TRADING STANDARDS

Fuel Quality Monitoring Programme

Test Results 2021–22

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Te Kāwanatanga o Aotearoa
New Zealand Government

Ministry of Business, Innovation and Employment (MBIE)
Hīkina Whakatutuki – Lifting to make successful

MBIE develops and delivers policy, services, advice and regulation to support economic growth and the prosperity and wellbeing of New Zealanders.

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Executive Summary

The Fuel Quality Monitoring Programme (**the Programme)** is managed by Trading Standards under the Ministry of Business, Innovation and Employment (MBIE).

Trading Standards (**TS**) maintains a comprehensive 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**). The Regulations made in 2011 and amended on 2 October 2017 and then on 26 August 2022 are currently in force.

The primary focus of the Programme is to monitor the quality of the fuel sold by retail fuel companies nationwide. It employs a statistical sampling scheme to ensure an acceptable probability of detecting non-compliance. The Regulations specify limits on several properties and content for premium and regular petrol grades, diesel, and biofuels such as biodiesel and ethanol.

A significant part of the Programme is to sample and evaluate the quality of fuels sold to consumers, which is done by taking samples from the dispenser nozzles at the retail point of sale.

The sampling and testing programme is independent of the Fuel Industry and focused primarily on retail sales. It complements the extensive sampling and testing that the Fuel Industry carries out at various stages during the manufacturing and supply processes. This provides confidence to consumers and all stakeholders around the quality and composition of petrol, diesel and biofuels.

This report gives an overview of the results of the Programme from 1 July 2021 to 30 June 2022. It is a technical report that provides useful information for fuel industry stakeholders and researchers. During this period, in total, 610 fuel samples were collected from approximately 1,300 fuel service stations, certain commercial sites and storage terminals throughout New Zealand. These include 548 routine samples, and samples taken in response to complaints and enquiries, biofuels, and marine fuels.

Analysis of sampling and testing conducted during the period of this report has confirmed that overall, fuel sold in New Zealand was of good quality and compliant with specifications prescribed in the Regulations.

There were a few instances when a sample at the retail site was found to be beyond specification. In two instances diesel samples have been found to be non-compliant according to the requirements of the Regulations. One diesel sample had water content of 397 mg/kg while the specified limit is 200 mg/kg and another diesel sample had sulphur content of 23.5 mg/kg while the specified limit is 10 mg/kg. There were a several instances of low cetane index in diesel. On investigation the relevant diesel shipment was found to be on specification for a combination of cetane index and cetane number.

A biodiesel B100 sample intended for non-retail supply was found to be non-compliant on oxidation stability although the relevant sample of blended fuel B10 was found to be compliant. At the same time, the content of FAME exceeded that of B10 that was stated to customers. Non-compliant biofuel identified by testing was subject to remedial action by the producer.

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

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Introduction

MBIE has national regulatory responsibility for several infrastructure areas that are fundamental to consumer safety, supporting consumer and business confidence and facilitating domestic and international trade.

TS is responsible for administering a number of these areas[1], including Fuel Quality Monitoring (FQM) which is focused on maintaining a programme to monitor and ensure the quality and compliance of New Zealand's retail fuel supply with the Regulations.

In the fuel quality monitoring area, activities include:

- sampling, testing, and analysing fuel quality including routine samples taken in accordance with a statistical sampling plan and samples taken as part of targeted projects or in response to complaints or emerging issues
- investigating consumer and trader complaints and responding to enquiries
- advising on and facilitating improvement of fuel industry 'best practice'
- developing and conducting projects in response to emerging issues
- contributing to work on regular amendments and updates to the Regulations
- maintaining strong and effective relationships (as the lead regulator) with fuel company technical managers, fuel retailers, industry associations and stakeholders within NZ and internationally
- representing New Zealand on international standards committees relating to fuel quality.

These activities and the Programme are funded from a proportion of the *Petroleum or engine fuel monitoring levy* that is supplied in accordance with the Energy (Petrol, Engine Fuel, and Gas) Levy Regulations 2017[2].

This report sets out the results of the Programme from 1 July 2021 to 30 June 2022.

Currently, the Regulations of 26 August 2022 are in place. However, this report relates to a period which was still covered by the Regulations enforced at the time, those of 2 October 2017[3].

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

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 website or in previous FQM Programme annual reports.[4]

Collection of fuel samples during this period was carried out under the direction of TS. The samples were then tested by Independent Petroleum Laboratory Ltd, and the results subsequently analysed by TS. Any non-compliance or abnormalities identified through testing were subject to analysis and follow-up investigation by TS. 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 considers each retail fuel company's market share in that area.

In total, 196 sample sets were collected from retail sites and the majority of sets included samples of regular and premium grade petrol and a sample of diesel. At some sites, premium petrol was not available during sample collector visits. However, there were several instances when four samples were collected from a site with two samples for premium petrol, one with RON 95 and another with RON 98 or above.

1 http://www.tradingstandards.govt.nz
2 https://www.legislation.govt.nz/regulation/public/2017/0147/latest/whole.html#DLM7296652
3 https://www.legislation.govt.nz/regulation/public/2011/0352/22.0/DLM4044701.html
4 http://fuelquality.tradingstandards.govt.nz/about-us/fuel-quality-monitoring-annual-reports/

The regional distribution of fuel 'sample sets' is shown in the table below:

Terminal/Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Whangarei	0	0	0	0	1	0	0	1	1	1	0	5	**9**
Auckland	1	3	1	3	4	3	3	3	3	5	8	7	**44**
Mt Maunganui	3	3	1	1	1	2	2	3	8	2	6	0	**32**
New Plymouth	1	0	1	0	0	0	0	0	2	0	0	2	**6**
Napier	1	1	0	1	1	1	0	0	0	0	2	0	**7**
Wellington	2	1	3	1	1	1	1	3	2	3	1	1	**20**
Nelson	2	1	1	1	1	1	1	3	1	2	1	2	**17**
Lyttelton	1	1	3	2	2	3	0	0	1	2	3	3	**21**
Timaru	0	0	1	1	1	0	3	1	0	0	0	1	**8**
Dunedin	1	1	0	1	0	3	1	1	2	2	2	4	**18**
Bluff	1	1	1	2	2	0	0	1	0	3	2	1	**14**
TOTAL	**13**	**12**	**12**	**13**	**14**	**14**	**11**	**16**	**20**	**20**	**25**	**26**	**196**

This report also covers the results of sampling and testing of biofuel that is featuring for some fuel supply companies. When non-retail sale products are utilised as components for retail market products, TS monitors their quality too because they are categorised by the Regulations. Some biodiesel samples, for example intended for non-retail sale, were initially suspected to be non-compliant before supply of blended fuel to customers (see section on Biofuels). Potentially non-compliant biofuels identified by sampling and testing were subject to remedial action by the producers.

A limited number of supplementary tests were added to the routine list of tests conducted. These included, firstly, a test on silver strip corrosion in petrol which is not yet specified in the Regulations as well as a test on appearance for diesel which is also not specified in the Regulations. The latter was added to the routine list of diesel properties tested to assess the level and nature of the potential presence of water and other contaminants that can be visually assessed.

Alongside the routine sampling and testing of fuel, TS monitors local wet stock management processes and procedures at the service stations' forecourts looking at established practices otherwise known in the industry as 'housekeeping'. This relates to the maintaining of the underground storage tanks (UST), minimizing fuel contamination (e.g. from water ingress), monitoring stock levels and maximizing fuel system cleanliness.

Adopting reliable wet stock management systems and practices can help improve fuel quality, prevent contamination, prolong equipment life, and reduce corrosion in vehicles' engine systems and thereby the owner's operating expenses. TS plans to continue keeping this local site management focus in the coming year and work with the fuel supply companies to ensure that they maintain 'best practice' and follow proper procedures as specified in their quality management systems to ensure the quality and composition of fuel is maintained right throughout the supply chain.

An analysis of the Programme data from previous years allows us to assume that the true proportion of suspected non-compliances can be taken as constant across terminals and brands. Alternatively, the system would have to consider elevated risks, sources of potential non-compliance, and unique conditions to identify regions with a higher risk of non-compliance.

The results of subsequent testing of fuel samples have been reported in accordance with their relevant specified limits set out in the Regulations. In accordance with the provisions of ISO Standard 4259[5], there are tolerances set out under the testing regime which allow for results to fall slightly outside the specified limits.

5 BS EN ISO 4259-2:2017 *Petroleum and related products - Precision of measurement methods and results. Part 2: Interpretation and application of precision data in relation to methods of test.*

Conclusion

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

In this report and as with previous reports, the anonymity of the source of the samples is maintained due to the commercial sensitivity of this information.

Petrol

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

The test method ASTM D2699[6] is prescribed in the Regulations for definition of RON while the test method ASTM D2700[7] is prescribed for definition of MON.

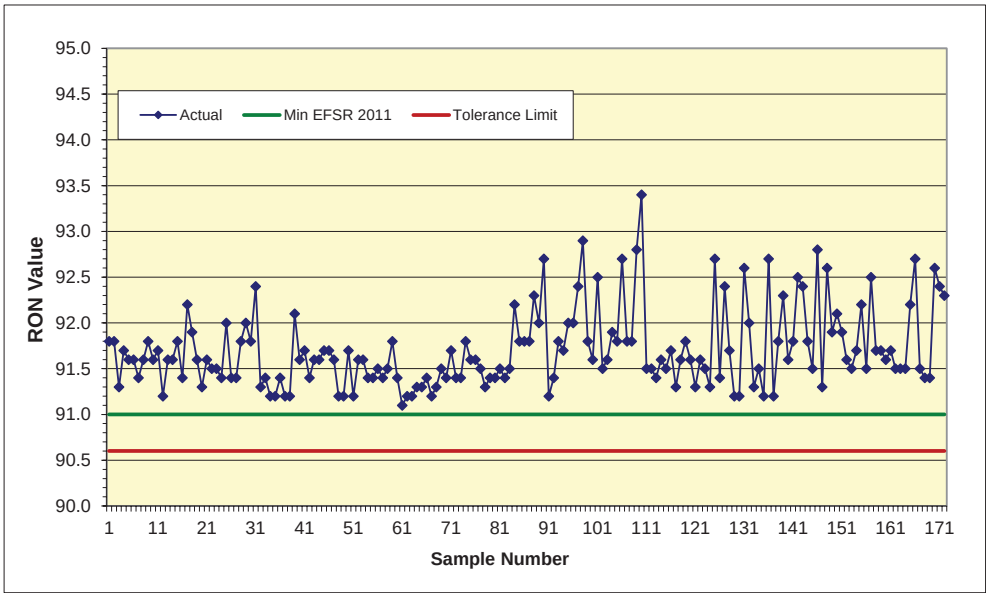
Here and below:
The abbreviation 'EFSR' stands for the specification limit prescribed in the Regulations.

RON 91

In total, 172 samples of regular petrol were collected, all of these were tested for RON and were within the minimum specified limit. All samples of regular petrol were tested for MON, and the results were above the minimum specified limit of 81.0 for MON. Fig. 1a and Fig. 1b below show the testing results for RON and MON respectively.

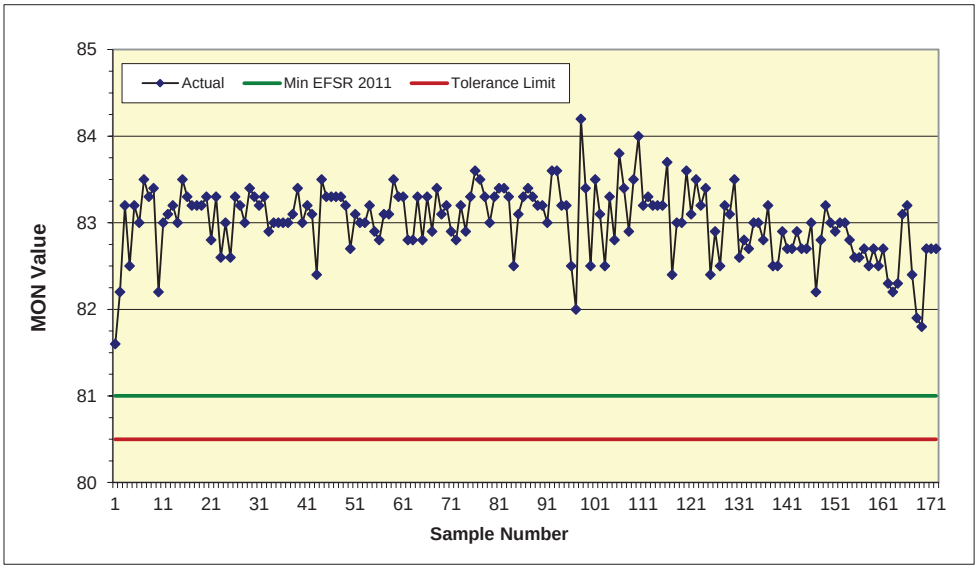
Here and below:
Each individual result is independent from others although they are connected in the graphs for the ease of interpretation.

Figure 1a: Test Results for Petrol RON 91, Year 2021-22



6 ASTM D2699–19e01 *Standard Test Method for Research Octane Number of Spark-Ignition Engine Fuel.*
Here and further in footnotes, the test method's version is shown that was current in the period of testing.
7 ASTM D2700-19 *Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel.*

Figure 1b: Test Results for MON, Regular Petrol RON 91, Year 2021-22



RON 95

In total, 132 samples of premium grade petrol were tested for RON 95. All samples met the minimum specified limit of 95.0 for RON. The same number of samples of petrol with RON 95 were tested for MON. Sample 99 was found to be on the specified limit for RON and Sample 33 was found to be on the specified limit for MON.

Fig. 2a and Fig. 2b below show the testing results for RON and MON respectively.

Figure 2a: Test Results for Petrol RON 95, Year 2021-22

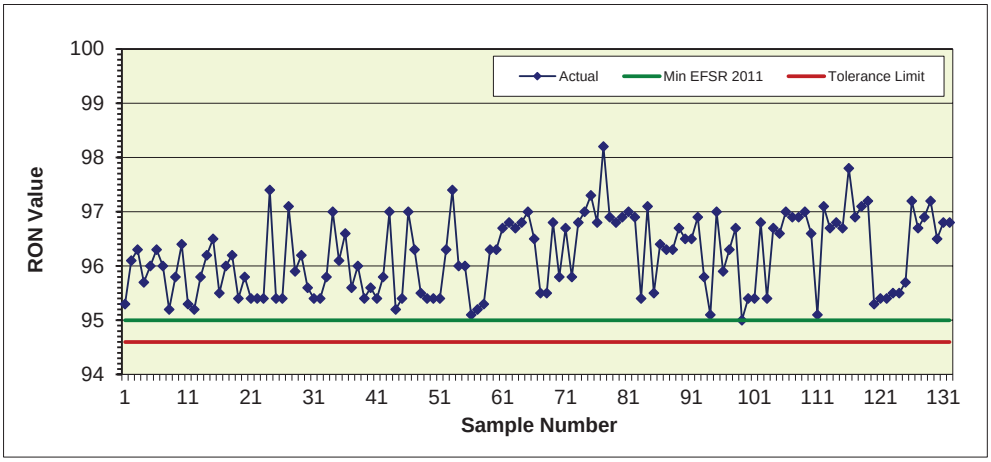
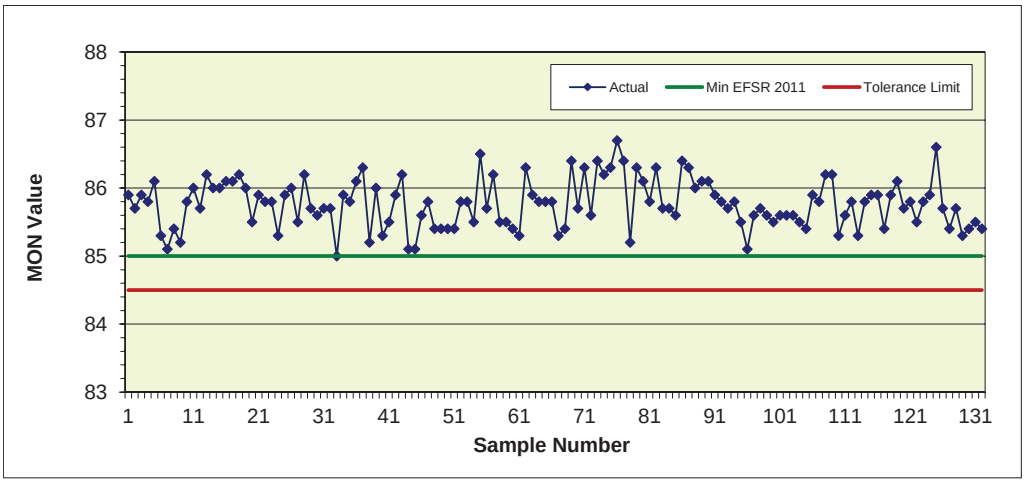


Figure 2b: Test Results for MON, Premium Petrol RON 95, Year 2021-22



RON 98 & ABOVE

No minimum value of RON for premium petrol sold in the retail market with an advertised RON above 95, is specified in the Regulations. This fuel is advertised as having properties that are superior or in addition to the regulated limits. Particularly, the advertised "RON 98" as referred in Fig 3a, must comply with Section 11 of the Regulations when tested by the test methods specified in Schedule 1 in the Regulations.

