Fuel Quality Monitoring Programme

Test Results 2011–12

MEASUREMENT AND
PRODUCT SAFETY SERVICE

Ministry of Business, Innovation & Employment

New Zealand Government

Disclaimer

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Executive Summary

The Fuel Quality Monitoring Programme (**the Programme**) administered by the Measurement and Product Safety Service has continued to sample and assess the quality of retail fuel in New Zealand and to monitor its compliance with the specifications set out in the relevant Engine Fuel Specifications Regulations **(the Regulations**).

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

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

This report is intended to give an overview of the results of the Programme from 1 July 2011 to 30 June 2012. During this period retail fuel samples were collected and tested from 103 of the approximately 1,100 fuel service stations in New Zealand.

It must be noted that for the period from the 1 July 2011 until 30 November 2011 the Engine Fuel Specifications Regulations 2008 were in force and for the period from the 1 December 2011 until 30 June 2012 the Engine Fuel Specifications Regulations 2011 were in force.

This report also covers the results of sampling and testing of fuel from the emerging market for biofuel. Biofuel testing at retail sites was focussed on specific monitoring of changes to the fuels parameters which can be influenced by the introduction of biofuel components, for example enhanced dry vapour pressure in ethanol blended petrol.

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 outside specifications but on subsequent investigation and analysis of the results they were found to be within established tolerance limits.

One non-compliant sample detected during the period of this report related to a regular petrol sample where the dry vapour pressure on investigation was found to be 85.8 kPa relative to a minimum limit of 80 kPa at the tolerance limit of 81.4 kPa.

This report details this non-compliant result and summarises the results of routine sampling during the period covered.

For further explanation or to comment on the reported results please contact the Ministry: Tel: 0508 627 774 or Email: fuelquality@mca.govt.nz

Introduction

The Measurement and Product Safety Service **(MAPSS)** is an operational unit within the Market Services Group of the Ministry of Business, Innovation and Employment. This unit has national responsibility for three infrastructure areas that are fundamental to consumer safety, supporting consumer and business confidence and facilitating domestic and international trade. MAPSS is responsible for:

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 MAPSS 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.

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.

MAPSS 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 2011 to 30 June 2012.

During this period the Programme was administered and maintained by MAPSS which formed part of the Ministry of Consumer Affairs within the wider Ministry of Economic Development.

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[1] or in previous Fuel Quality Monitoring Programme Reports for 2008-09, 2009-10 or 2010-11.

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

Any non-compliance or abnormalities identified through testing were subject to analysis and follow-up investigation by MAPSS. 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 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 launched in response to detection of several non-compliant samples during the period from mid-2010 to late 2011. This project included a brief sub-project investigating other oxygenates content in petrol blended with ethanol. Both projects were successfully completed in July 2012.

A limited number of additional tests on properties related to extended storage, washed gum content in petrol in particular, were added to the routine list of tests conducted. This included a test on appearance which is not specified in the Regulations but was completed in the routine list of diesel properties tested to enhance MAPSS 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.

1 http://www.consumeraffairs.govt.nz/for-business/by-business-type/for-fuel-industry/acts-and-regulations

Statistical analysis of the Programme's data from previous years with regard to estimating the proportion of non-compliance detected has allowed MAPSS 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 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[2] as described in previous annual test result reports.

The non-retail market of biofuels is emerging in New Zealand and the Programme has identified a number of areas for improvement of the quality of biodiesel and ethanol blended petrol. 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.

Engine Fuel Specifications Regulations 2011 came into force on 1 December 2011 and amended some of the fuel specifications. This report is the first one since the updated Regulations and follows the three reports issued by the Ministry since 2008.

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 relevant applicable Regulations.

Terminal/Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Whangarei	0	0	0	0	0	0	1	2	1	0	0	0	**4**
Auckland	2	2	3	2	3	2	4	4	4	3	3	1	**33**
Mt Maunganui	3	0	3	1	2	4	0	1	0	1	0	1	**16**
New Plymouth	0	1	0	0	0	2	1	0	0	0	0	1	**5**
Napier	0	0	0	1	0	0	0	0	0	1	0	0	**2**
Wellington	0	1	1	1	1	2	0	1	2	0	2	1	**12**
Nelson	3	1	0	0	0	0	1	0	0	0	0	0	**5**
Lyttleton	0	0	1	2	1	0	2	0	3	3	0	0	**12**
Timaru	0	1	0	1	1	0	0	0	0	0	1	0	**4**
Dunedin	0	2	0	1	0	0	1	0	1	0	1	0	**6**
Bluff	0	0	0	1	1	0	0	2	0	0	0	0	**4**
Total	**8**	**8**	**8**	**10**	**9**	**10**	**10**	**10**	**11**	**8**	**7**	**4**	**103**

2 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)

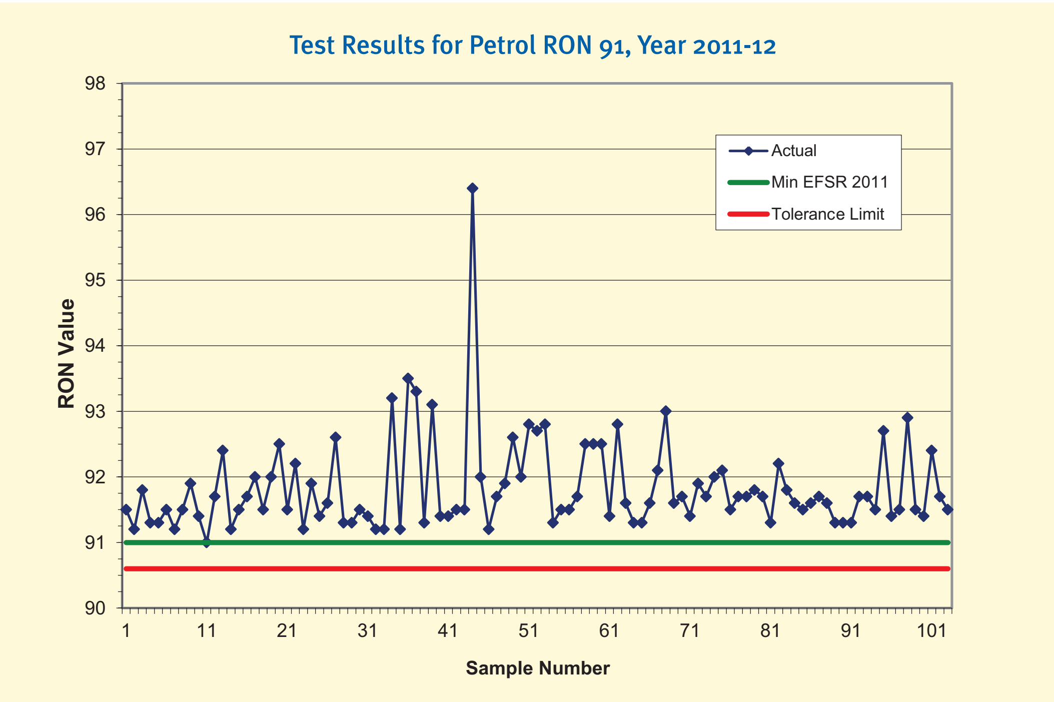
RON 91

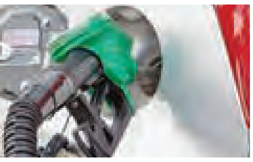
In total, 103 samples of regular petrol were collected and tested. Fig. 1a and 1b below show the testing results for RON and MON respectively.

All samples except one were found to be above the minimum specification limit of 91.0 for RON. One sample was 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.

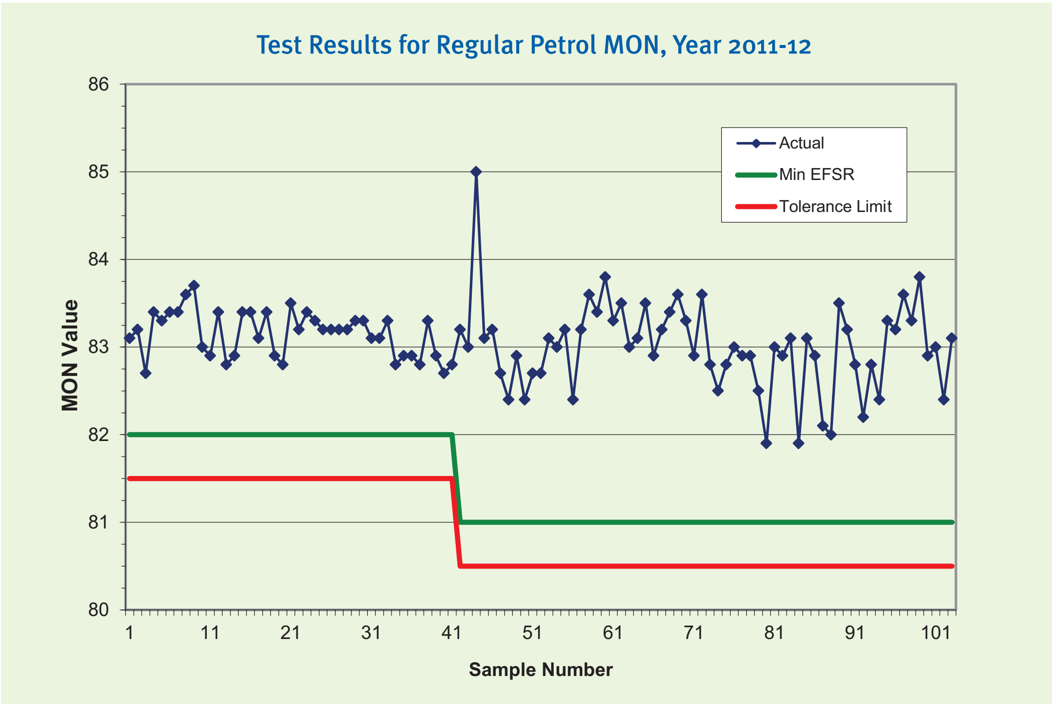




Sample 44 was found to be high on RON and MON with results, respectively, of 96.4 and 85.0. Although the presence of ethanol (test result of 9.77%) should have enhanced both RON and MON, it is believed that the relatively high figures for RON and MON were the result of a misdelivery of RON 95 petrol into a storage tank for RON 91. 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 either of 82.0 for MON by 1 December 2011 or after that date when the specified MON limit was amended to 81.0.

Fig. 1b



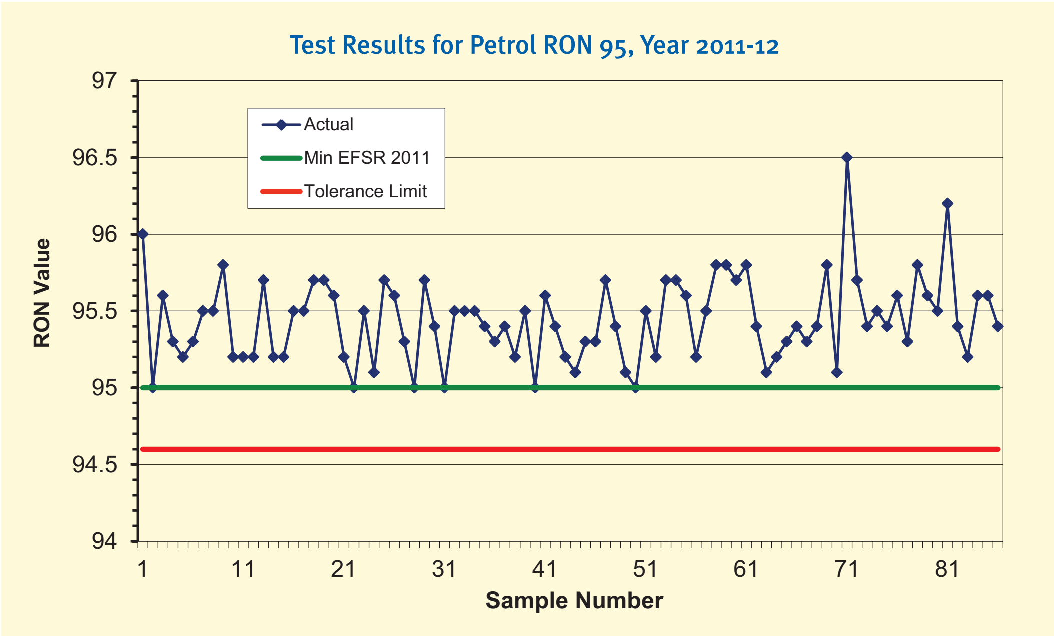
RON 95

In total, 86 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. Six samples were found to be on the limit.

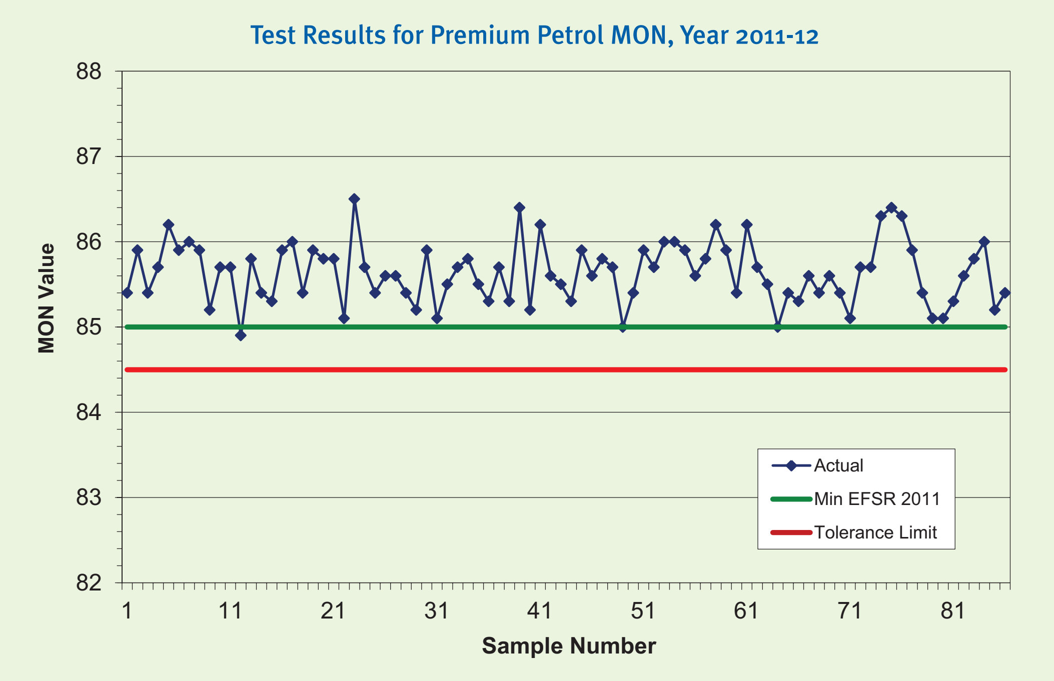
All samples except one were found to have MON on or above the minimum specification limit of 85.0 for premium petrol. The exception was Sample 12 with MON of 84.9 which is well within the test tolerance limit i.e. above 84.5. This result is an average of two determinations by the same operator, initial of 84.8 and repeated of 85.0, with the repeatability condition satisfied, r=0.2. The relevant figure for RON was above the minimum limit. The corrected tolerance limit for premium petrol[3] for an average of two results is not different from the tolerance limit for a single test: 84.5 minimum, therefore, on investigation, the testing result for Sample 12 was found to be compliant.

