Fuel Quality Monitoring Programme

Test Results 2012–13

TRADING STANDARDS

Ministry of Business, Innovation & Employment

New Zealand Government

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Fuel Quality Monitoring Programme
TEST RESULTS 2012–13

Executive Summary

The Fuel Quality Monitoring Programme (**the Programme**) is administered by Trading Standards. Trading Standards is the new name that has been adopted for the former Measurement and Product Safety Service. 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[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 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.* when 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 2012 to 30 June 2013. During this period retail fuel samples were collected and tested from 103 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 how fuel properties can be affected by the introduction of biofuel components. This could for example result in an enhanced dry vapour pressure in ethanol blended petrol.

Regarding non-retail sale of biofuels the attention remained on giving feedback to the fuel producers to improve their production processes before their fuel entered the fuel supply chain.

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.

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

1 http://www.legislation.govt.nz/regulation/public/2011/0352/latest/whole.html

Introduction

The Measurement and Product Safety Service was an operational unit within the Market Services Group of the Ministry of Business, Innovation and Employment until October 2013 when its name was changed to Trading Standards.

Trading Standards has national responsibility for three infrastructure areas that are fundamental to consumer safety, supporting consumer and business confidence and facilitating domestic and international trade. The three areas are:

Legal Metrology (Trade Measurement) – administering and enforcing the Trade Measurement System that ensures that measurements used in trade are accurate and goods are transacted on the basis of recognised weight and measure.

Consumer Product Safety – oversight of consumer product safety, including investigation of emerging issues nationally and internationally and the development of appropriate responses to mitigate significant risks posed to New Zealand consumers.

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; and
- Investigating consumer and trader complaints and responding to enquiries; and
- Advising on and facilitating improvement of fuel industry 'best practice'; and
- Developing and conducting projects in response to emerging issues; and
- Contributing to work on regular amendments and updates to the Engine Fuel Specifications Regulations; and
- Maintaining strong and effective relationships (as regulator) with fuel company technical managers, fuel retailers, industry associations and stakeholders within NZ 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 1989[2].

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

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.

This report sets out the results of the Programme from 1 July 2012 to 30 June 2013.

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[3] or in previous FQM Programme annual reports for the period from 2008 to 2012.

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, 103 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 costs 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 launched last year in response to detection of several non-compliant samples during previous years. This project included a brief sub-project investigating other oxygenates content in petrol blended with ethanol. While both initial projects were successfully completed in mid-2012, they were recognised as important and were continued throughout the period of this report.

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.

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

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

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 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.

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[4] 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).

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.

On the whole, 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	1	0	0	0	1	1	0	1	0	0	1	**5**
Auckland	3	5	3	3	0	2	2	1	3	3	2	1	**28**
Mt Maunganui	1	1	3	2	3	2	0	0	2	1	0	1	**16**
New Plymouth	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Napier	0	2	0	0	0	1	0	2	0	0	0	0	**5**
Wellington	3	1	2	0	2	1	1	0	0	0	2	0	**12**
Nelson	1	0	1	1	0	0	1	1	0	0	0	1	**6**
Lyttleton	1	0	1	0	2	0	2	2	1	1	2	0	**12**
Timaru	0	1	0	1	0	1	0	1	0	1	0	0	**5**
Dunedin	1	0	0	1	0	2	0	0	0	3	0	0	**7**
Bluff	0	0	0	0	2	0	0	1	2	0	1	0	**6**
Total	**10**	**11**	**10**	**8**	**9**	**10**	**8**	**8**	**9**	**9**	**7**	**4**	**103**

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)

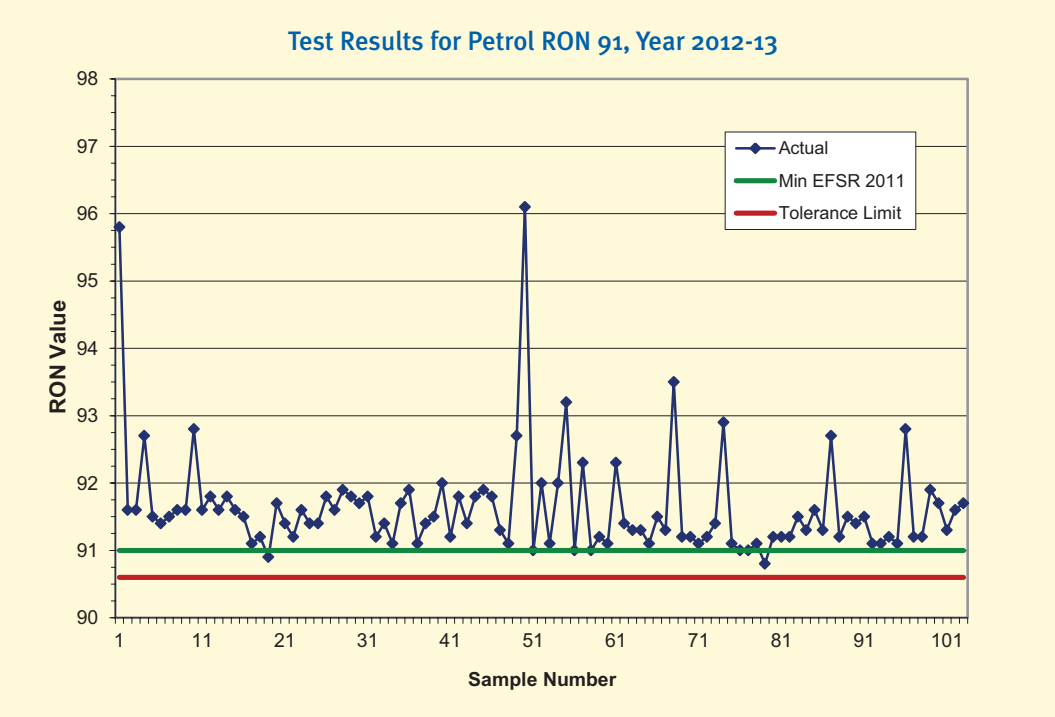
RON 91

In total, 103 samples of regular petrol were collected and tested. Fig. 1a and 1b below show the testing results for RON and MON respectively.

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

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.



Samples 19 and 79 were found to be below the prescribed minimum limit of 91.0 on RON with results, respectively, of 90.9 and 90.8. Sample 19 was only marginally below the specification limit and well within the tolerance limit so it was deemed to be compliant.

In the second instance, the sample was initially found to be close the tolerance limit with the testing result for RON of 90.7. The tests repeated by two operators returned the figures of 90.6 (by the same operator, with the repeatability condition satisfied, r=0.2) and 91.0 (by another operator, with the reproducibility condition satisfied, R=0.7). On investigation it was found that the average of 90.8 was above the testing tolerance limit of 90.6 so, according to the established policy, sample 79 was interpreted as compliant. The corrected tolerance limit[5] for RON for two results by the same operator, is not different from the tolerance limit for a single test: 90.6 minimum, therefore the testing result for Sample 79 was confirmed to be compliant.

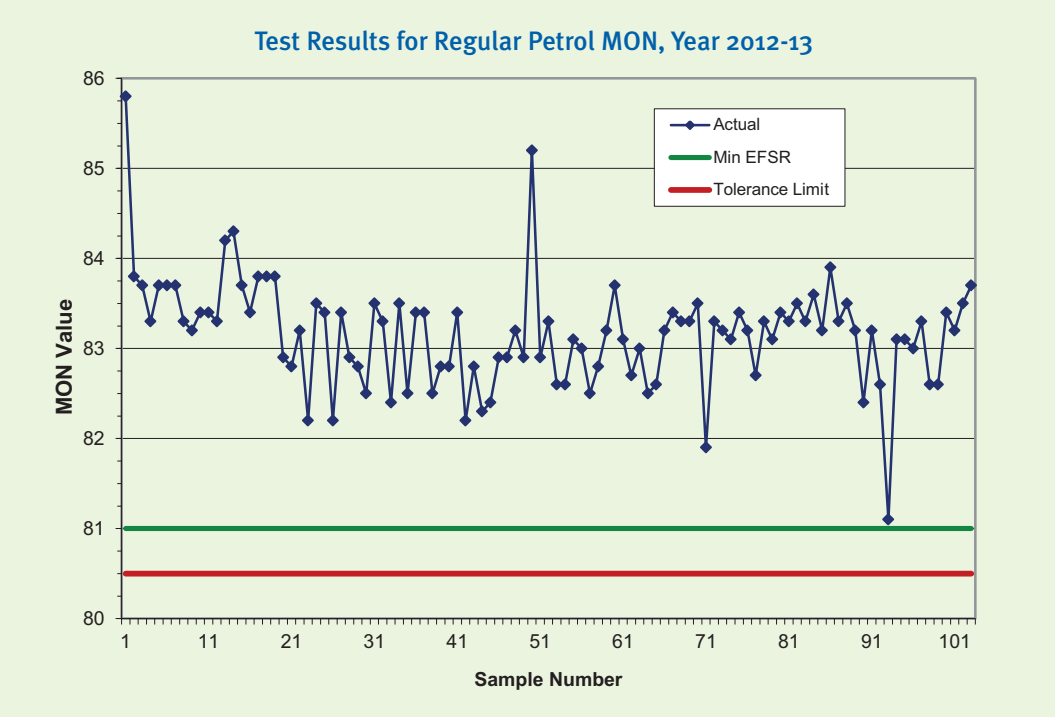
The respective figure for MON was found to be compliant: 83.1.

Samples 1 and 50 were found to be high on RON with results, respectively, of 95.8 and 96.1. The presence of ethanol (test results were, respectively, 9.54% and 9.39%) should have enhanced both RON and MON, it is believed that the relatively high figures for RON (and for MON, see Fig.1b below) were the result of ethanol presence. No effective deterioration of the product quality is expected after blending high octane petrol into petrol with a lower octane.

All samples were found to be above the minimum specification limits of 81.0 for MON. Samples 1 and 50, again, were found to be high on MON with results, respectively, of 85.8 and 85.2. Sample 93 was found to be the lowest, 81.1.

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

Fig. 1b



5 The tolerance limit for two tests, based on the equation for the reproducibility (18), Section 7.2.3, ISO 4259:2006.

RON 95

In total, 87 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 except one were found to be above or on the minimum specification limit of 95.0 for RON. Eight samples were found to be on the specification limit.

Sample 30 was initially found to be below the specification limit with testing result for RON of 94.8. The repeated test returned the same figure of 94.8. On investigation it was found that the average of the two tests was within the testing tolerance limit of 94.6 therefore Sample 30 was treated as compliant.

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

An exception was Sample 44 which was initially found to be 84.8, *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 figure of 85.1, with the reproducibility condition satisfied, R=0.9. On investigation it was found that the average of the two tests was on the specification limit of 85.0 therefore Sample 30 was interpreted as compliant. The relevant figure for RON was above the minimum limit.

Fig. 2a

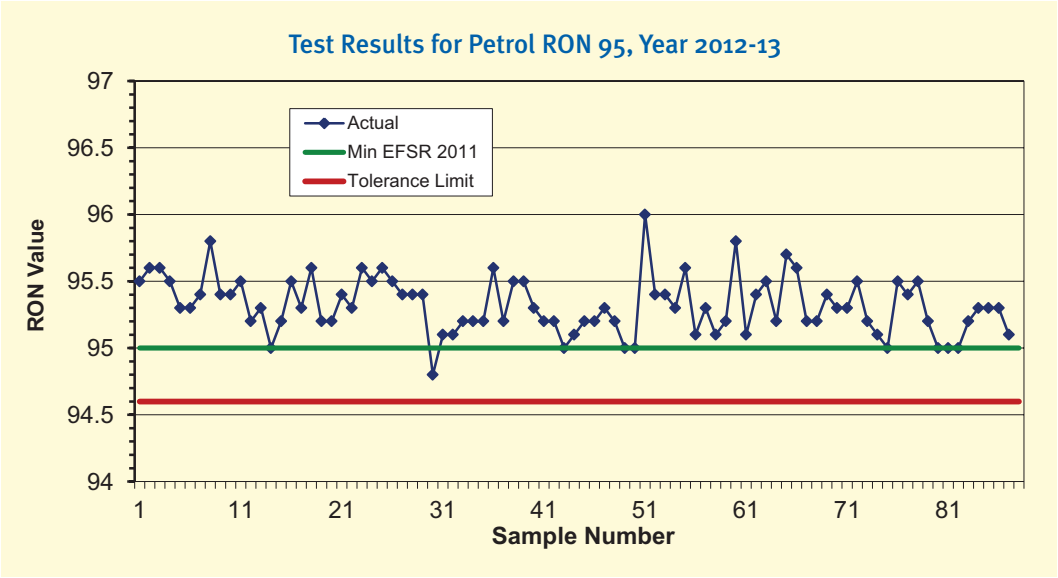
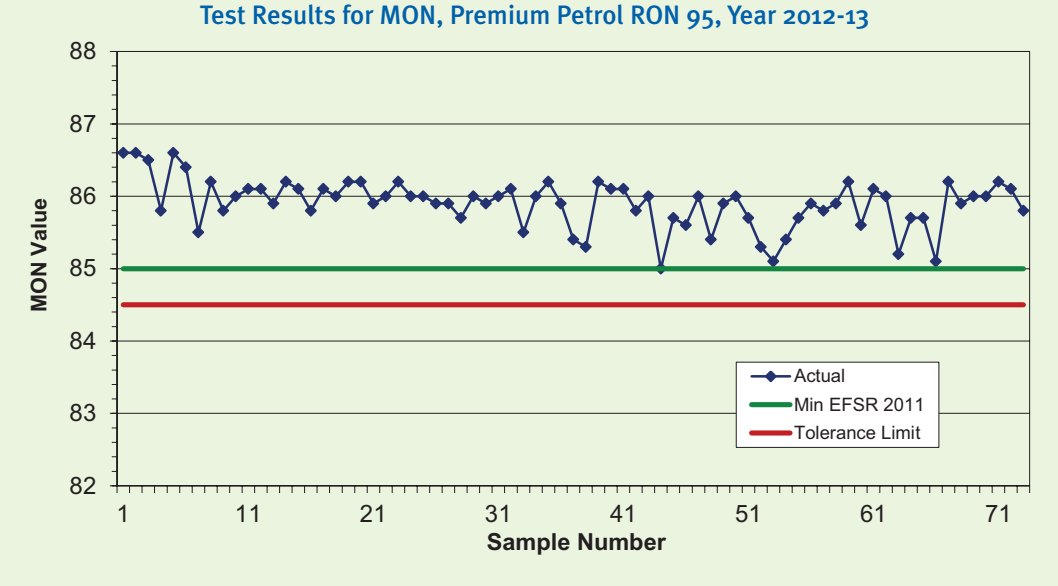