The Fair Trading Act 1986 allows for this advertised limit to be enforced if there is a mis-description. Based on that, it can be interpreted that the actual figures of RON must not be lower than 98 or, as advertised, lower than 100.

A minimum limit for MON is neither specified in the Regulations nor advertised for premium petrol with an advertised RON of 98 or above. Therefore, the limit for premium petrol has been used as a benchmark.

In total, 58 samples of petrol with advertised RON 98 and above were collected and tested. All samples with a RON of 98 or above were found to be higher than the advertised minimum limit.

No minimum MON is specified for premium petrol with RON above 95. All samples were found to have MON above the specified limit of 85.0 for premium petrol.

Fig. 3a and Fig. 3b below shows the testing results for RON and MON respectively. Only the tolerance limit for RON 98 is show in the graph for RON.

Figure 3a: Test Results for Petrol RON 98 & above, Year 2021-22

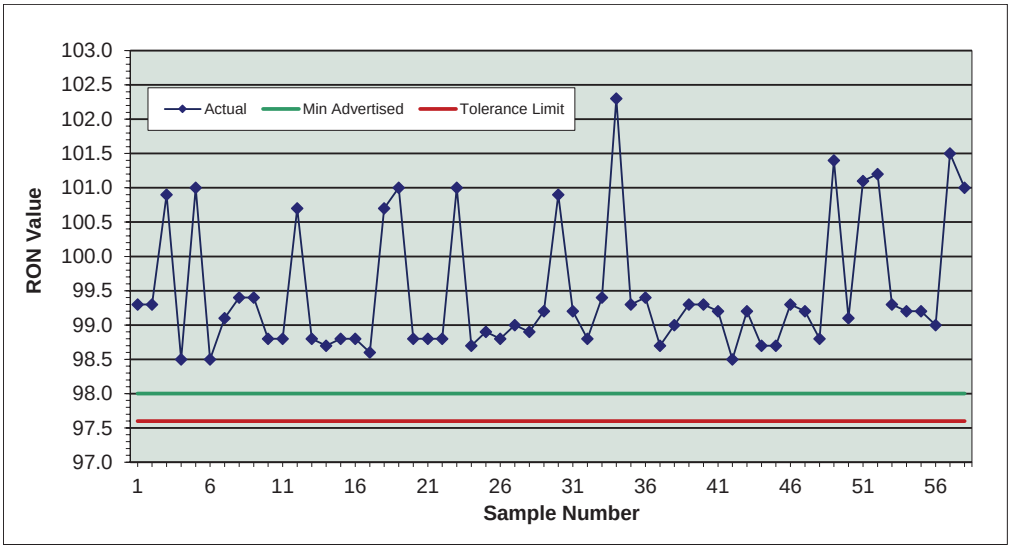
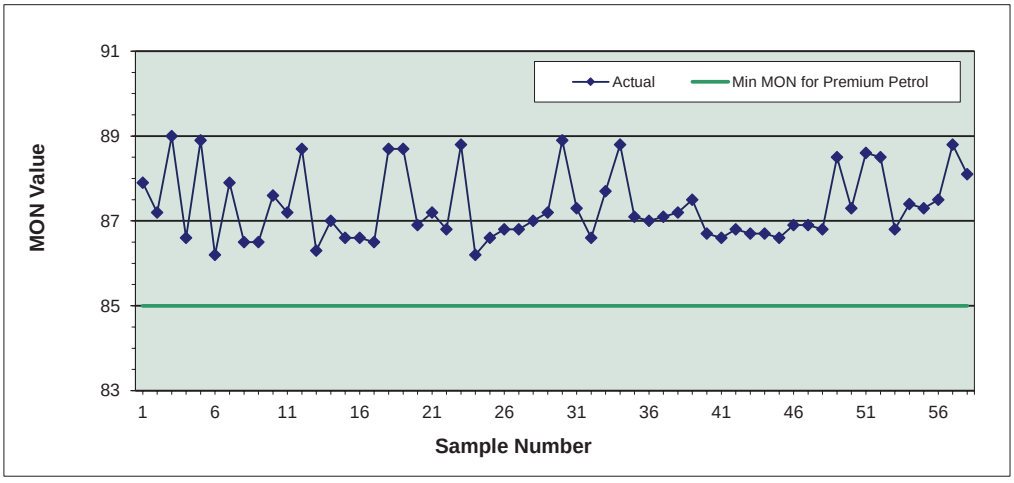


Figure 3b: Test Results for MON, Premium Petrol RON 98 & above, Year 2021-22



Evaporation Percentage

The test method ASTM D86[8] is prescribed in the Regulations for the definition of the volume percentage of evaporated petrol at the three fixed temperatures: at 70ºC, 100ºC and 150ºC. 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, RON 98 and above).

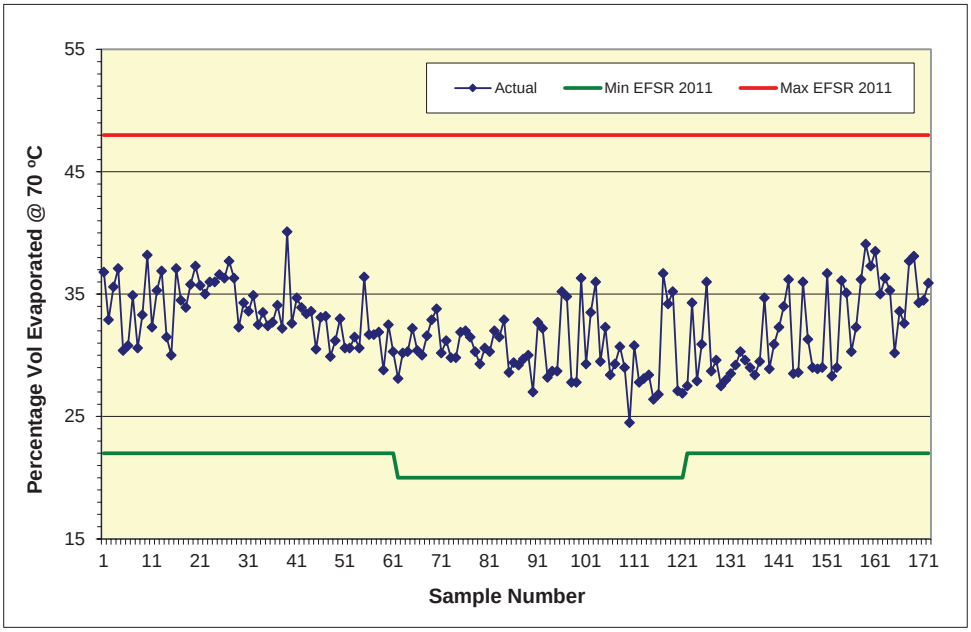
RON 91

Percentage Volume Evaporated at 70°C

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

All 172 samples were found to be within the prescribed specified limits above the minimum specified limit of 22% in all seasons including the summer period when the specified minimum limit for E70 is permitted to be 20% (see Fig. 4a).

Figure 4a: Test Results for E70, RON 91, Year 2021-22



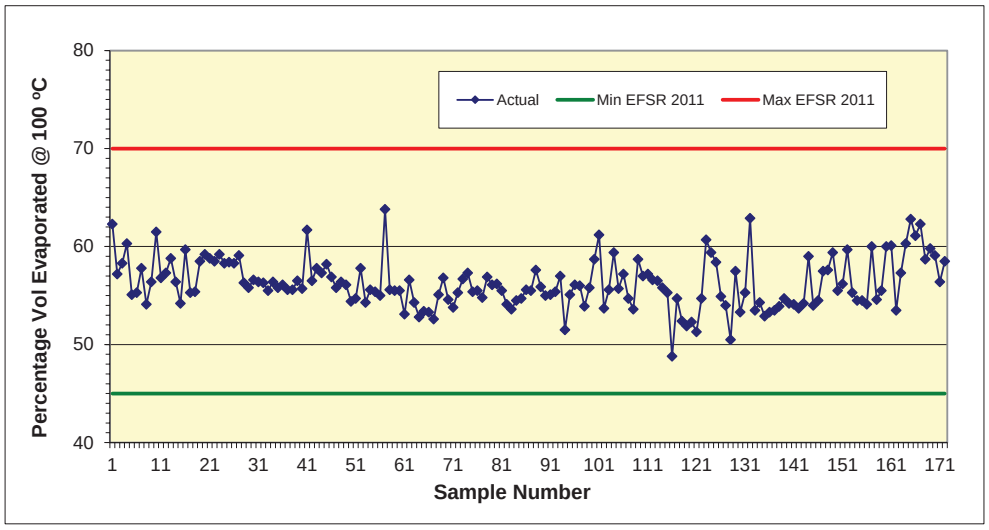
8 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure.*

Percentage Volume Evaporated at 100°C

All 172 samples were found to be within the specified limits of 45% to 70%.

The minimum tolerance limit is 43.8% and maximum tolerance limit is 70.9% (not shown in Fig. 4b).

Figure 4b: Test Results for E100, RON 91, Year 2021-22

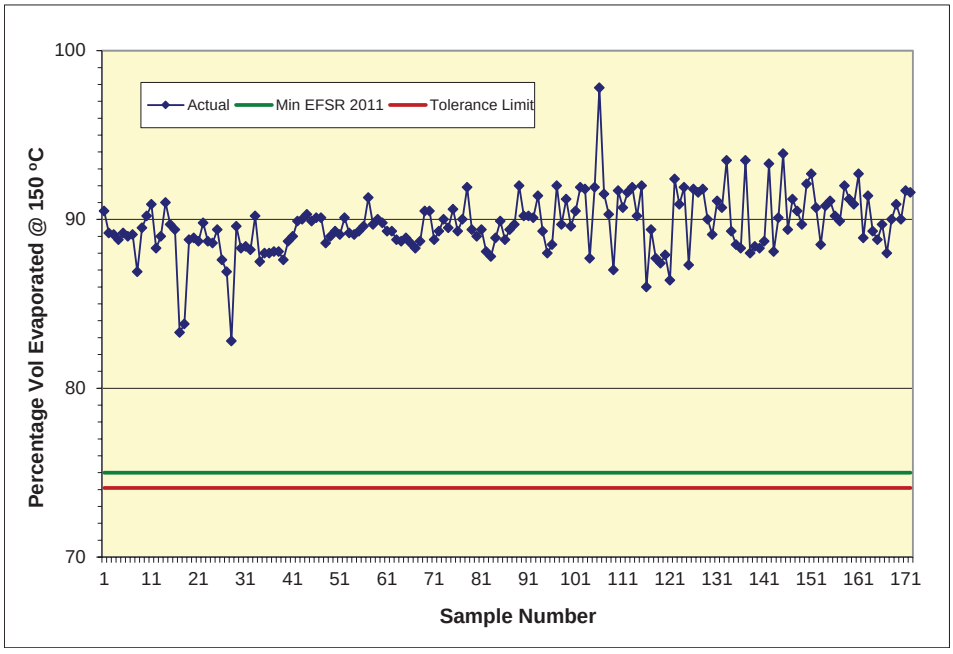


Percentage Volume Evaporated at 150°C

All 172 samples were found to be above the minimum specified limit of 75%. The minimum tolerance limit is 74.1%.

No maximum limit is prescribed by the Regulations for this property.

Figure 4c: Test Results for E150, RON 91, Year 2021-22



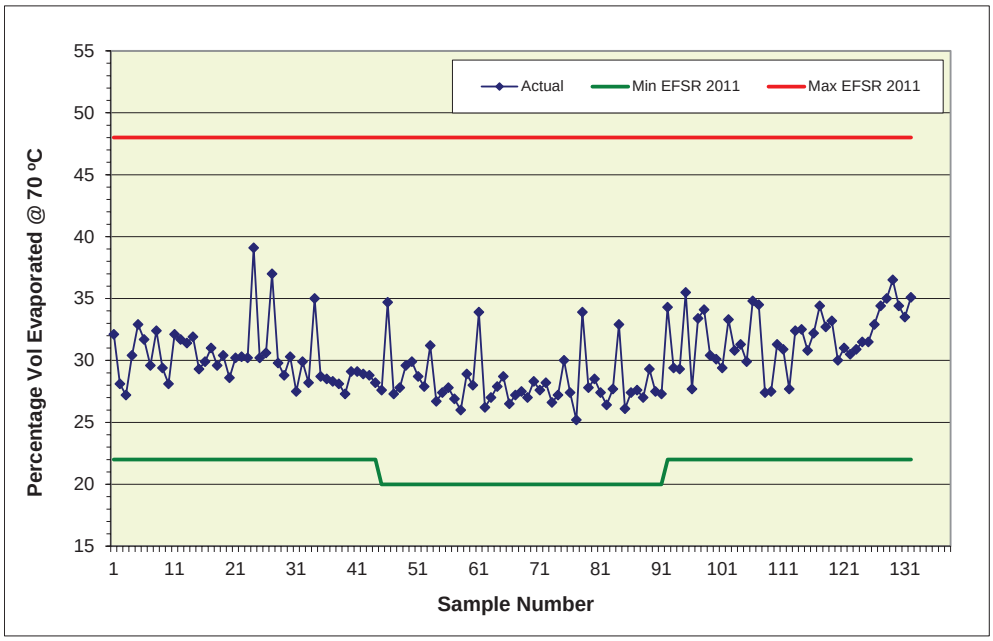
RON 95

Percentage Volume Evaporated at 70°C

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

All 138 samples were found to be within the prescribed specified 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%.

