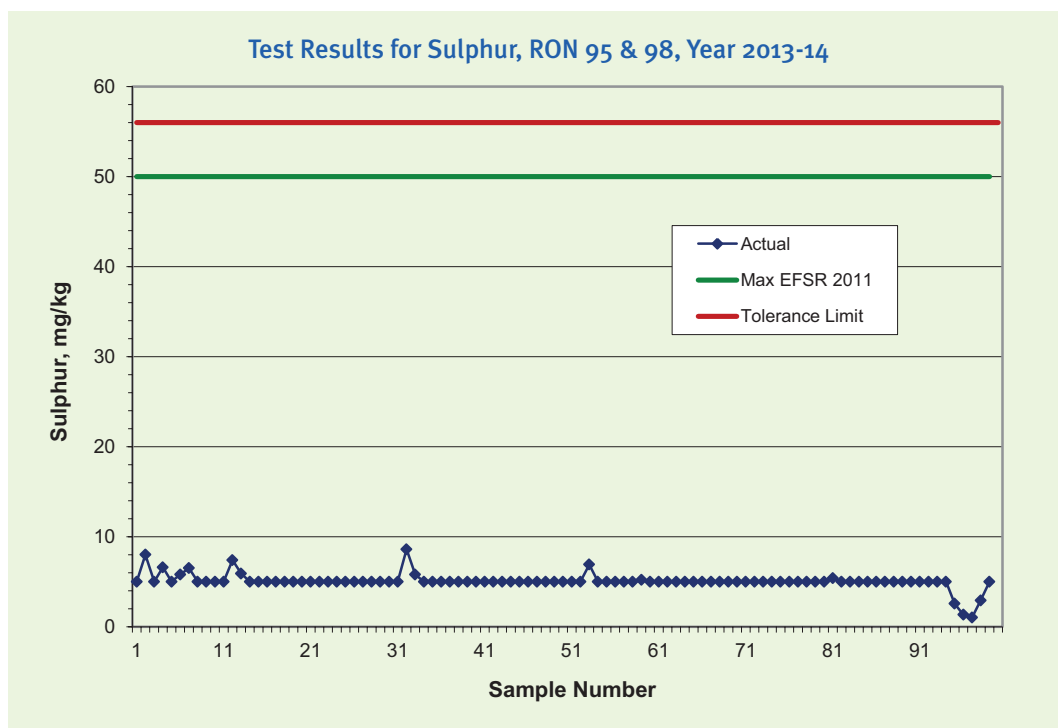
⁸ ASTM D5453 – 12 *Standard Test Method for Determination of Total Sulphur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence.*



RON 95 & 98

All results for premium petrol were found to be well within the prescribed maximum limit.

Fig. 9b



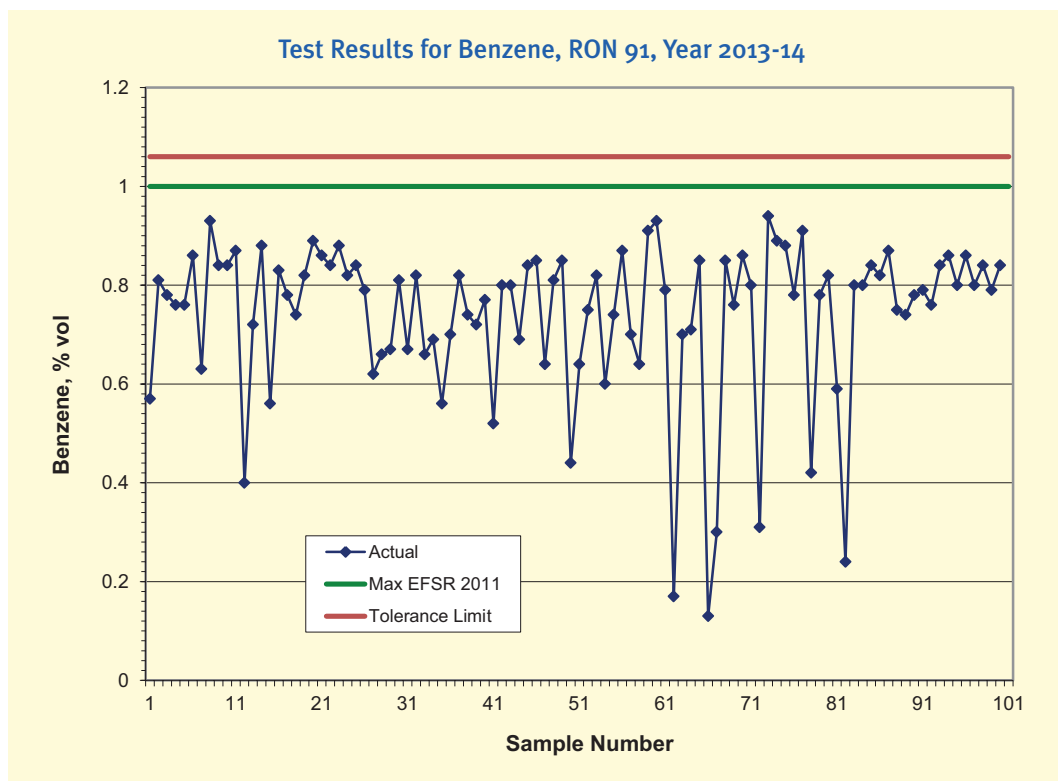
Benzene and Total Aromatics

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.

RON 91

All results for benzene content in regular petrol were below 0.95% (Fig.10a).

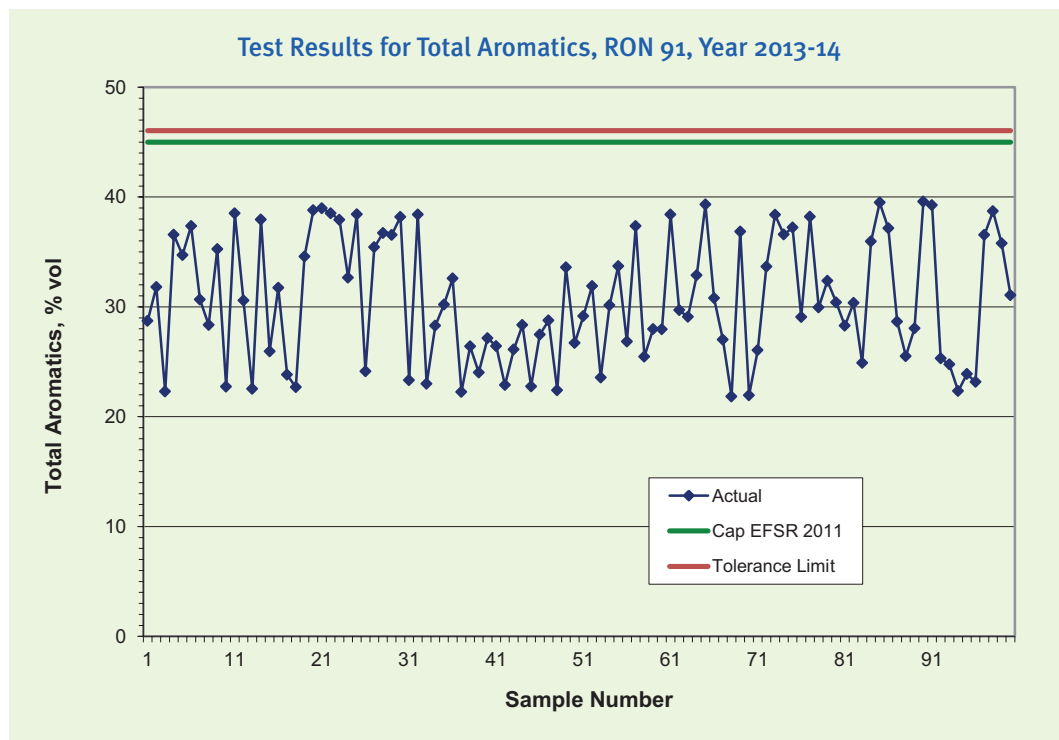
Fig. 10a





All results on total aromatics were found to be below 40% (Fig. 10b).