Fig. 2b



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

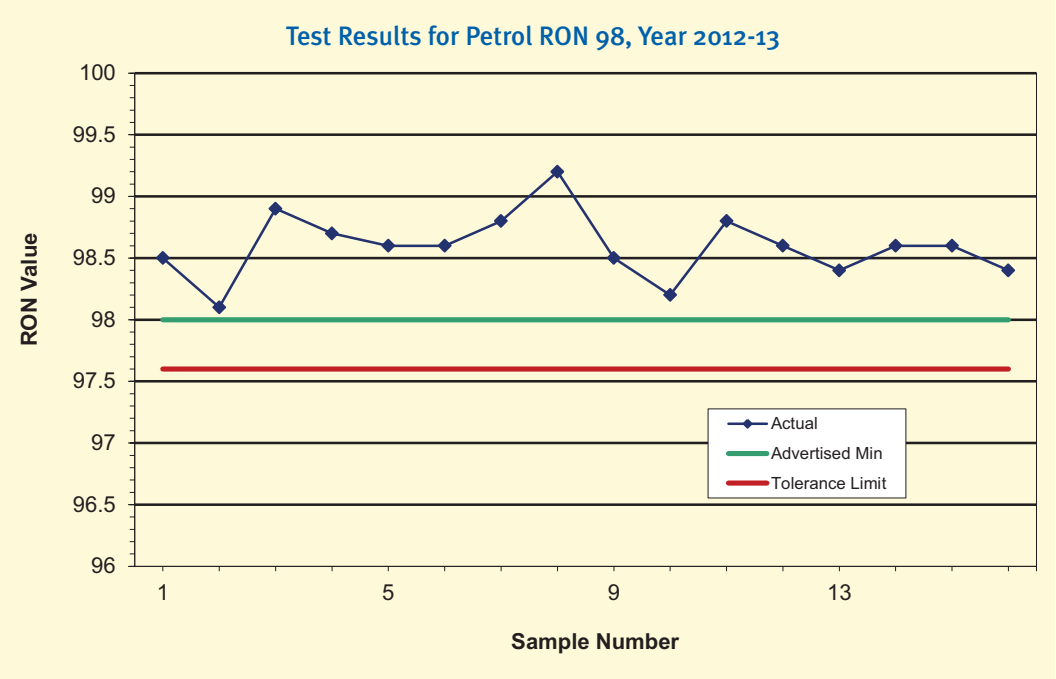
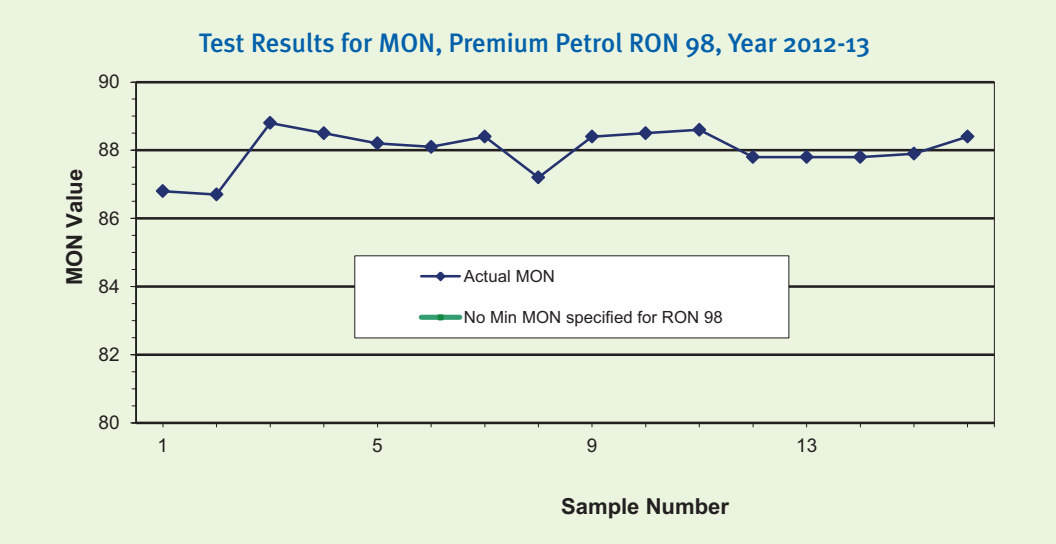

Test Results for Petrol RON 98, Year 2012-13
RON Value
100
99.5
99
98.5
98
97.5
97
96.5
96
1
5
9
13
Sample Number
Actual
Advertised Min
Tolerance Limit

Fig. 3b


Test Results for MON, Premium Petrol RON 98, Year 2012-13
MON Value
90
88
86
84
82
80
1
5
9
13
Sample Number
Actual MON
No Min MON specified for RON 98

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

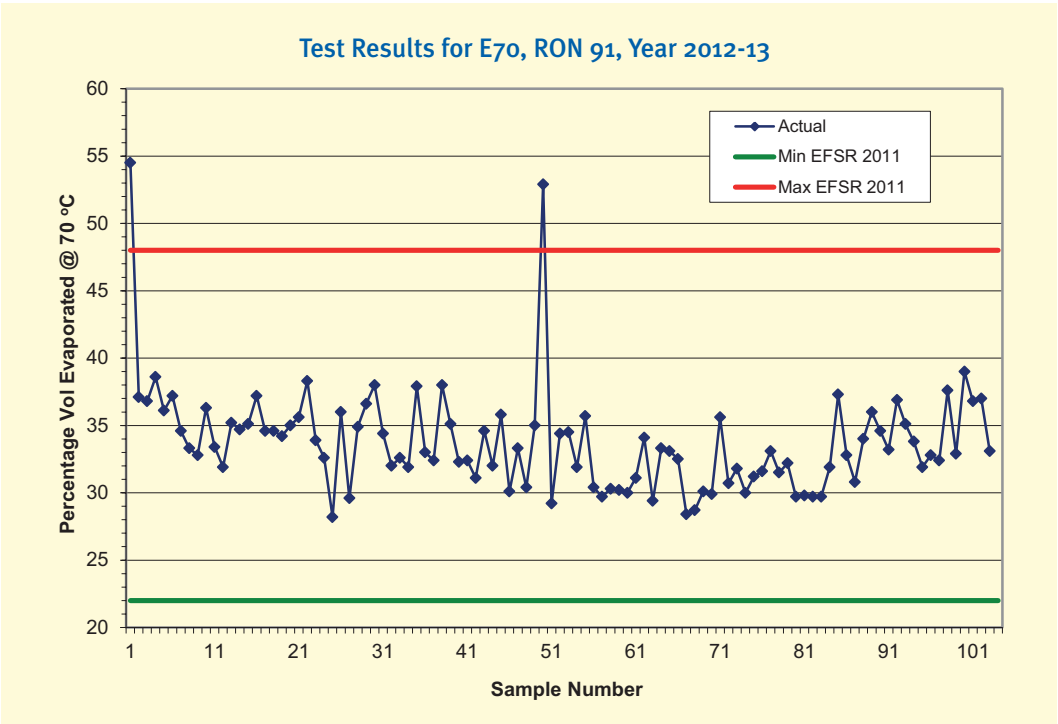
Percentage Volume Evaporated @ 70°C

For petrol not containing ethanol, the minimum specification limit is 22% and maximum specification limit is 48% while the minimum tolerance limit is 20.5% and maximum tolerance limit is 49.2%.

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.

Samples 1 and 50 were found to be within the maximum specification limit established for ethanol blends with the testing results of, respectively, 54.5% and 52.9%. According to the Regulations (Footnote 1 in Schedule 1), the E70 maximum is increased by 1% per 1% volume ethanol in the blend therefore when the ethanol content was found to be, respectively, 9.54% and 9.39% (i.e. approx. 10% and 9%), the prescribed limits were calculated as 58% and 57%. Accordingly, the results were found to be within the limit.

Fig. 4a

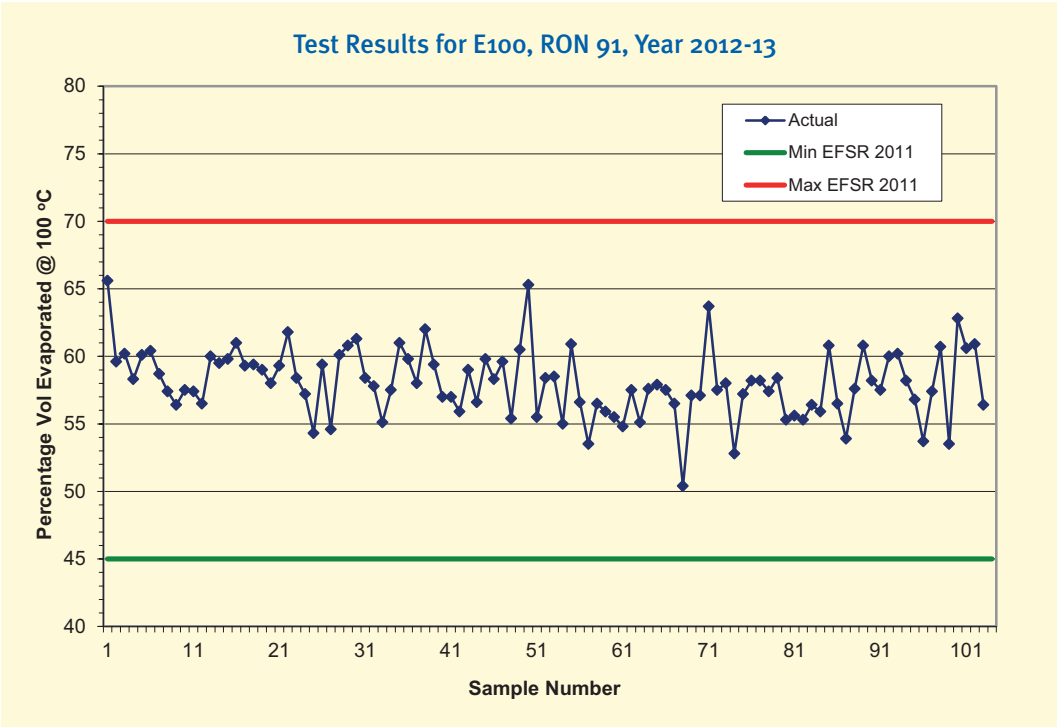


Percentage Volume Evaporated @ 100°C

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



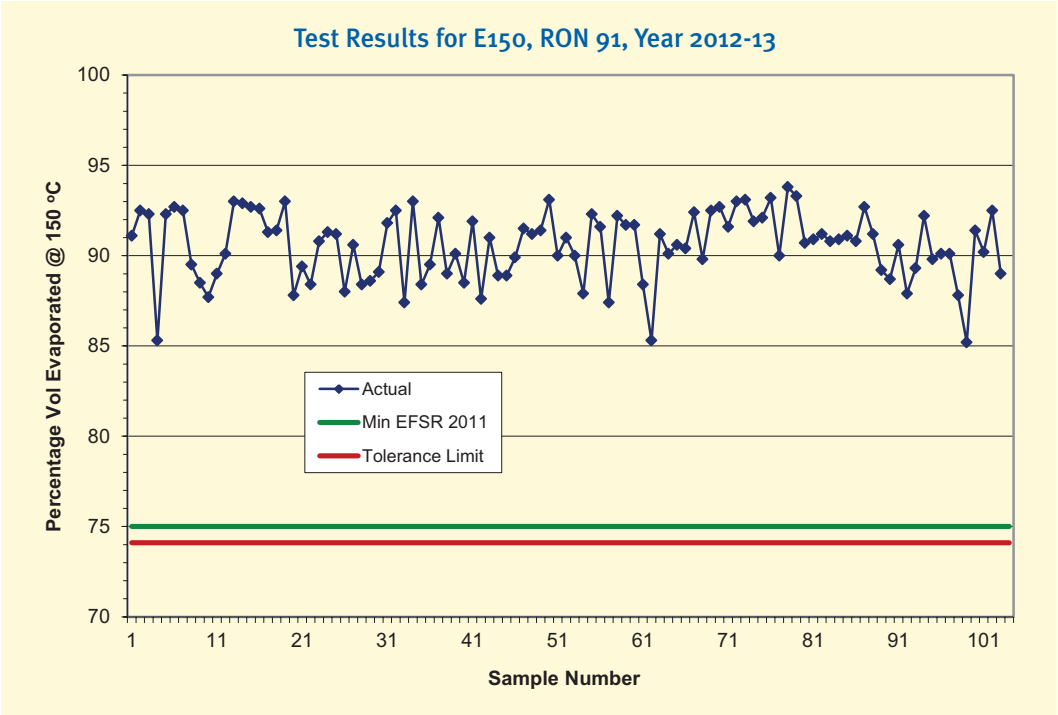
Percentage Volume Evaporated @ 150°C

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.

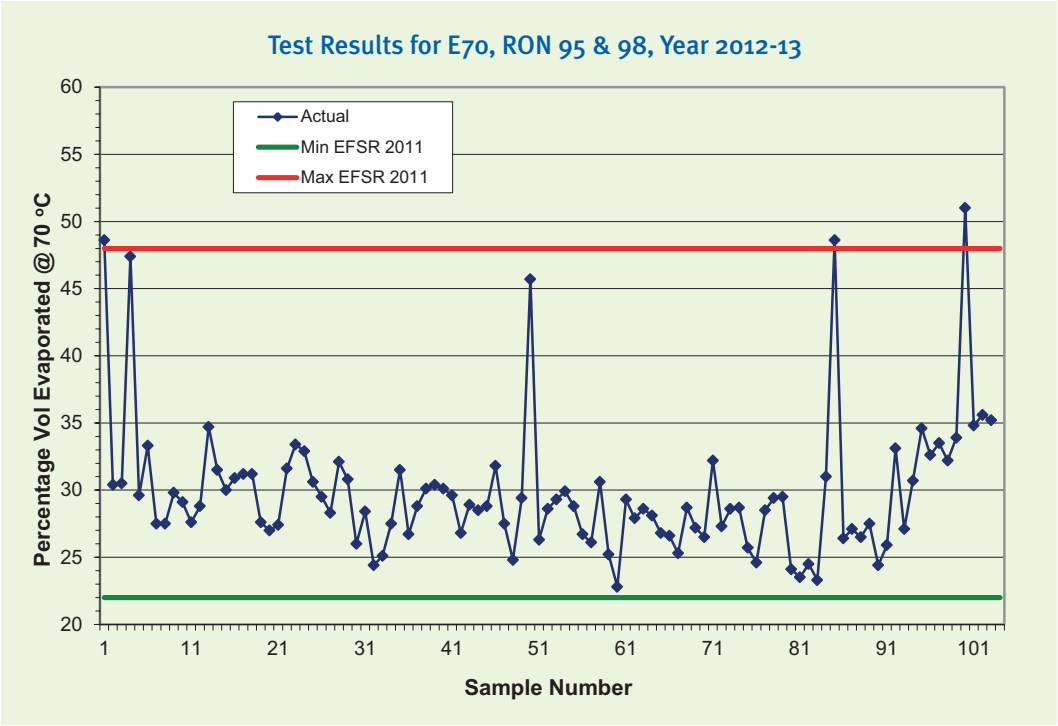
All results for samples with ethanol, are set out in a Table 1 below. They were all found to be within the prescribed limits for ethanol blends.