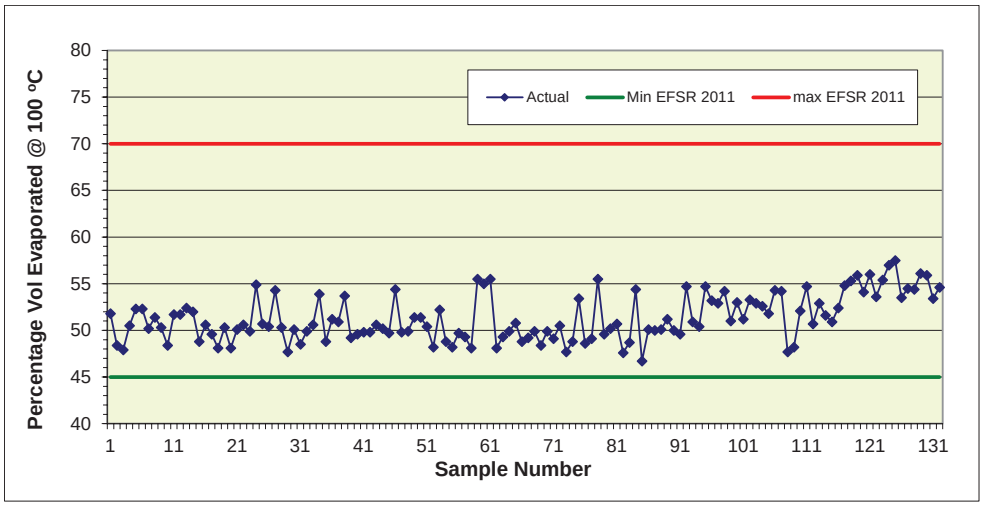
Figure 5a: Test Results for E70, RON 95, Year 2021-22



Percentage Volume Evaporated at 100°C

All samples were found to be within the specified limits of 45% to 70%. As in case of regular petrol, the tolerance limits are 43.8% and 70.9% (not shown in Fig 5b).

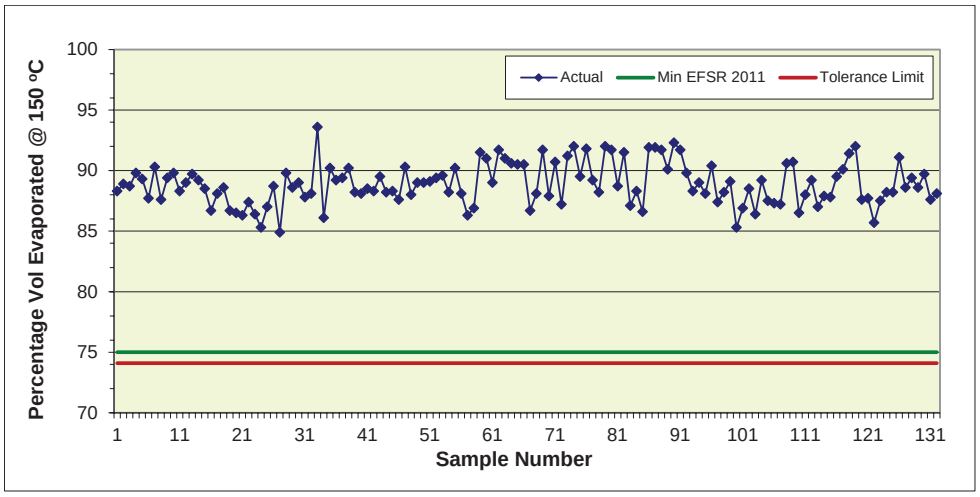
Figure 5b: Test Results for E100, RON 95, Year 2021-22



Percentage Volume Evaporated at 150°C

All samples were found to be above the minimum specified limit of 75% (Fig. 5c). The minimum tolerance limit is 74.1%. No maximum is prescribed by the Regulations for this parameter.

Figure 5c: Test Results for E150, RON 95, Year 2021-22



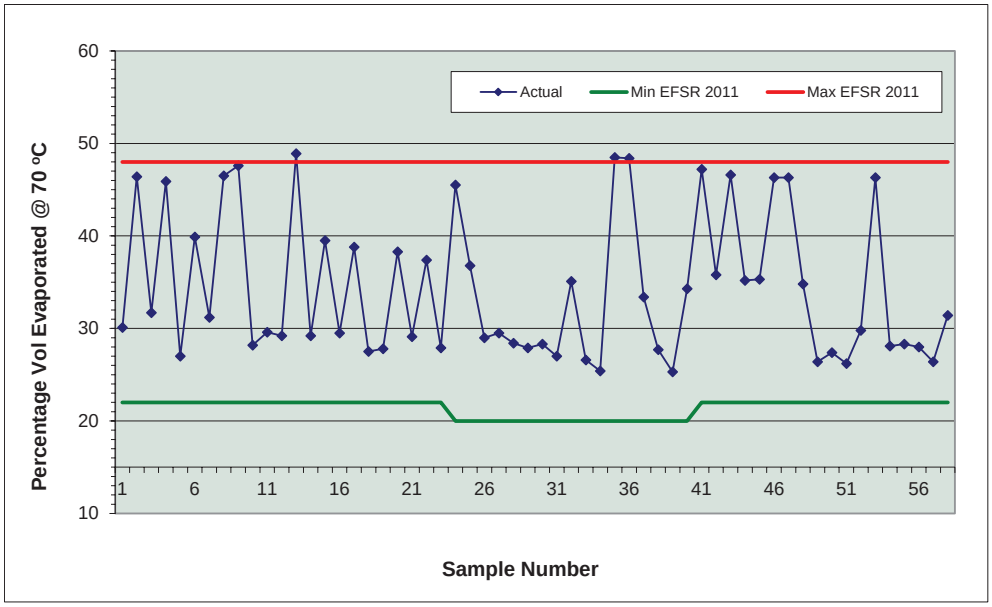
RON 98 & above

Percentage Volume Evaporated at 70°C

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

Most results were found to be within the specified limits of 22% to 48% except for three ethanol blended samples. According to the Regulations (Footnote 2 in Schedule 1), the maximum allowed percentage of volume evaporation at 70ºC (E70) is increased by 1% per each 1% volume of ethanol in the blend. Samples 13, 35 and 36 were found to be in a range from 48.4% to 48.9% with ethanol content, respectively, from 8.74% to 9.17%.

Figure 6a: Test Results for E70, RON 98 & above, Year 2021-22

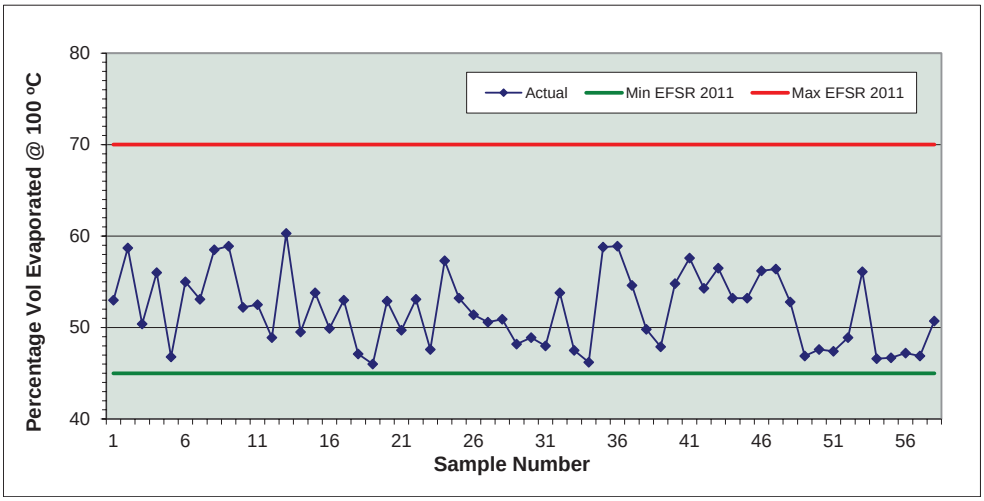


Percentage Volume Evaporated at 100°C

All samples were found to be within the specified limits of 45% to 70% (Fig 6b).

The tolerance limits are 43.8% and 70.9% respectively (not shown in Fig 6b).

Figure 6b: Test Results for E100, RON 98 & above, Year 2021-22

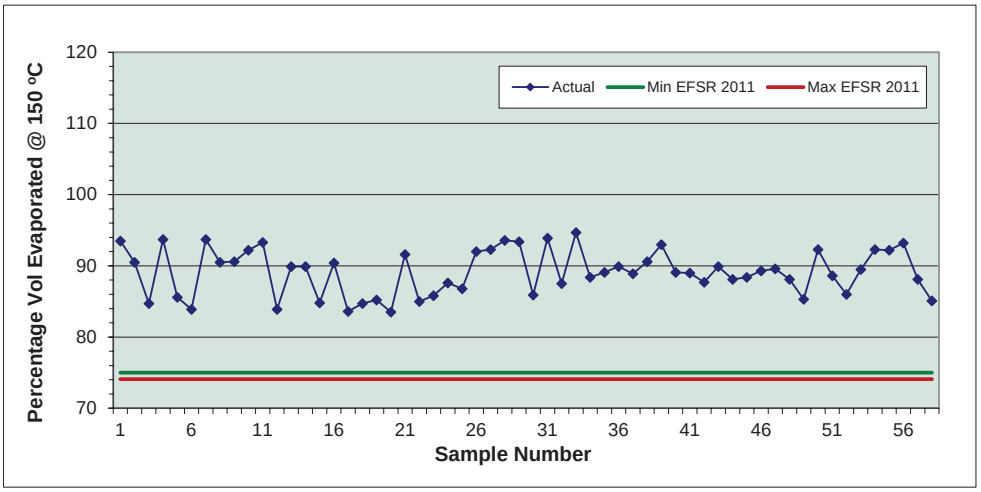


Percentage Volume Evaporated at 150°C

All samples were found to be above the minimum specified limit of 75% (Fig. 6c).

The minimum tolerance limit is 74.1%. No maximum is prescribed by the Regulations for this parameter.

Figure 6c: Test Results for E150, RON 98 & above, Year 2021-22



Final Boiling Point (FBP)

The test method ASTM D86[9] is prescribed in the Regulations for distillation end point (or 'final boiling point') in petrol.

All samples were found to be below the specified maximum limit of 210ºC for both regular and premium grades (Fig.7). The maximum tolerance limit is 214ºC.

Figure 7a: Test Results for Final Boiling Point, RON 91, Year 2021-22

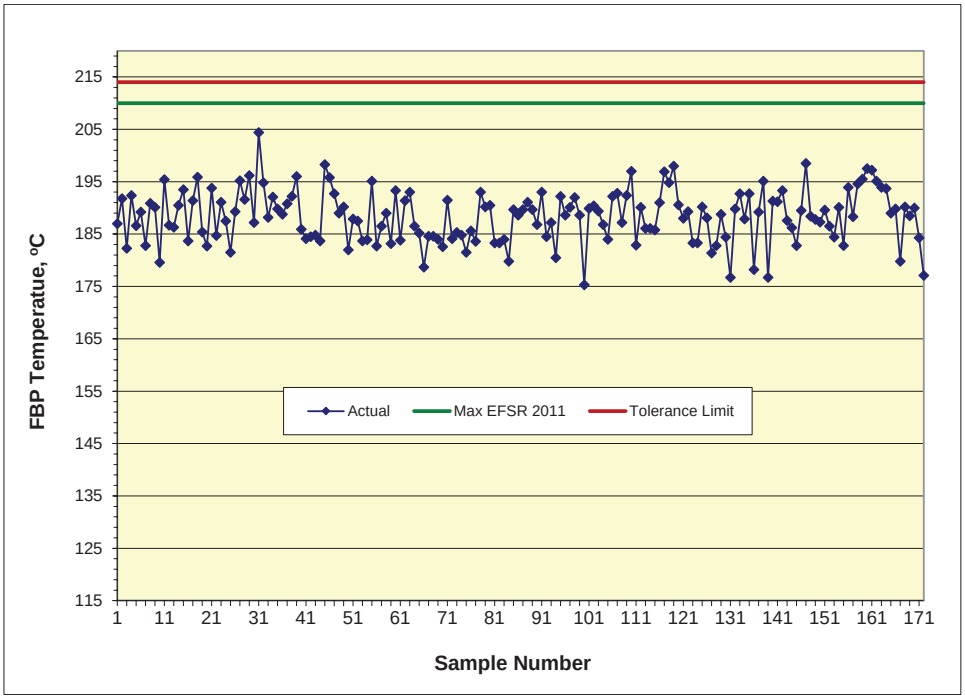
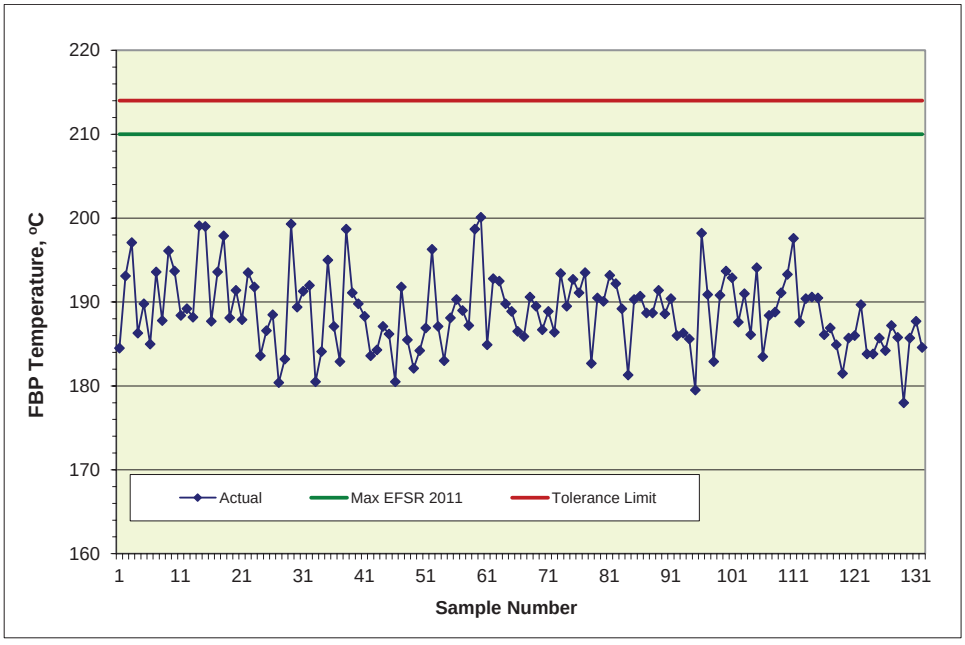
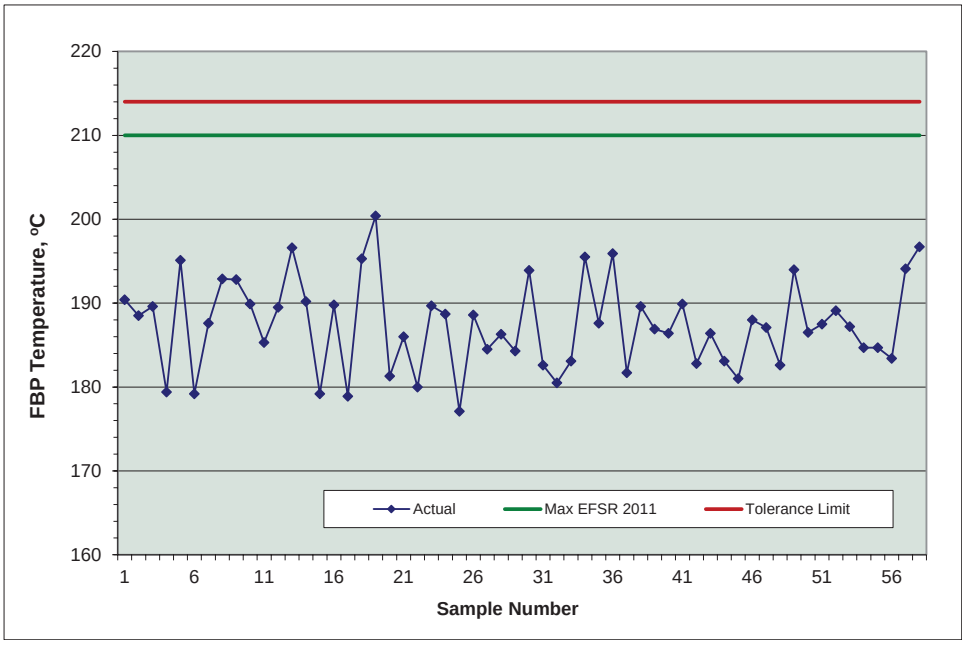