Fig. 10b



RON 95 and 98

All samples of premium petrol were found to be well within the prescribed maximum limit for benzene.

For premium petrol, the majority of the results on total aromatics were below 44%. Only six samples were found to exceed this figure with the largest result on total aromatics was found to be 43.97% for Sample 20 (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 five major fuel retail companies and from The New Zealand Refining Company Ltd for the period ending on 30 June 2014. 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. 10c

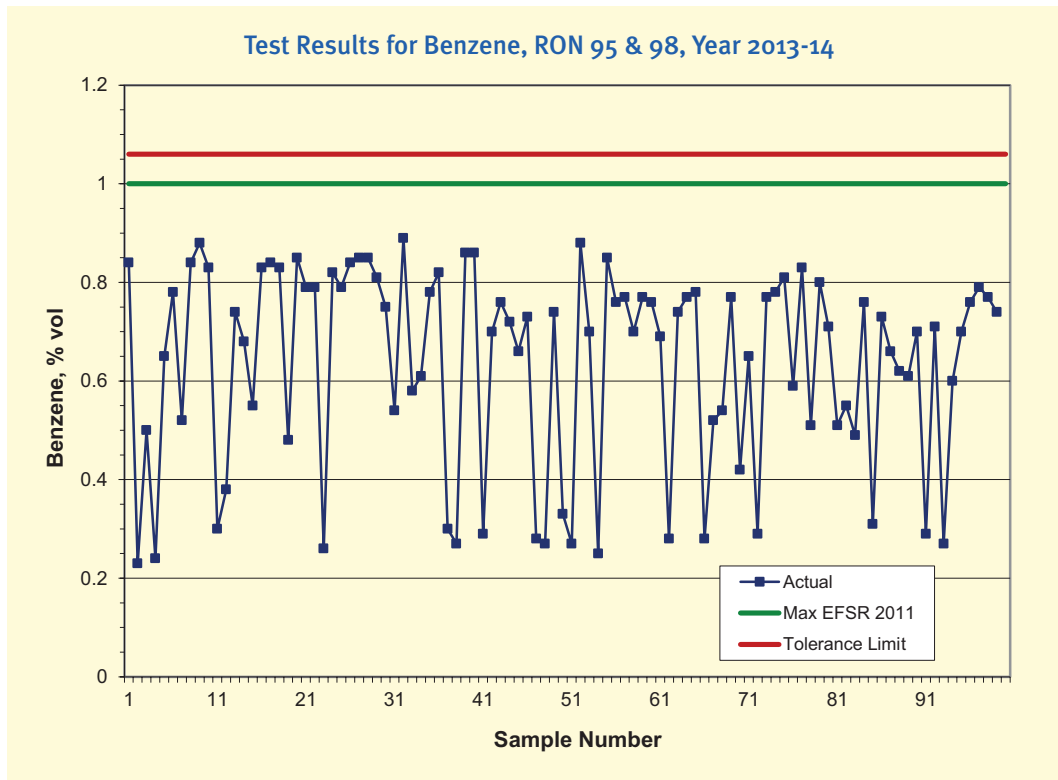
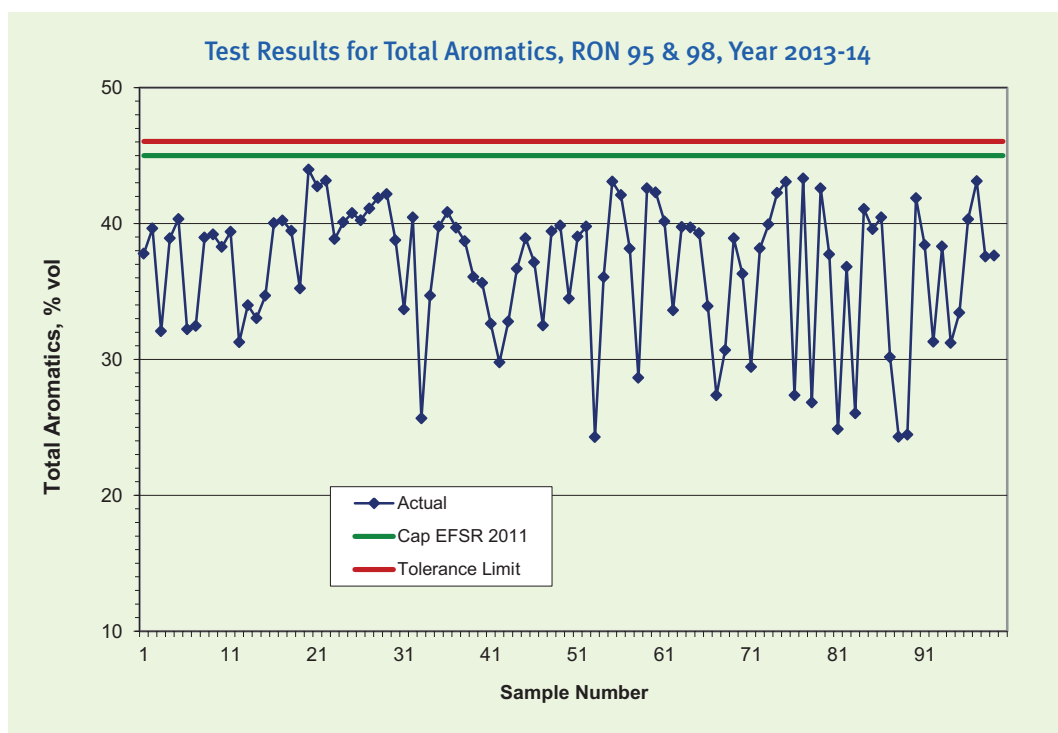