Table 1

Sample	Ethanol Content, % Vol	Limit for Ethanol Blend, % Vol	Percentage Volume Evaporated @ 70°C
1	9.40	57	48.6
4	8.72	57	47.4
50	9.33	57	45.7
85	9.25	57	48.6
100	9.37	57	51.0

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

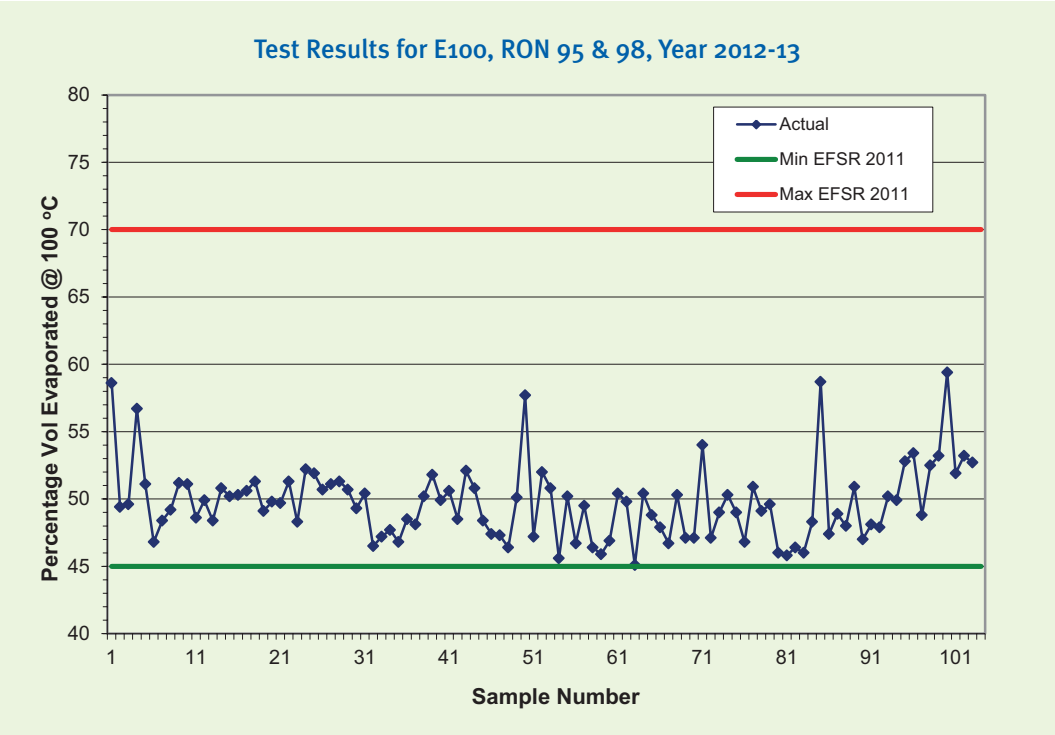


Percentage Volume Evaporated @ 100°C

All samples were found to be within the specification limits from the minimum of 45% to the maximum of 70%. Sample 63 was found to be the lowest, 45.1%.

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

Fig. 5b



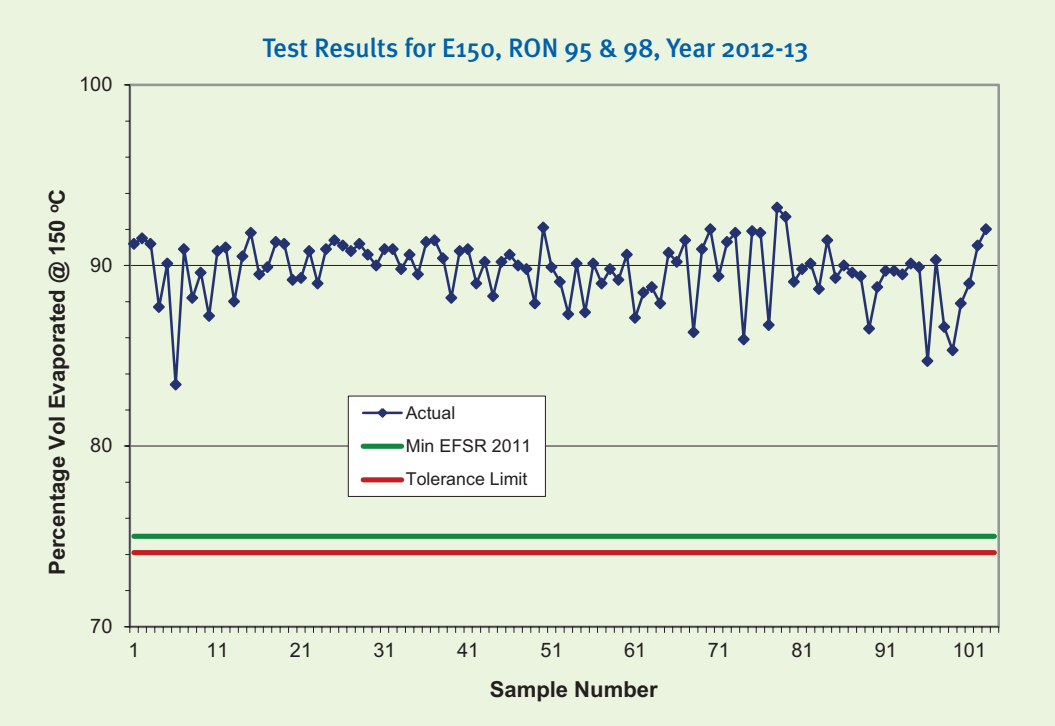
Percentage Volume Evaporated @ 150°C

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 202.1°C was found for Sample 21 of premium petrol.

Fig. 6a

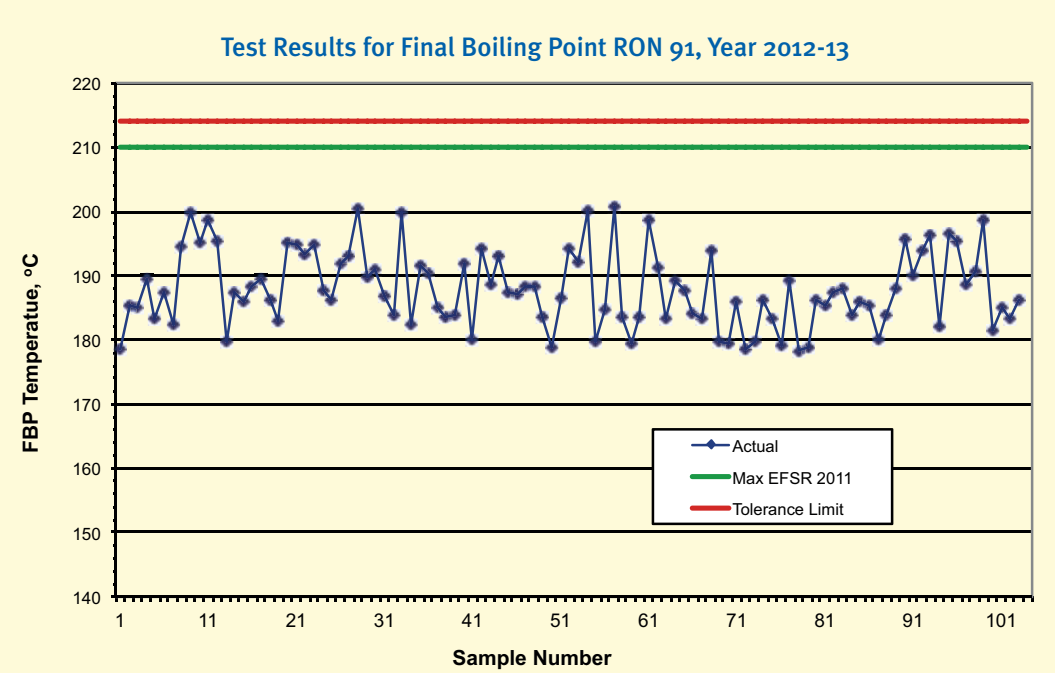
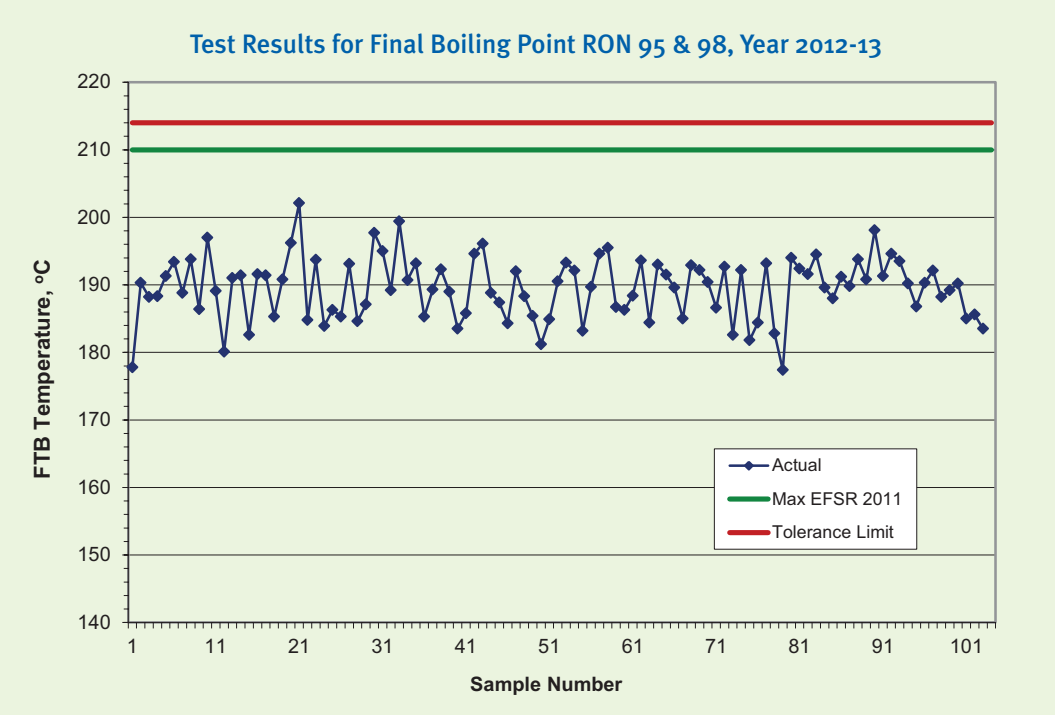


Fig. 6b



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 D86[6]. Fortunately, residue content was found to be well below the specified maximum limit of 2% volume.

Fig. 7a

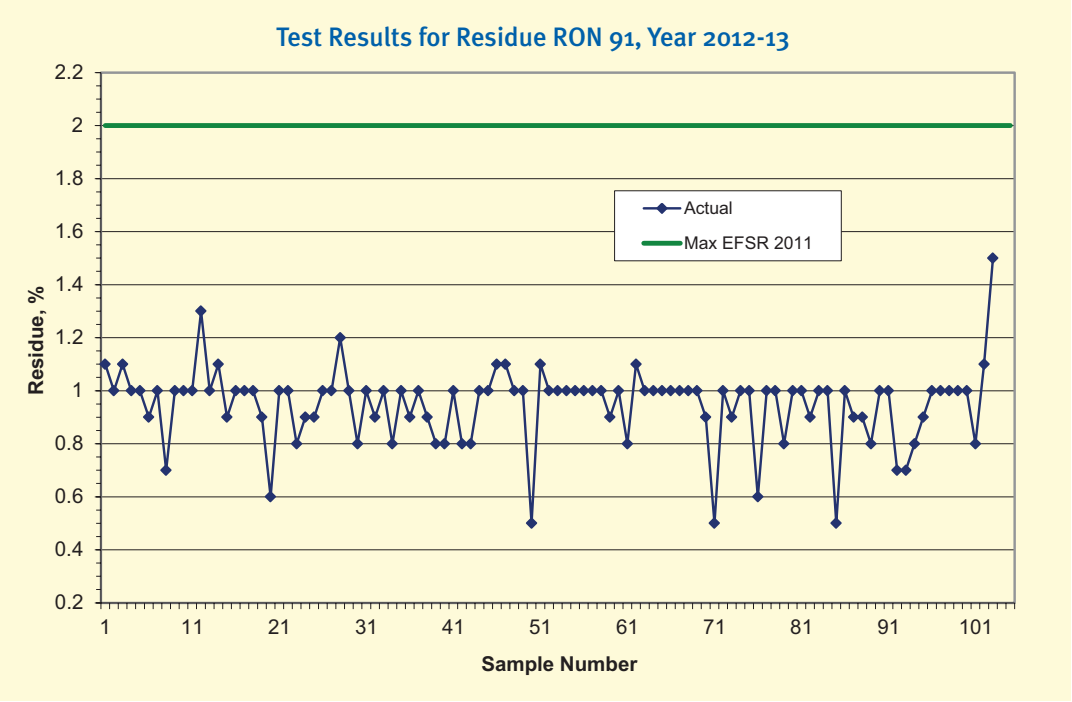
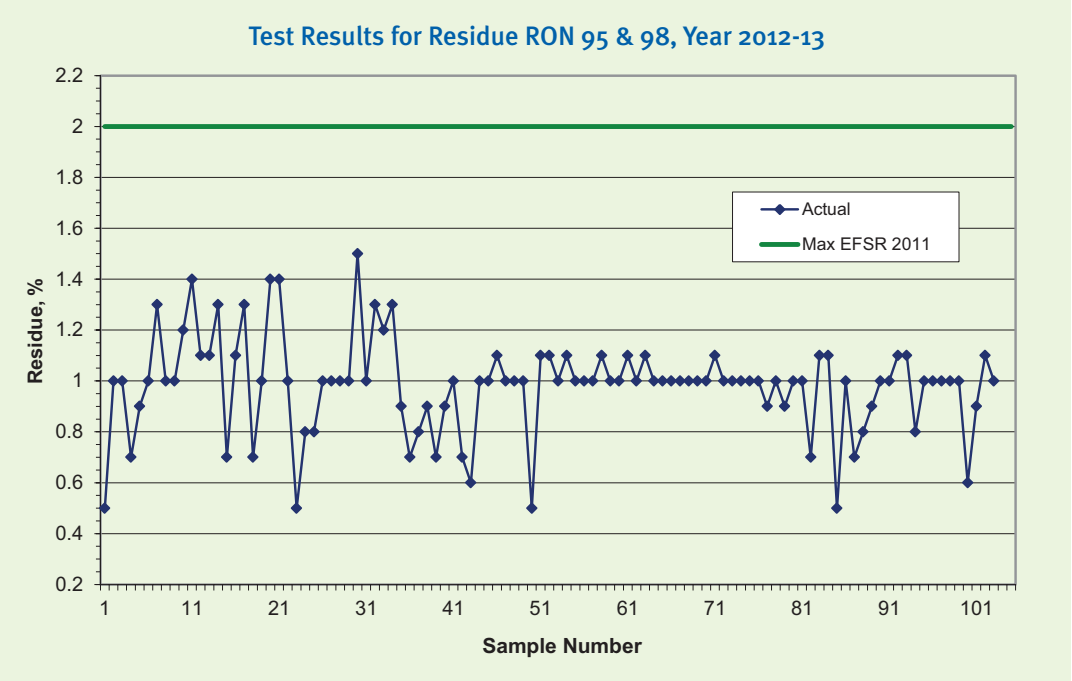


Fig. 7b



6 ASTM D86 – 11b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.

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.