Fig. 2a



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

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, 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, 17 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

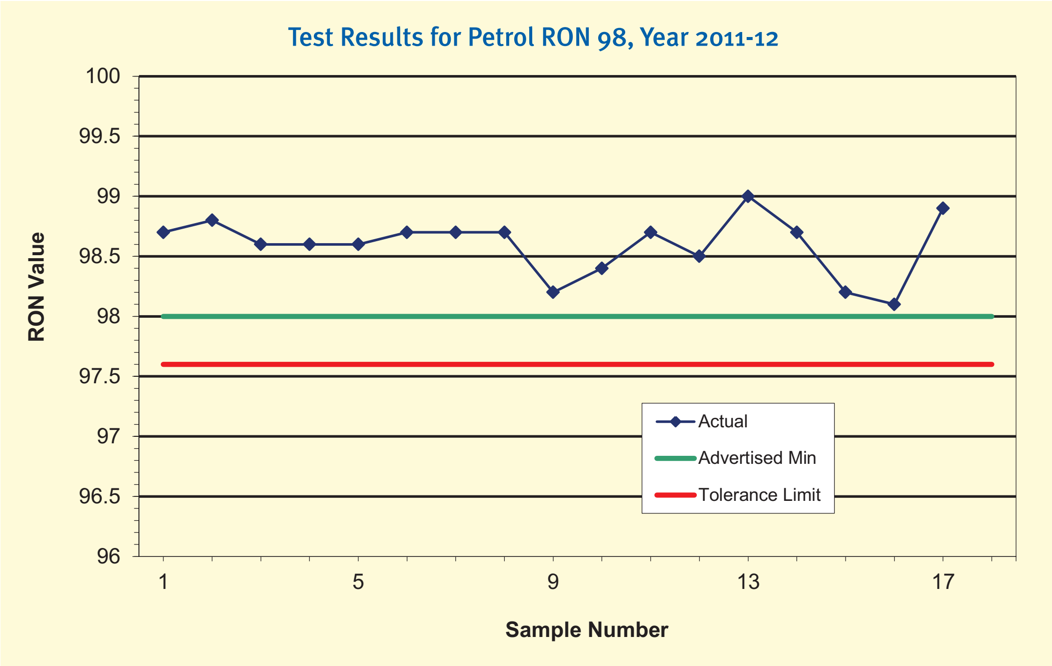
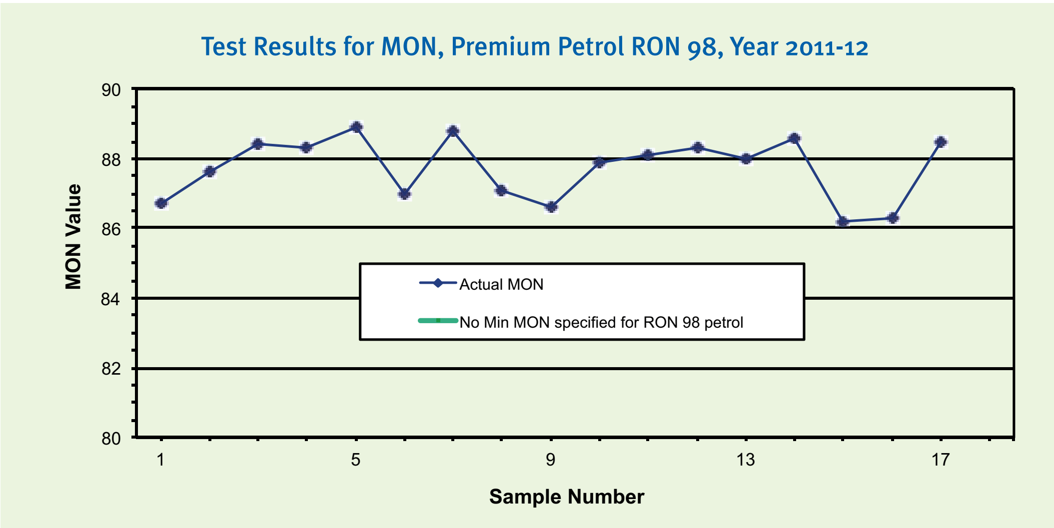
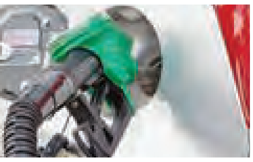

Test Results for Petrol RON 98, Year 2011-12
RON Value
100
99.5
99
98.5
98
97.5
97
96.5
96
1
5
9
13
17
Sample Number
Actual
Advertised Min
Tolerance Limit

Fig. 3b


Test Results for MON, Premium Petrol RON 98, Year 2011-12
MON Value
90
88
86
84
82
80
1
5
9
13
17
Sample Number
Actual MON
No Min MON specified for RON 98 petrol



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

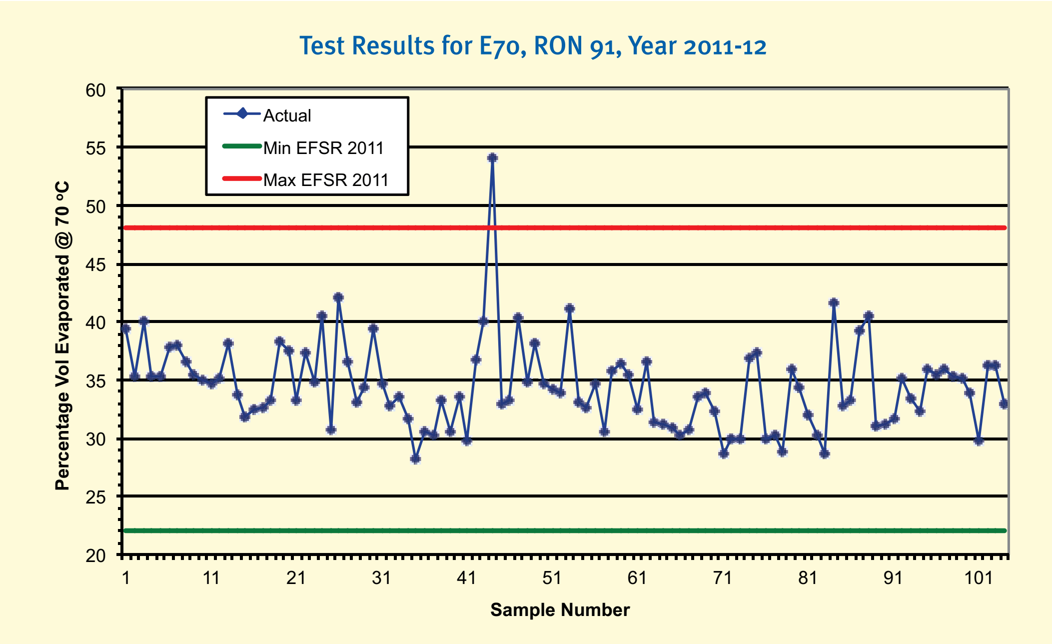
Percentage Volume Evaporated @ 70°C

Sample 44 was found to be within the maximum specification limit established for ethanol blends with the testing result of 54.1%. 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 9.77% (i.e. approximately 10%), the prescribed limit was calculated as 58% and the result was within this limit.

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

Further, all samples were found to be within the prescribed specification limits with the minimum limit of 22% at all seasons including the summer period of 2011-12 when the specified minimum limit for E70 is allowed to be 20%, according to the Footnote 1 in the Regulations of 2011.

Fig. 4a

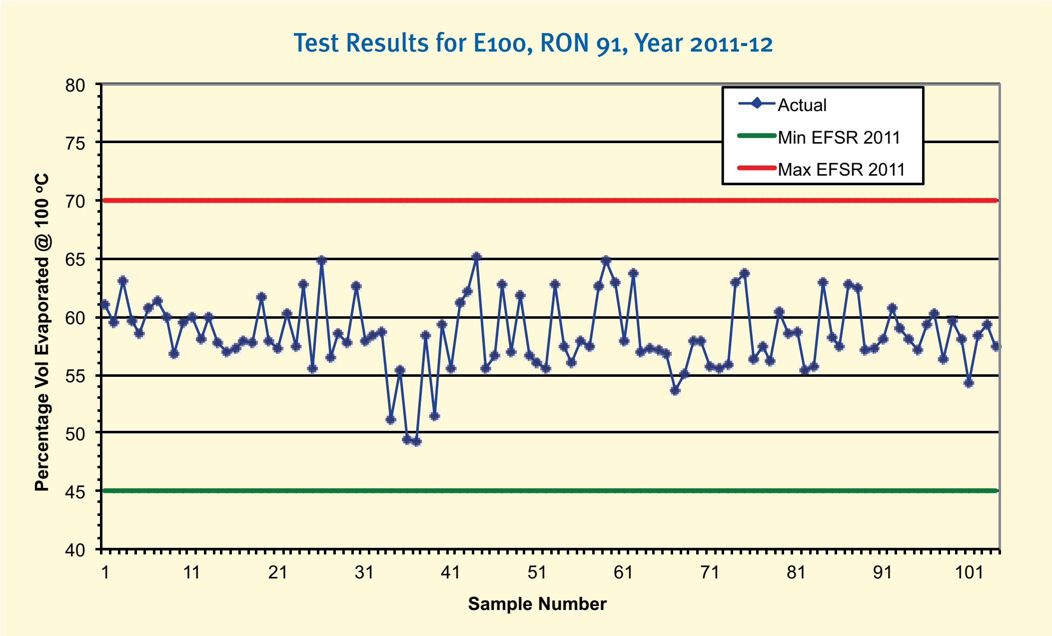


Percentage Volume Evaporated @ 100°C

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



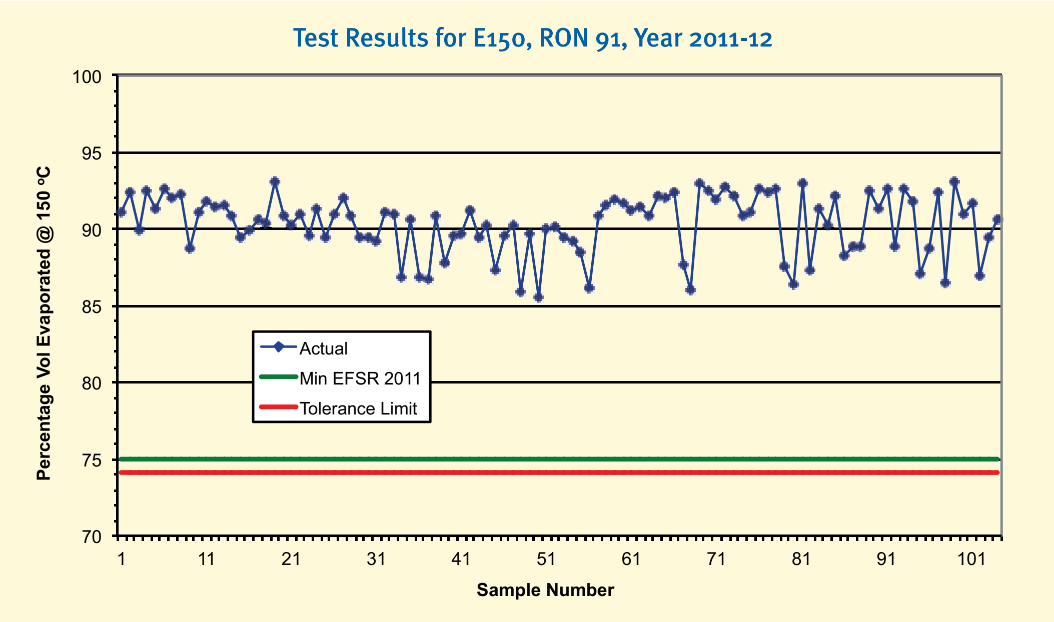
Percentage Volume Evaporated @ 150°C

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

Percentage Volume Evaporated @ 70°C

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
44	9.71	58	48.3
53	8.98	57	49.5
95	10.00*)	58	48.6
98	8.88	57	48.5

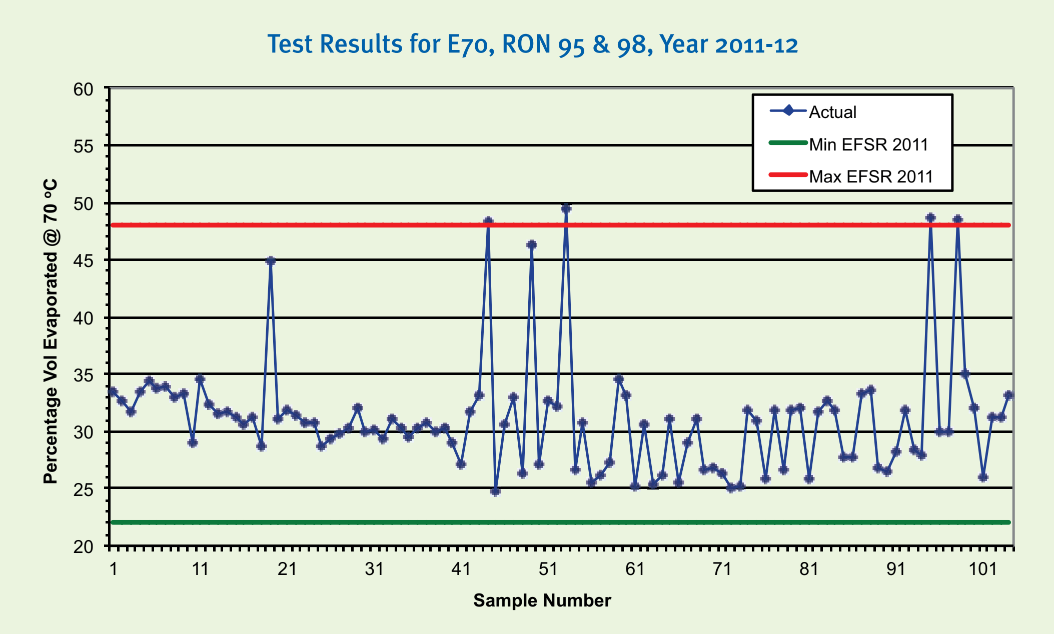
*) As advertised. Ethanol content was not tested

As in case of regular petrol, the tolerance limits are 20.5% and 49.2% accordingly.