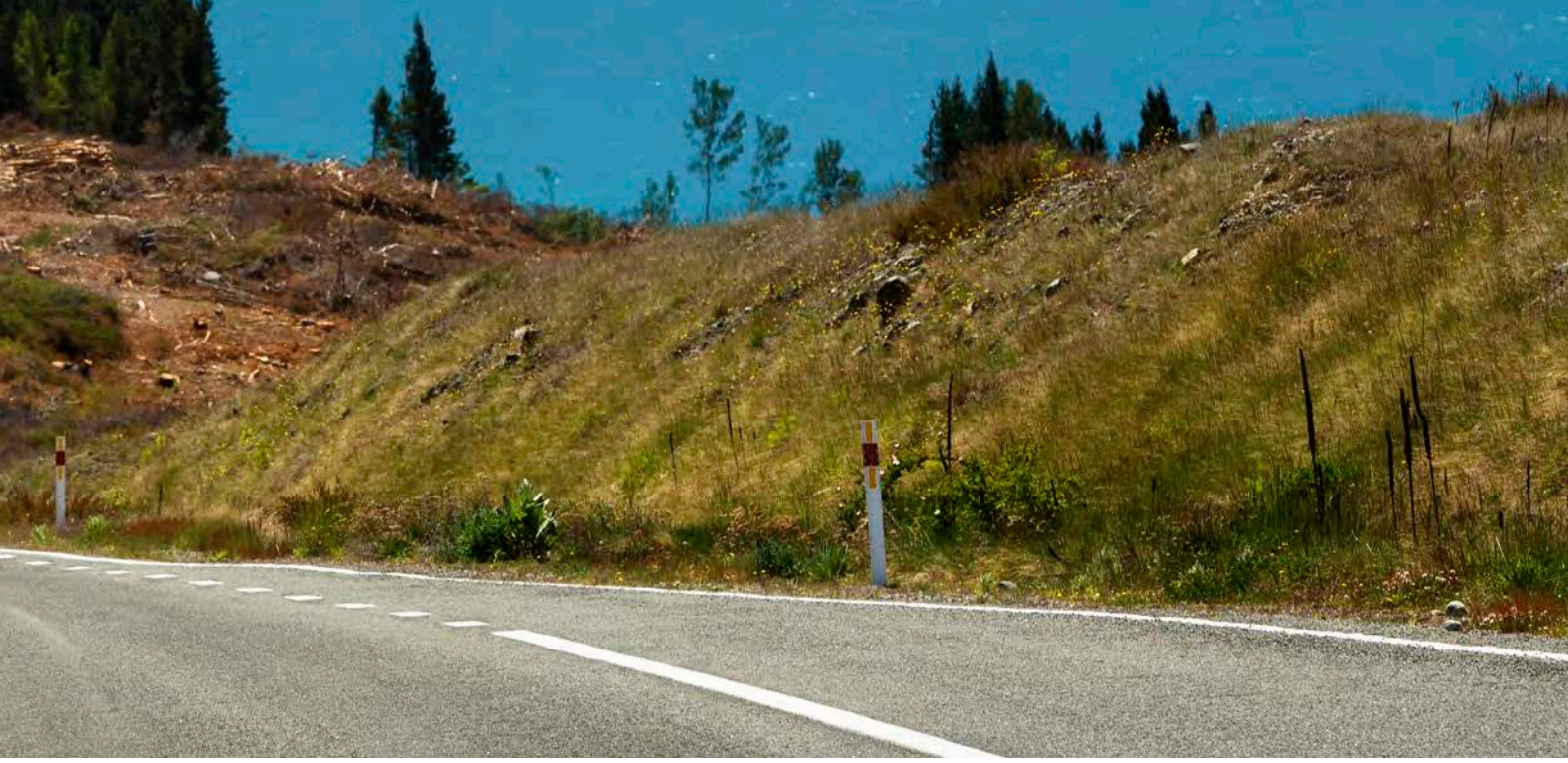
Figure 7b: Test Results for Final Boiling Point, RON 95, Year 2021-22



9 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.

Figure 7c: Test Results for Final Boiling Point, RON 98 & above, Year 2021-22





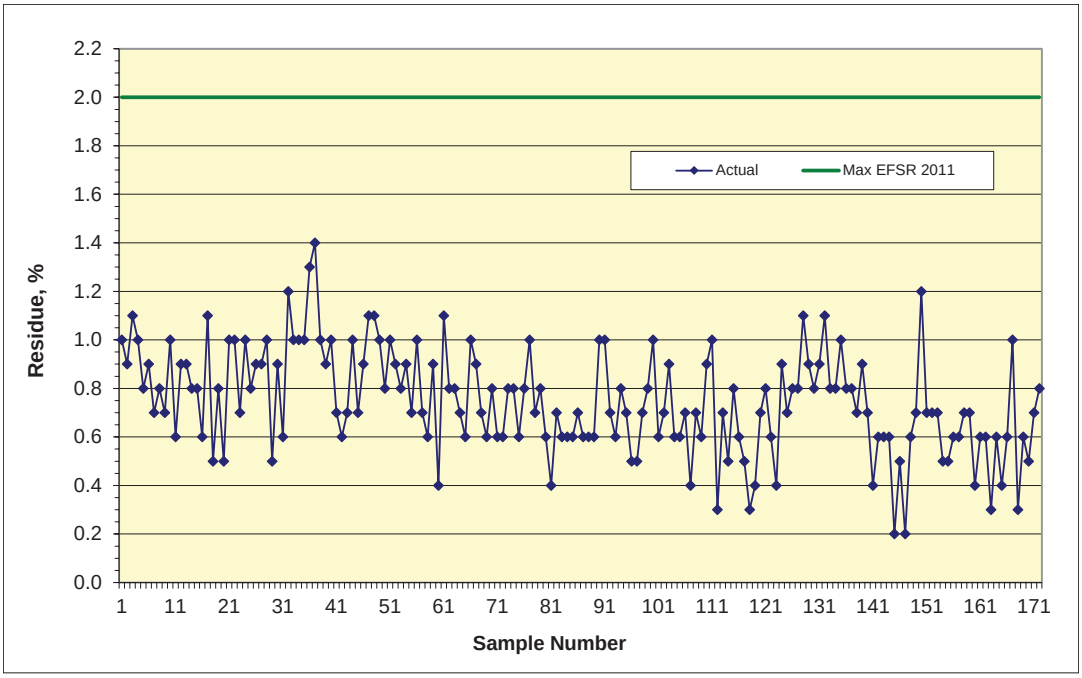
Residue

All samples were found to be within the limits for both regular and premium grades (Fig. 8).

Distillation residue, according to the standard ASTM D86[10], is usually expected to be within a certain range and serves primarily as an indicator of a satisfactory distillation process. This is one of the process control parameters as defined by the laboratory. However, repeatability and reproducibility for residue is not defined in the standard. Therefore, no tolerance limit for residue could be defined in ASTM D86. Fortunately, residue content was found to be below the specified maximum limit of 2% volume.

All results for regular and premium petrol were found to be not exceeding 1.4%. The minimum results for regular and premium petrol were reported as 0.2% and 0.1%, respectively.

Figure 8a: Test Results for Residue, RON 91, Year 2021-22



10 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.

Figure 8b: Test Results for Residue, RON 95, Year 2021-22

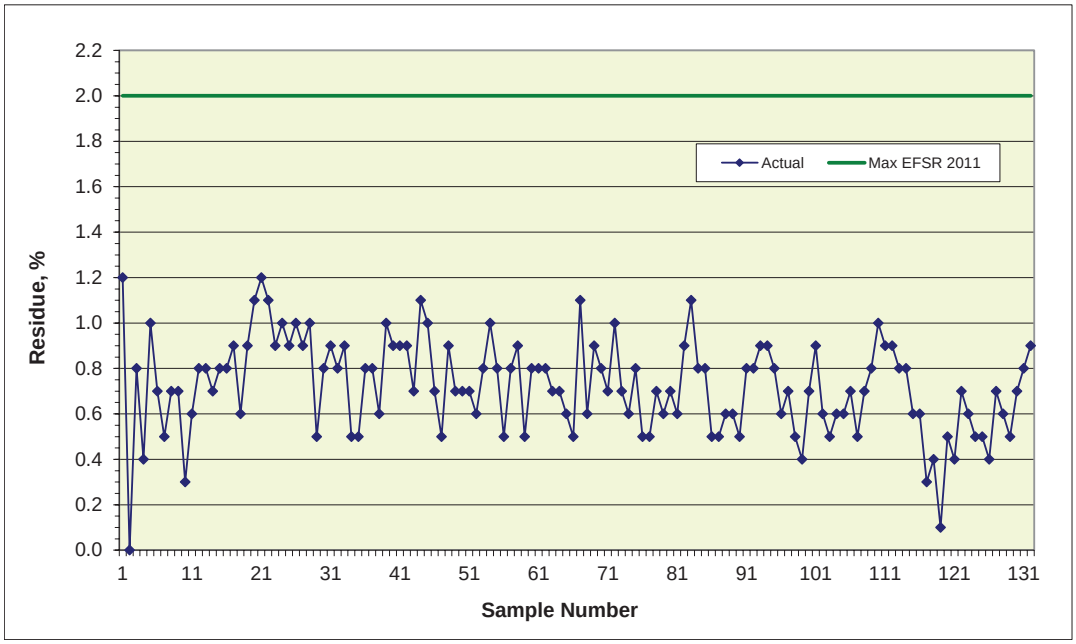
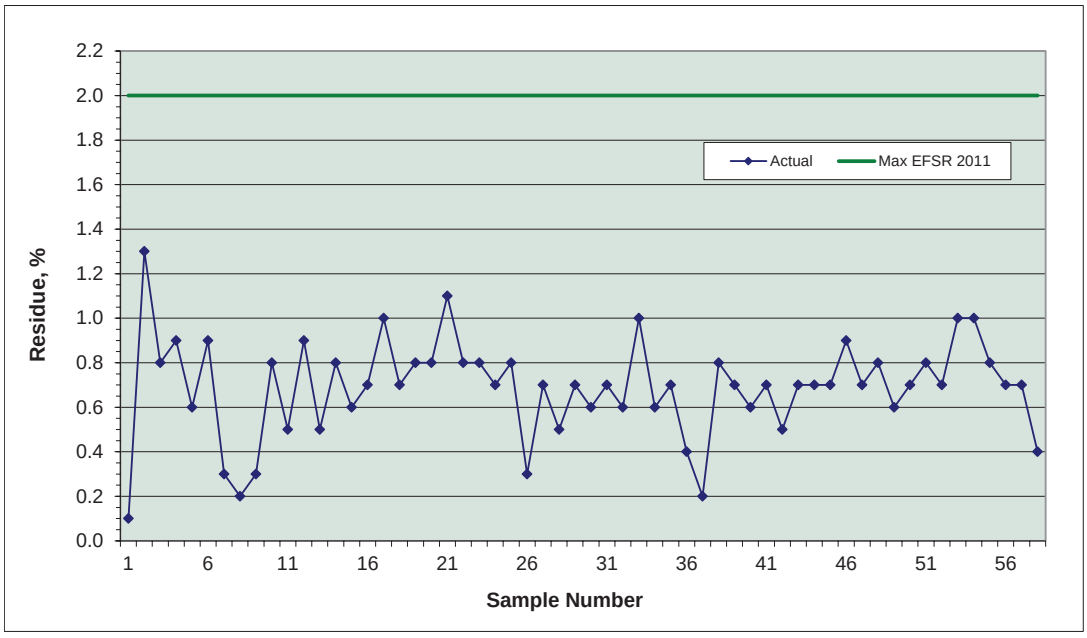


Figure 8c: Test Results for Residue, RON 98 & above, Year 2021-22



Dry Vapour Pressure Equivalent

The test method ASTM D5191[11] is prescribed in the Regulations for vapour pressure in petrol.

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

The vapour pressure must be tightly controlled at high temperatures to reduce the possibility of hot fuel handling problems, such as vapour lock or excessive evaporative emissions. Vapour lock is a problem that may occur when the liquid fuel converts into gas while still in the car fuel system. This could disrupt the operation of the fuel pump, causing loss of feed pressure and may result in loss of power or complete stalling. At lower temperatures, a sufficiently high vapour pressure is needed to allow ease of starting and good warm-up performance.

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 these are 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. 9 by a minimum dip.

The lines before and after the dip, are the next lowest maximum, 80 kPa, which is prescribed for the North Island, for the autumn and spring seasons, respectively, from 1 April to 31 May inclusive and from 1 September to 30 November inclusive.

The maximum limits prescribed for winter in the North Island from 1 June to 31 August inclusive, are equal to the 90 kPa level which is shown in the graph by two top lines. The maximum limit for winter in the South Island is 95 kPa (not shown).

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

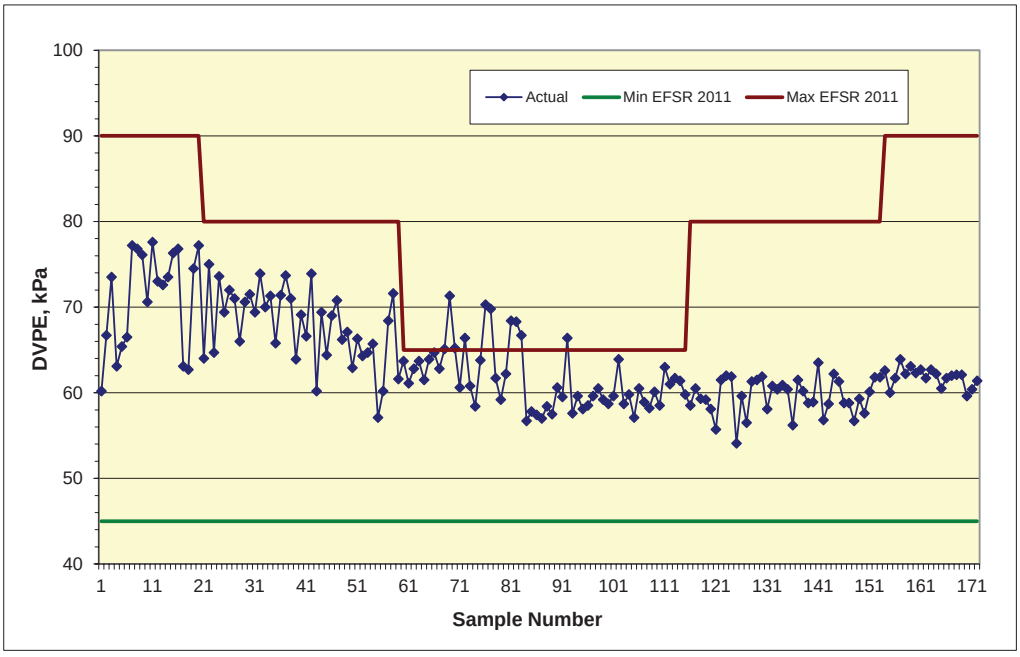
Tolerance limits related to the maximum specified limits are not shown since they are only approx. 3% above each relevant limit.

RON 91

In the summer period, ten samples were initially found to be above the lowest maximum at the time. However, all these were subsequently found to be within the specified limits for their region and season.

The ten samples which had results above the limit of 65 kPa in figure 9a, were found to be below the maximum limit of 75 kPa for summer in South Island which is the region the samples were taken from.