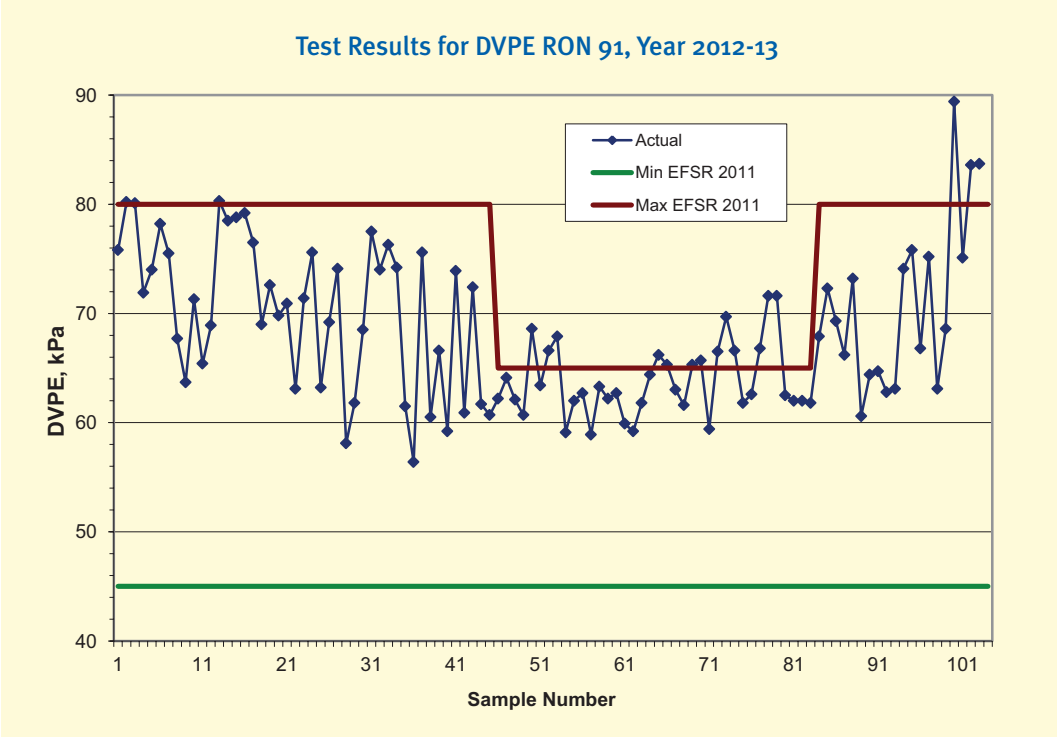
The top line before and after the dip, is the next lowest maximum, 80 kPa, which is prescribed for the North Island, for the autumn and spring periods.

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: 2, 3, and 13, were well within the maximum limit of 90 kPa for winter.

There were also 13 samples found to be above the lowest maximum in the summer period.

Sample 50 was found to contain ethanol, 9.39% (see also section on E70 above). Therefore, according to a condition in the Regulations (Footnote 4, Schedule 1) the maximum limit for this sample is 72 kPa in Auckland and Northland, summer season. Sample 50 was found to be 68.6 kPa, *i.e.* within the specification maximum limit for ethanol blend in the region.

Further, three samples: 66, 69, and 72, which were found to be in the range from 65.3 kPa to 66.5 kPa, were well within the maximum limit of 70 kPa for the rest of North Island.

Other eight samples in the summer season, which were found to be in the range from 66.2 kPa to 71.6 kPa, were from South Island. They were found to be well within the seasonal maximum limit of 75 kPa for the region.

Finally, Samples: 100, 102, and 103, were found to be within the maximum limit of 90 kPa for the North Island, winter 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, Samples: 2, and 3, were well within the maximum limit of 90 kPa for winter.

There were also 19 samples found to be above the lowest maximum in the summer period.

Sample 50 was found to contain ethanol, 9.33% (see also section on E70 above). Therefore, according to a condition in the Regulations (Footnote 4, Schedule 1) the maximum limit for this sample is 72 kPa in Auckland and Northland, summer season.

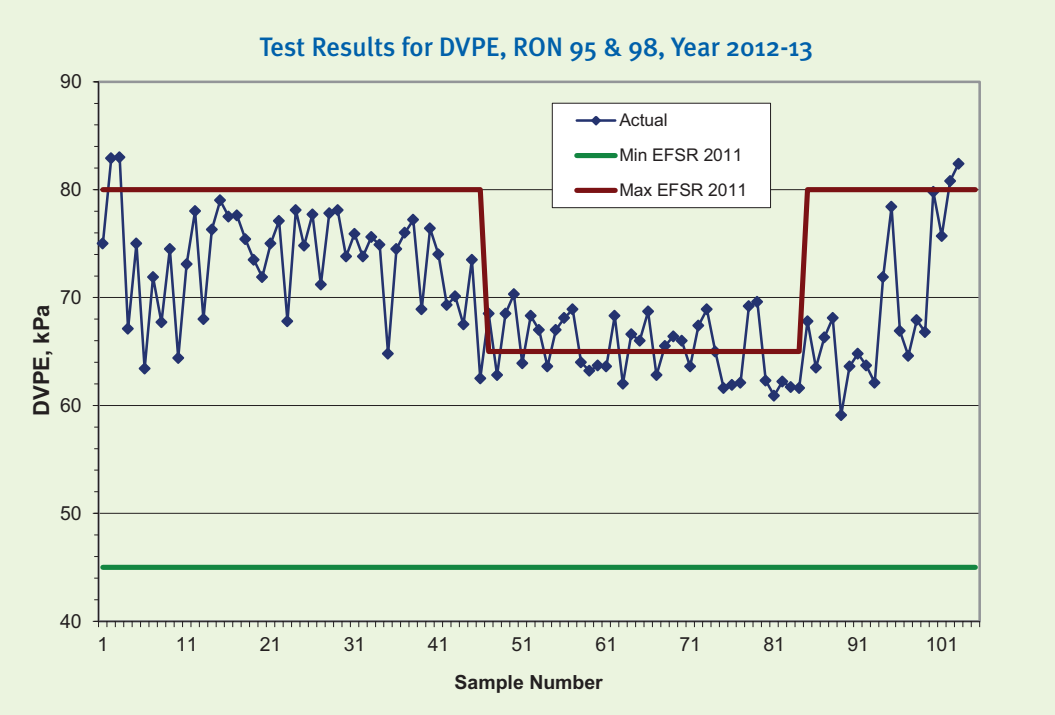
Sample 50 was found to be 70.3 kPa, *i.e.* within the specification maximum limit for ethanol blend in the region.

Further, six samples: 47, 56, 57, 66, 69, and 72, which were found to be in the range from 66.4 kPa to 68.9 kPa, were within the maximum limit of 70 kPa for the rest of North Island.

Other 11 samples in the summer season, which were found to be in the range from 65.5 kPa to 69.6 kPa, were from South Island. They were found to be well within the seasonal maximum limit of 75 kPa for the region.

Finally, Samples: 102 and 103, were found to be well within the maximum limit of 90 kPa for the North Island, winter 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

FVI = DVPE + (0.7 x E70)

FVI serves as an indicator of the hot running performance (the tendency for vapour lock).

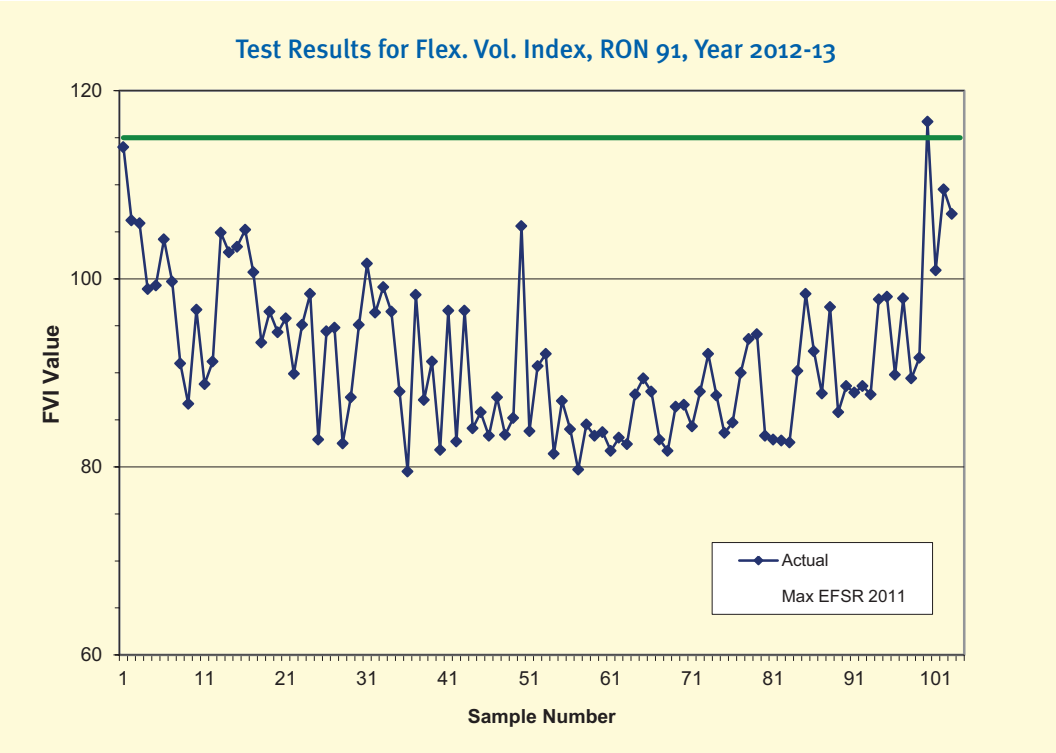
No definition of the FVI value is given in the related ASTM Standards prescribed in the Regulations (D86 and D5191[7]) and no reproducibility value is identified. As a result of this the FVI serves only as a helpful indicator but cannot be used in a strict compliance analysis.

RON 91

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

Sample 100 was found to be above the specified limit with the result of 116.7. The enhanced figure for FVI is in correlation with the enhanced figure for DVPE (Fig. 8a). On investigation, an additional test for ethanol content, to check whether Sample 100 qualifies for the FVI maximum limit of 130.0 specified for petrol blended with ethanol for winter (Footnote 3, Schedule 1), returned a negative result. Since both parameters involved in FVI, *i.e.* E70 and DVPE, were found to be on specification, as well as due to the absence of a reference figure for the tolerance limit, it was concluded that the sample was only marginally non-compliant.

Fig. 8c



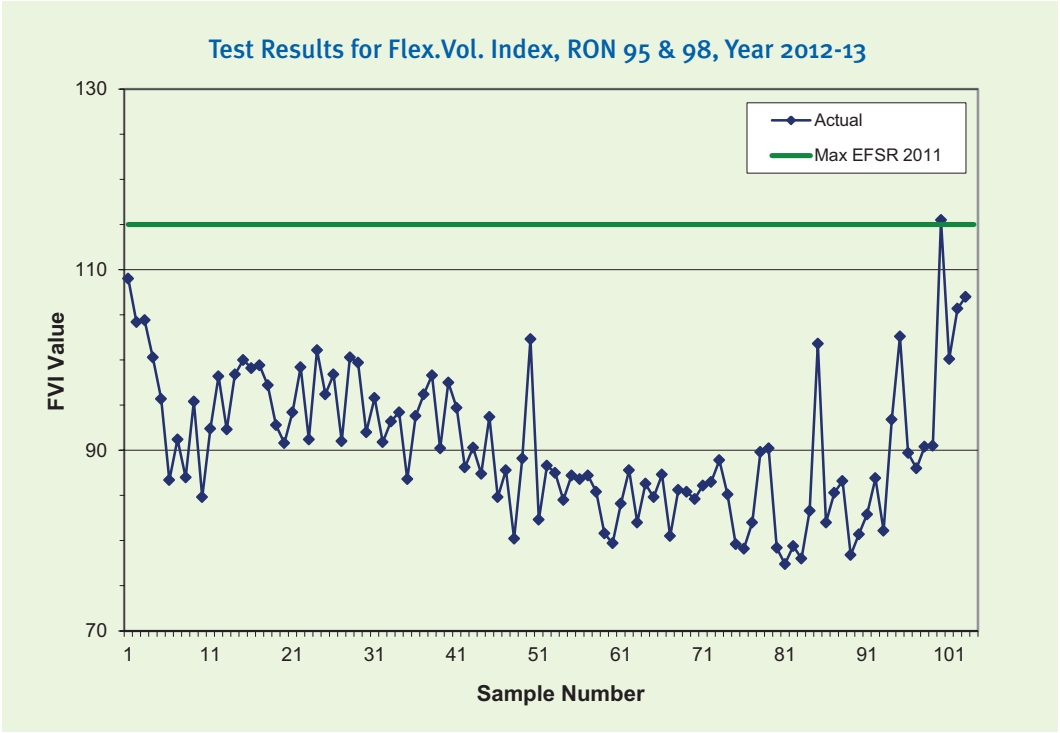
7 ASTM D5191 – 13 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)*.

RON 95 & 98

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

Sample 100 was found to be well within the maximum limit of 130.0 specified for petrol blended with ethanol (in this case, 9.37% blend) for winter (Footnote 3, Schedule 1), with the testing result of 115.5.

Fig. 8d



Sulphur

The scope of the test method IP 497[8] 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.

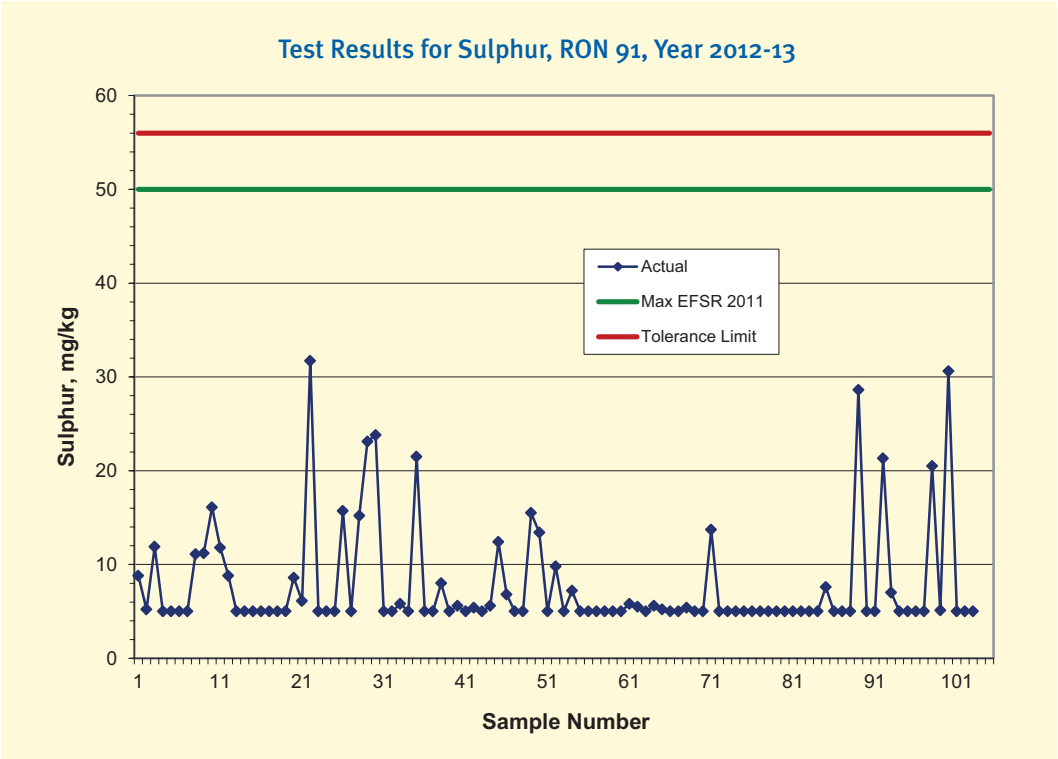
The ASTM standard D5453[9] which is also prescribed in the Regulations along the IP 497, gives results down to a fraction of 1 mg/kg although it was not used for petrol by the testing laboratory this year.