Although the actual ethanol content in Sample 95 was not tested, the result is still below the tolerance limit of 49.2% for petrol without ethanol.

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 of 2011-12 when the specified minimum limit for E70 is allowed to be 20%, according to the Footnote 1 in the Regulations of 2011.

Fig. 5a

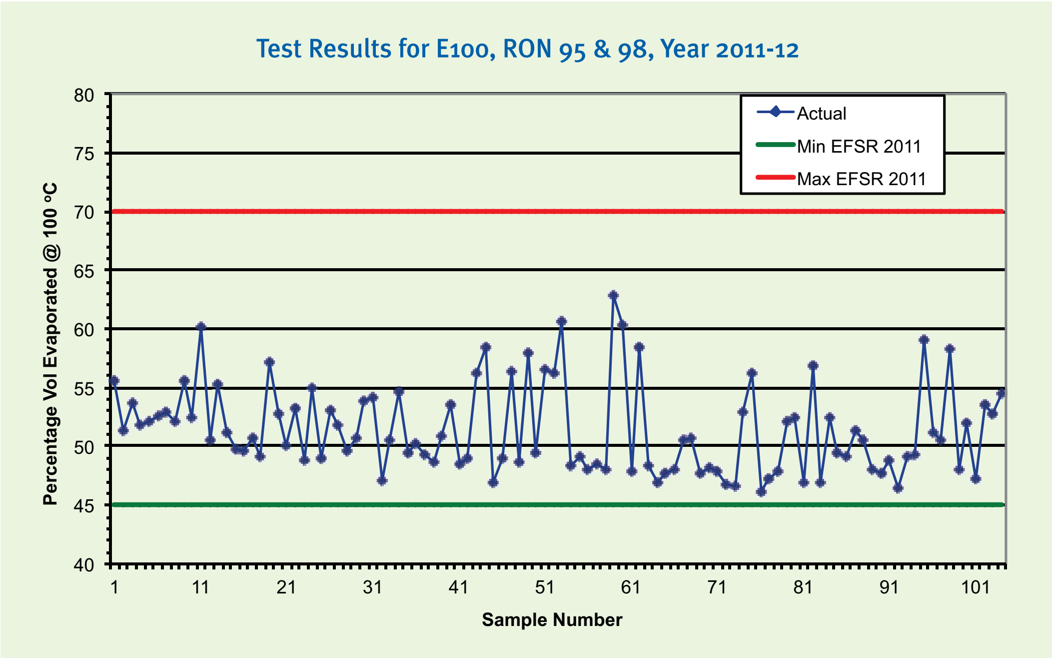


Percentage Volume Evaporated @ 100°C

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

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

Fig. 5b



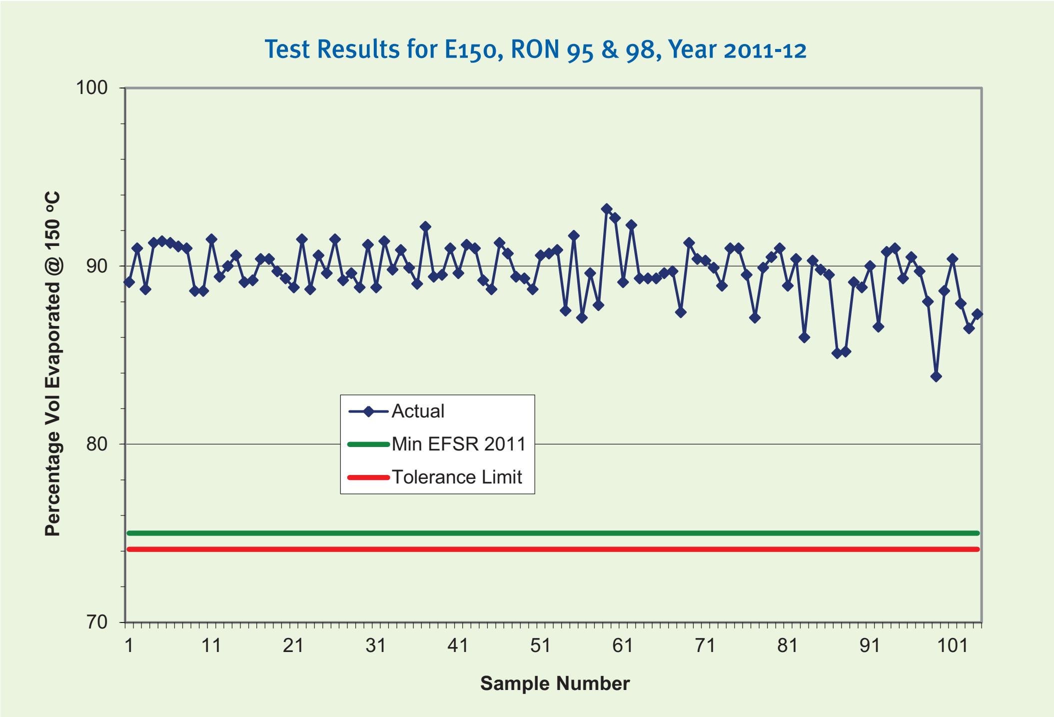
Percentage Volume Evaporated @ 150°C

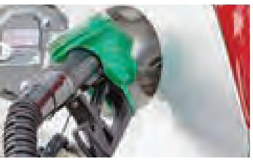
All samples were found to be above the minimum specification limit of 75%.

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 201.6°C was found for Sample 36 of regular petrol.

Fig. 6a

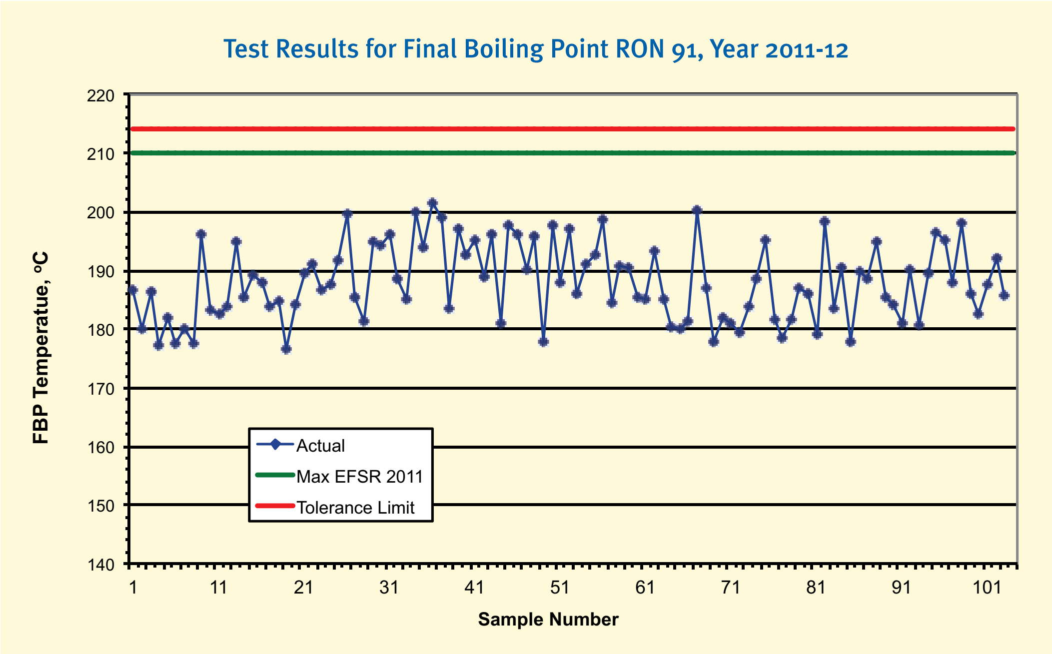
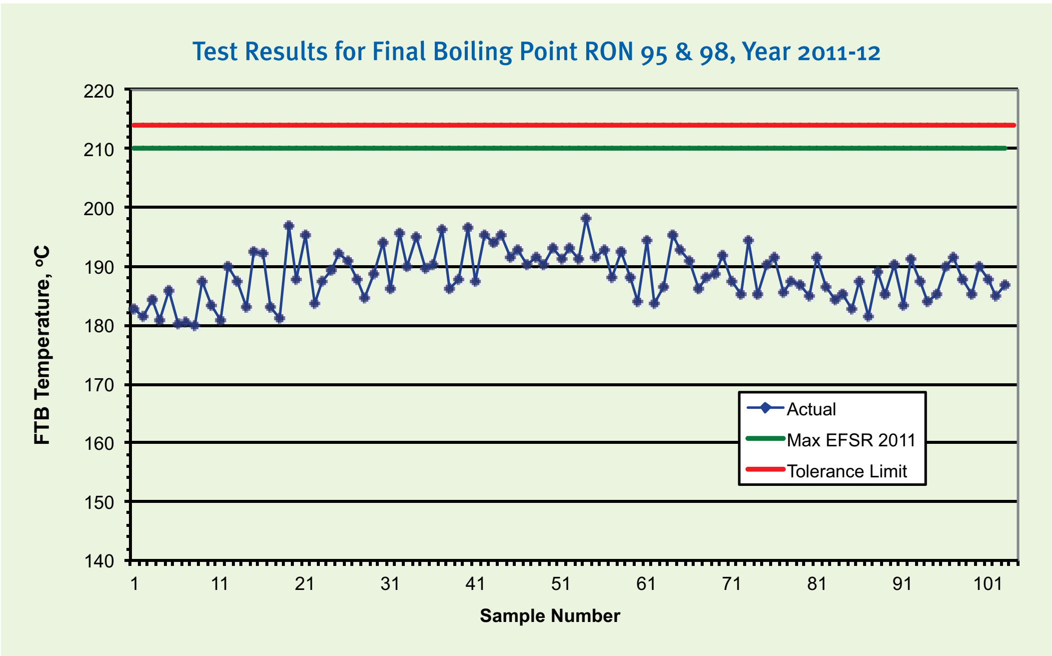


Fig. 6b



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 D86[4]. Fortunately, residue content was found to be well below the specified maximum limit.

Fig. 7a

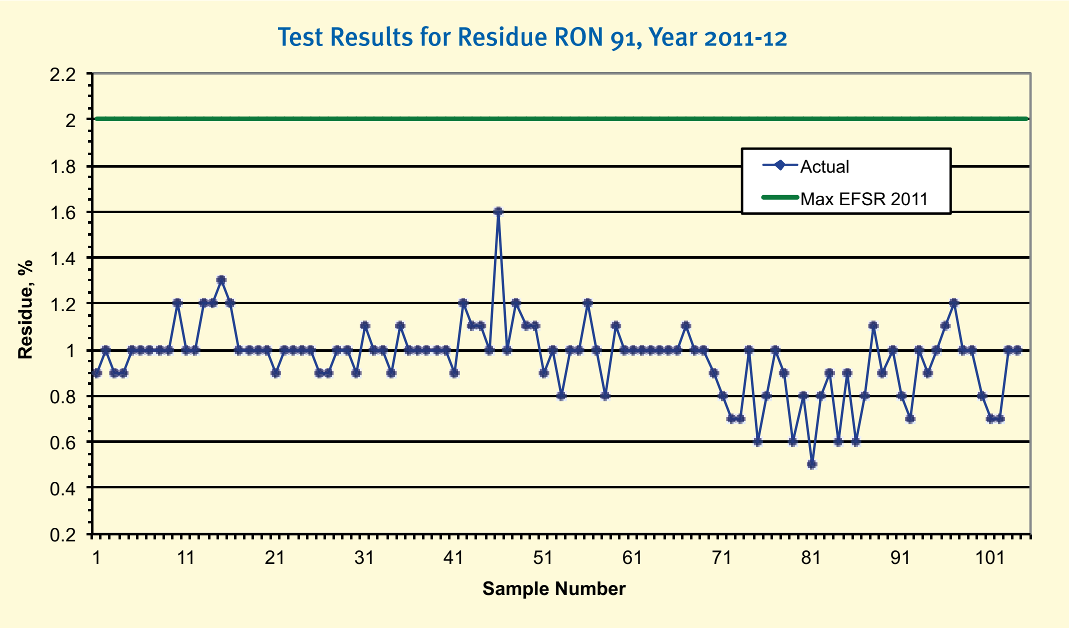
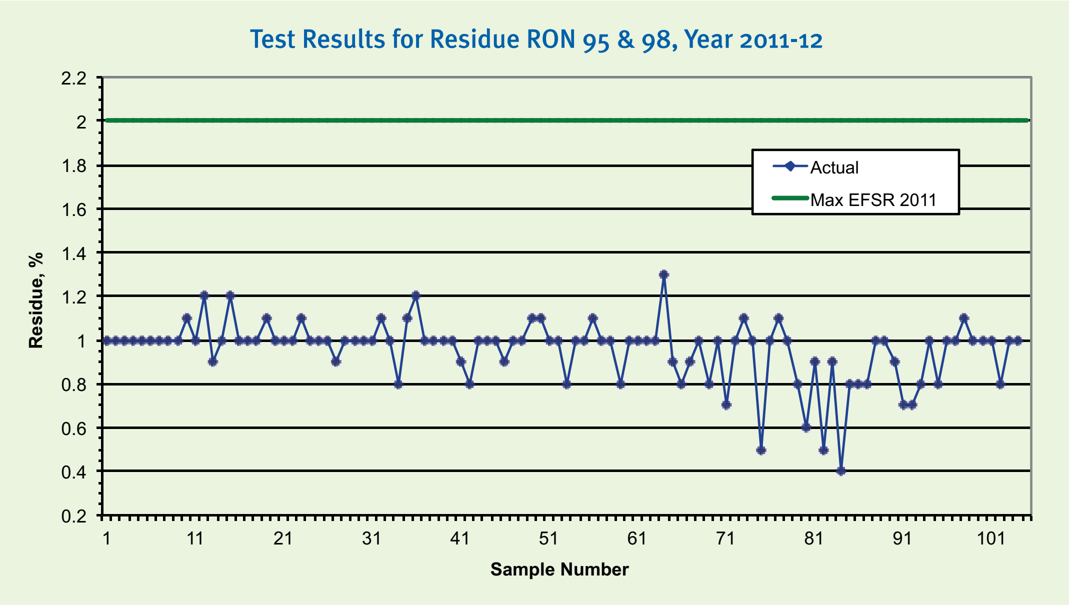
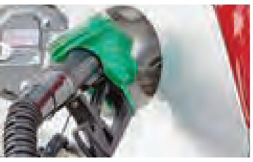


Fig. 7b



4 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 rest of 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.