Figure 9a: Test Results for DVPE, RON 91, Year 2021-22



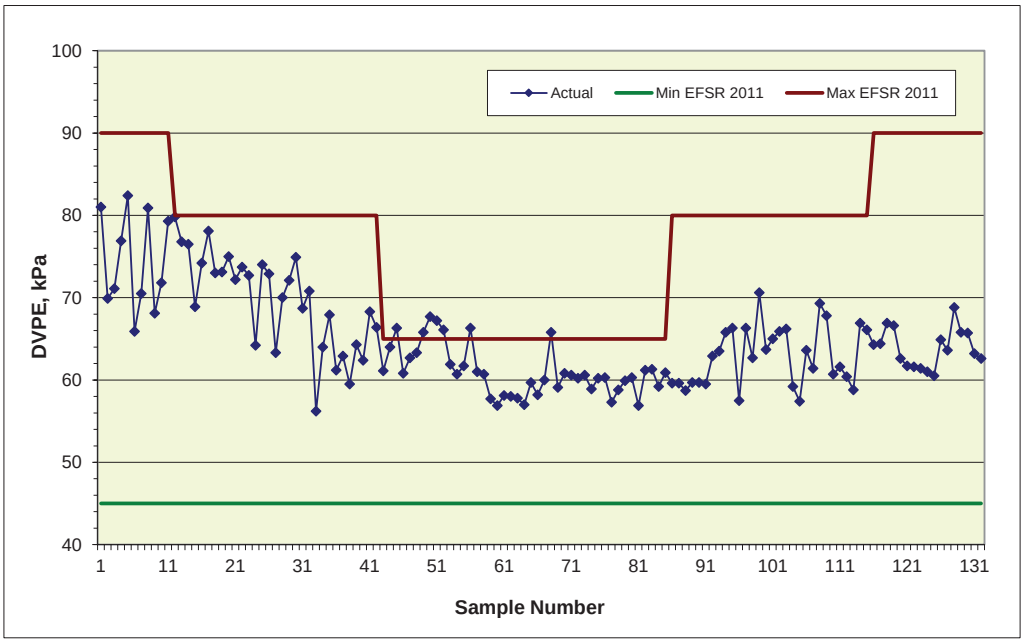
11 ASTM D5191-20 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method).*

RON 95

All 132 samples except one were found to be within the specified limits for premium petrol (Fig. 9b). As in the case with regular petrol, in the summer period, seven samples were initially found to be above the lowest maximum with actual results in the range from 65.8 kPa to 67.7 kPa. Six of them were below the maximum limit of 75 kPa for summer in South Island where the samples were taken.

However, Sample 45 was from the Auckland and Northland region and with the initial result of 66.3 kPa appeared to be above the specified limit for the region. After repeated testing the second and third result were 61.9 kPa and 64.5 kPa respectively, with the reproducibility condition of 2.3 kPa not met. Therefore, the three results were recognised as inconsistent, and a corrective action request was raised within the testing laboratory. The laboratory conducted an internal investigation to improve the quality of testing process. Since the first result was on the tolerance limit of 66.3 kPa for a single test, it was recognised as compliant when taken alone.

Figure 9b: Test Results for DVPE, RON 95, Year 2021-22

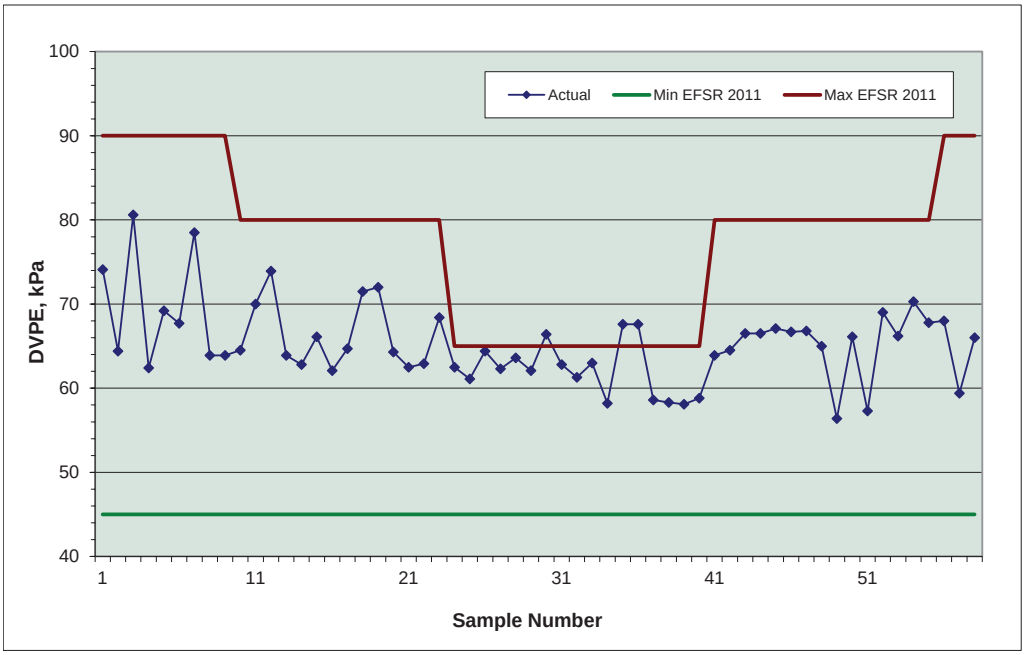


RON 98 & ABOVE

All 58 samples were found to be within the specified limit for premium petrol RON 98 and above (Fig. 9c). Three samples were initially found to be above the lowest maximum at the time. However, these were subsequently found to be within the specified limit for their region or as a blend with ethanol.

In the figure 9c, Sample 30 which had the result of 66.4 kPa was found to be below the maximum limit of 75 kPa for summer in South Island where the sample was taken. Samples 35 and 36 which were both found to be 67.4 kPa were from the North Island. They are ethanol blended petrol with ethanol content above 8% each. According to Footnote of the Regulations, for premium grade petrol blended with more than 1% oxygenates, the maximum vapour pressure allowed in summer season in Auckland and Northland is 72 kPa and for the rest of North Island is 77 kPa.

Figure 9c: Test Results for DVPE, RON 98 & above, Year 2021-22



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)

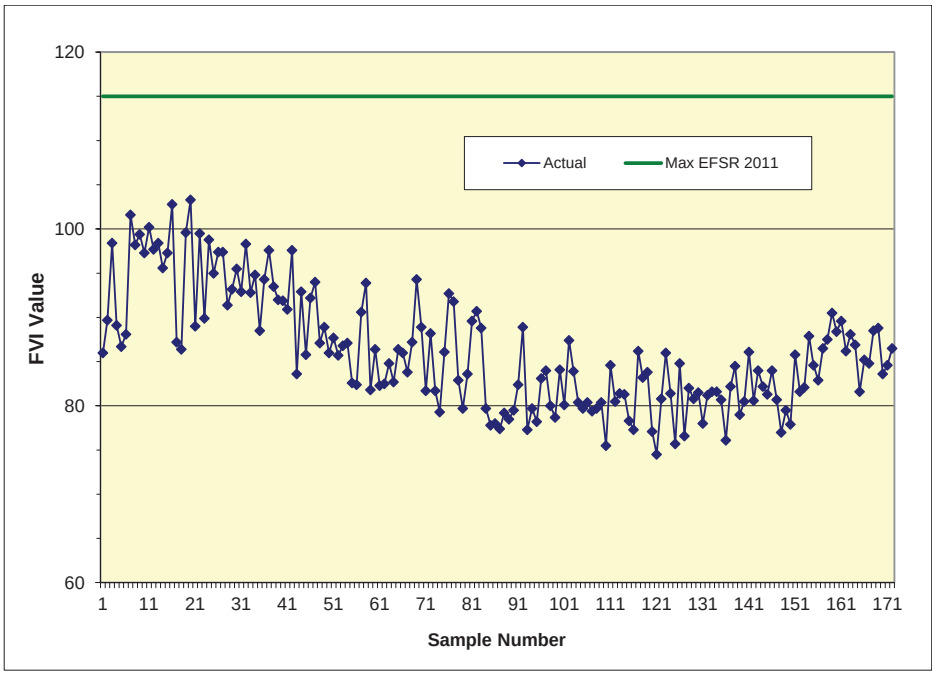
FVI serves as an indicator of the hot running performance (the tendency for vapour lock).

No definition of the FVI value is given in the related ASTM Standards prescribed in the Regulations (D86 and D5191[12]) and therefore, 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 of regular petrol were found to be below the specified maximum limit of 115.0, with the maximum value of 103.3 (Fig 9d).

Figure 9d: Results for Flex. Vol. Index, RON 91, Year 2021-22

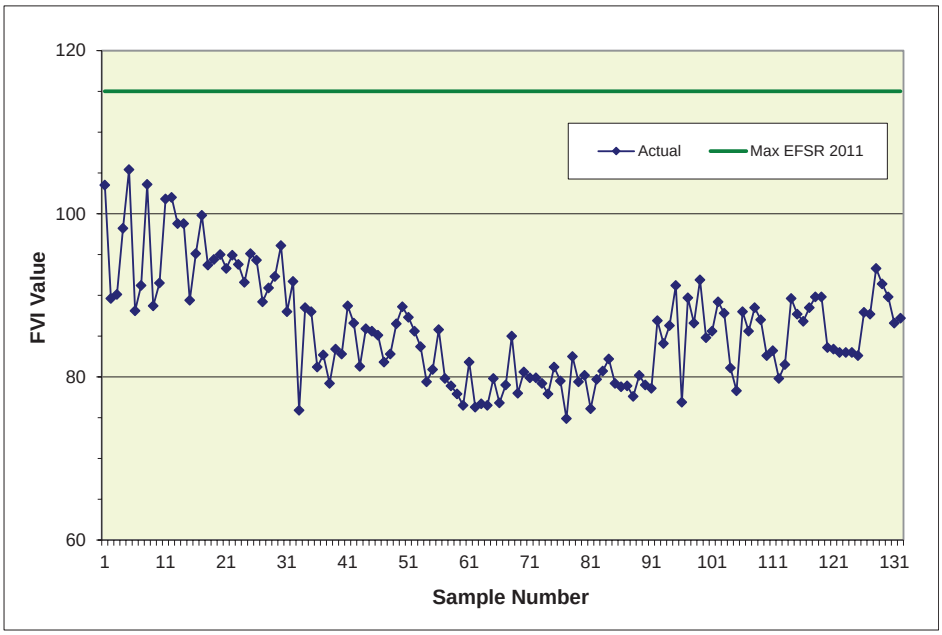


12 ASTM D5191 - 20 *Standard Test Method Method for Vapor Pressure of Petroleum Products (Mini Method).*

RON 95

All samples of premium petrol were found to be below the specified maximum limit of 105.4.

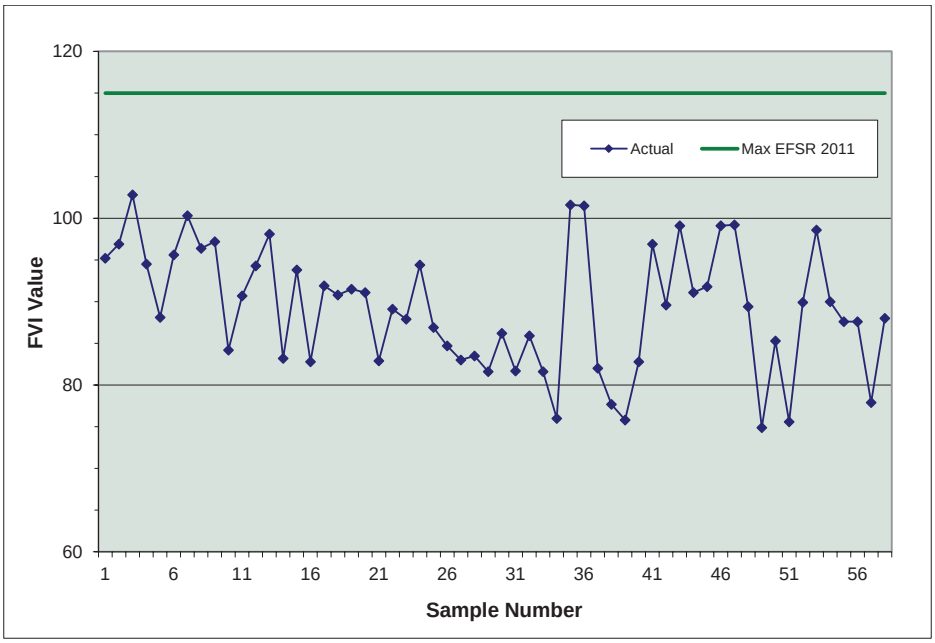
Figure 9e: Results for Flex. Vol. Index, RON 95, Year 2021-22



RON 98 & ABOVE

All samples of premium petrol were found to be below the specified maximum limit of 115.0, with the maximum value of 102.8.

Figure 9f: Results for Flex. Vol. Index, RON 98 & above, Year 2021-22



Sulphur

Sulphur has a significant impact on vehicle emissions by reducing the efficiency of catalysts. Sulphur also adversely affects heated exhaust gas oxygen sensors. Reductions in sulphur will provide immediate reductions of emissions from all catalyst-equipped vehicles on the road.[13]

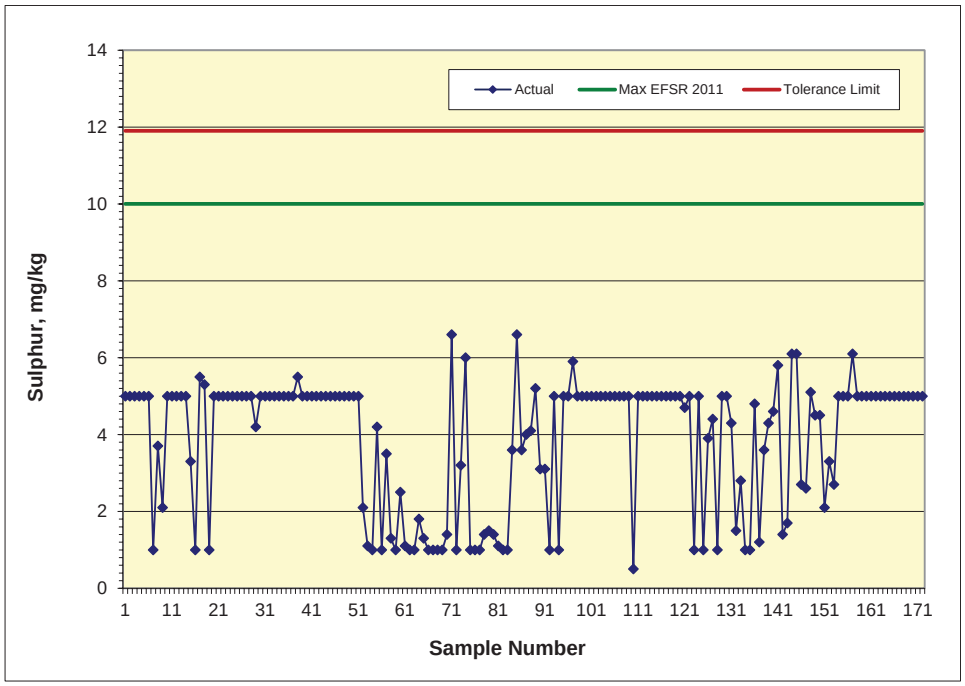
The scope of the test method IP 497[14] prescribed in the Regulations is from 5 to 60 mg/kg.

The ASTM standard D5453[15] which is also prescribed in the Regulations along the IP 497, gives results down to a fraction of 1 mg/kg with the tolerance limit of 11.9 mg/kg. There are two different tolerance limits identified for the two methods: 11.8 mg/kg for IP497:2019 and 11.9 mg/kg for ASTM D5453-19a (only the tolerance limit for ASTM D5453-19a is shown on Fig.10).

RON 91

All 172 samples tested for sulphur for regular petrol were found to be below the prescribed maximum limit with the largest value of 6.6 mg/kg.