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 Samples 22 and 100 were found to exceed 30 mg/kg with the actual figures, respectively, of 31.7 and 30.6 mg/kg.

Fig. 9a



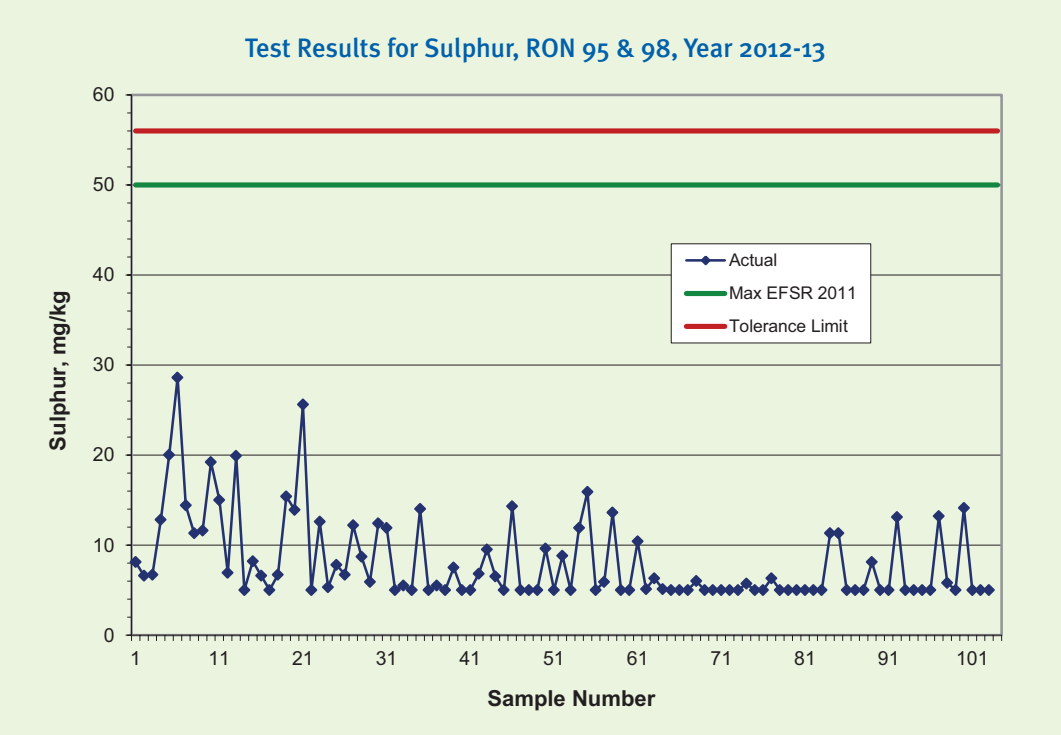
8 BS EN ISO 20884:2011, BS 2000-497:2011 *Petroleum products – Determination of sulphur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry.*

9 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

The majority of the results for benzene content were below 0.95%. Only Sample 51 was found to exceed this figure with the result of 0.98%.

For RON 91, the majority of results on total aromatics were found to be below 40% (Fig. 10b). Only three samples were found in a range from 40% to 41%.

Fig. 10a

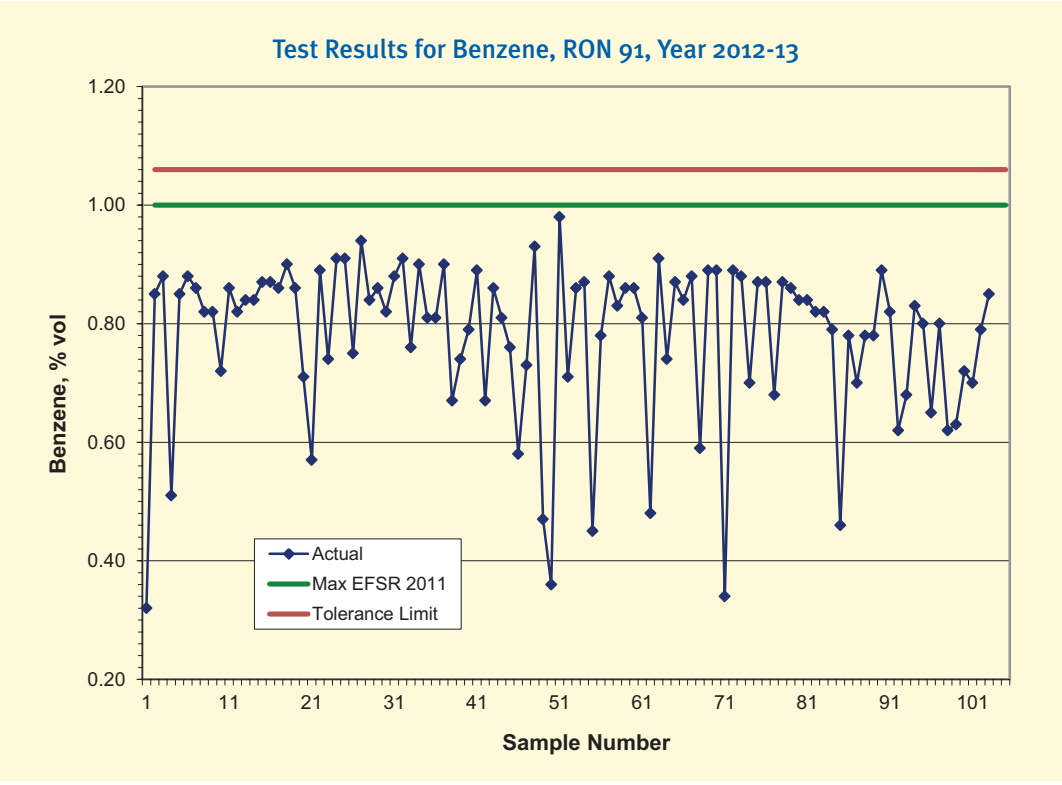


Fig. 10b

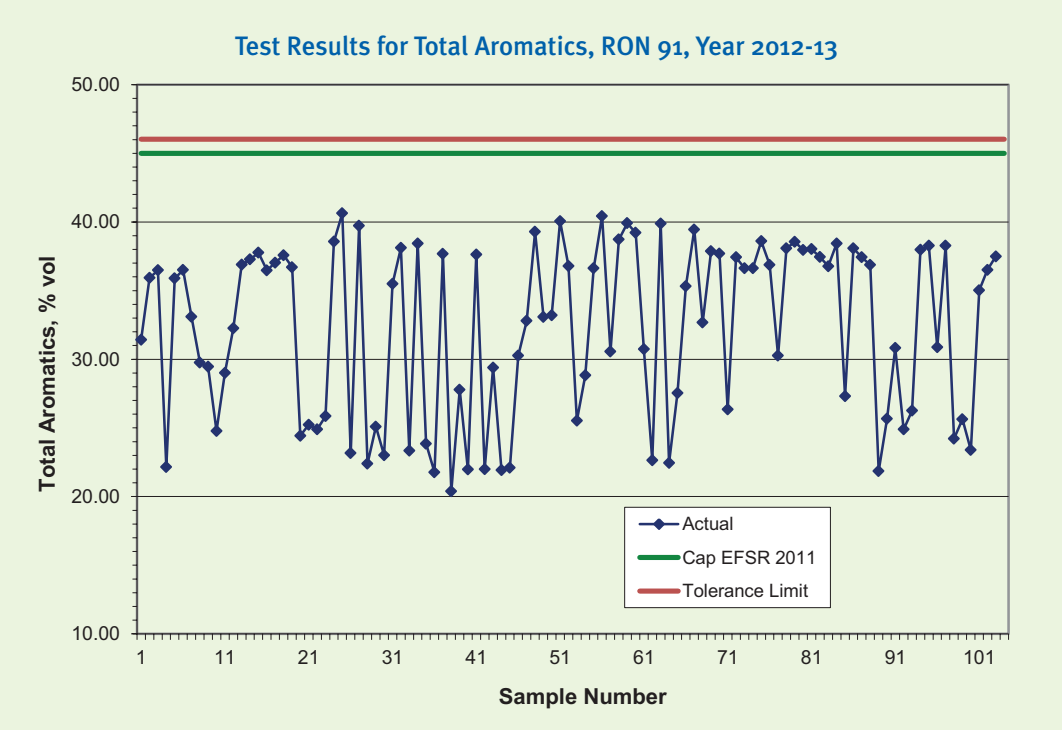
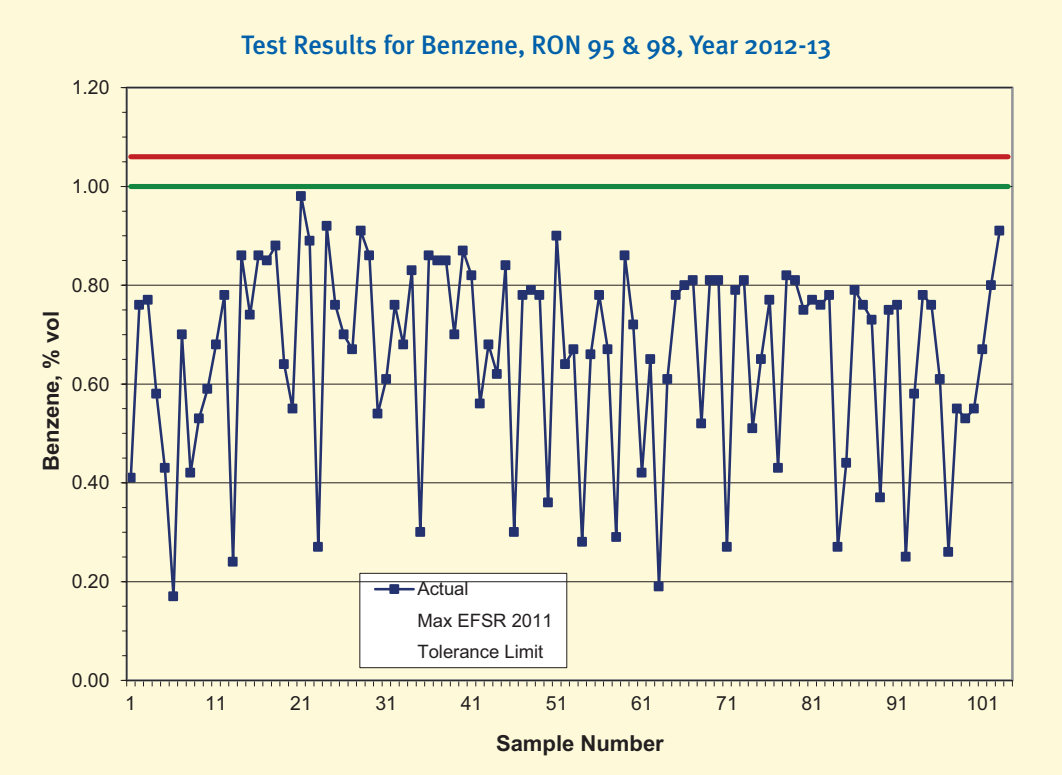


Fig. 10c

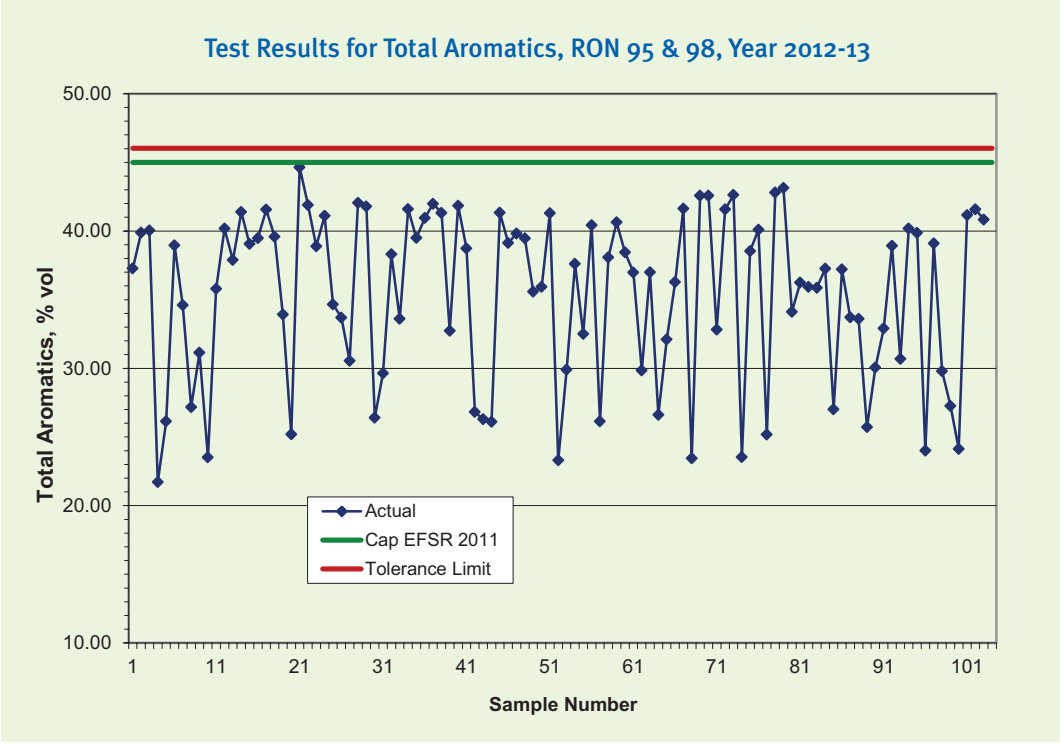


RON 95 and 98

All samples except one were found to be well within the prescribed maximum limit for benzene. Sample 21 was found to be close to the specification limit with the actual figure of 0.98% while other results were on or below 0.92%.

For premium petrol, the majority of the results on total aromatics were below 42%. Only six samples were found to exceed this figure with the largest result on total aromatics was found to be 44.64% for Sample 21 (Fig. 10d).

Fig. 10d



Pool Average

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.