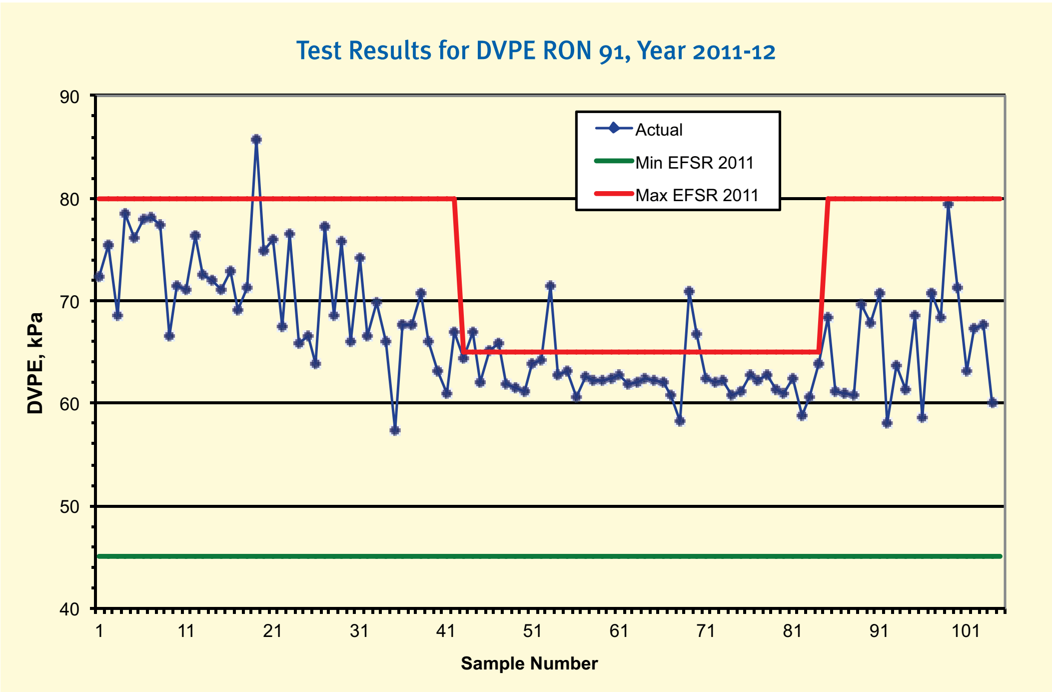
Tolerance limits for the maximum limits are not shown since they are only approx. 2% above each relevant limit.

RON 91

In various periods, seven samples were initially found to be above the lowest maximum at the time.

Of those seven, Sample 19 was initially found to be 85.6 kPa which is above the specification limit of 80 kPa for the rest of North Island

Fig. 8a



during the spring season. When repeated by a different operator, the test returned the figure of 86.0 kPa which means the average was 85.8 kPa with the reproducibility condition satisfied, R=2.5 kPa. Further, it was found to contain oxygenates but ethanol content was below 1% therefore Footnote 3, Schedule 1, the Regulations 2008, does not apply.

On investigation, Sample 19 was found to be above the tolerance limit of 81.4 kPa and treated as non-compliant. The relevant testing procedure and processes were reviewed by the fuel supplier and resulting improvements made to ensure the non-compliance was not repeated.

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

Samples: 69, and 70, which were found to be, respectively, 70.9 and 66.7 kPa, were from South Island and well within the maximum limit of 75 kPa for summer.

Sample 46 which was found to be 65.1 kPa, was from the Auckland and Northland region and just above the maximum limit of 65 kPa for summer. On investigation, it was found that it is well within the tolerance limit of 66.3 kPa and can be treated as compliant.

Sample 47, which was found to be 65.9 kPa, was from the rest of North Island and well within the maximum limit of 70 kPa for summer.

Finally, Samples 44 and 53 were found to contain ethanol, 9.77% and 2.64%, respectively (see also section on E70 above). Therefore, according to a condition in the Regulations of 2011 (Footnote 4, Schedule 1) the maximum limit for these samples is 77 kPa in the rest of North Island, summer season. Samples 44 and 53 were found to be 66.9 and 71.5 kPa, respectively, i.e. well within the maximum limit for ethanol blend in the region.

RON 95

A group of samples from 2 to 14, which were found to be in a range from 80.5 to 84.2 kPa, were collected in a period from July to August and appeared to be all well below their respective maximum limits for winter, 90 kPa for North Island and 95 kPa for South Island.

There were six samples that were initially found to be above the lowest maximum at the summer period.

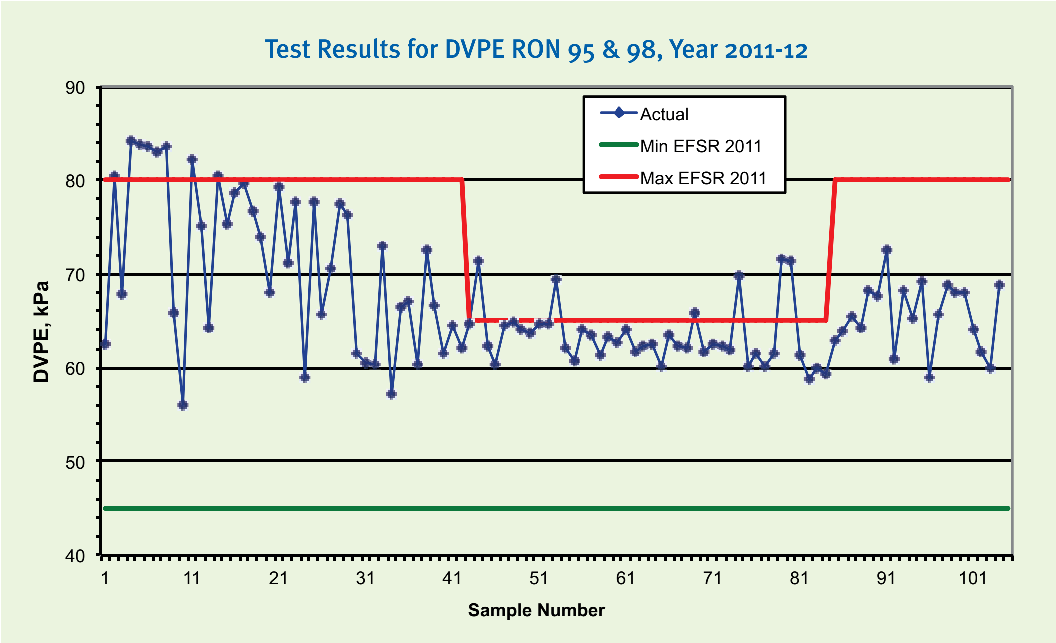
Samples 44 and 53 were ethanol blends (see Table above).

Respectively, Sample 44 was found to be 71.4 kPa and Sample 53 was found to be 69.5 kPa i.e. well within the maximum limit of 77 kPa for ethanol blends in the rest of North Island, summer season, according to a condition in the Regulations of 2011 (Footnote 4, Schedule 1).

Samples: 69, 74, 79, and 80, which were found to be in a range from 65.9 to 71.4 kPa, were all well below their maximum limit for summer, 75 kPa for South Island.

To sum up, all samples were found to be within the limits for premium petrol (Fig. 8b).

Fig. 8b



Flexible Volatility Index

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

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

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

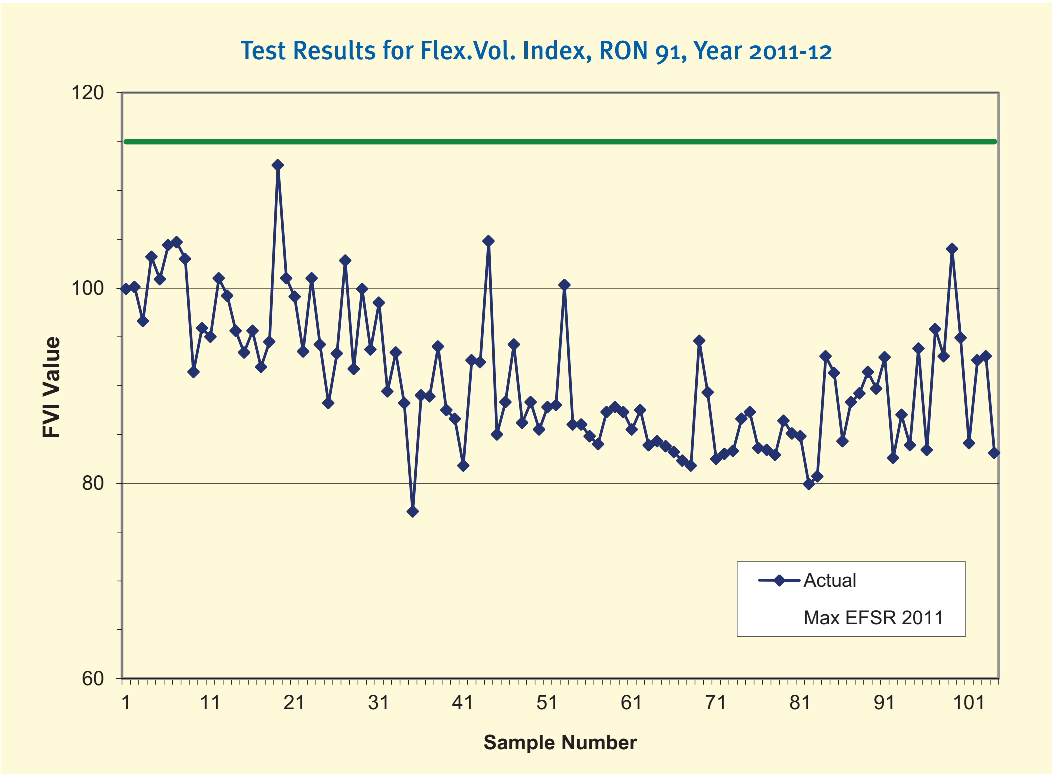
No definition of the FVI value is given in the related ASTM Standards prescribed in the Regulations (D86 and D5191[5]) and no reproducibility value is identified. As a result of this the FVI serves only as a helpful indicator but cannot be used in a strict compliance analysis.

RON 91

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

Sample 19 was found to be the closest to the specified limit with the result of 112.6.

Fig. 8c

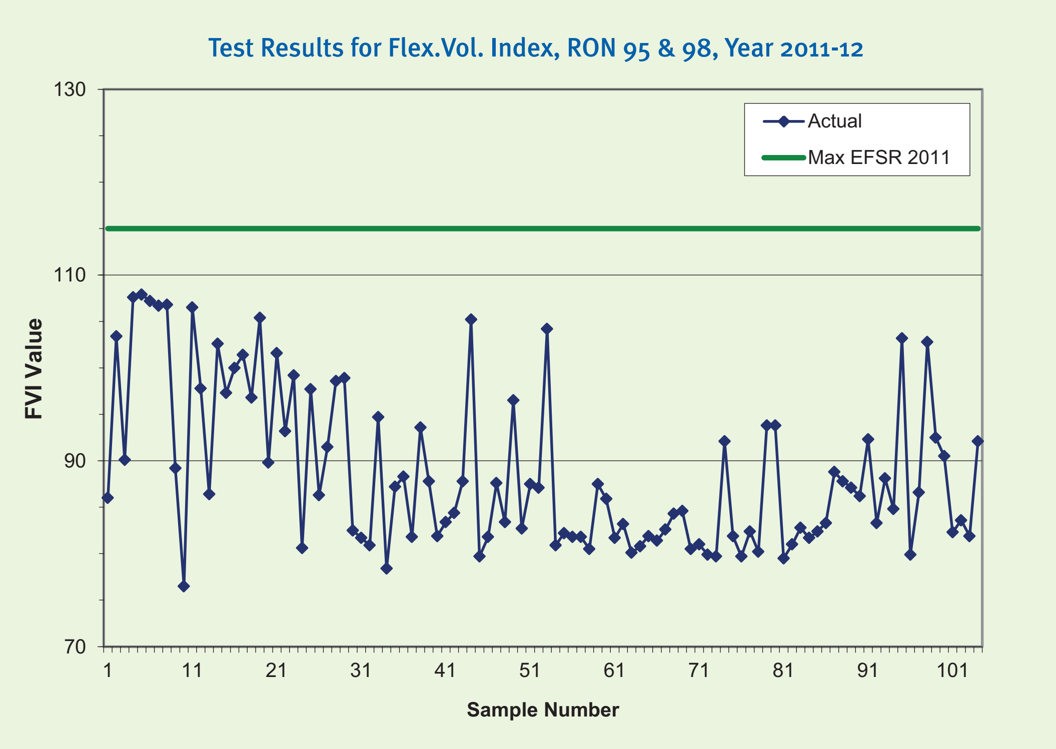


5 ASTM D5191 – 12 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)*.

RON 95

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

Fig. 8d



Sulphur

Note: the scope of the test method IP 497[6] 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.

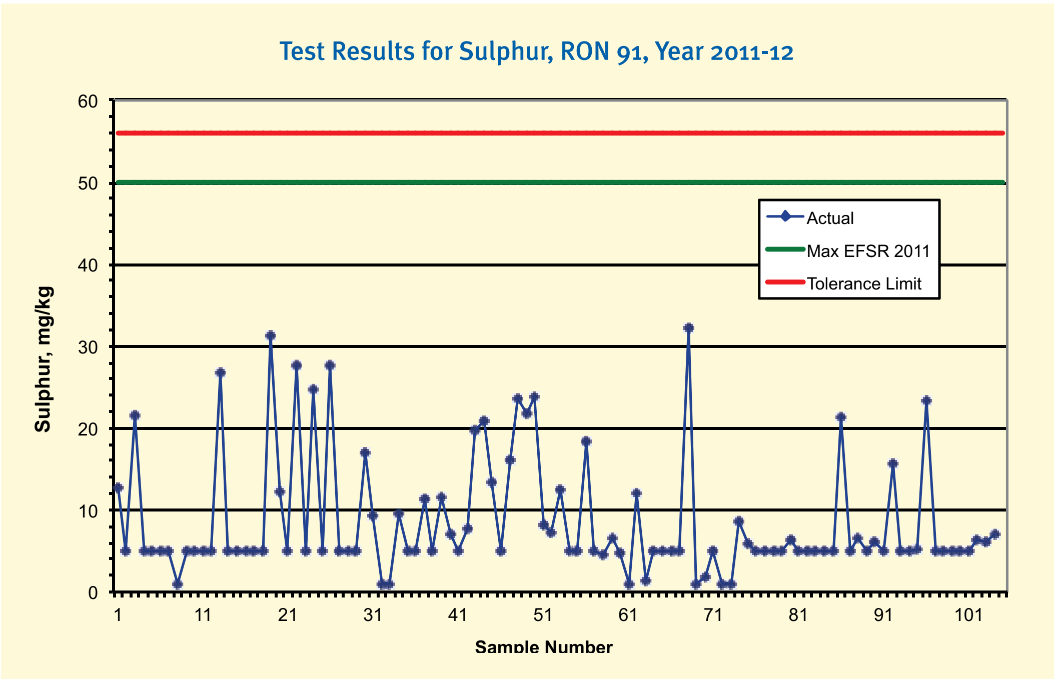
A number of results by the ASTM standard D5453[7] which is also prescribed in the Regulations along the IP 497, gave results down to a fraction of 1 mg/kg (Fig. 9).