Figure 10a: Test Results for Sulphur, RON 91, Year 2021-22

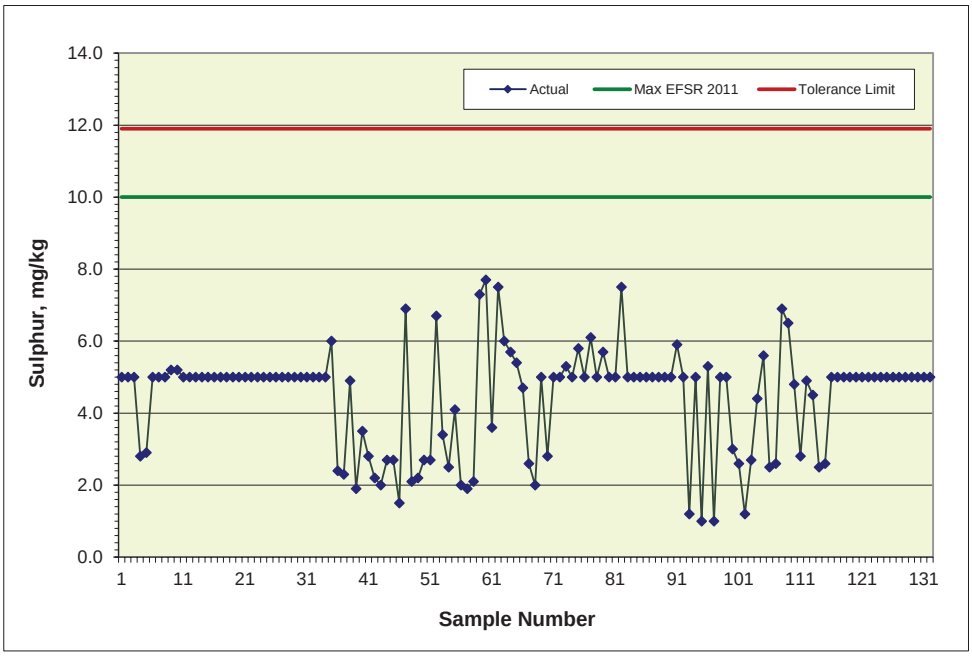


13 *Worldwide Fuel Charter,* 6th Ed., 2019, p.17.
14 IP497 EN ISO 20884:2019 *Petroleum products - Determination of sulfur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry* .
15 ASTM D5453–19a *Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence.*

RON 95

All 132 results for premium petrol were found to be below the prescribed maximum limit of 10 mg/kg with the largest value of 7.7 mg/kg.

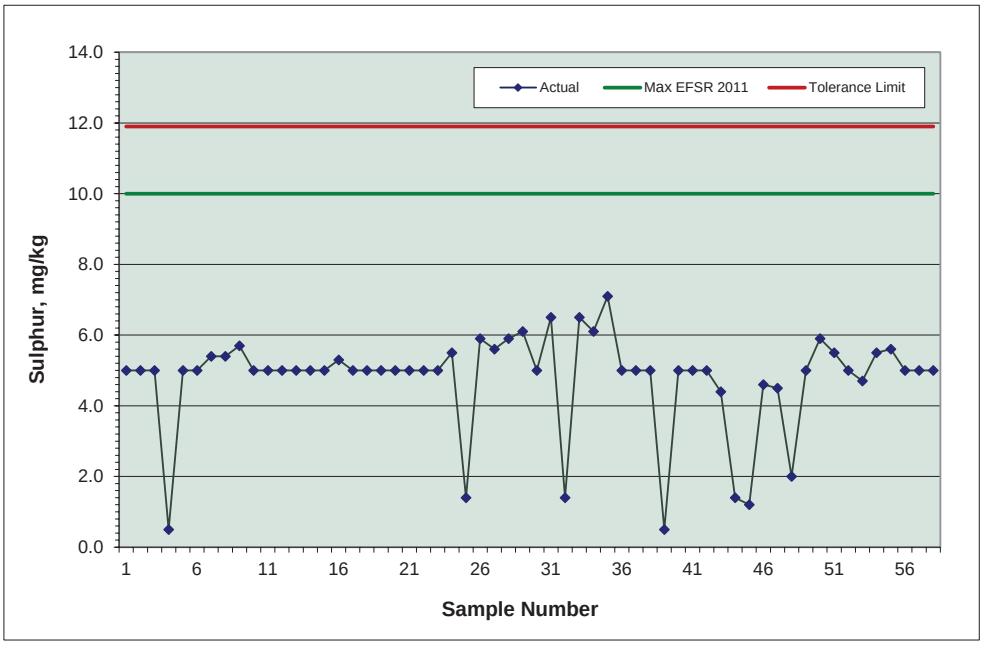
Figure 10b: Test Results for Sulphur, RON 95, Year 2021-22



RON 98 & ABOVE

All 58 results for premium petrol 98 and above were found to be below the prescribed maximum limit 7.1 mg/kg.

Figure 10c: Test Results for Sulphur, RON 98 & above, Year 2021-22



Benzene and Total Aromatics

The test method ASTM D5580[16] is prescribed in the Regulations for aromatic compounds including benzene.

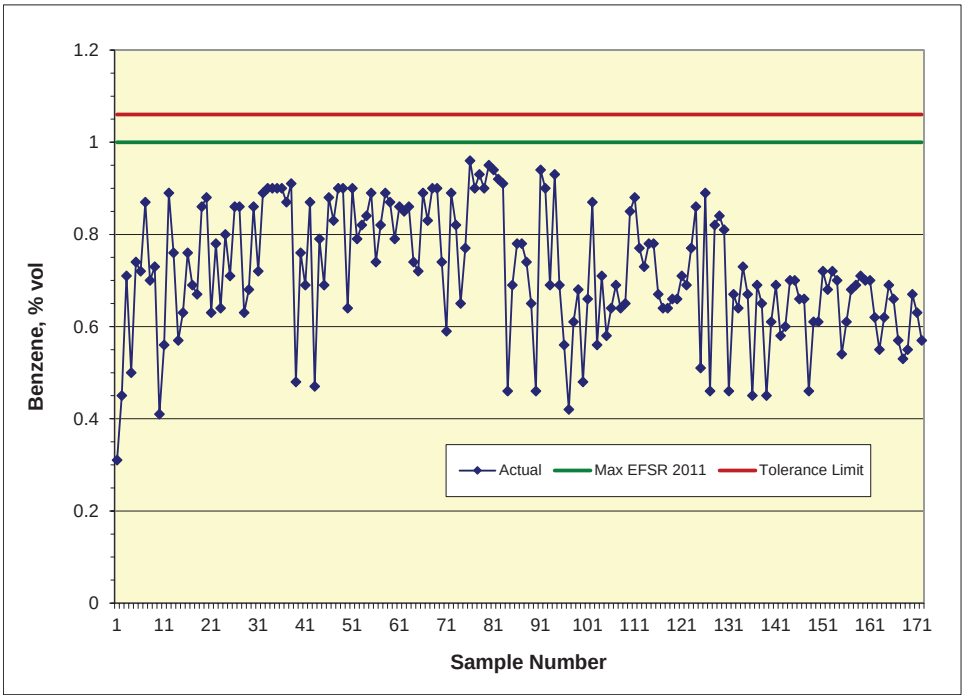
All samples were found to be below the prescribed maximum limits, for both benzene (maximum 1% vol) and total aromatic compounds (45% vol maximum cap) for regular as well as premium grade of petrol with the tolerance limits of 1.06% for benzene and of 46.03% for the maximum cap in total aromatics.

RON 91

All 172 results tested for benzene content in regular petrol were found to be below 1% with the highest result 0.96% (Fig.11a).

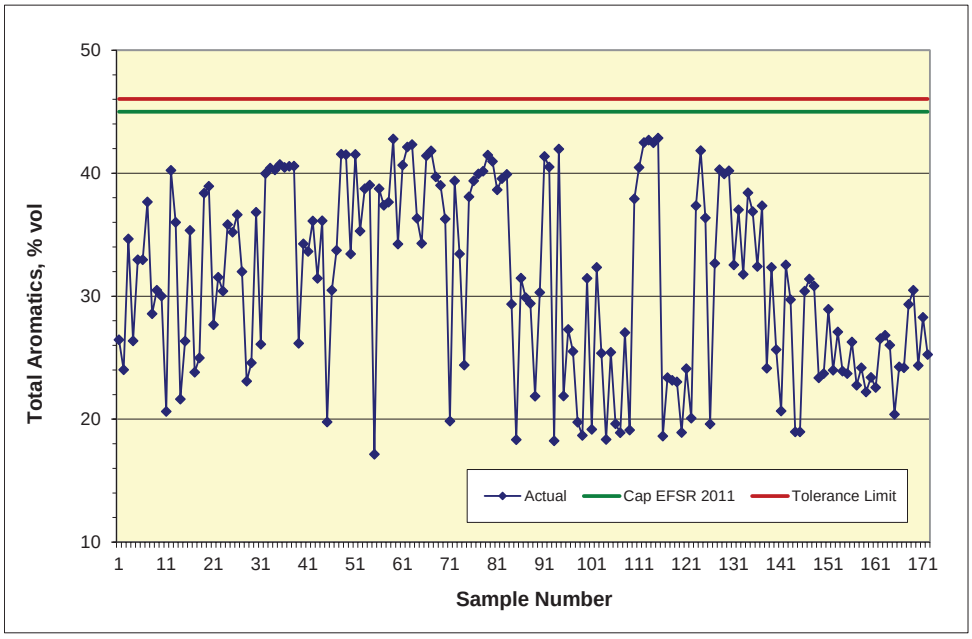
All results of total aromatics were found to be below the prescribed limit with the highest result 42.85% (Fig. 11b).

Figure 11a: Test Results for Benzene, RON 91, Year 2021-22



16 ASTM D5580-21 *Standard Test Method for Determination of Benzene, Toluene, Ethylbenzene, p/m-Xylene, o-Xylene, C9 and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography.*

Figure 11b: Test Results for Total Aromatics, RON 91, Year 2021-22



RON 95

All 132 samples of premium petrol tested for benzene were found to be below the prescribed maximum limit with the highest result for a sample reported as 0.92%.

For premium petrol, all results on total aromatics were found to be below the maximum limit of 45% with the highest result 42.77% (Fig. 11d).

Figure 11c: Test Results for Benzene, RON 95, Year 2021-22

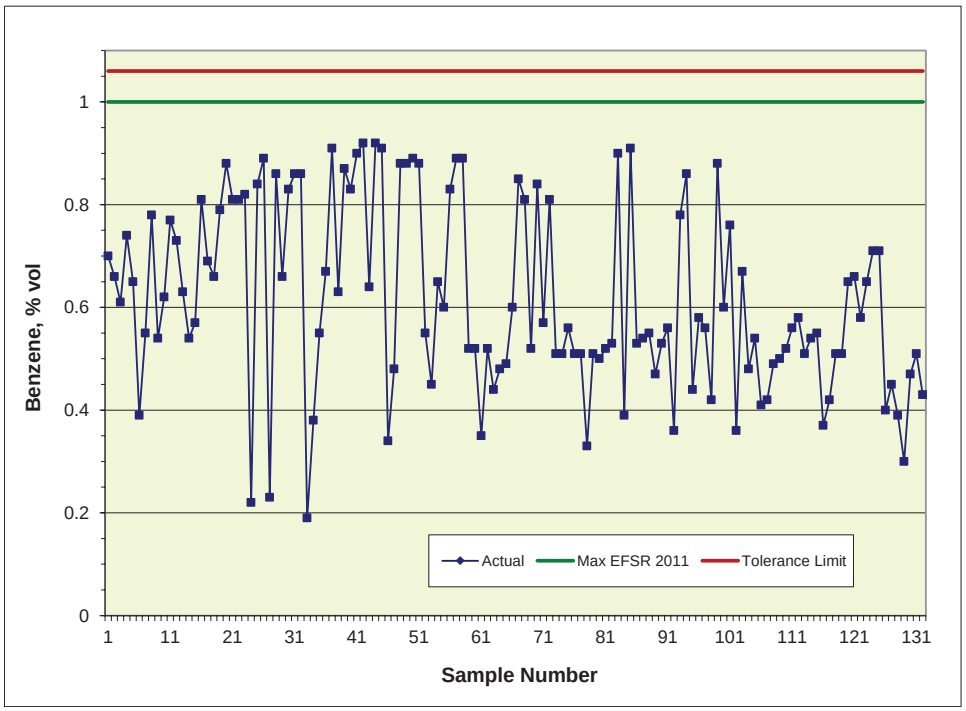
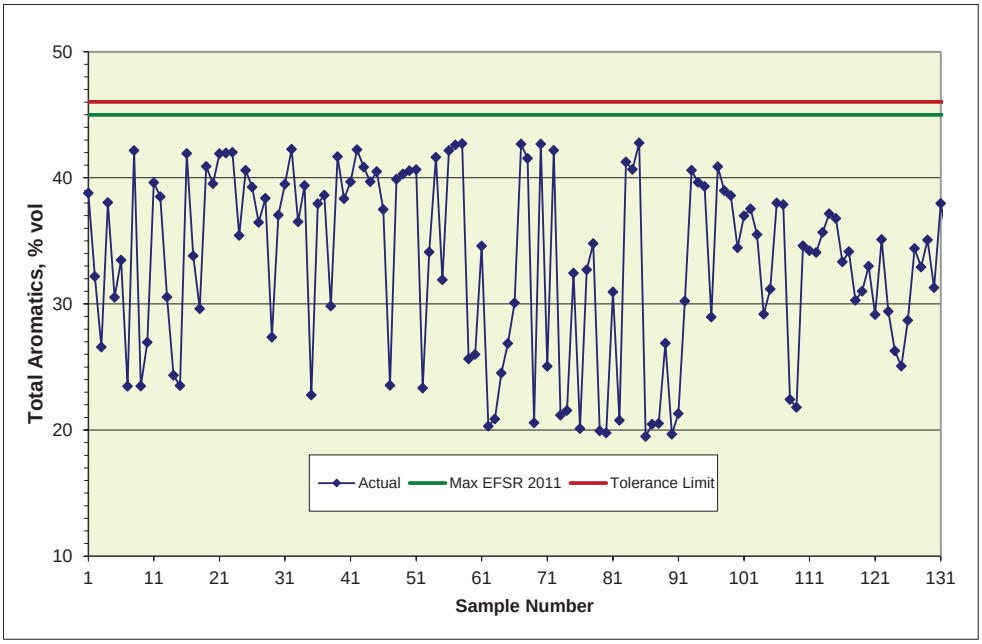


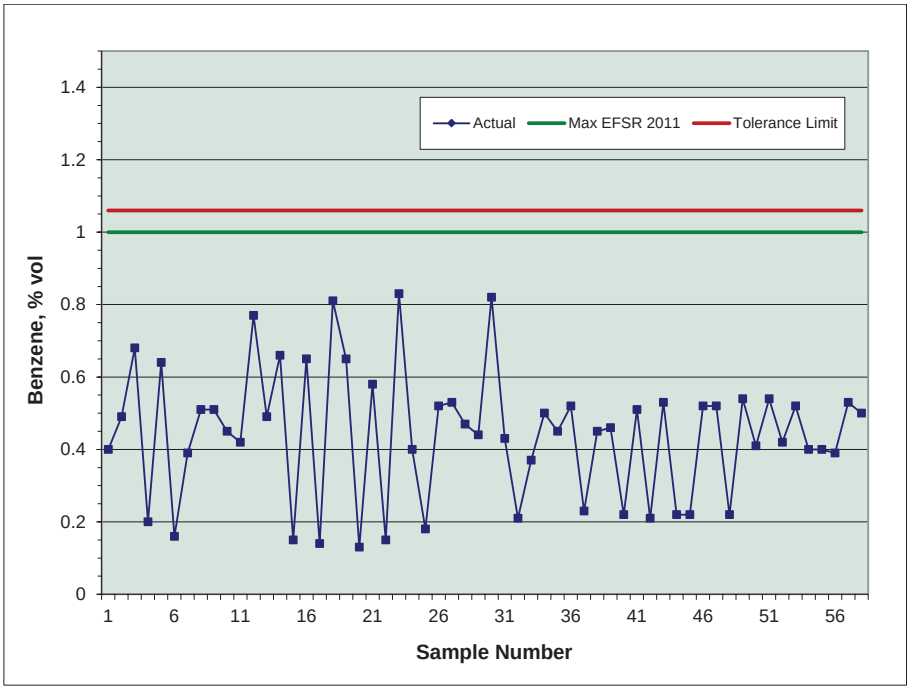
Figure 11d: Test Results for Total Aromatics, RON 95, Year 2021-22



RON 98 & ABOVE

All 58 samples of premium petrol RON 98 and above tested for benzene were found to be below the prescribed maximum limit with the largest result for a sample reported as 0.83%.