During the period of this report, 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 31 December 2012. 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.

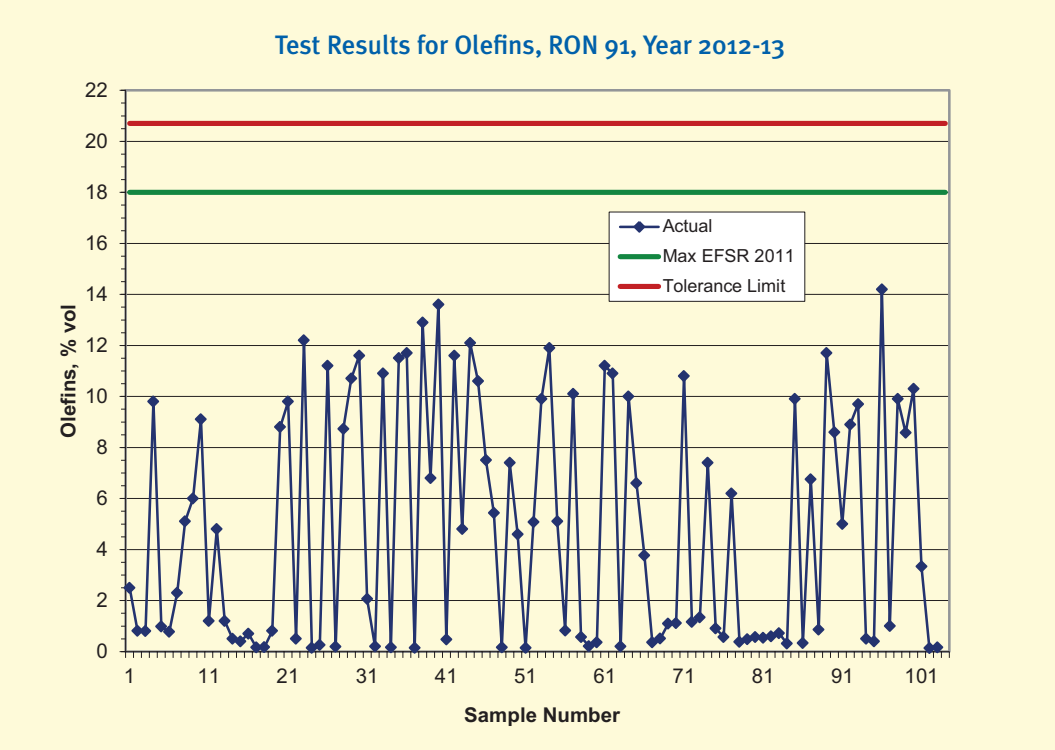
Olefins

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 96 was found to exceed this figure with the result of 14.2.

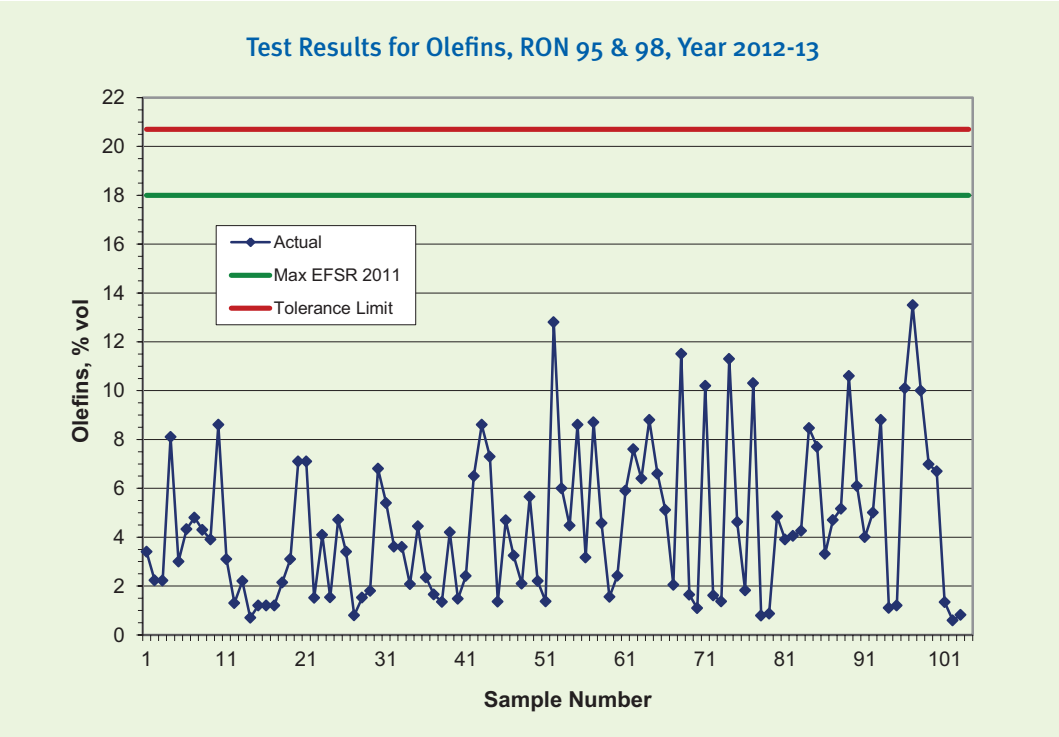
Fig. 11a



RON 95 & 98

For premium petrol, all results were found to be below 12% except Samples 52 and 96 with the actual figures of, respectively, 12.8% and 13.5% (Fig. 11b).

Fig. 11b



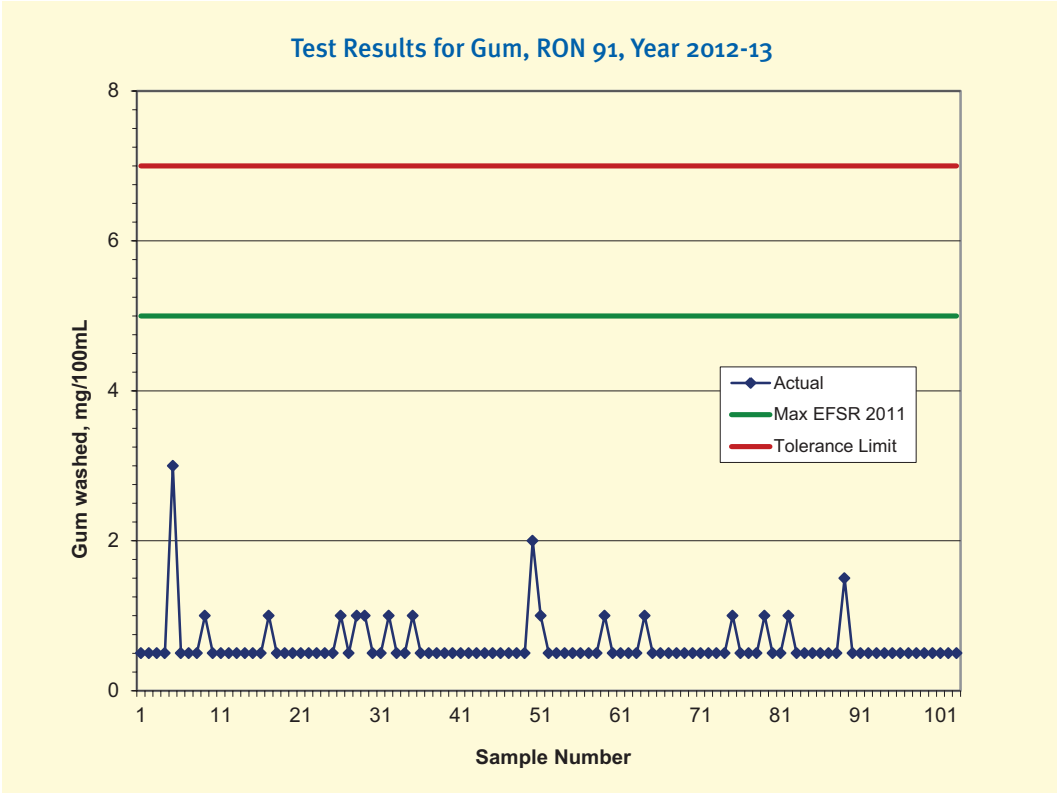
Existent Gum (solvent washed)

The threshold of the test method ASTM D381[10] 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 well below the specification maximum limit (Fig. 12).

RON 91

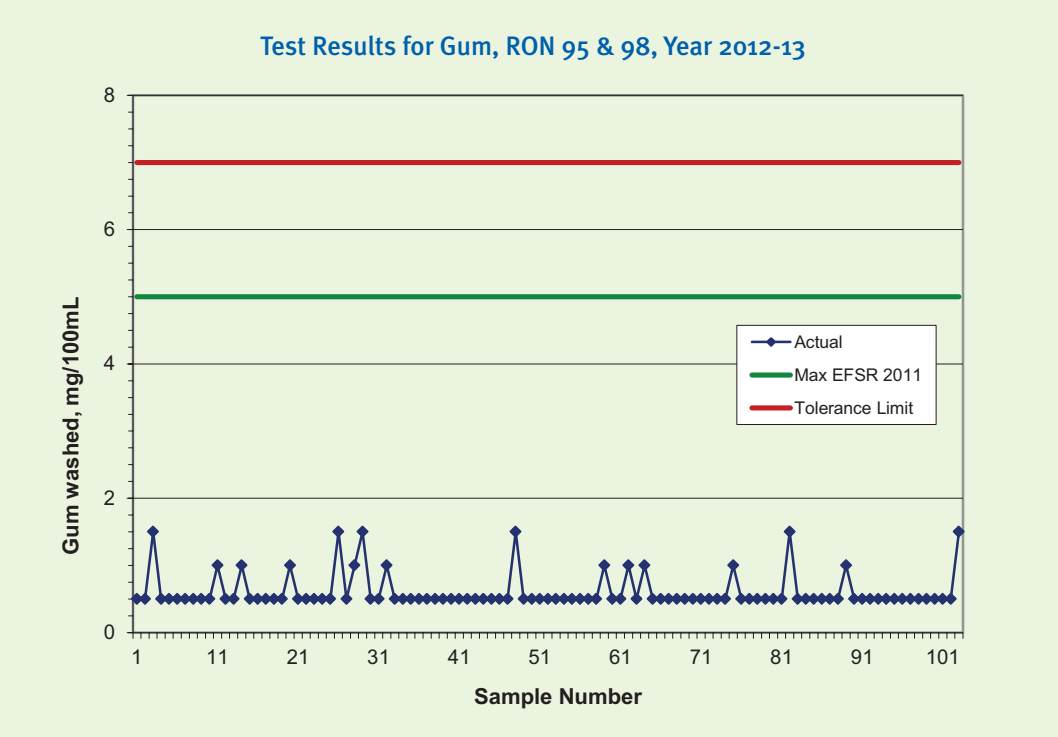
Fig. 12a



10 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 has not been usually done due to the relatively short periods of storing fuel by the retail industry. The test will be added from January 2014 to the regular list of tests with a special testing frequency.

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

The number of suspected non-compliance cases was low and there were no repeated cases of non-compliance identified.

One marginally non-compliant sample detected during the period of this report related to a sample of premium petrol where the flexible volatility index on investigation was found to be above the prescribed limit of 115.0 with an actual figure of 116.7.

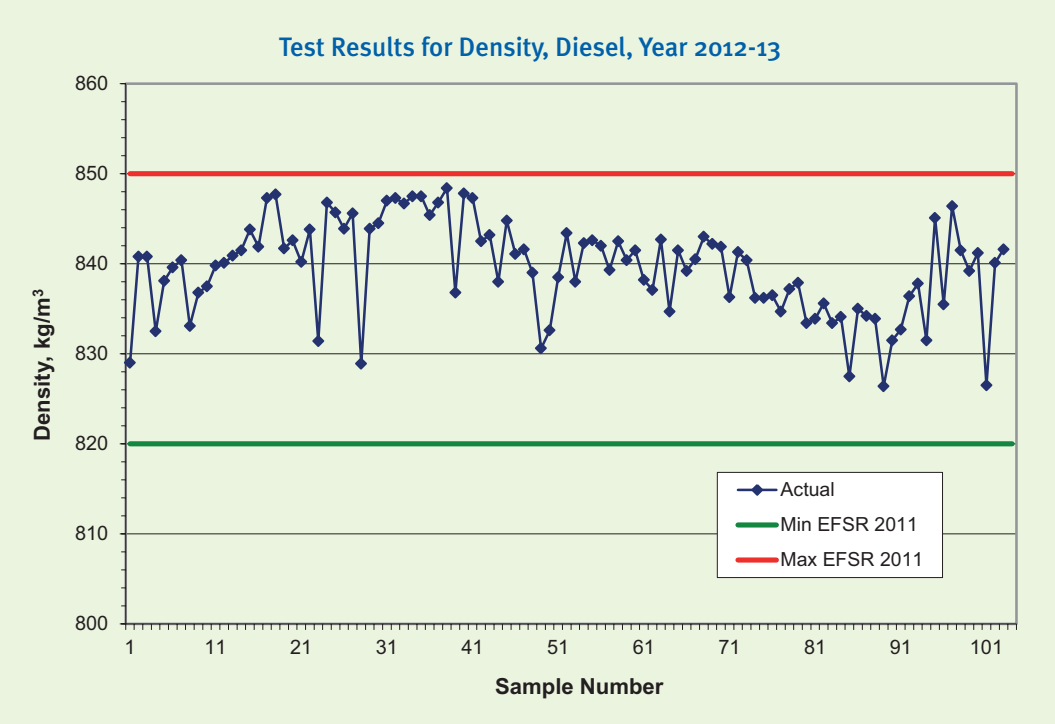
Only this sample was found to be outside specification after subsequent additional analysis. The product was deemed to be marginally non-compliant however no follow-up action was undertaken due to the fact that this is a derived parameter which is calculated from the measured value of DVPE and the value of E70 which both were found to be within their specified limits (see above) as well as due to the absence of a reference figure for the tolerance limit.

In a number of instances the results were initially found beyond the prescribed limits and on subsequent investigation they were found to be within the tolerance limits. These instances included: two cases in relation to research octane number in regular petrol, one case in relation to research octane number in premium petrol, and one case in relation to motor octane number in premium petrol.

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 848.4 kg/m^3 at the maximum tolerance limit of 850.7 kg/m^3.