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 19 and 68 were found to exceed 30 mg/kg with the actual figures, respectively, of 31.2 and 32.3 mg/kg.

Fig. 9a



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

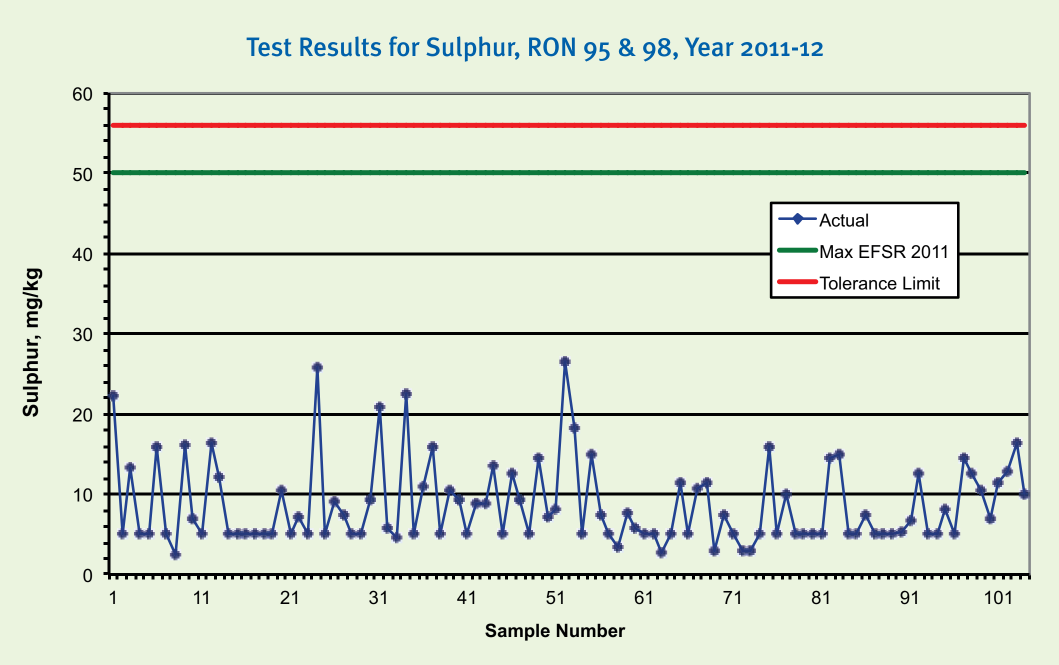
7 ASTM D5453 – 09 *Standard Test Method for Determination of Total Sulphur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence.*

RON 95

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

No samples were found to exceed 30 mg/kg.

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 were below 0.95%. Only 5 samples were found to exceed this figure with only one result of 0.99%.

Fig. 10a

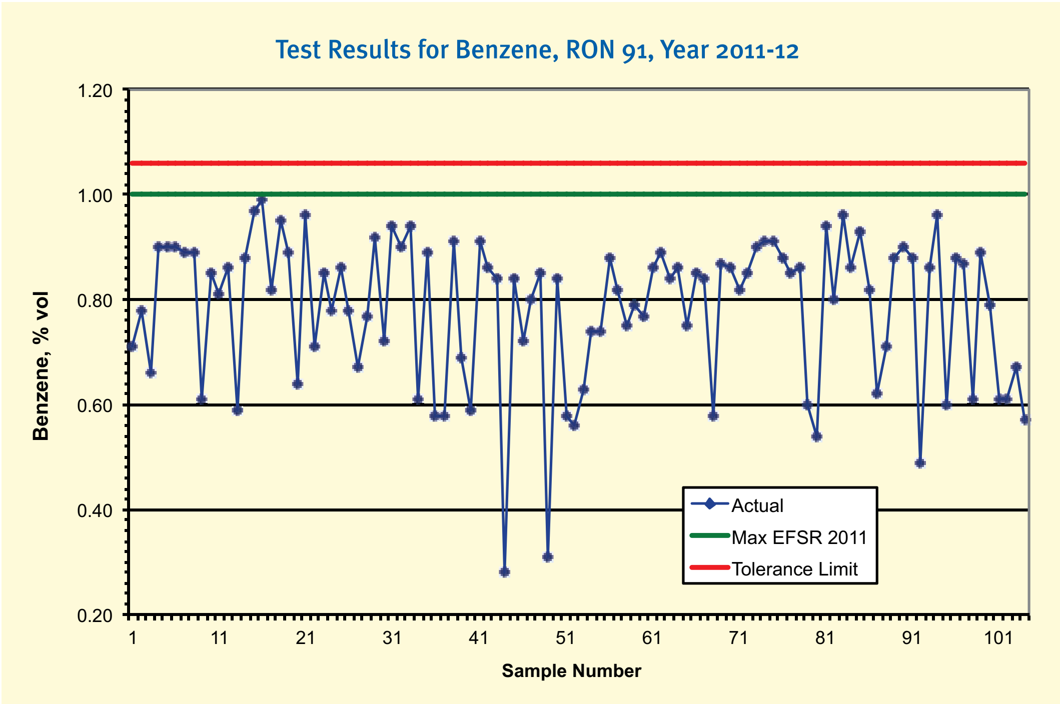
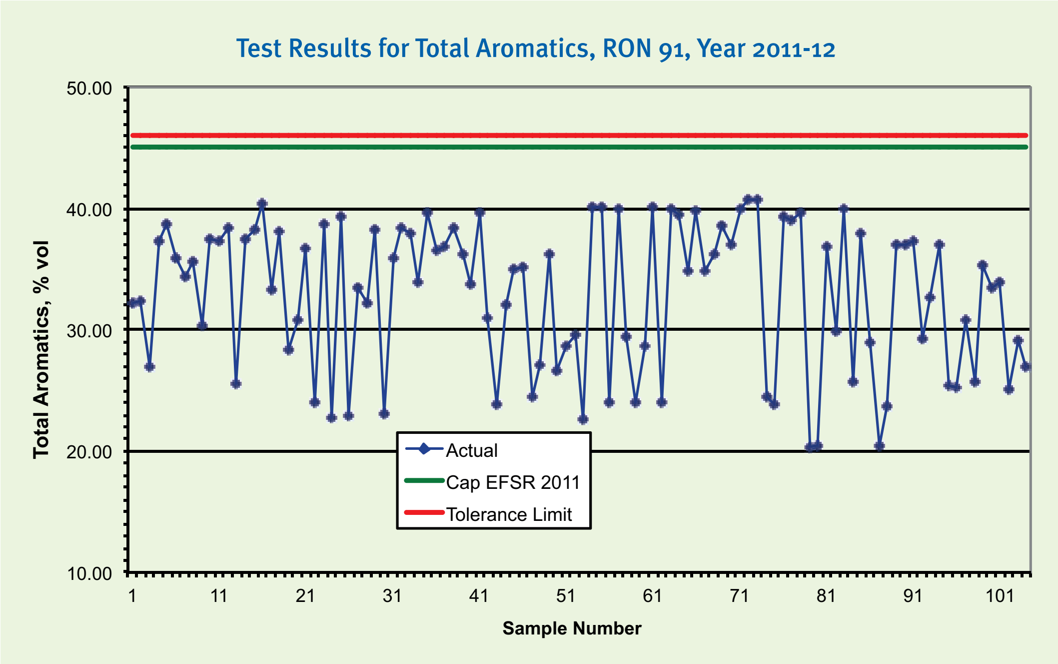


Fig. 10b



RON 95 and 98

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

For premium petrol, the majority of the results on total aromatics were found to be below 42% (Fig. 10d). 23 samples were found to exceed this figure with the largest result on total aromatics was found to be 44.11 % for Sample 28 (Fig. 10d). All results were found to be compliant.

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.

Data on 'pool average' was collected from five major fuel retail companies and from The New Zealand Refining Company Ltd. 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. The pool average total aromatics is 42% vol. maximum.

Fig. 10c

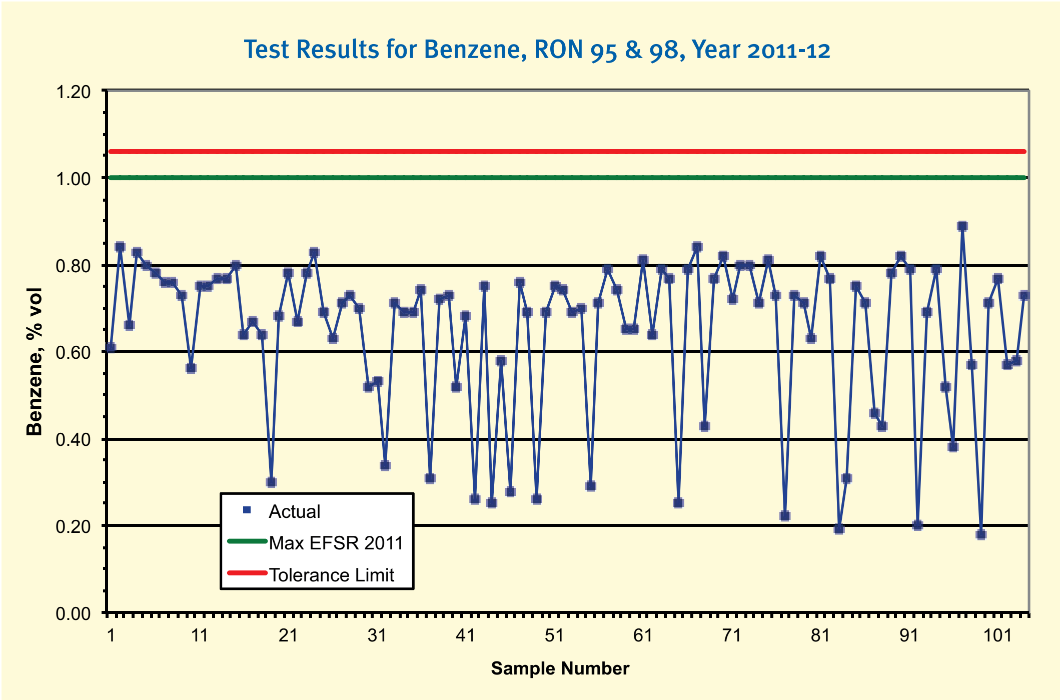
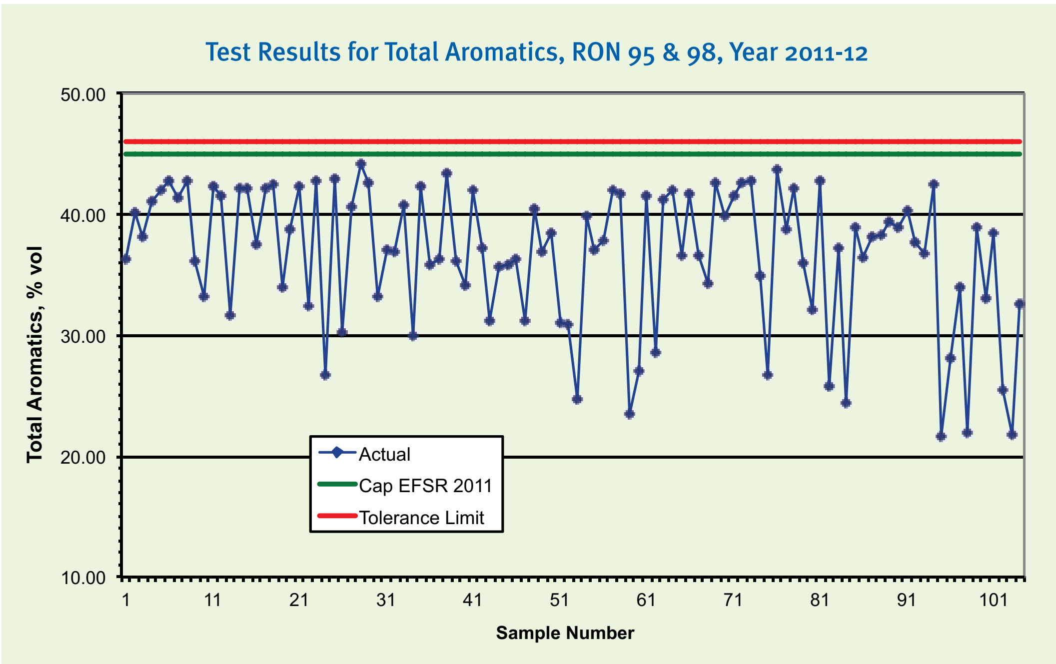