Fig. 10d





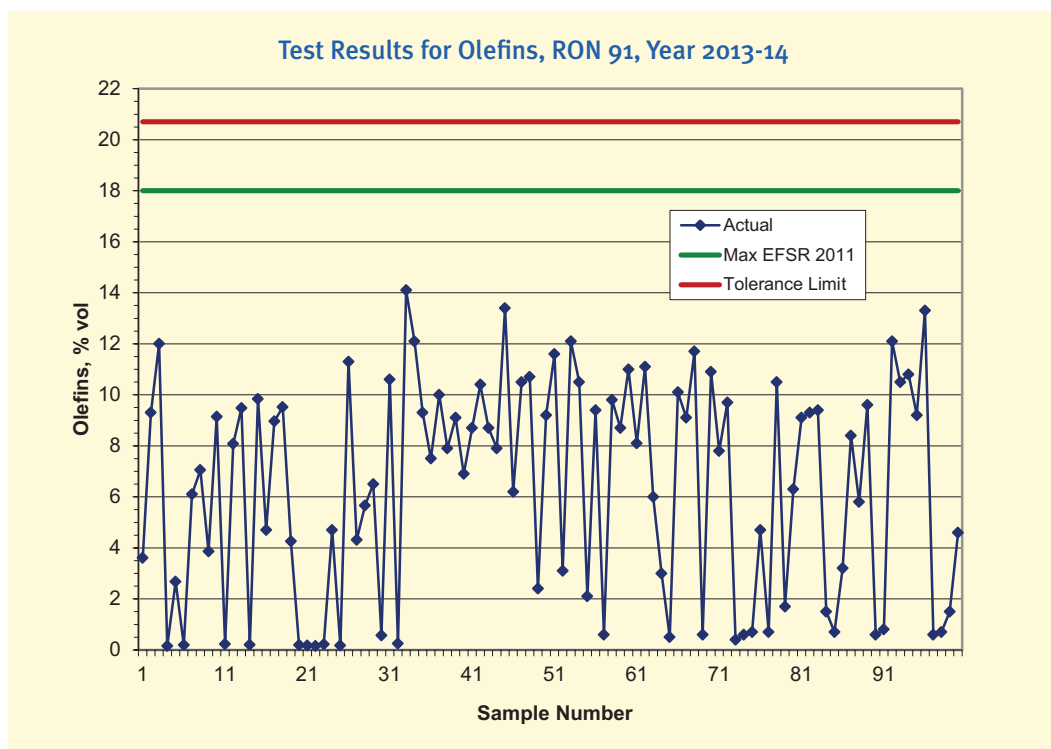
Olefins

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 33 was found to exceed this figure with the result of 14.1%.

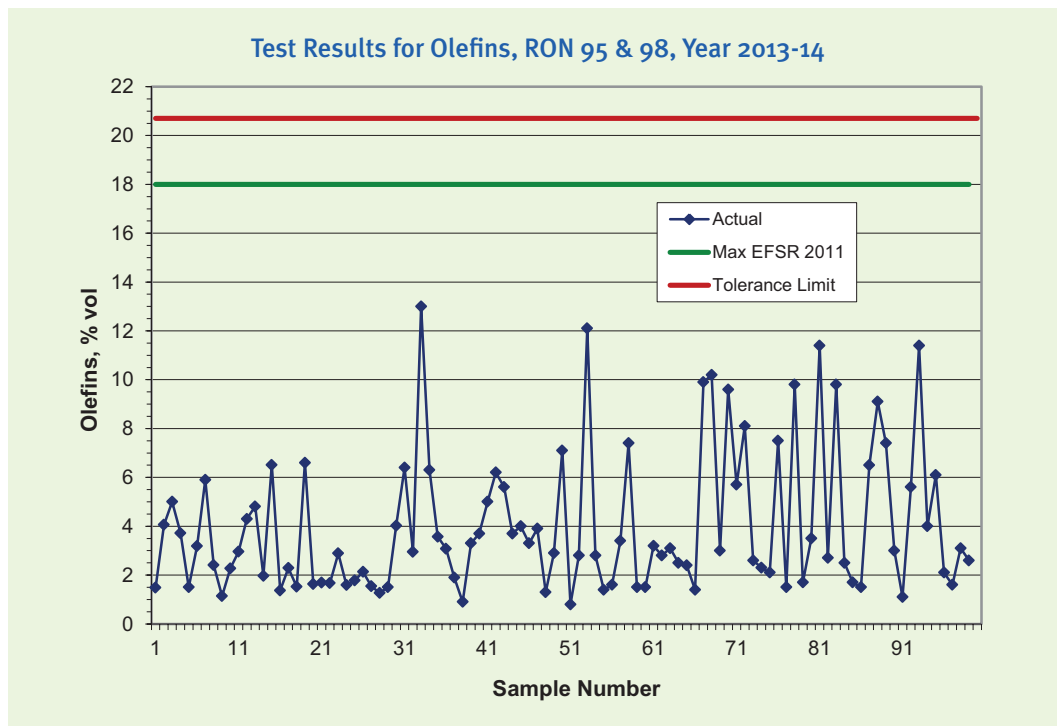
Fig. 11a



RON 95 & 98

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

Fig. 11b





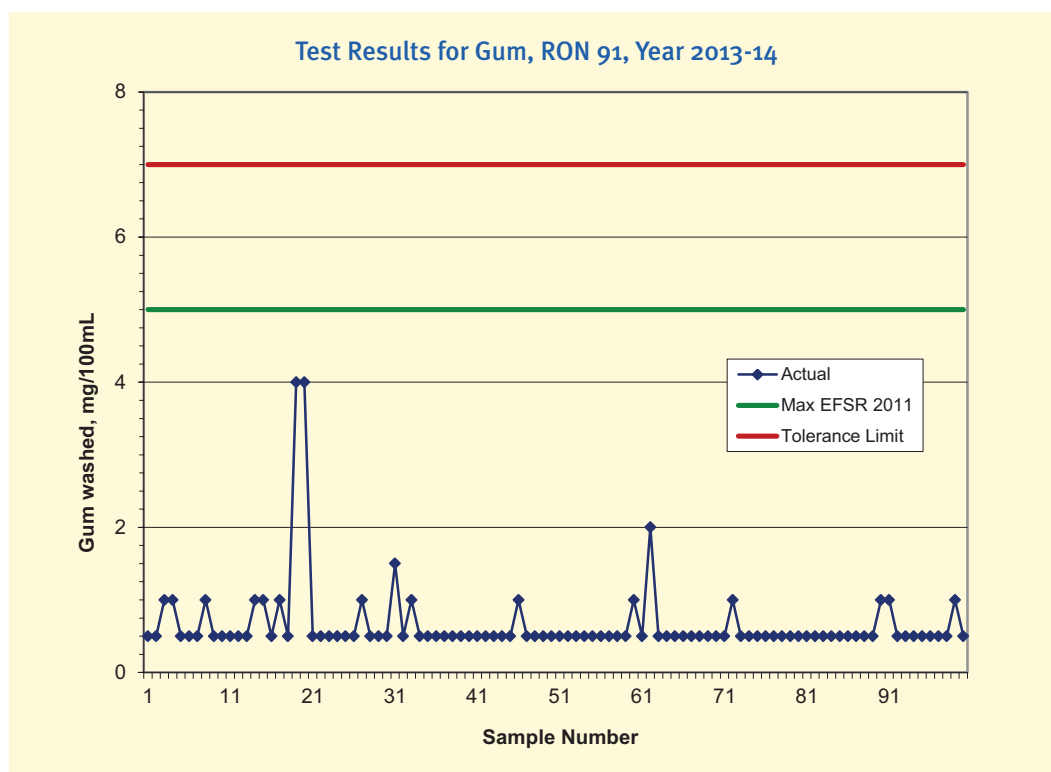
Existent Gum (solvent washed)

The threshold of the test method ASTM D381⁹ 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.

For both regular and premium petrol, all results were found to be below the specification maximum limit (Fig. 12).