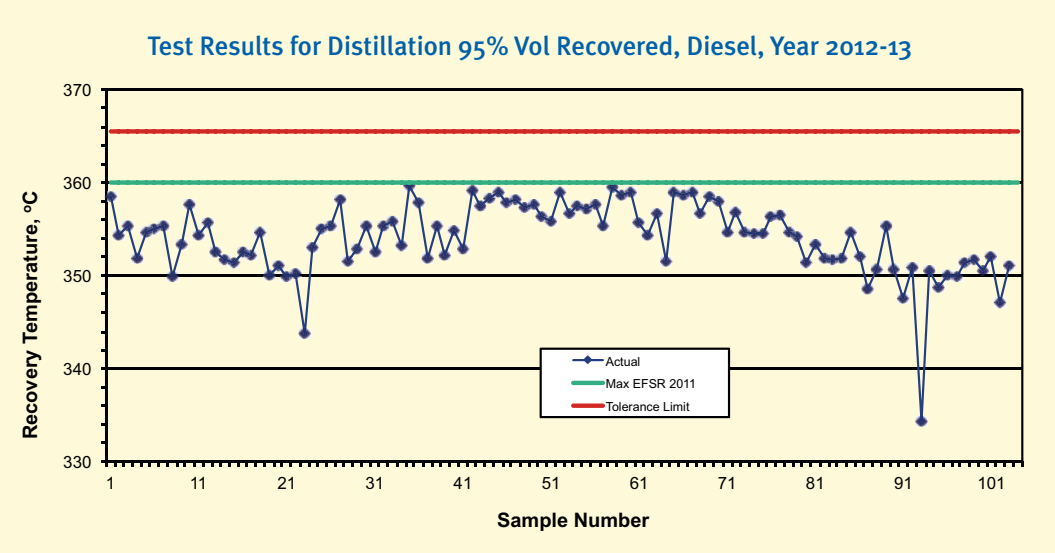
Distillation

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

Samples 35 and 58 were found to be close to the limit with the actual results of 359.6°C and 359.5°C, respectively. The tolerance limit is 365.5°C.

Sample 93 was found to be the lowest with the actual figure of 334.3°C although there is no prescribed minimum limit for this property.

Fig. 14



Cetane Index

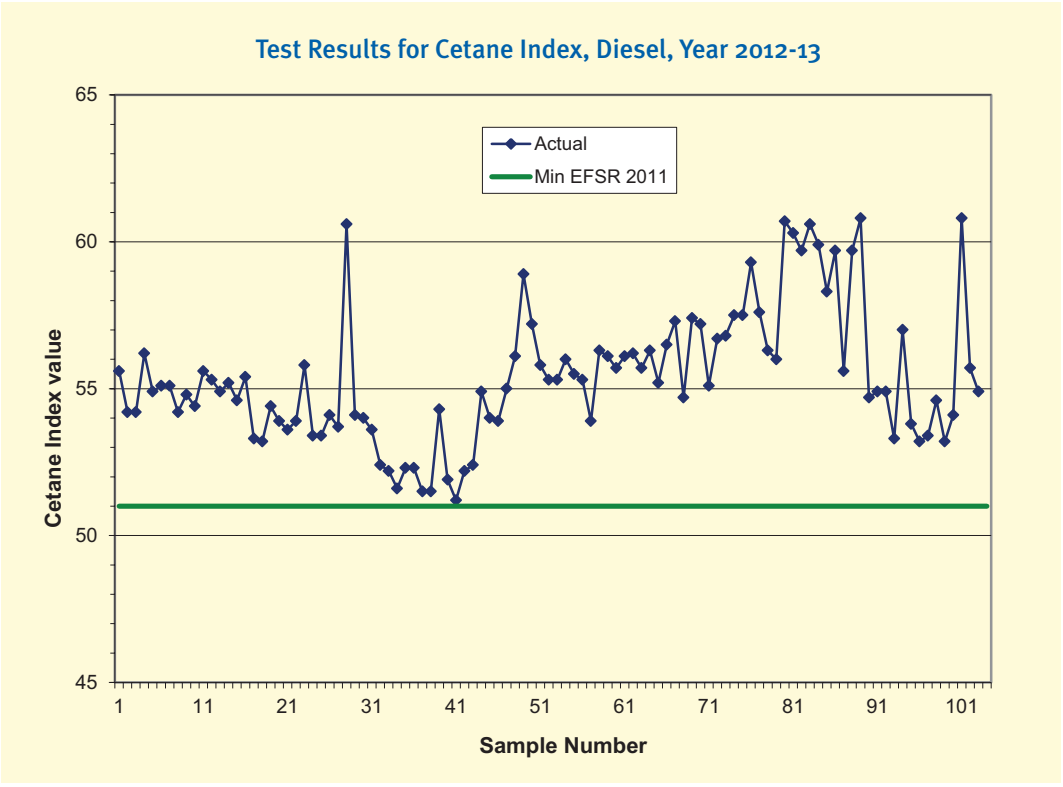
The cetane index, according to ASTM D4737[11] prescribed in the Regulations 2011, is not tested for but calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine for determining cetane number is not available and/or cetane improvers are not used.

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

Sample 41 was found to be the lowest with the actual figure of 51.2.

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



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

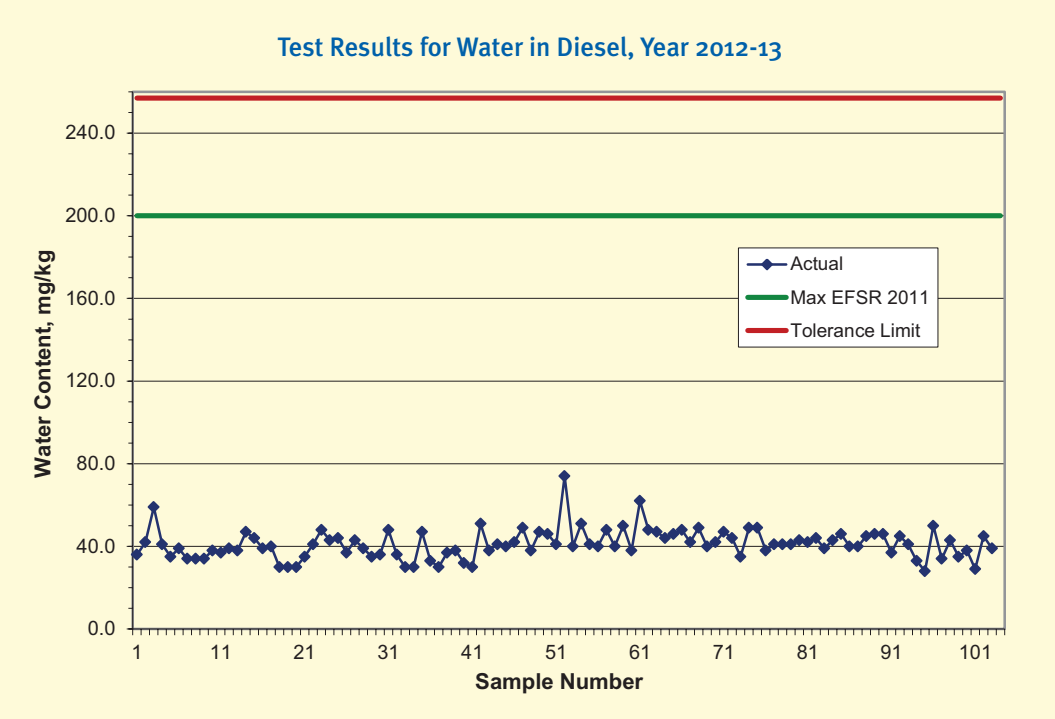
Water

The test for water content according to IP 438[12] 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 within the specification limit with actual testing results not exceeding 80 mg/kg. Sample 52 was found to be the largest with the results of 74 mg/kg.

Fig. 16

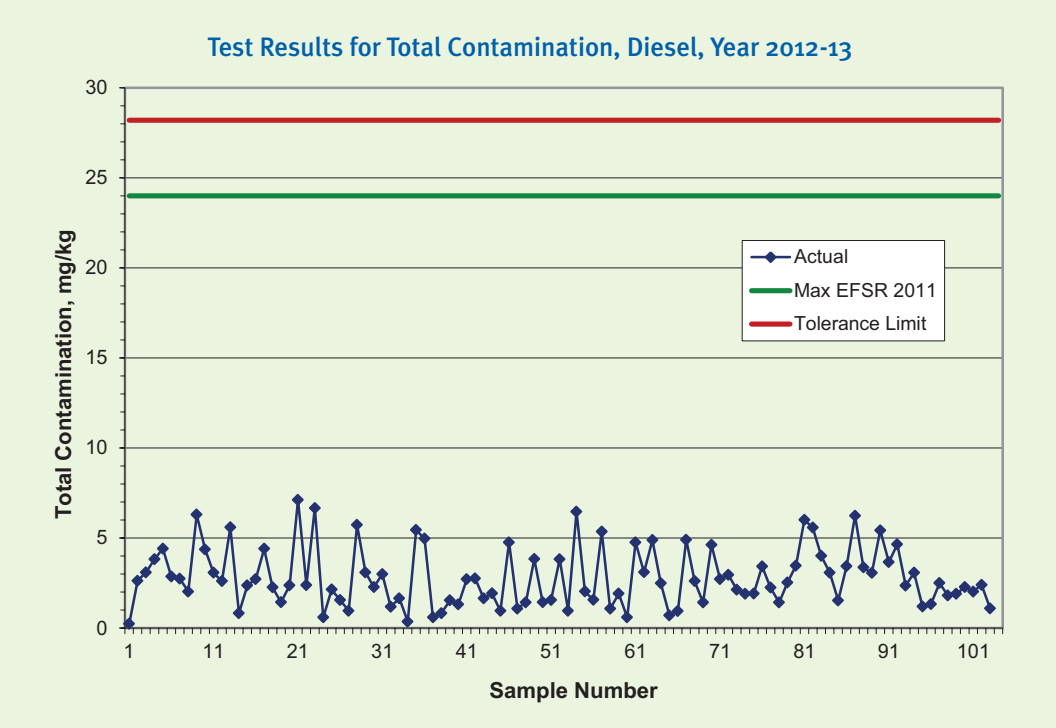


12 BS EN ISO 12937:2001, BS 2000-438:2001. Petroleum products. Determination of content. Coulometric Karl Fischer titration method.

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

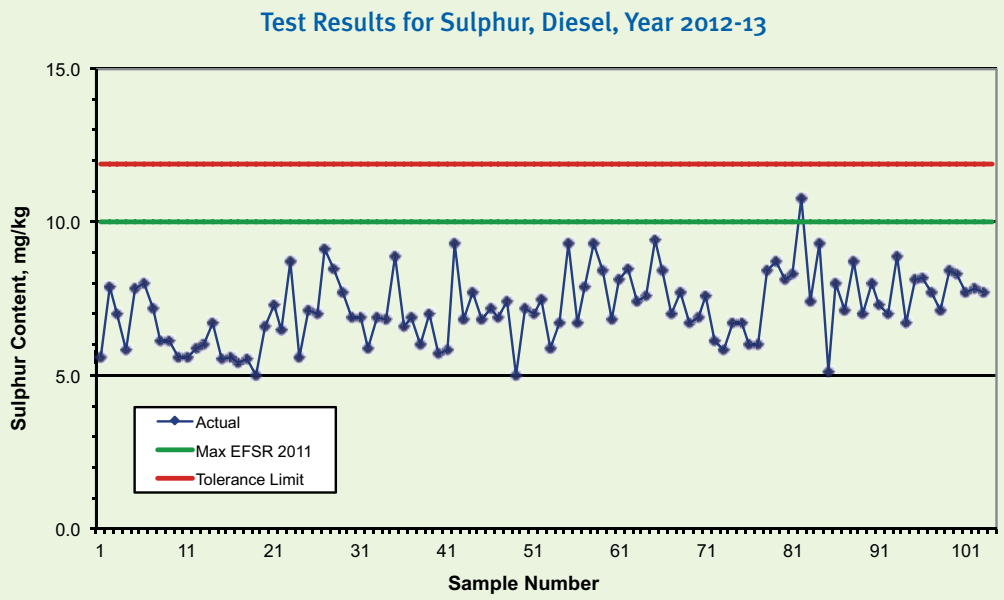


Sulphur

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

Sample 82 was initially found to be 11.3 mg/kg at the tolerance limit of 11.8 mg/kg. The tests repeated by another operator returned the figure of 10.2 mg/kg with the reproducibility condition satisfied, R=3.1 mg/kg. A corrected tolerance limit for two results is not applicable for two different operators. On investigation it was found that the average of 10.8 mg/kg was well within the testing tolerance limit so, according to the established policy, Sample 82 was deemed to be compliant.

Fig. 18



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.

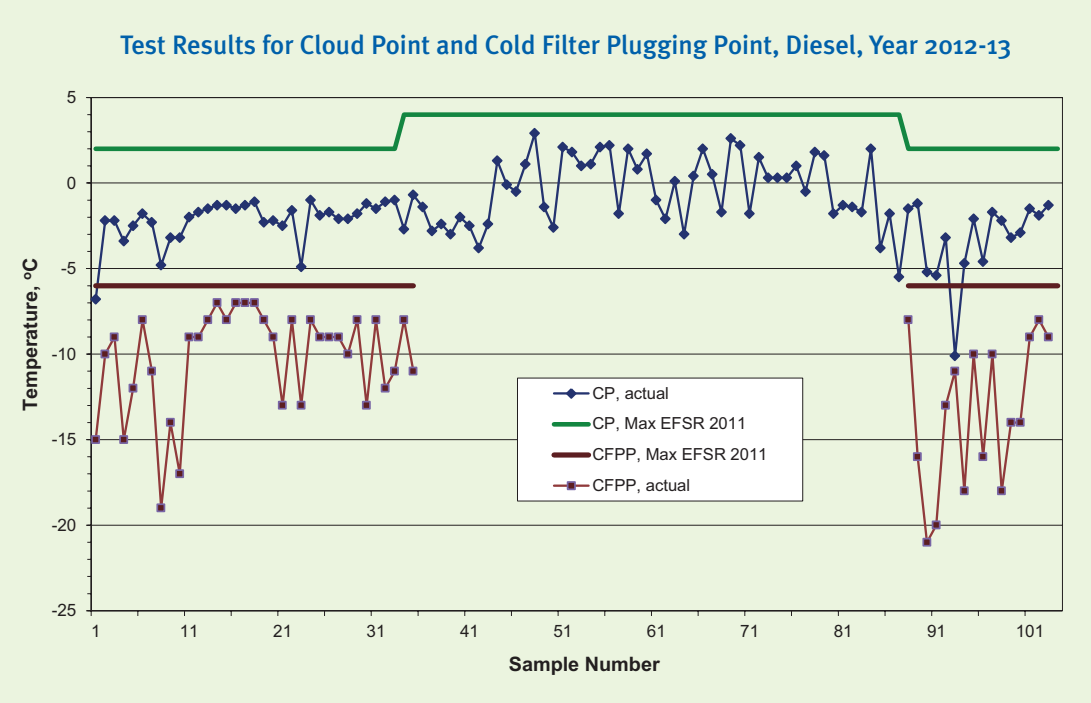
For the period of summer in Schedule 2 (season definitions in Section 5, the Regulations) from 15 October to 14 April inclusive, the lowest maximum limit of CP +4°C is prescribed for all New Zealand excluding Auckland and Northland.

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 48 returned the highest testing result for summer, +2.9°C, at the maximum limit of +4°C.

The lowest figure for CP was found to be –10.1 C for Sample 93 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.