Fig. 10d

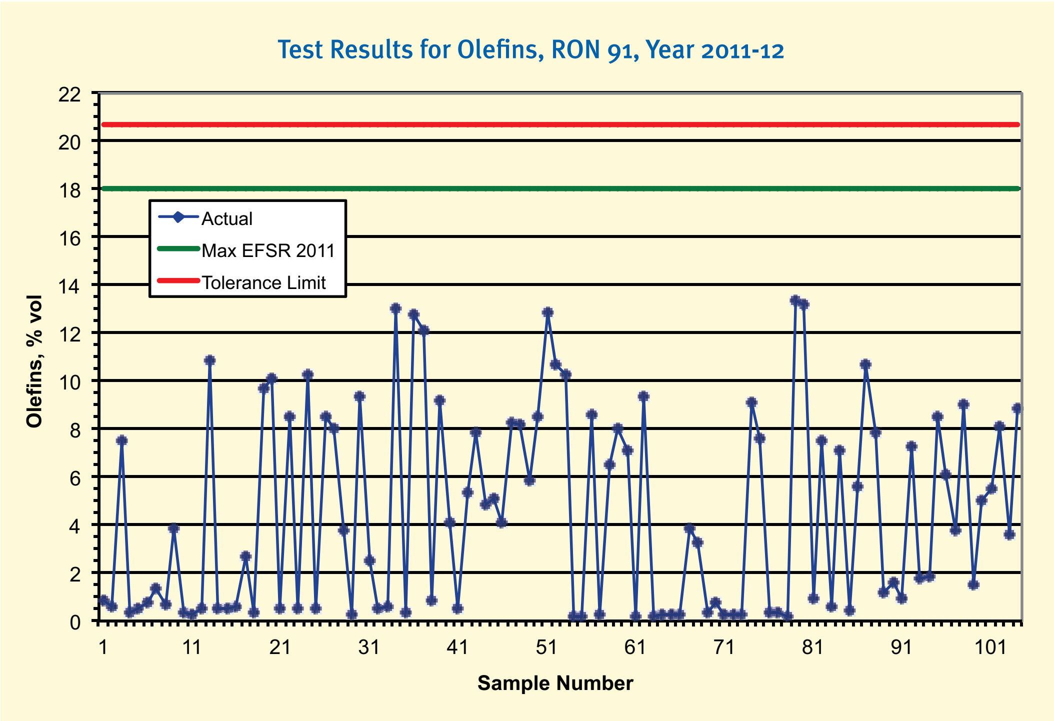


Olefins

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

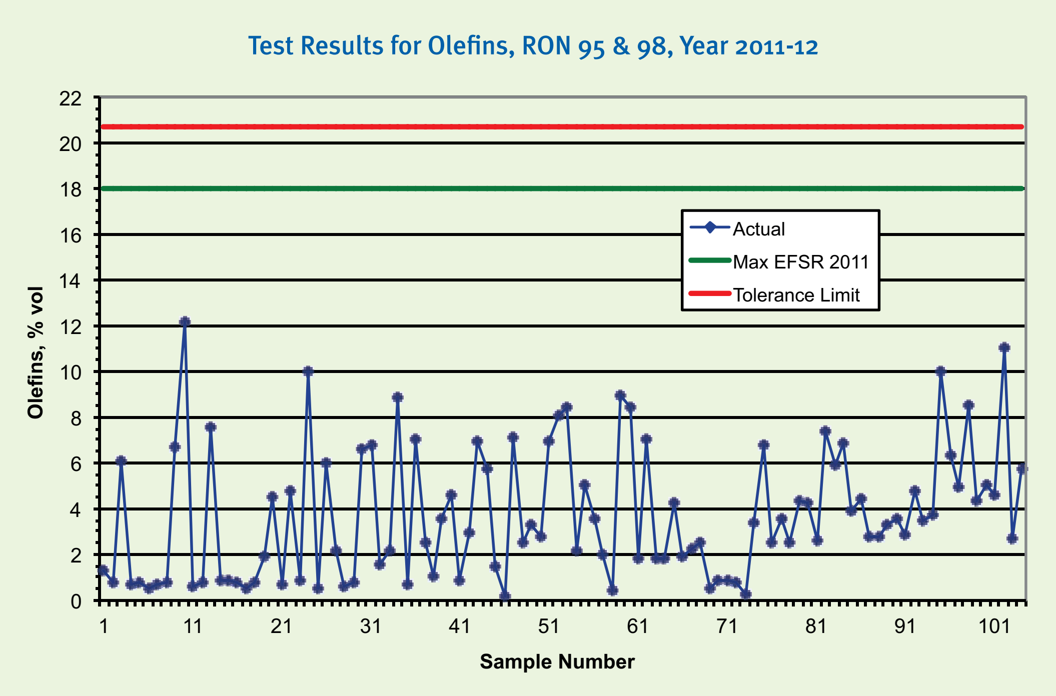
For RON 91, all results were found to be below 14% (Fig. 11a).

Fig. 11a



For premium petrol, all results were found to be below 12% except Sample 10 with the actual figure of 12.2% (Fig. 11b).

Fig. 11b

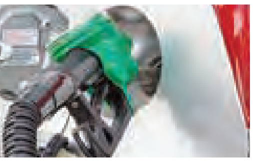


Other Specification Parameter Testing

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 washed gum was added at the end of the period to the regular list of tests. All results were found to be within the prescribed limit. In the next annual test report the test results for washed gum will be reported in detail.

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 non-compliant sample detected during the period of this report related to a sample of regular petrol where dry vapour pressure on investigation was found to be beyond the tolerance limit with an average figure of 85.8 kPa. The product was deemed to be noncompliant and a follow-up action was undertaken with the responsible fuel supplier.

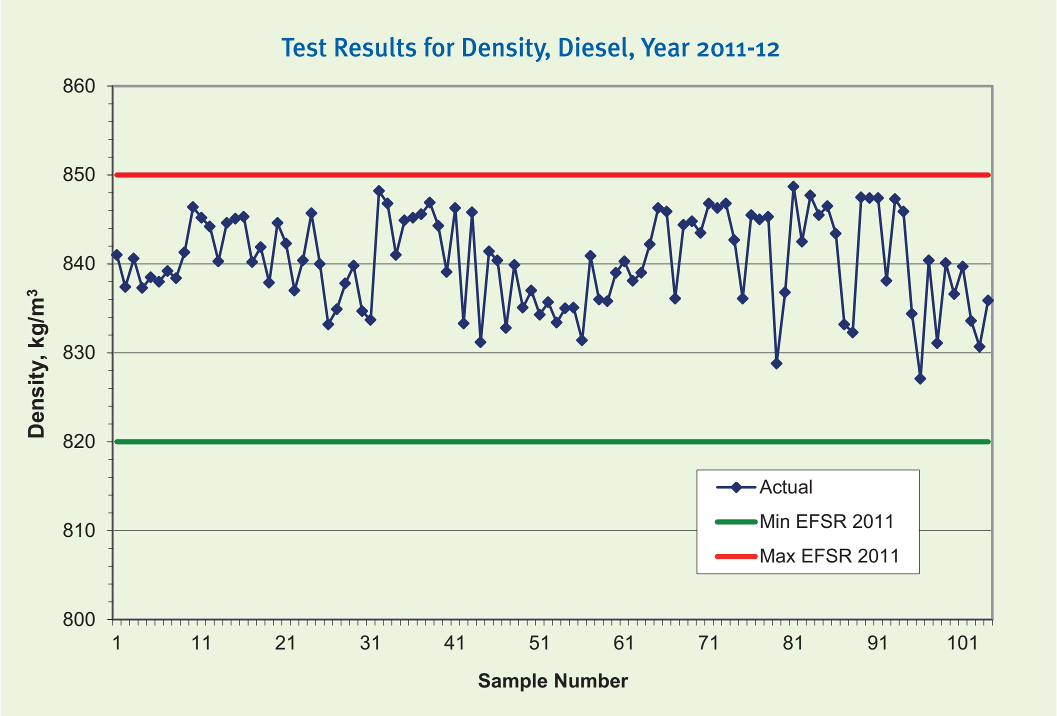
In a number of instances the results were initially found beyond the prescribed limits however on subsequent investigation they were found to be within the tolerance limits. These instances included: one case in relation to motor octane number in premium petrol, one case in relation to evaporation percentage E70 in premium petrol, one case in relation to dry vapour pressure in regular petrol and three cases in relation to other oxygenates in both regular and premium petrol.

Usually, other oxygenates are tested along with the ethanol content. When it was realised that some test results were causing concern a joint investigation was undertaken with the relevant supplier to test ethanol blended samples including comparative testing of sub-samples overseas. As a result, it was found that in some instances excessive figures were coming from the New Zealand testing laboratory. Some adjustments to the procedure were made by the New Zealand laboratory and further results of testing appeared to be compliant and in line with the other laboratories. This project is also mentioned in the *Biofuels* section in this report.

Diesel

Density

Fig. 12



All results were found to be within the specification limits which are 820 kg/m³ and, respectively, 850 kg/m³ with the maximum figure of 848.7 kg/m³ at the maximum tolerance limit of 850.7 kg/m³.

Distillation

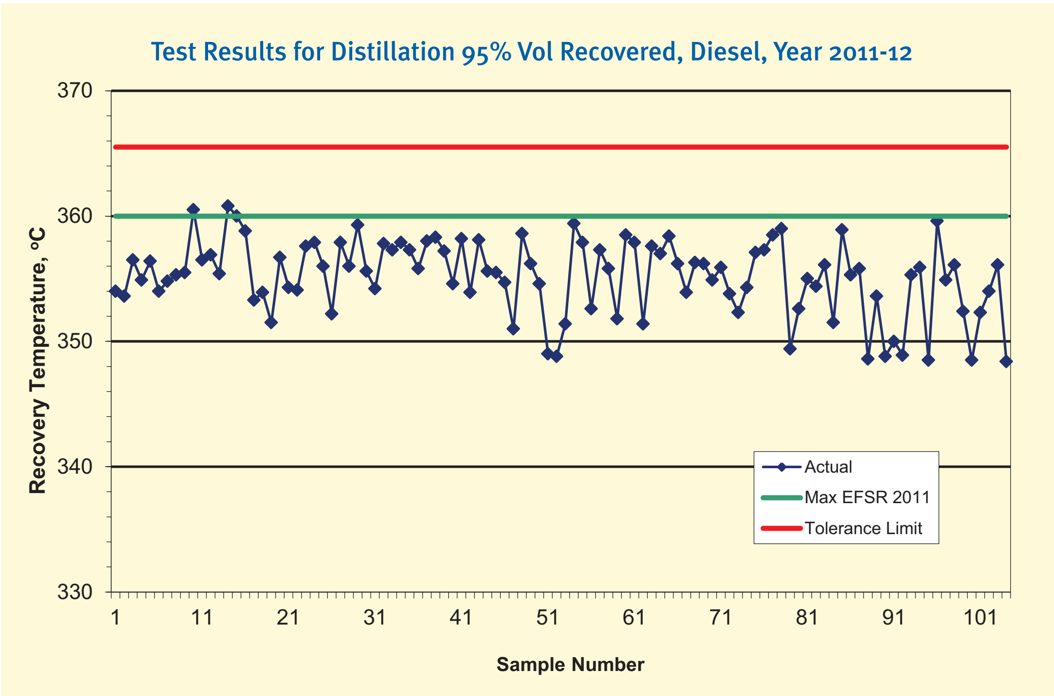
All samples except two were found to be below the specification maximum limit of 360°C for distillation at 95% volume recovered (T95).

Samples 10 and 14 were found to be slightly above the limit with the actual results of 360.5°C and 360.8°C, respectively, but well within the tolerance limit of 365.5°C.

Further analysis was done with respect to the final boiling point values. Although this test is not specified by the Regulations, the parameter was routinely tested as part of the testing process for distillation as per ASTM D86[8].

There is no reason to suspect the two slightly elevated T95 results were abnormal. Given that Samples 10 and 14 were found to be well within the tolerance limit, they are regarded as compliant.

Fig. 13a



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

Cetane Index

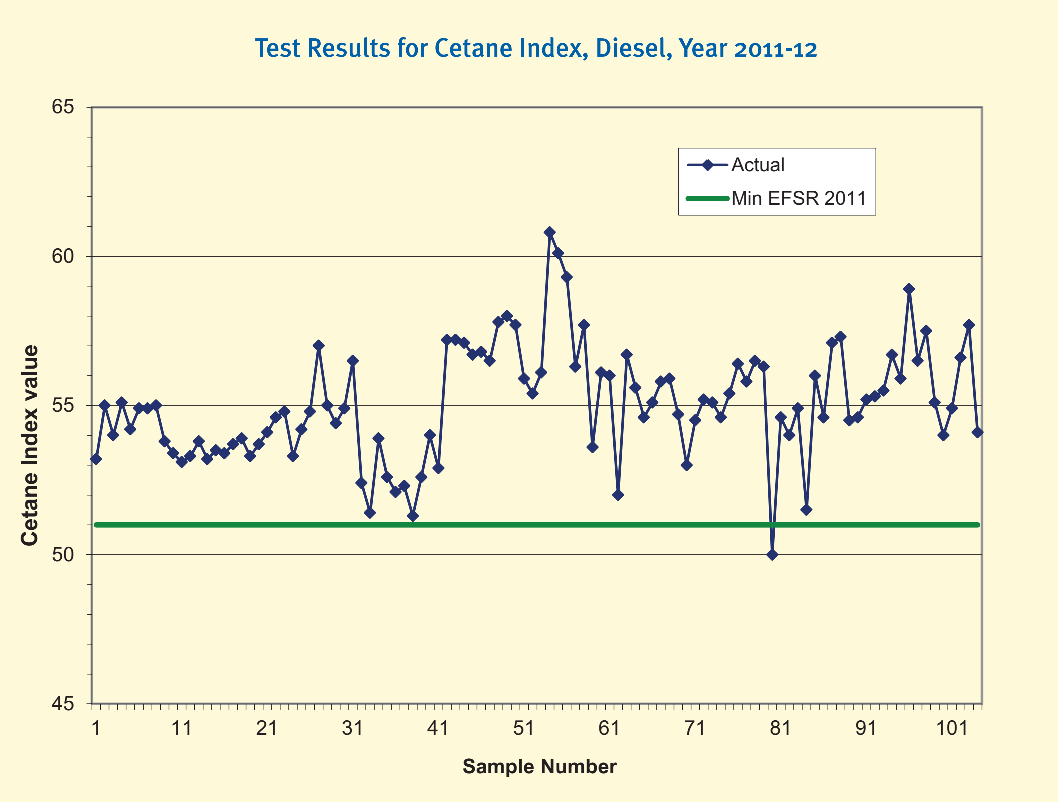
The cetane index, according to ASTM D4737[9] prescribed in the Regulations 2011, is not tested for but calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine for determining cetane number is not available and/or cetane improvers are not used.

All samples except one were found to be above the minimum limit of 51 (Fig.14).

Sample 80 was initially found to be 50.0. 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.

When the density and distillation[10] tests were repeated by a different operator, the recalculation returned the figure of 50.2 which means the average was 50.1 with an estimate for 'reproducibility condition' satisfied, R=2. On investigation, it was found that in the certificate of quality exhibited by diesel supplier for the relevant batch, cetane number was 51.2 and cetane index was 49.2.

Fig. 14



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

10 The pairs of recovery temperatures T10, T50 and T90 used in the two calculations were found to be, in the first and second tests, respectively: 205.1 and 204.7°C, 259.7 and 261.3°C, and 333.2 and 334.6°C, with the maximum difference of 1.6°C at the repeatability of 0.94°C and the reproducibility of 2.97°C.