RON 91

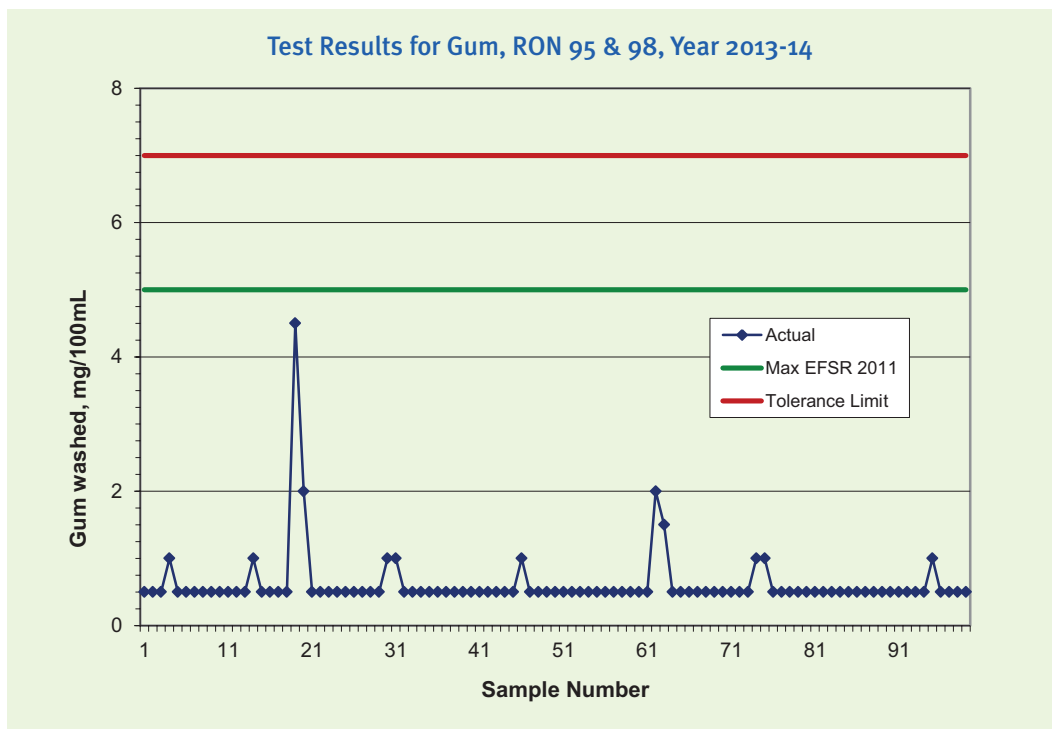
Fig. 12a



⁹ 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 was also conducted on other parameters and properties prescribed in the Regulations. This included screening for the content of: lead, manganese and phosphorus, through 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 is not 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 surely 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 required 10%.



Summary for Petrol Test Results

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

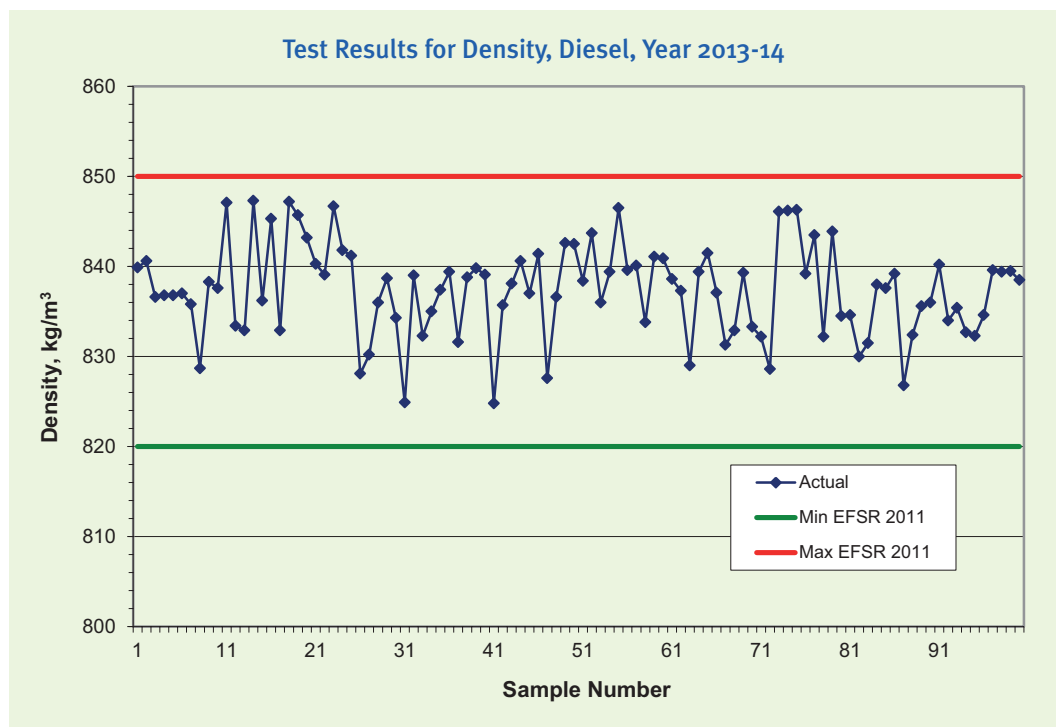
The suspected non-compliant sample detected related to a sample of premium petrol where the motor octane number on investigation was found to be below the specified limit of 85.0 with an actual figure of 84.9. Only this sample was found to be outside specification after subsequent additional testing and analysis however the average was well within the tolerance limit of 84.6 therefore the product was deemed to be compliant.



Diesel

Density

Fig. 13



All results were found to be within the specification limits which are 820 kg/m^3 and, respectively, 850 kg/m^3 with the maximum figure of 847.3 kg/m^3 at the maximum tolerance limit of 850.7 kg/m^3 .



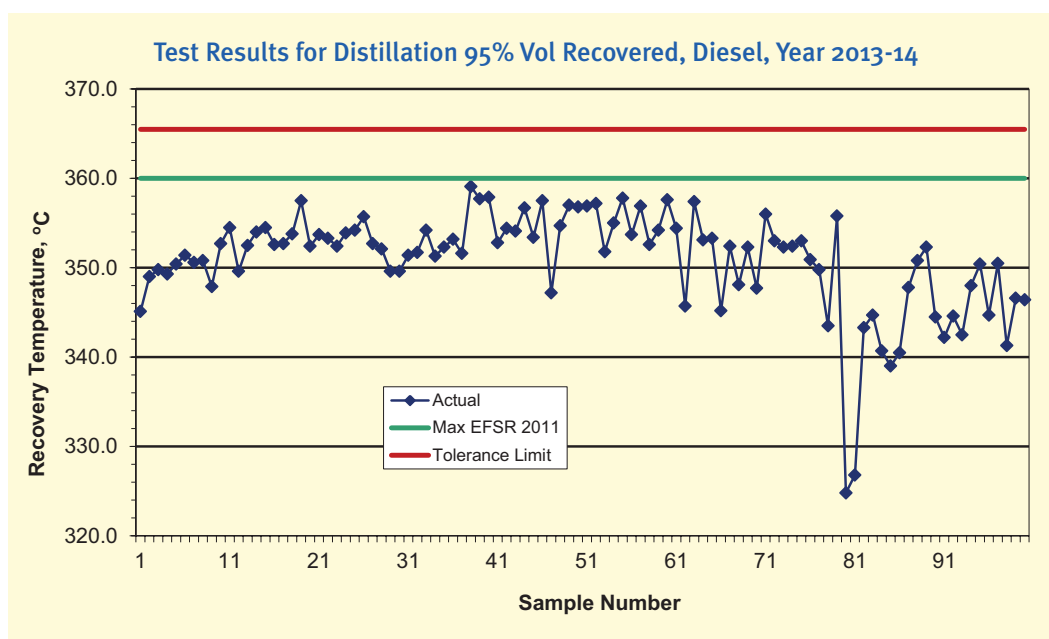
Distillation

All samples were found to be below the specification maximum limit of 360°C for distillation at 95% volume recovered (T₉₅).

Sample 80 was found to be the lowest with the actual figure of 328.4°C although there is no prescribed minimum limit for this property.

Sample 38 was found to be the closest to the limit with the actual result of 359.1°C (Fig. 14). The tolerance limit is 365.5°C.