Figure 11e: Test Results for Benzene, RON 98 & above, Year 2021-22

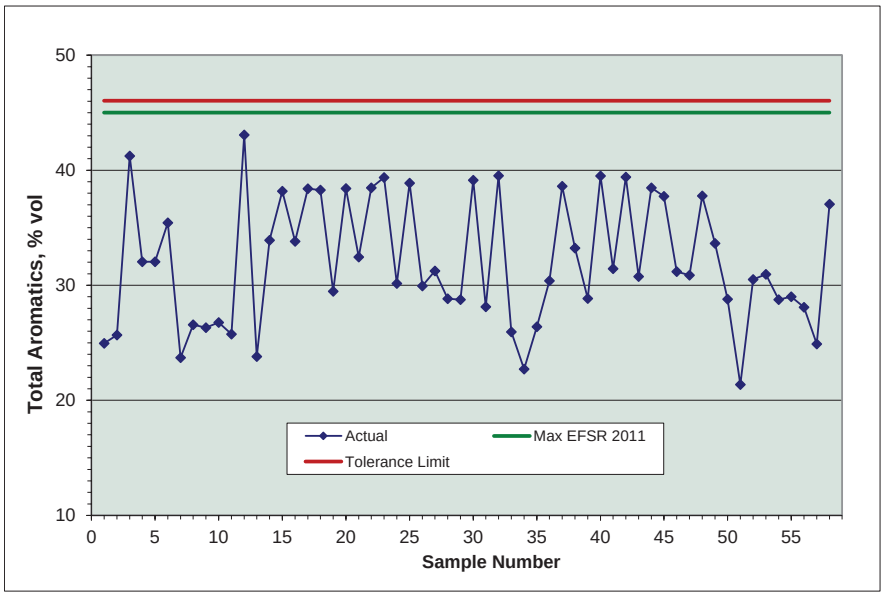


For premium petrol RON 98 and above, all results on total aromatics were found to be below the maximum specified limit of 45% with the highest result being 43.07% (Fig. 11f).

According to Section 19 of the Regulations, actual amounts of petrol which were produced or imported, must be considered to calculate the 'pool average' figures for the total aromatic compounds for each calendar month. Pool average figures mean each month averages reported by producers and/or importers according to the Regulations. The pool average specification for total aromatics is 42% vol maximum.

Data on 'pool average' was collected from four fuel retail companies which import petrol for the one-year period ending on 30 June 2022 and from The New Zealand Refining Company Ltd in the period which ended on 31 March 2022. The actual results were found to be below the required limits. Due to the commercial sensitivity of the calculation process, the actual results were not included in this report.

Figure 11f: Test Results for Total Aromatics, RON 98 & above, Year 2021-22



Olefins

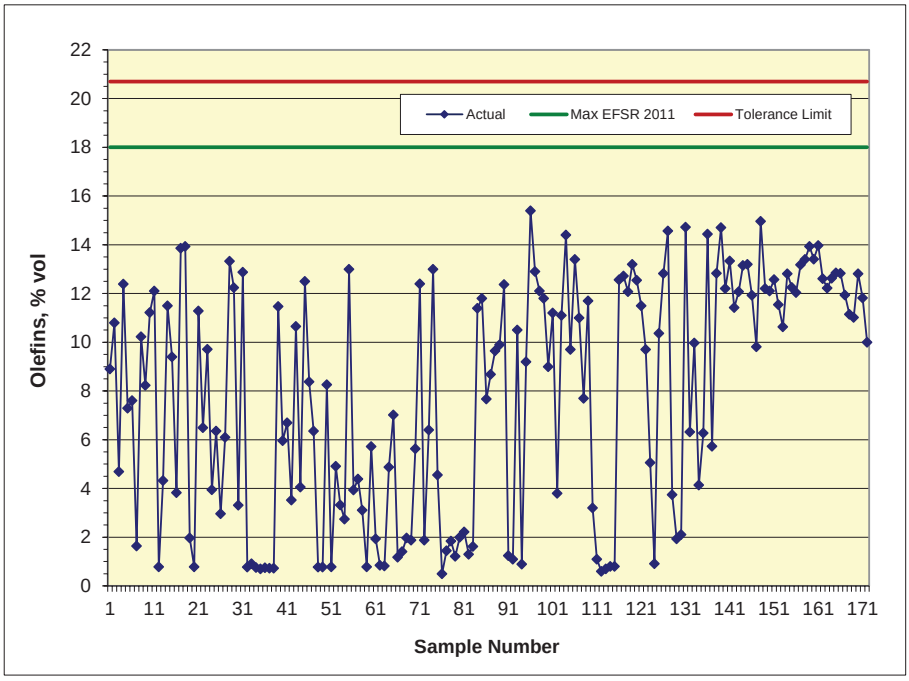
The test methods ASTM D1319[17] and ASTM D6839[18] are prescribed in the Regulations for olefins content.

The majority of samples were tested using D6839; all samples were found to be below the specified maximum limit of 18% vol with the tolerance limit of 19.6% identified for D6839 and 20.7% for D1319.

RON 91

For regular petrol, most results were found to be below 15% (Fig. 12a) except one sample with a result of 15.40%.

Figure 12a: Test Results for Olefins, RON 91, Year 2021-22

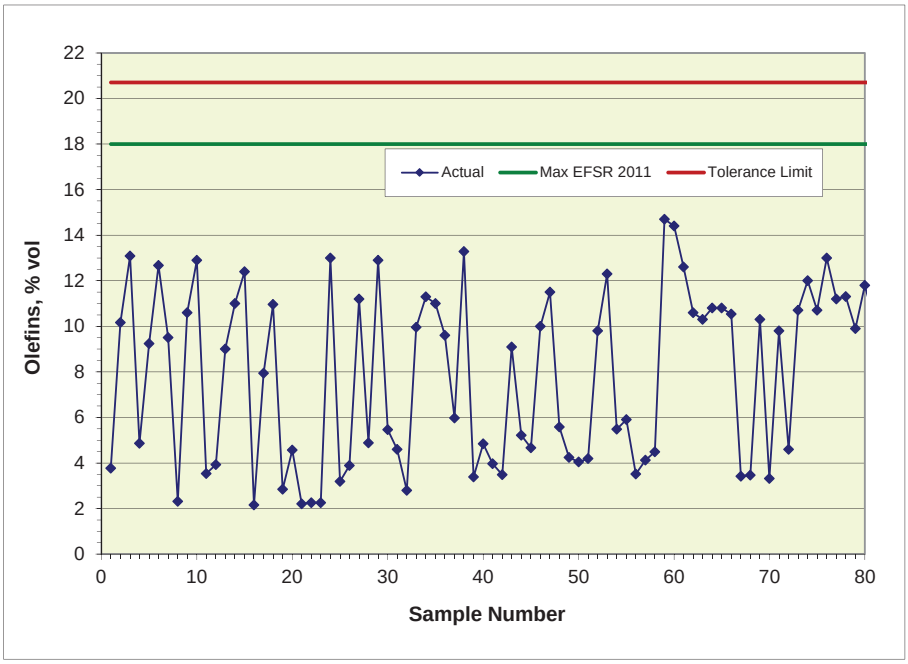


17 ASTM D1319-20a *Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption.*
18 ASTM D6839-18 *Standard Test Method for Hydrocarbon Types, Oxygenated Compounds, and Benzene in Spark Ignition Engine Fuels by Gas Chromatography.*

RON 95

For premium petrol RON95, most results were found to be below 14% (Fig. 12b) except two samples with the highest result of 14.7%.

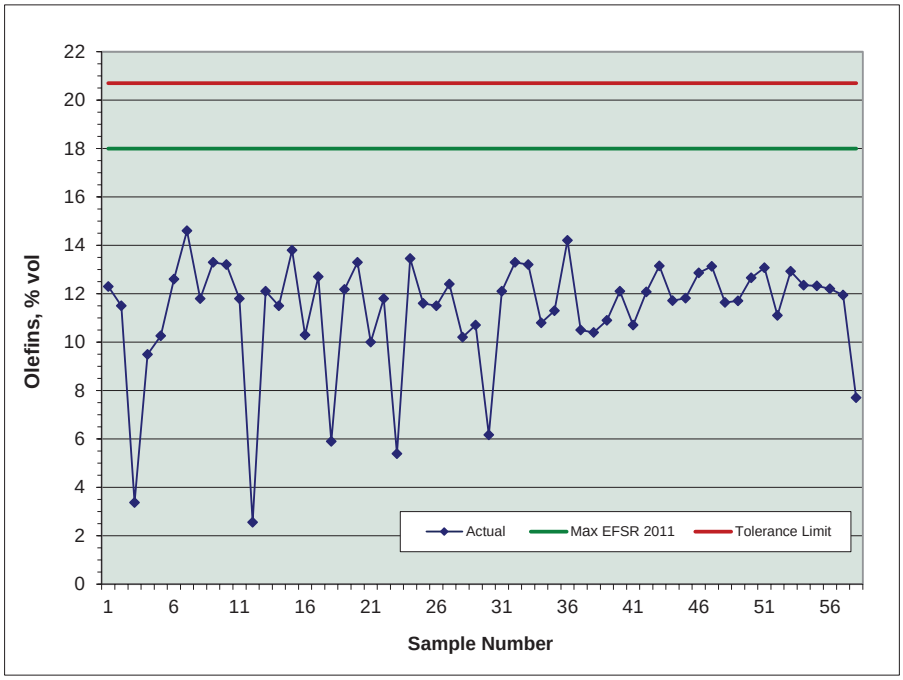
Figure 12b: Test Results for Olefins, RON 95, Year 2021-22



RON 98 & ABOVE

For premium petrol RON98 and above, most of the results were found to be below 14% (Fig. 12c) except two samples with the highest result 14.6%.

Figure 12c: Test Results for Olefins, RON 98 & above, Year 2021-22



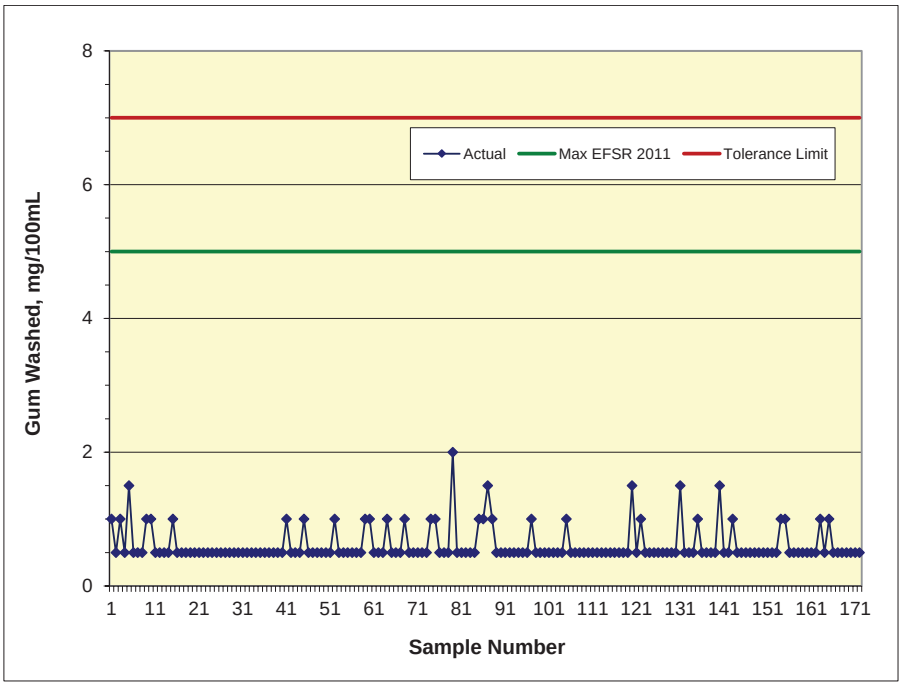
Existent Gum (solvent washed)

The threshold of the test method ASTM D381[19] prescribed in the Regulations is 0.5 mg/100mL. Therefore, the lowest line of testing results that is shown in Fig. 13, is 0.5 mg/100mL, when the actual figures found to be at or below this indicative level. The specified maximum limit is 5.0 mg/100mL, with the tolerance limit of 7.0 mg/100mL.

RON 91

For regular petrol, all results were found to be below the maximum specified limit. (Fig. 13a).

Figure 13a: Test Results for Gum, RON 91, Year 2021-22

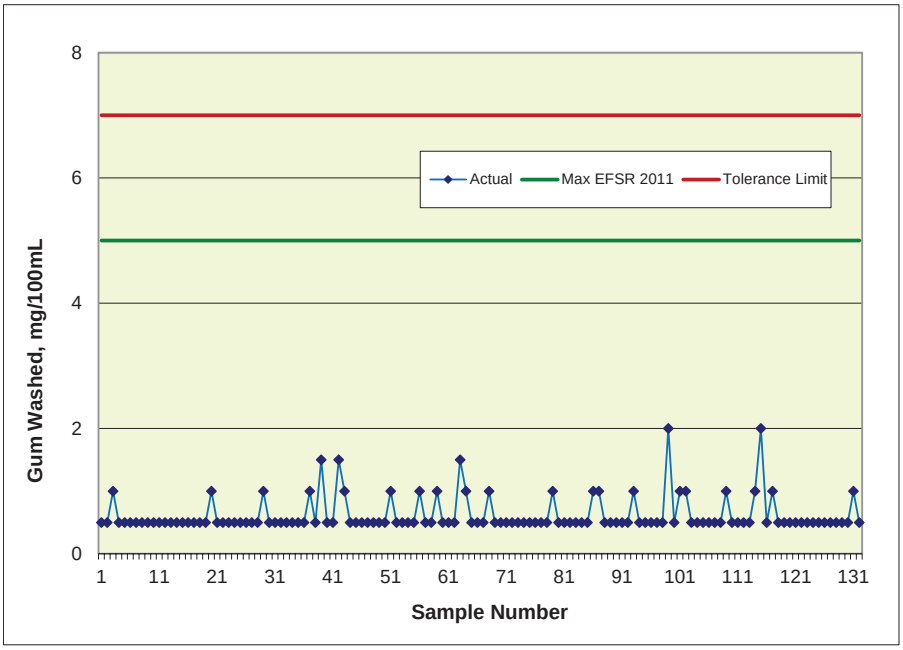


RON 95

For premium petrol RON 95, all results were found to be below the specified limit of 5.0 mg/100mL (Fig. 13b).