Moreover, the certificate reports that a cetane improver was used so the calculation by the method in ASTM D4737, may not be vindicated. Therefore, the average result of cetane index for Sample 80 which was found to be above 47 at the reported cetane number higher than 51, according to Schedule 2 of the Regulations, was regarded to be compliant.

The two respective figures of cetane index were also calculated for comparison, by the ASTM D976[11] method which was discontinued to be the prescribed method on 1 Dec 2011, and were found to be, respectively, 50.0 and 50.4.

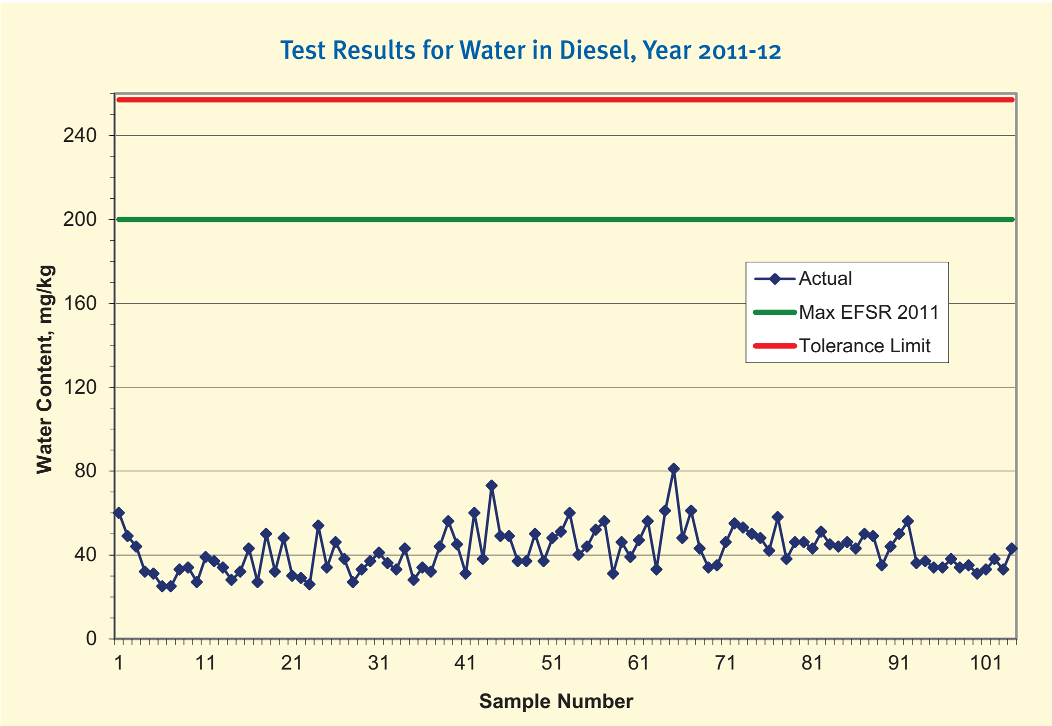
Water

The test for water content means water held in solution. **Note:** this is not a test for free water content.

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. Water held in solution in amounts not exceeding that prescribed in the Regulations, should not cause any vehicle operability issues.

The water content in all the tested samples was found to be within the specification limit of 200 mg/kg, with actual testing results not exceeding 80 mg/kg except one: Sample 65 with the results of 81 mg/kg.

Fig. 15

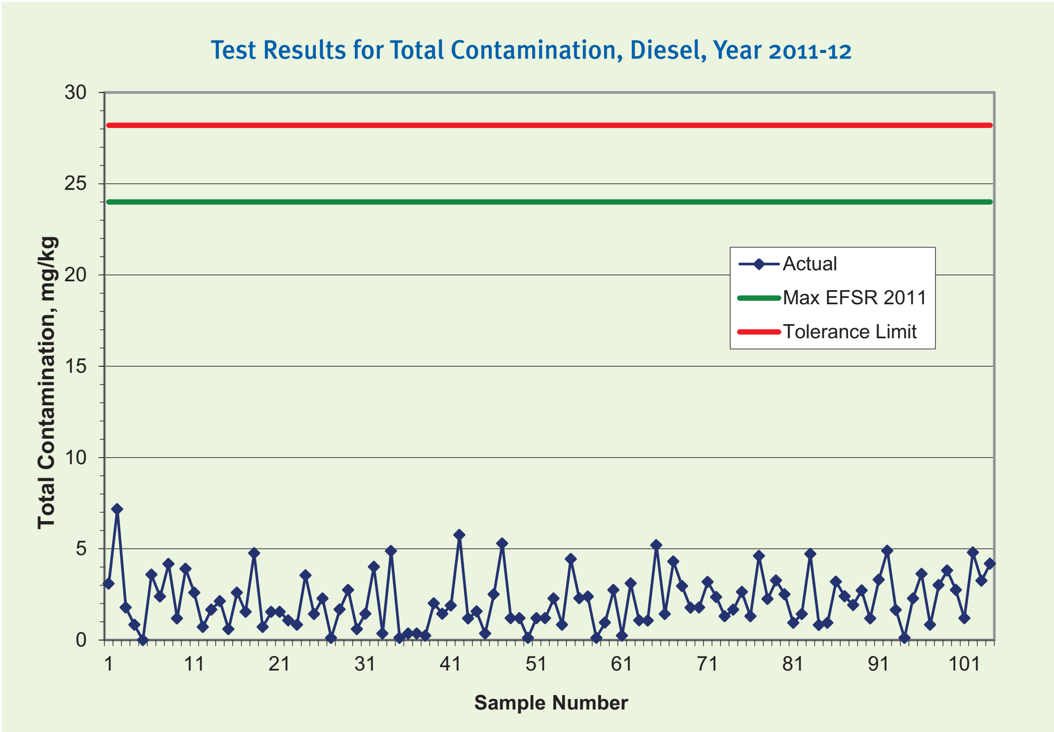


11 ASTM D976 – 06(2011) *Standard Test Method for Calculated Cetane Index of Distillate Fuels.*

Total Contamination

All samples were found to be well below the maximum limit of 24 mg/kg specified in the Regulations (Fig. 16).

Fig. 16

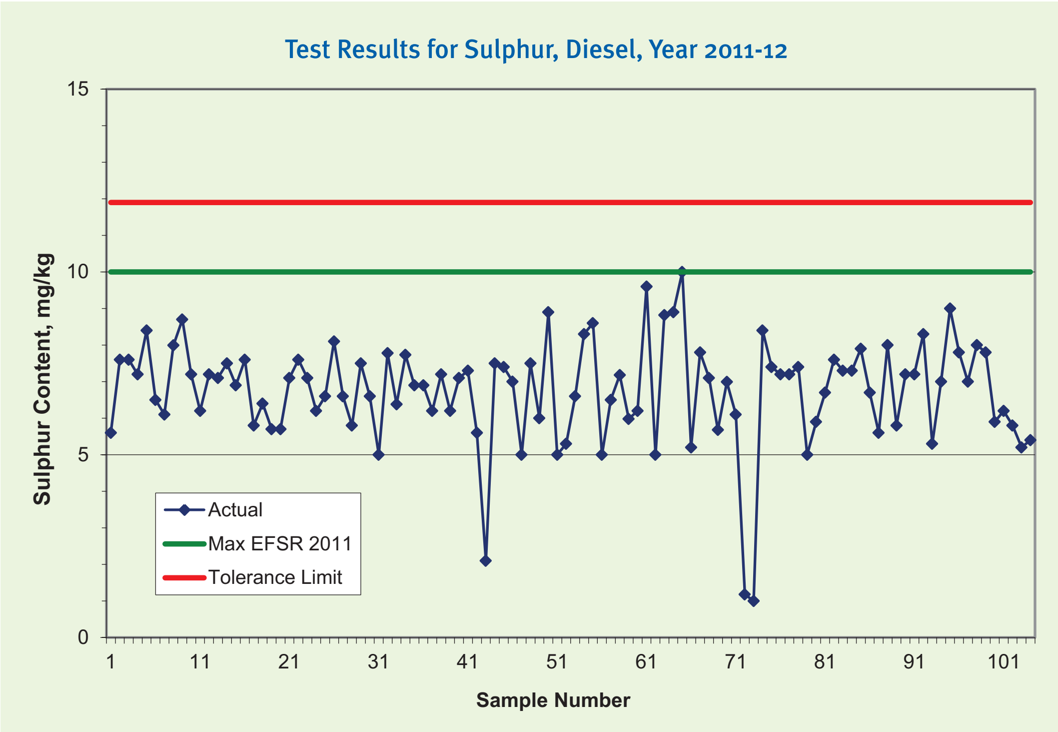


Sulphur

All samples except one were found to be below the maximum limit of 10 mg/kg specified in the Regulations (Fig. 17).

Sample 65 was found to be on the maximum limit with the actual figure of 10.0 mg/kg at the tolerance limit of 11.9 mg/kg.

Fig. 17



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.18). 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.

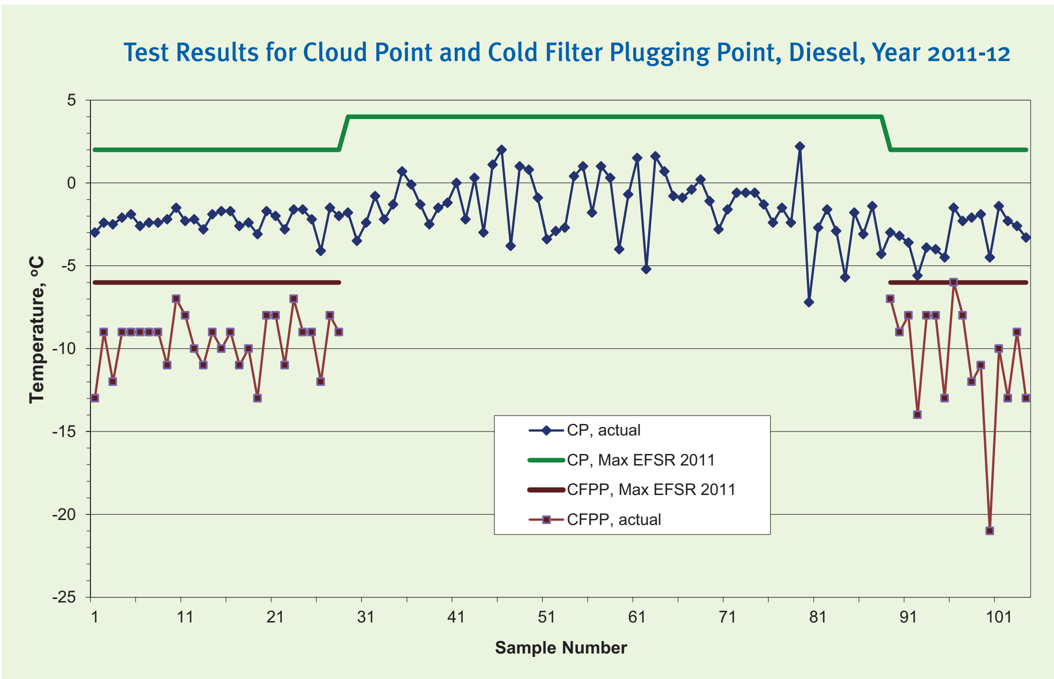
The bottom line before and after the pedestal, is the next lowest maximum, +2°C, which is prescribed for all New Zealand in winter, from 15 April to 14 October inclusive.

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. Samples 46 to 79 returned two highest testing results for summer, +2.0 and +2.2°C, respectively, at the maximum limit of +4°C. They were from two different regions, the first from Auckland and Northland while the second one from South Island.

The lowest figure for CP was found to be –7.2 C for Sample 80 from South Island.

Fig. 18



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.18). 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 within the maximum limit of specified in the Regulations for the winter season with one result on the limit.

Sample 96 from South Island was found to be on the maximum limit for CFPP at the tolerance limit of –4.2°C. This sample had a result of –1.5°C for CP which was well within the prescribed maximum of +2°C.

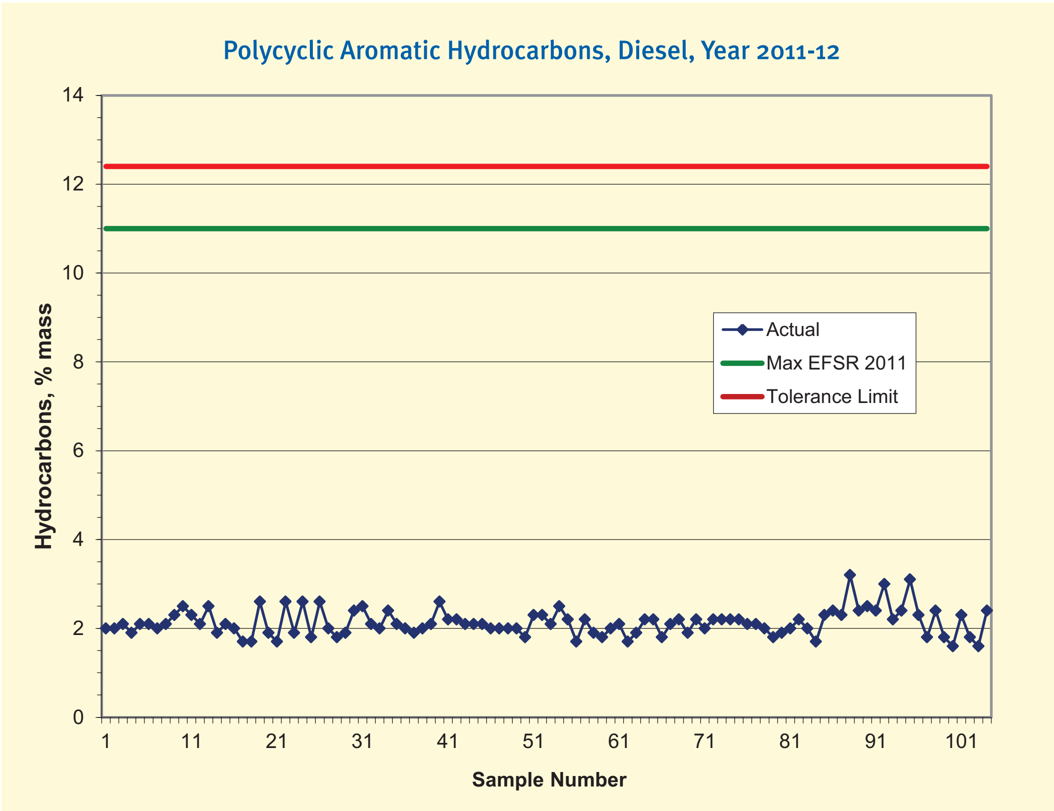
Sample 100 was found to have the lowest CFPP of –21°C with a relatively low result for CP of –4.5°C.