Fig. 14



Cetane Index

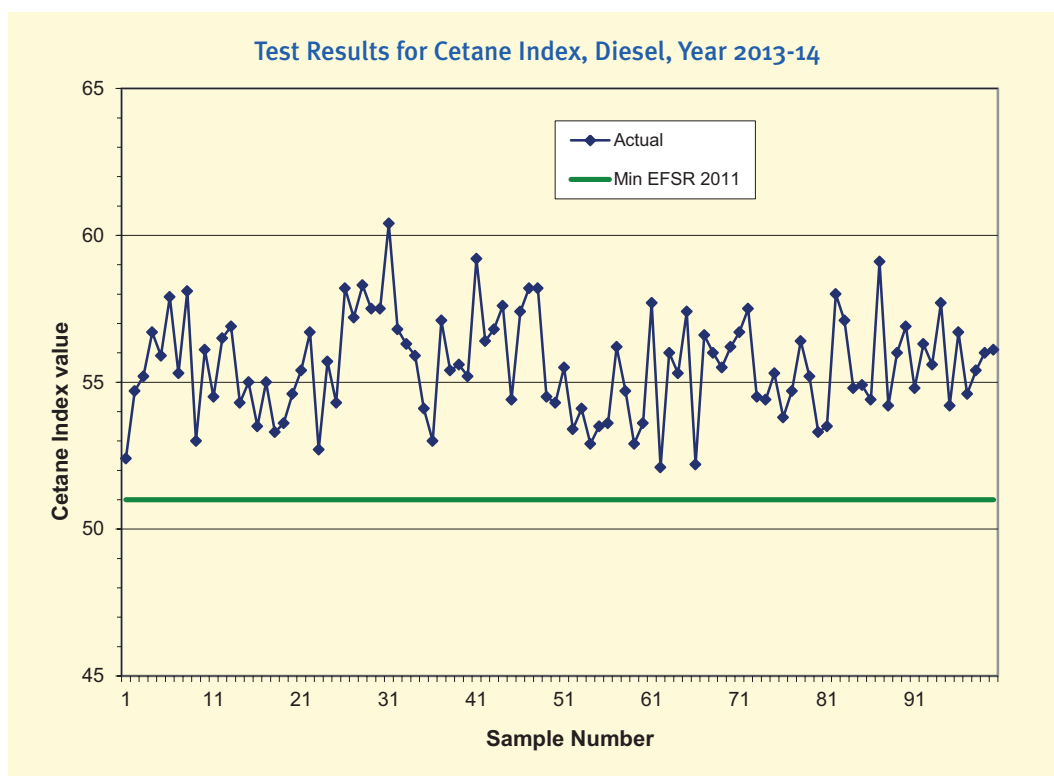
The cetane index, according to ASTM D4737¹⁰ prescribed in the Regulations 2011, is not tested for but calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine for determining cetane number is not available and/or cetane improvers are not used.

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

Sample 62 was found to be the lowest with the actual figure of 52.1.

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 ± 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



¹⁰ ASTM D4737 – 10 Standard Method for Calculated Index by Four Variable Equation.



Water

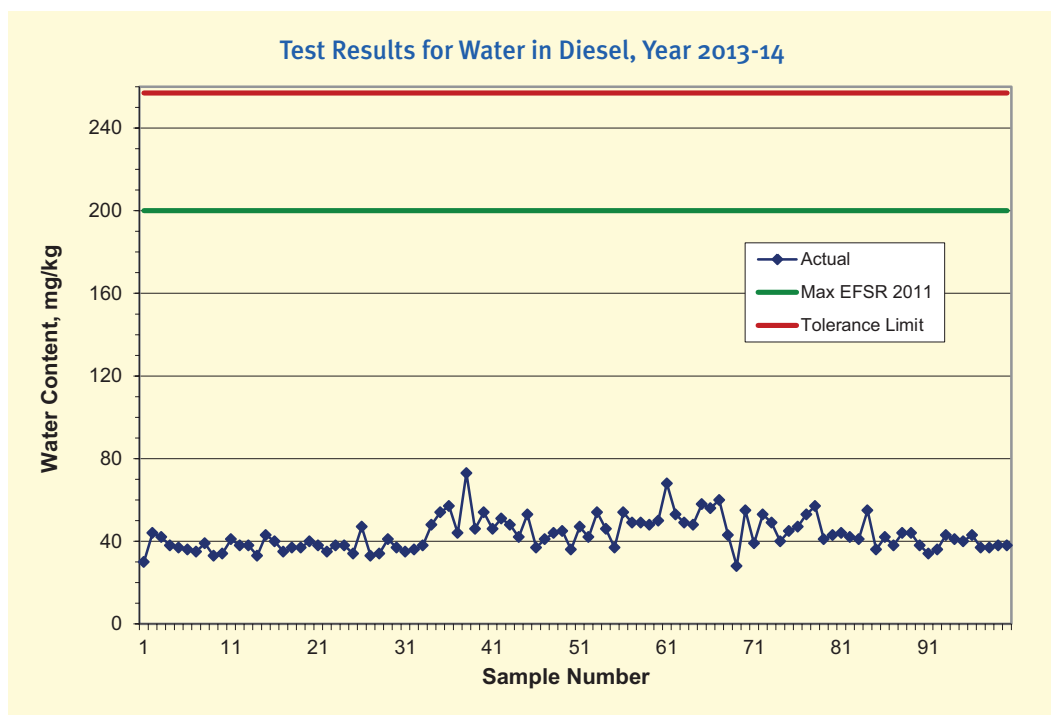
The test for water content according to IP 438¹¹ means water held in solution.

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 with actual testing results not exceeding 80 mg/kg. Sample 38 was found to be the largest with the results of 73 mg/kg.

Fig. 16

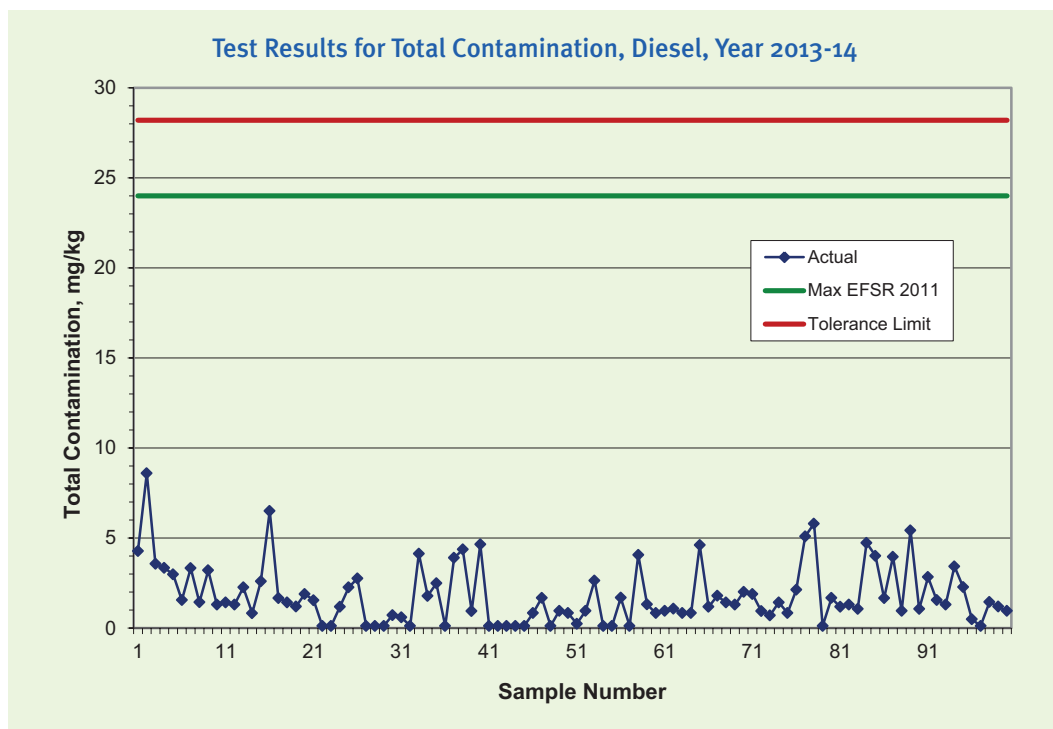


¹¹ BS EN ISO 12937:2001, BS 2000-438:2001. *Petroleum products. Determination of content. Coulometric Karl Fischer titration method.*

Total Contamination

All samples were found to be well below the maximum limit of 24 mg/kg specified in the Regulations (Fig. 17). The tolerance limit is 28 mg/kg.