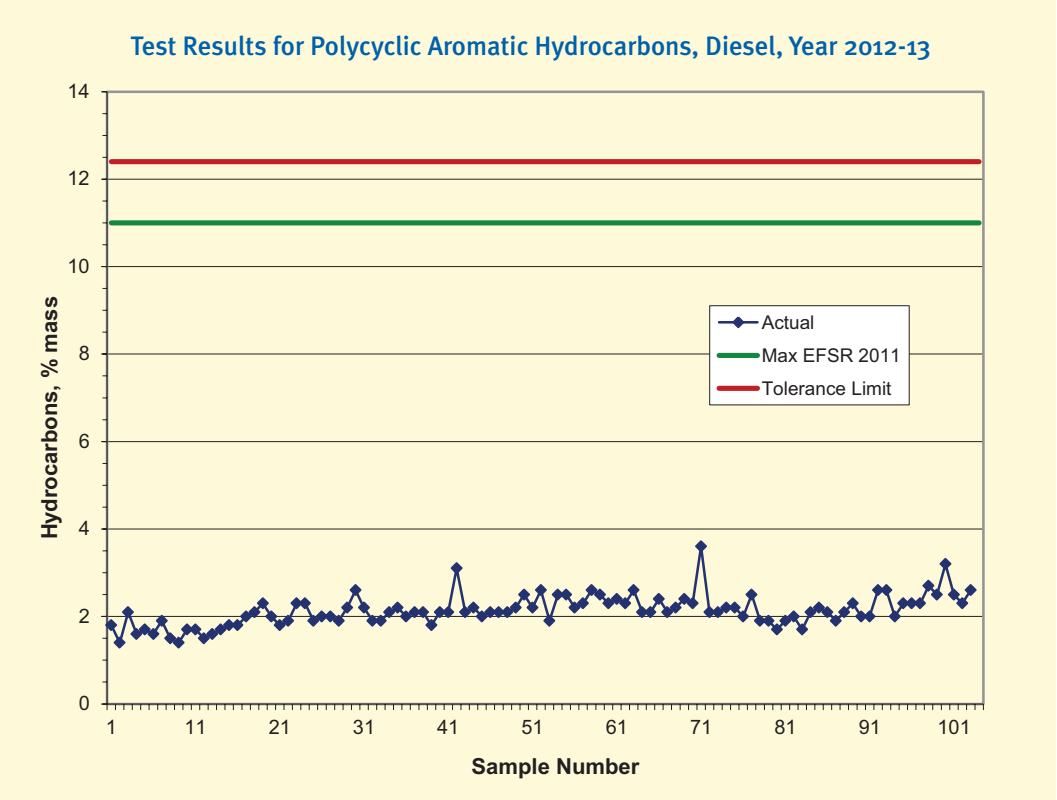
All samples were found to be below the maximum limit specified in the Regulations for the winter season.

Sample 90 was found to have the lowest CFPP of –21°C with a relatively average result for CP of –5.2°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 4%.

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, a significant number of samples were found to be relatively high.

In particular, Samples 10 and 49 were found to be comparatively high with the testing results, respectively, of 1.53 and 1.69.

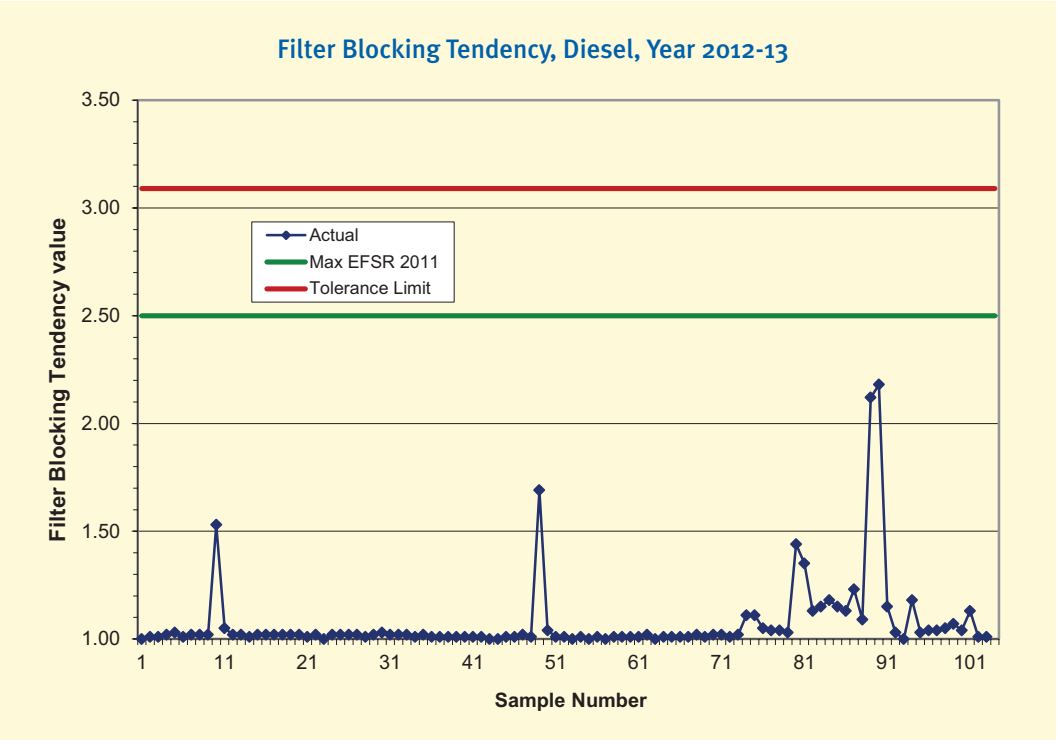
A half of samples from Sample 75 onwards were found to be above 1.10, *i.e.* elevated compared to the usual average.

Samples 89 and 90, both from South Island, were found to be the highest two with the testing results, respectively, of 2.12 and 2.18.

Sample 90 was initially found to be 2.24. When repeated by the same operator, the test returned the figure of 2.12, with the repeatability condition satisfied r=0.35.

An investigation on Sample 89 was completed two months later after the initial test, in the framework of a quality reassurance programme. The sample was retested by the same and other operators for the sake of consistency several times. While the eight retest results were found to be within the range from 1.38 to 2.12, with the reproducibility condition not always satisfied, the initial test result of 2.12 was included in the Fig.21 due to the extended time period between the initial test and final repeats.

Fig. 21

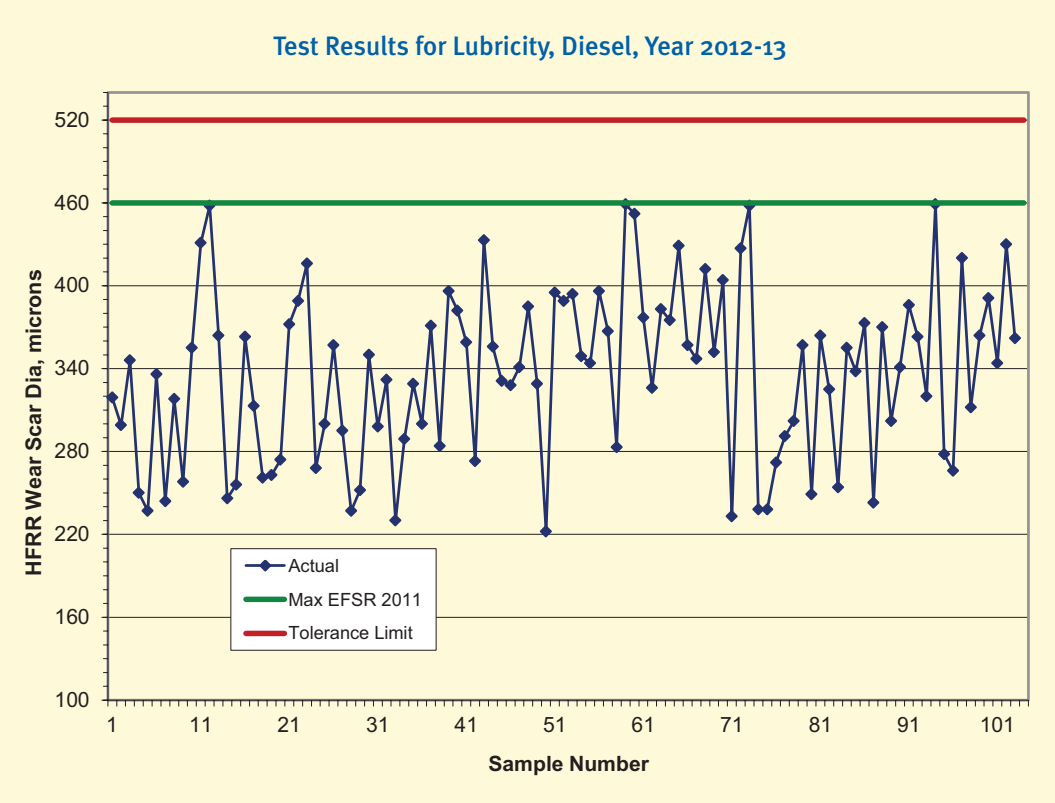


Lubricity

All samples 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.

Samples 12, 59, 73, and 95 were found to be practically on the specified maximum limit with the actual figures of 458 or 459 µm at the tolerance limit of 520 µm.

Fig. 22

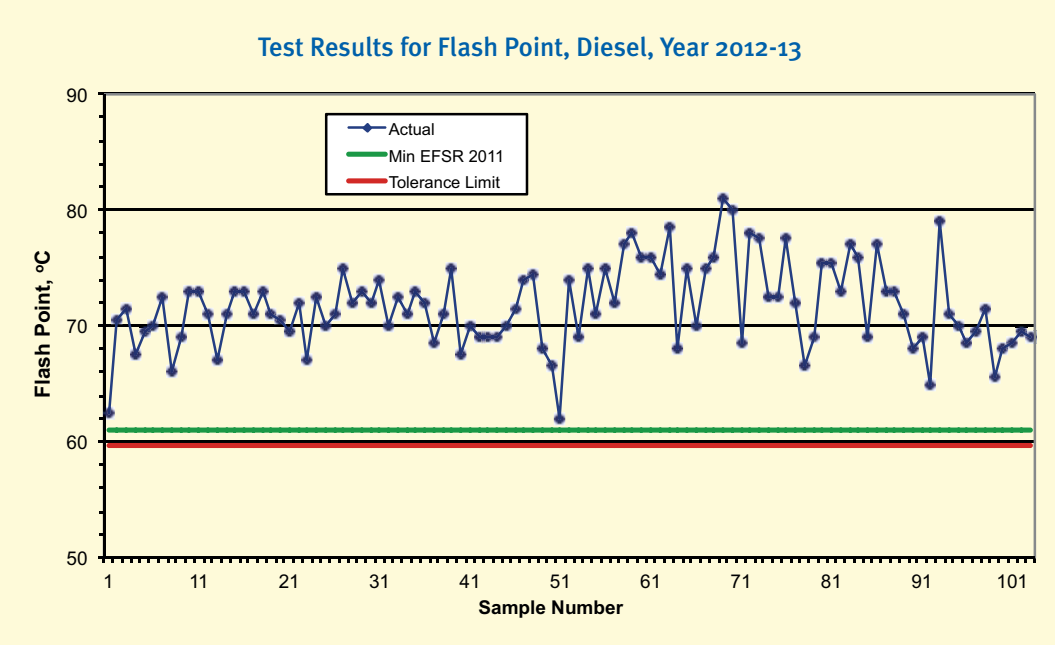


Flash Point

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

The majority of the test results were in the range above 70°C with the minimum result of 62.0°C for Sample 51 at the tolerance limit of 59.6°C.

Fig. 23



Summary for Diesel Test Results

On the whole, a few samples were found to be close to the specification limit although there were no suspected non-compliance cases identified.

In a few instances the results for filter blocking tendency were initially found relatively high although within the prescribed limits. After further analysis and investigation the suspect test results were confirmed to be compliant.

This year, testing diesel for appearance according to the ASTM standard D4176[13] which is not listed in the Regulations, was continued. This was done to maintain confidence that water in bulk and/or other contamination, if present, would be identified. This testing did identify two samples with the presence of bulk water or other contamination however after repeated testing on the retained tins, the results appeared to be not confirmed and therefore were discarded as inconsistent due to sampling error. Other samples were immediately collected from the same sites and their test results were found to be all on specification.

Testing for oxidation stability of diesel has not been usually done as well as that for petrol due to the relatively short periods of storing fuel by the retail industry. The test will be added from January 2014 to the regular list of tests with a special testing frequency.

13 ASTM D4176 – 04(2009) *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

As in the last year, this blend was tested 8 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 to be compliant with the relevant specifications in the Regulations.

Ethanol blended petrol E3 and E10

This year, a special project on ethanol blended petrol conducted last year, was continued with the intention to confirm that blended petrol was within specifications. It focussed on dry vapour pressure in particular because samples had previously been found close to the limit and outside specification. 18 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.

Some anomalously high results on other oxygenates content received last year were not observed this year. Remedial actions and procedural improvements implemented by the testing laboratory, appeared to be successful.

Ethanol blended petrol E85

One retail site in New Zealand offers 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 dispenser at the site is 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[14] which was chosen as a reference standard for the list of properties to be tested.

14 ASTM D5798 – 11 *Standard Specification for Ethanol Fuel Blends for Flexible Fuel Automotive Spark Ignition Engines.*

Two samples taken during the report period, were found to be within prescribed specifications according to ASTM D5798, with the ethanol content of 84.30% and 85.46%, with the tolerance limit of 85.64% in the second instance.

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

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 Schedules 3 in the Regulations while the B10 and B20 blends were tested according to the Regulation 17.

In total, 10 samples of biodiesel were collected from production plants or non-retail refuelling sites and tested. These include 12 samples of B100 and 2 samples of B20.

Biodiesel B100

Problems with accurate measurement of FAME (Fatty Acid Methyl Esters) content remained in the focus of the testing programme. The variety of feedstock leads to some diversity in results on FAME content identified by the EN 14103 standard.

Four samples of B100 were tasted during the reported period. A few samples were found to be below the minimum limit but within the tolerance limit.

A new version of the standard, EN 14103:2011, was issued in May 2011 by CEN (European Committee for Standardisation). After receiving sets of comparative data on FAME content, 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.

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 marginally above the specified maximum limit with figures of 553 and 598 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, various glycerides were initially found to be above the prescribed maximum limits. After technology adjustments in response to Ministry's advices, the glycerides were brought under the required limits.

In three 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.

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'.

Five 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, the FAME content was found to be above the advertised maximum of 10%

with the actual figure of 12.4% and the tolerance limit, accordingly, of 10.4%. The filter blocking tendency for this sample was found to be below the maximum limit of 2.5 although relatively high: 2.36. The fact that the filter blocking tendency was again found to be above the figure of 2.0 stimulates the Ministry to consider a tighter specification limit for this property.

In another instance, biodiesel which was supposed to be a B5 blend returned the figure of FAME content of 10.2% (the average of two test results, respectively, of 10.2 and 10.3%) with the filter blocking tendency of 3.81 (the average of two results, respectively, of 4.14 and 3.48, with the tolerance limit of 3.09), *i.e.* much higher than the specification limit.

In both 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.

Finally, biodiesel B20 was found to be on specification although both times the FAME content was lower than the advertised 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 unique perspectives and issues are represented and considered internationally.