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. 19

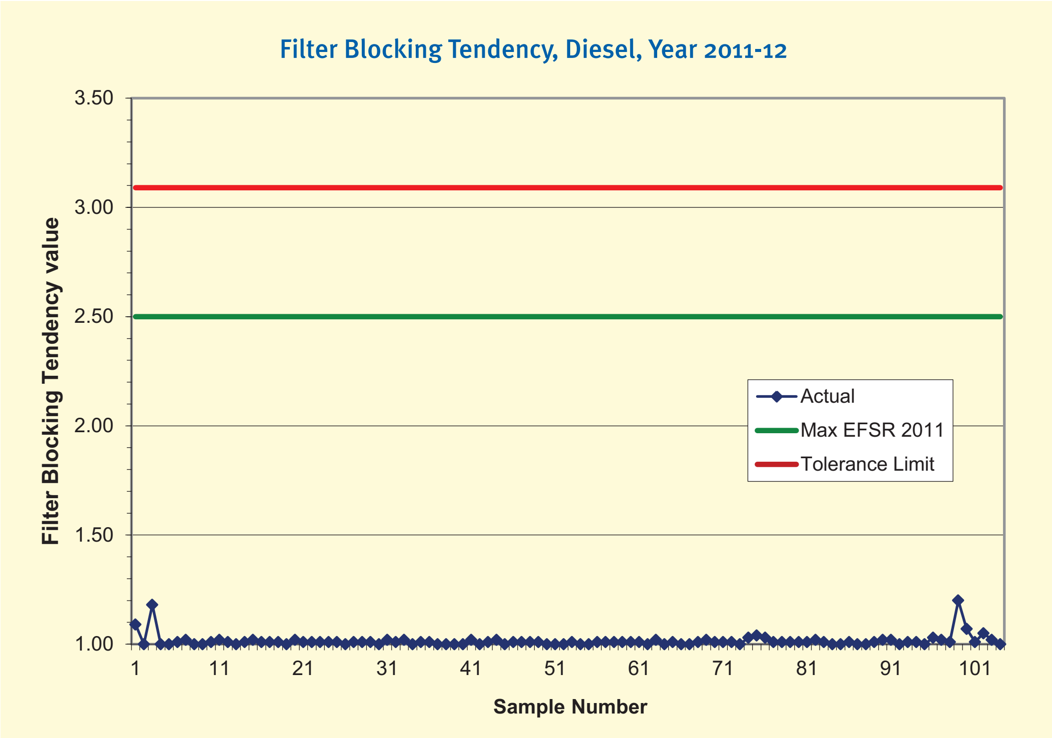


Filter Blocking Tendency

All samples were found to be within the specified maximum limit of 2.5 for filter blocking tendency. The vast majority of actual figures were in the range from 1.00 to 1.05 which means practically perfect filtering.

Samples 3 and 99 were found to be the highest two with the testing results, respectively, of 1.18 and 1.20.

Fig. 20

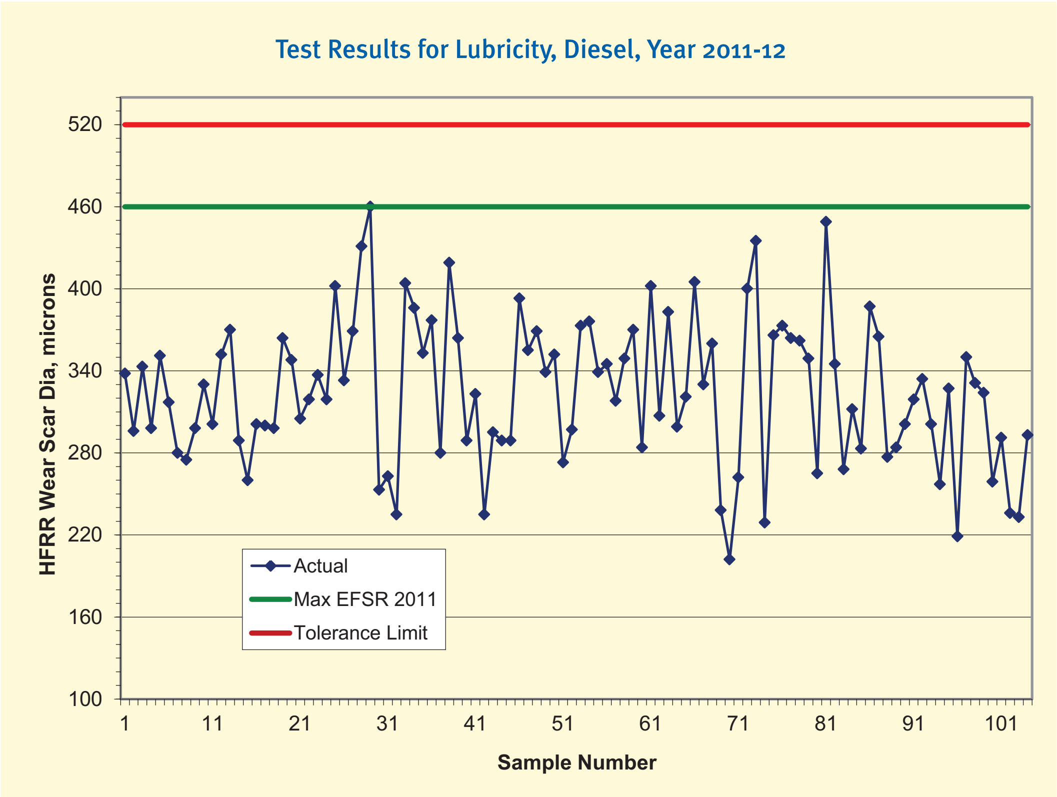


Lubricity

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 29 was found to be on the maximum limit with the actual figure of 460 µm. The tolerance limit for lubricity is 520 µm maximum.

Fig. 21

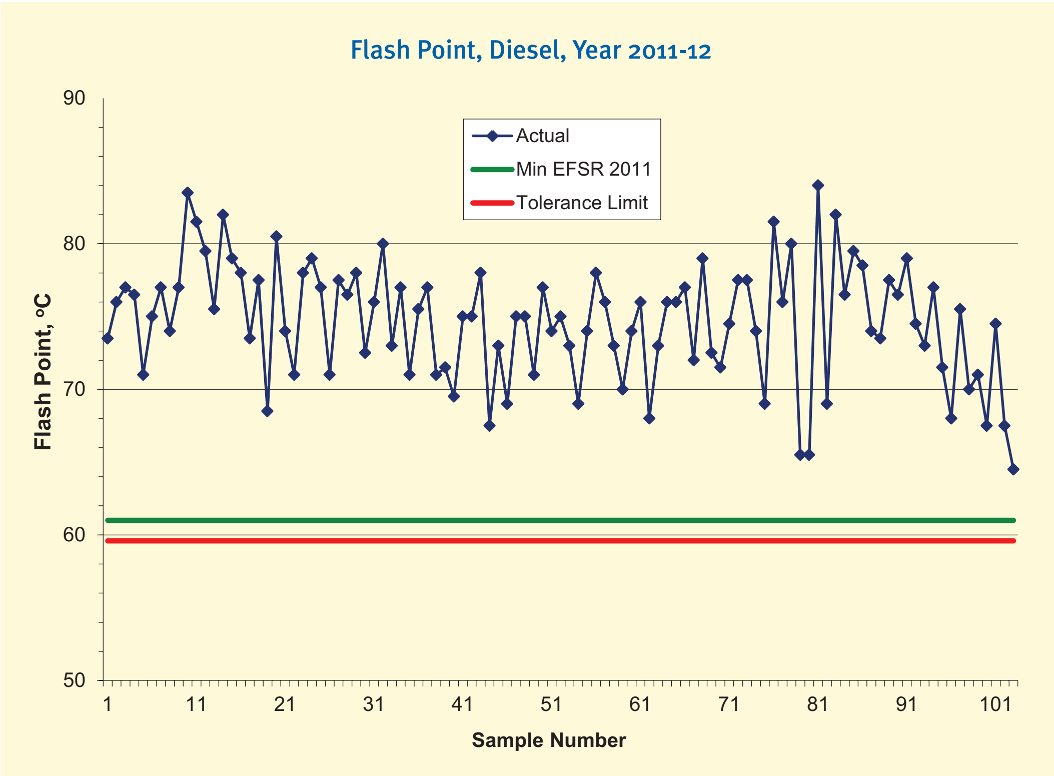


Flash Point

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 70°C with the minimum result of 64.5°C for Sample 103 at the tolerance limit of 59.6°C.

Fig. 22



Summary for Diesel Test Results

On the whole, the number of suspected non-compliance cases was low and there were no repeated cases of non-compliance identified.

In a few instances the results were initially found beyond the prescribed limits but on subsequent analysis they were found to be within the tolerance limits. These instances include two cases in relation to distillation temperature at 95% recovered and one case in relation to cetane index. Only the cetane index was required to be recalculated since the initial result of 50.0 was found to be close to the estimated tolerance limit of 49.8. After further analysis and investigation the average figure of 50.1 was interpreted as compliant.

This year, MAPSS continued testing diesel for appearance according to the ASTM standard D4176[12] which is not listed in the Regulations. This was done to maintain confidence that water in bulk and/or other contamination, if present, would be identified. This testing did not identify any samples with adverse results in relation to the presence of bulk water or other contamination.

12 ASTM D4176 – 04(2009) *Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)*.

Biofuels

Summary of Testing

Various biofuels such as biodiesel as well as ethanol and its blends, 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

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 compliant with the relevant specifications in the Regulations.

Ethanol blended petrol E3 and E10

This year, a special project on ethanol blended petrol was conducted 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. The project was conducted over a period of three months. 16 sample sets of regular and premium petrol blended with ethanol and labelled as E3 and E10 were sampled and tested from the retail sites of two retail fuel supply companies.

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

At the same time, some anomalously high results on other oxygenates content were received. An additional project was launched in collaboration with retail fuel supply companies to identify the source of the suspicious results. In the framework of this sub-project, comparative tests were done in overseas laboratories on the same samples. The successful outcome of this sub-project was the identification of some inconsistencies in testing procedures used in the New Zealand laboratory. Remedial actions and procedural improvements were implemented and subsequent controlled testing results confirmed consistent approaches between the laboratories.

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[13] which was chosen as a reference standard for the list of properties to be tested. Two samples taken with an interval between them of approximately one month were found to be within prescribed specifications according to ASTM D5798.

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

Ethanol for blending

The ethanol produced for blending with petrol in E10 blends (10% ethanol blend with mineral petrol), was tested twice at a supplying terminal. All properties were found to be within the specifications prescribed by Schedule 4 of the Regulations.

Non-Retail Fuel Sampling and Testing

In the year 2011-12, the Ministry continued sampling and testing biodiesel, in particular, B100 (pure biodiesel) and B20 (20% blend with mineral diesel). Biodiesel B100 was tested according to the requirements of Schedules 3 in the Regulations while the blend B20 was tested according to the Regulation 17.

A limited number of biodiesel producers claimed the government biodiesel subsidy in the year 2011-12 so the focus of the testing programme was on products from these producers. In total, 13 samples of biodiesel were collected from production plants or non-retail refuelling sites and tested. These include 11 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. While a new version of the standard, EN 14103:2011, was issued in May 2011 by CEN (European Committee for Standardisation), the Ministry has continued to test biodiesel by the modified method[14] of the current standard method.

It had appeared that the EN 14103:2011 method sometimes gave lower results even when it was clear that the feedstock was unambiguously identified and an anomaly in FAME content reading was not expected. At the same time, the majority of the samples were found to be on specification regarding the FAME content provided it was measured by the modified method approved by the Ministry. A few samples were found to be below the minimum limit but within the tolerance limit.

After receiving sets of comparative data on FAME content, MAPSS continues to contribute to the on-going review of the standard by international standard committees such as CEN and ISO.

Water content in B100 was sometimes found to be above the maximum limit of 500 mg/kg. In two instances, the results were found to be marginally above the specified maximum limit with figures of 513 and 576 mg/kg at the tolerance limit of 590 mg/kg. 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.

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13 ASTM D5798 – 11 S*tandard Specification for Ethanol Fuel Blends for Flexible Fuel Automotive Spark Ignition Engines.*

14 http://www.consumeraffairs.govt.nz/for-business/by-business-type/for-fuel-industry/approved-alternative-testing/ester-content-in-Biodiesel%20

In two other instances, the stock was kept for more than 6 month and when biodiesel was tested (primarily, to compare data on FAME content) the samples returned high figures for water content: 2,100 and 780 mg/kg, respectively. These products were excluded from the fuel supply chain and returned to the plant for reprocessing.

After technology adjustments in response to MAPSS recommendations last year, various glycerides in B100 were found to be within the prescribed limits.

The specification in the Regulations for phosphorus content in biodiesel B100 changed on 1 December 2011 from the maximum limit of 10 mg/kg to that of 4 mg/kg. The data on phosphorus received by MAPSS throughout 3 years of biodiesel quality monitoring was always below 1 mg/kg so test results on phosphorus remained within the specification throughout the year 2011-12 covered by this report.

The overall quality of B100 biodiesel was found to be further improved this year when the results compared with the previous year's test result data.

Biodiesel B20

This blend was inferred to be a final product supplied to customers by MAPSS 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 by MAPSS to be an essential parameter for the product to be 'fit for purpose'.

Unfortunately, one of the planned samplings was cancelled due to the plant operation logistics so only two samples were collected, one at the plant dispenser and another at the non-retail point of sale.

The FAME content in the sample from the non-retail point of sale was found to be 18.6%, i.e. within the expected range of up to 19.3% while that from the plant dispenser returned an elevated result of 22.7%. The latter was noted by the producer.

The filter blocking tendency was found to be below the maximum limit of 2.5 although relatively high: 1.94 and 1.18, respectively, for the samples from the plant dispenser and the non-retail point of sale. These results were accepted as compliant but remedial action was undertaken by the producer with respect to the product at the plant dispenser.

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. On the whole, the overall quality of the B20 blend was found to be significantly improved this year when the test results are compared with those of previous years.

IN CONCLUSION, it must be noted that none of the potentially non-compliant fuels identified by sampling and testing biodiesel entered the retail fuel supply chain and they were subject to remedial action by the producers before subsequent release or disposal.

NOTE

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

MAPSS 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.