Fig. 17





Sulphur

Sulphur content can be tested according to IP 497¹² or ASTM D5453¹³ prescribed in the Regulations 2011.

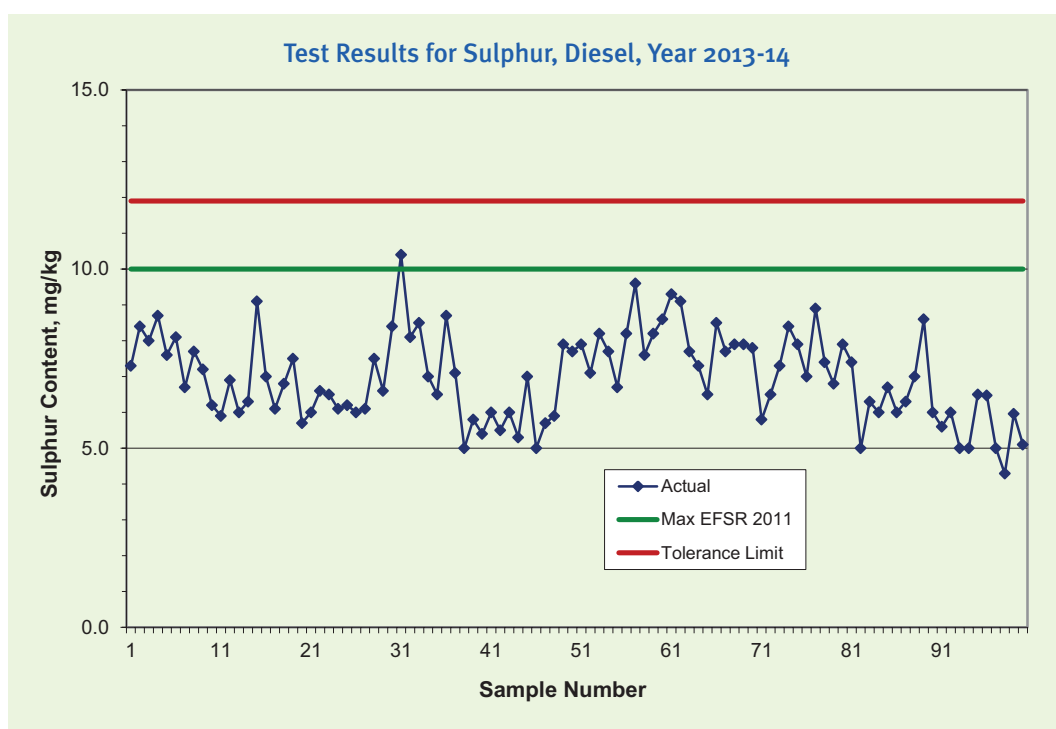
All samples except one were found to be below the maximum limit of 10 mg/kg specified in the Regulations (Fig. 18).

Sample 31 was initially found to be 11.1 mg/kg at the tolerance limit of 11.8 mg/kg. The tests

repeated by the same operator returned the figure of 9.8 mg/kg with the repeatability condition satisfied, $r=1.9$ mg/kg (IP 497).

A corrected tolerance limit for two results is 11.6 mg/kg. On investigation it was found that the average of 10.45 mg/kg was well within the testing tolerance limit so, according to the established policy, Sample 31 was deemed to be compliant.

Fig. 18



¹² IP 497 ISO 20884:2011: *Petroleum products — Determination of sulfur content of automotive fuels — Wavelength-dispersive X-ray fluorescence spectrometry.*

¹³ 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

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.

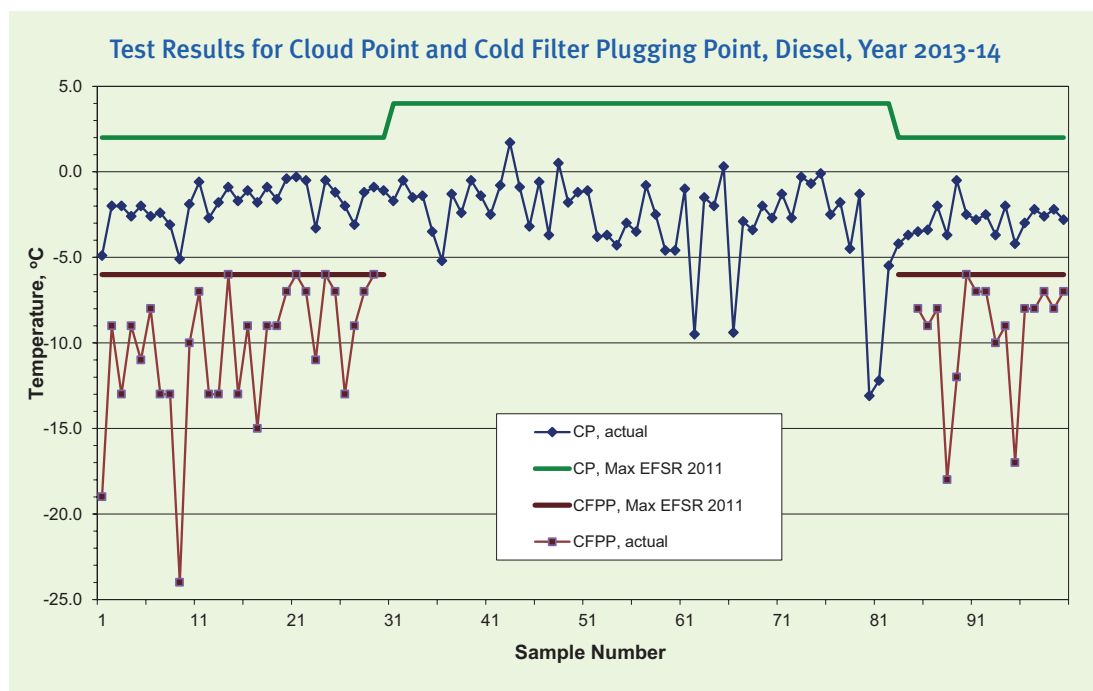
For the period of summer in Schedule 2 (season definitions in Section 5, the Regulations) from 15 October to 14 April inclusive, the lowest maximum limit of CP +4°C is prescribed for all New Zealand excluding Auckland and Northland.

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 43 returned the highest testing result for summer, +1.7°C, at the maximum limit of +4°C.

The lowest figure for CP was found to be -13.1°C for Sample 80 from South Island.

Fig. 19





Cold Filter Plugging Point

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°C .

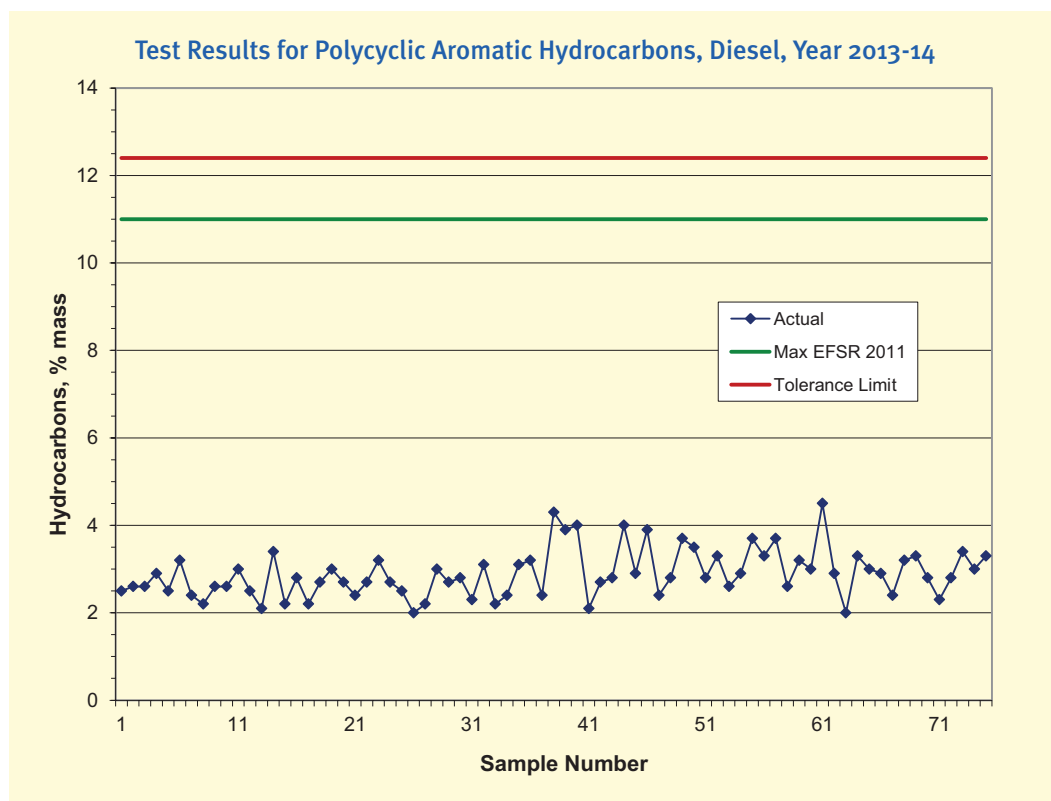
All samples were found to be below the maximum limit specified in the Regulations for the winter season.

Sample 9 was found to have the lowest CFPP of -24°C with a result for CP of -5.1°C .

Polycyclic Aromatic Hydrocarbons

All samples were found to be well below the maximum limit of 11% specified in the Regulations. The actual testing results were found to be below 5%.

Fig. 20

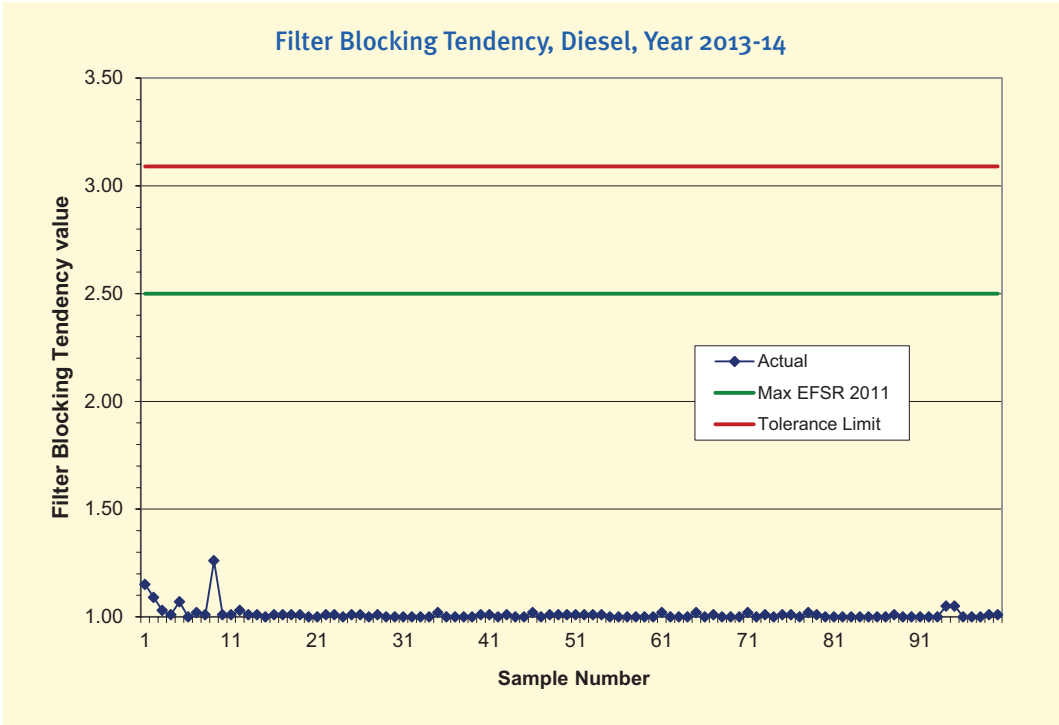


Filter Blocking Tendency

All samples were found to be within the specified maximum limit of 2.5 for filter blocking tendency. While the majority of actual figures were in the range from 1.00 to 1.05

which means practically perfect filtering. Sample 9 was found to be the largest with the results of 1.26. This is the sample which was found to have the lowest CFPP (see above).

Fig. 21





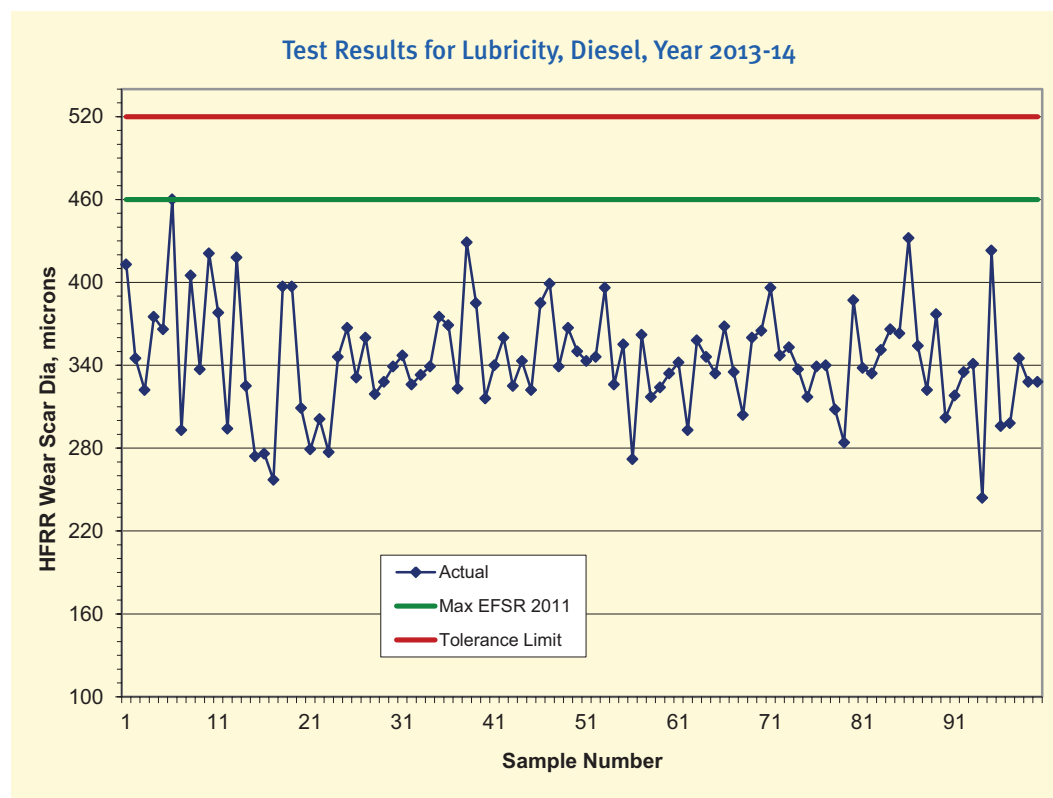
Lubricity

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 μm .

Sample 6 was found to be on the specified maximum limit. The tolerance limit is 520 μm .

Fig. 22

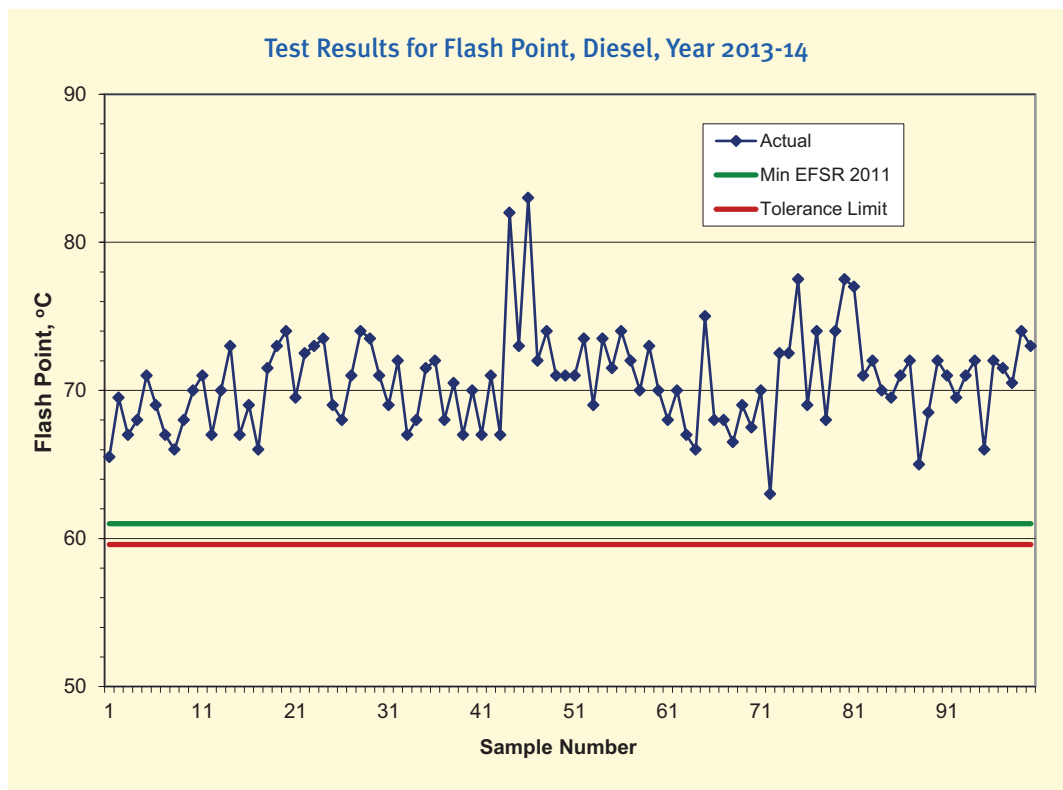


Flash Point

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 63.0°C for Sample 72 at the tolerance limit of 59.6°C.

Fig. 23





Summary for Diesel Test Results

There was only one case of suspected non-compliance identified and there were no repeated cases of non-compliance identified in previous reporting years.

The one suspected non-compliant sample detected during the period of this report related to a sample of diesel where the sulphur content on investigation was found to be above the specified limit of 10 mg/kg with an actual figure of 11.1 mg/kg. The sample was initially found to be outside specification but after subsequent additional testing and analysis an average value of 10.5 mg/kg was confirmed. This value is well within the corrected tolerance limit of 11.6 mg/kg therefore the product was deemed to be compliant.

In the past, testing for oxidation stability of diesel has not been normally 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 has been added since January 2014 to the regular list of tests with a special testing frequency of approximately two tests per month. All results were found to be well within the maximum specified limit of 25 g/m³ with the largest of 9 g/m³.

This year, testing diesel for appearance according to the ASTM standard D4176¹⁴ 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.

¹⁴ 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, not all actual results are shown due to the commercial sensitivity of the data and because some of this testing is done on properties not controlled by the Regulations.

Retail Fuel Sampling and Testing

Biodiesel B5

As in the 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 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. 11 sample sets of regular and premium petrol blended with ethanol and labelled as E3 and/or 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

Two retail sites in New Zealand offer ethanol blended petrol 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 D5798¹⁵ 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 81.46% and 82.62%, with the tolerance limit of 85.64%.

The need to include into the Regulations specifications for ethanol blended petrol with ethanol content above 10%, is currently being considered by the Ministry.

¹⁵ ASTM D5798-14 *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), B20 (20% blend with mineral diesel), and B10 (10% blend with mineral diesel). Biodiesel B100 was tested according to the requirements of Schedule 3 in the Regulations while the B10 and B20 blends were tested according to the Regulation 17.

In total, 12 samples of biodiesel were collected from production plants or non-retail refuelling sites and tested. These include six samples of B100 and six samples of blends B10 or B20.

Biodiesel B100

The variety of feedstock leads to some diversity in results on FAME (Fatty Acid Methyl Esters) content identified by the EN 14103:2011 standard. Therefore, problems with accurate measurement of FAME content remained in the focus of the testing programme. The Ministry in collaboration with the Independent Petroleum Laboratory 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 six were found to be below the minimum limit but within the tolerance limit.

In two initial instances, water content was found to be above the maximum limit of 500 mg/kg. In particular, the results were found to be above the specified maximum limit with figures of 548 and 601 mg/kg at the tolerance limit of 590 mg/kg. After corrective actions implemented by the producer, the water level was found to be on specification in other two samples. However, once the B100 biodiesel is

blended with mineral diesel, the final figures for water content in the resulting blends are expected to be well within the permissible limits.

Further, total acid number was initially found to be above the prescribed maximum limits. After technology fine-tuning in response to Ministry's advice, the acidity was brought under the required limits.

In four instances, total contamination was found far above the prescribed maximum limit. After corrective actions, the results of repeated tests were found to be within the specification. Because the sampling and testing took place prior to any Biofuel E100 be sold / supplied there was no risk to end consumers / users.

Biodiesel B10 and B20

These blends were inferred 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 and two samples of B20 were collected, some at the plant dispenser and others at the non-retail point of sale.

In biodiesel B10, in one instance the FAME content was found to be far above the stated maximum of 10% with the actual figure of 26.9% and the tolerance limit of 10.4%. The result indicates that there could be a problem with homogeneity of the biodiesel mix. The filter blocking tendency for this sample was found to be 1.56 at the maximum limit of 2.5.

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 supplied to customers.

Finally, biodiesel B20 was found to be on specification although both times the FAME content was lower than the stated figure of 20%.

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

In conclusion, it must be noted that 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 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.