19 ASTM D381-19 *Standard Test Method for Gum Content in Fuels by Jet Evaporation.*

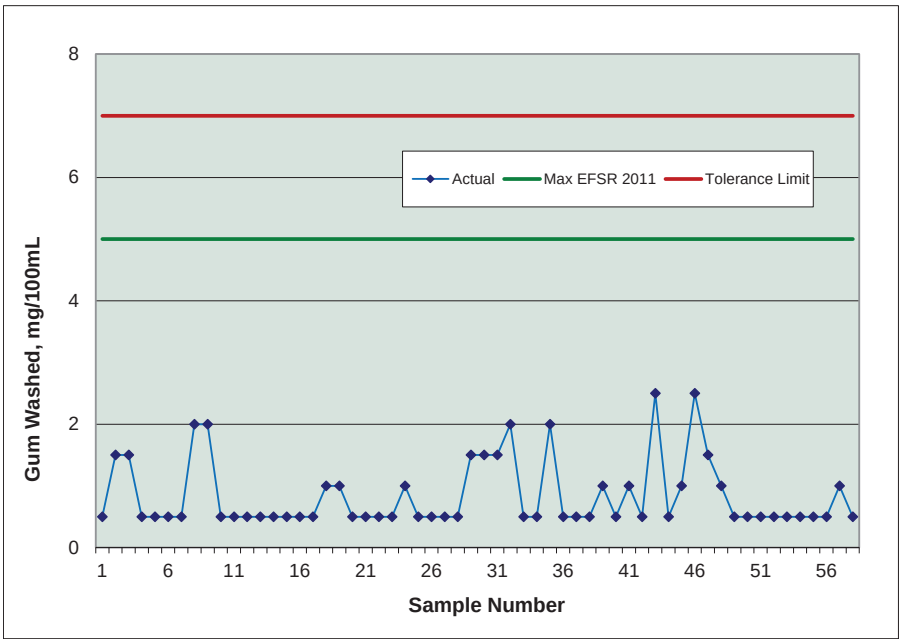
Figure 13b: Test Results for Gum, RON 95, Year 2021-22



RON 98 & ABOVE

For premium petrol RON 98 & above, all results were found to be not higher than 2.5 mg/100mL (Fig. 13c).

Figure 13c: Test Results for Gum, RON 98 & above, Year 2021-22



Other Specification Parameter Testing

Testing and analysis, at a lower frequency, was also conducted on other parameters and properties prescribed in the Regulations. This included screening for the content of contaminants such as lead and manganese which are not expected to be present in fuel. The screening is done by a test method conditionally agreed between the Ministry and the testing laboratory[20]. For phosphorus, this is done by means of an initial identification of its presence on the threshold of resolution by the specified method[21]. These results have not been included in this report as they were found to be not higher than the threshold and therefore below the specified limit.

The ethanol content in petrol blends was also tested and found to be below the specified limit. Test results are discussed in the Biofuel section.

Further, 20 samples of regular petrol and 21 samples of premium petrol were tested for copper strip corrosion[22] and a small number of samples for oxidation stability[23]; all of them were found to be compliant.

Finally, a few samples of petrol with an advertised RON of 100+ were tested. All results were found to be within the specifications of Schedule 1 in the Regulations.

Summary for Petrol Test Results

There were no instances when a petrol sample would have been identified as non-compliant according to the requirements of the Regulations.

However, there was one sample with a result for vapour pressure of 66.3 kPa that was found to be above the specified limit for the region and season (65 kPa). Repeated testing revealed a problem with conformance to the reproducibility condition, and only the out of specification result was reported.

Two test results for RON and MON of premium petrol were found to be on the minimum specified limit according to the Regulations. The samples were accepted as compliant without repeated testing.

In addition, 52 samples of regular petrol and 56 samples of premium petrol were tested for silver strip corrosion and the results were acceptable, although the test method is not yet stipulated in the Regulations. The importance of this test was highlighted after the active sulphur contamination incident in 2017-18 (see Report for yr. 2018-19).

The Ministry is now considering to propose the inclusion of a silver strip corrosion test for active sulphur presence, into the Regulations.

20 ASTM D5185–18 *Standard Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES).*
21 ASTM D3231–18 *Standard Test Method for Phosphorus in Gasoline.*
22 ASTM D130-19 *Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test.*
23 ASTM D525-12a (2019) *Standard Test Method for Oxidation Stability of Gasoline (Induction Period Method).*

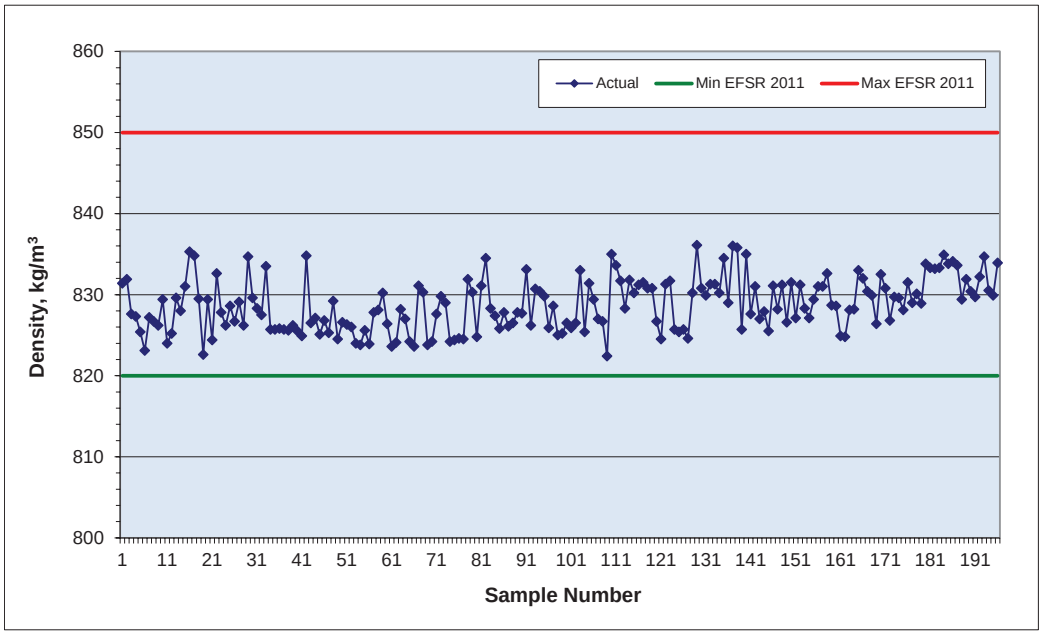
Diesel

Density

Density of diesel at 15ºC can be tested according to ASTM D1298[24] or ASTM D4052[25] prescribed in the Regulations. There are two tolerance limits identified using these two methods. The minimum limit of 820 kg/m^3 and the maximum limit of 850 kg/m^3.

All 196 samples were found to be within the specified limits (Fig 14). The tolerance limits, 819.3 and 850.7 kg/m^3 for D1298 and 819.6 and 850.3 for D4052 kg/m^3 respectively, are not shown on Fig. 14 since their close proximity to the limits.

Figure 14: Test Results for Density, Diesel, Year 2021-22



24 ASTM D1298-17 *Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method*.
25 ASTM D4052-18a *Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter*.

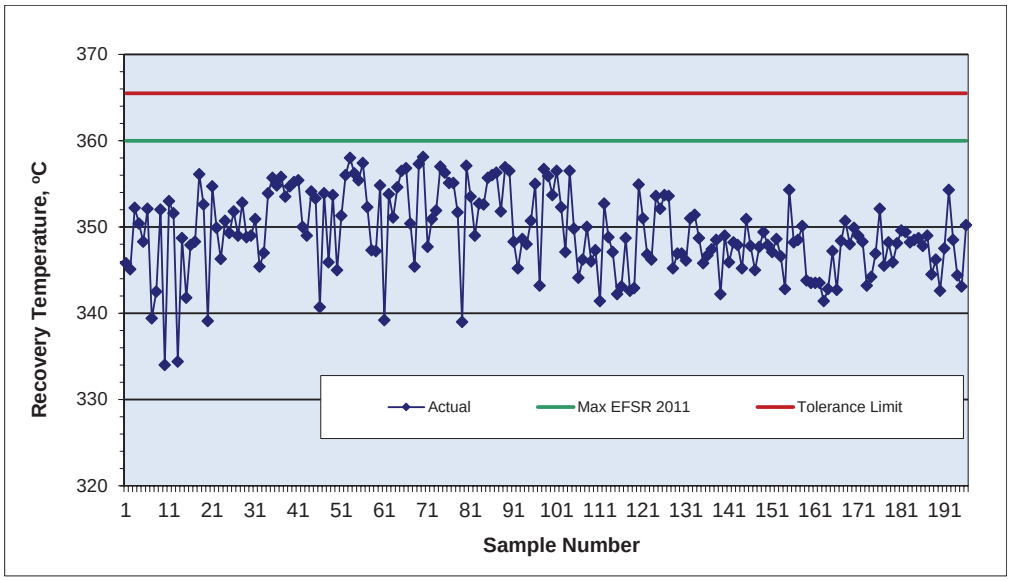
Distillation

The distillation test measures the percentage of vaporised fuel as the temperature increases. This defines the temperature (ºC) at which 95% volume is recovered. The temperature should be tested by ASTM D86[26], prescribed in the Regulations.

All 196 samples were found to be below the specified maximum limit of 360ºC for distillation at 95% volume recovered (T95) at the tolerance limit of 365.5ºC.

The highest and lowest actual results were 358.1ºC and 334ºC respectively, although there is no prescribed minimum limit for this property.

Figure 15: Test Results for Distillation 95% Vol Recovered, Diesel, Year 2021-22



26 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*.

Cetane Index

Cetane is a measure of the compression ignition behaviour of a diesel fuel; higher cetane levels enable quicker ignition. Cetane influences cold start-ability, exhaust emissions and combustion noise. In general, higher cetane enables improved control of ignition delay and combustion stability, especially with modern diesels which use high amounts of exhaust gas recirculation.[27]

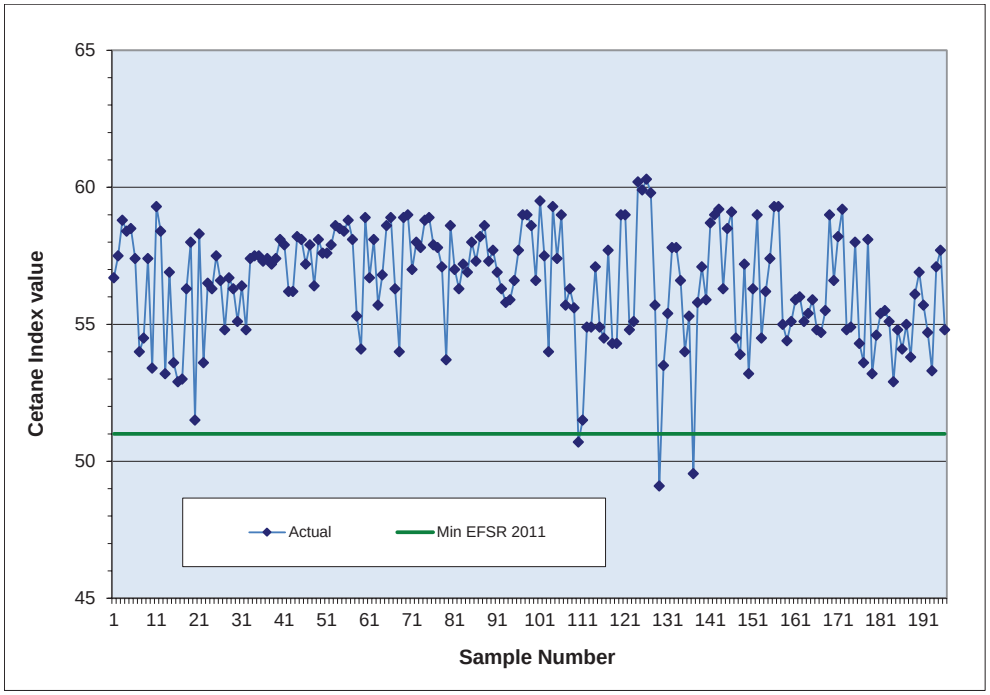
The cetane index, according to ASTM D4737[28] prescribed in the Regulations, is not tested for but calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine, for determining cetane number, is not available and/or cetane improvers are not used.

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.

193 samples out of 196 tested were found to be above the minimum limit of 51 (Fig.16). Sample 110 with actual results of 50.7, was above the estimated tolerance limit.

Two Samples, 129 and 137, were found to be below the estimated tolerance limit. Sample 129, with an average index of 49.1 after two tests, was sampled as a commercially supplied marine grade fuel that is treated as Marine Gas Oil (MGO). Properties of MGO are specified in the international standard, ISO 8217-2017, where the minimum cetane index for the relevant grade is specified as 40. Sample 137 was diesel sold by retail sale where the cetane index was found to be out of specification with an average result of 49.55 and the actual figures of 49.4 and 49.7 received by the same operator. The testing laboratory issued a certificate of non-conformance for this sample. Further investigation revealed that the certificate of quality accompanying the wholesale supply of the relevant shipment of diesel had listed figures of cetane index as well as cetane number which were recorded as 47.9 and 51.7 respectively. The Regulations state that a minimum cetane index of 47 is allowed with a minimum cetane number of 51. Therefore, Sample 137 was finally accepted as compliant.

Figure 16: Test Results for Cetane Index, Diesel, Year 2021-22



27 *Worldwide Fuel Charter.* 6th Ed., 2019, p.64.
28 ASTM D4737-16 *Standard Method for Calculated Index by Four Variable Equation.*

Water

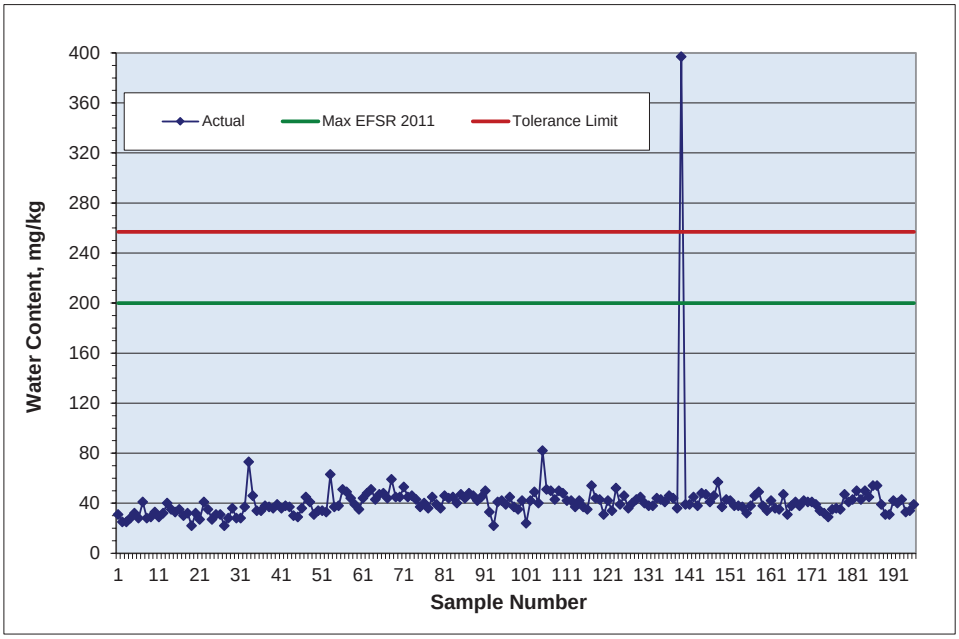
The test for water content is done in accordance with IP438[29] which determines the total water present in a diesel sample held either in solution or in solution and free water.

Water is partially soluble 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.

Out of 196 tested samples 195 were found to be below the maximum limit of 200 mg/kg specified in the Regulations (Fig. 16). One sample was found to be out of specification with an average of 397 mg/kg with actual figures of 383 and 411 mg/kg received by two operators.

The testing laboratory issued a certificate of non-conformance for this sample. An additional test using the appearance test method ASTM D4176 revealed the presence of a significant amount of free water and particulates. Remedial actions were undertaken by the fuel retail company and follow up testing confirmed the issue had been rectified. Additional sampling at the time of fuel delivery to UST was done and the testing of this sample confirmed the fuel was within specification. Further, a second follow-up appearance test returned a 'clear & bright' result. One customer claimed problems with their vehicle around the time of the initial sampling and their expenditure for the vehicle's damage repair was reimbursed by the fuel retail company.

Figure 17: Test Results for Water in Diesel, Year 2021-22

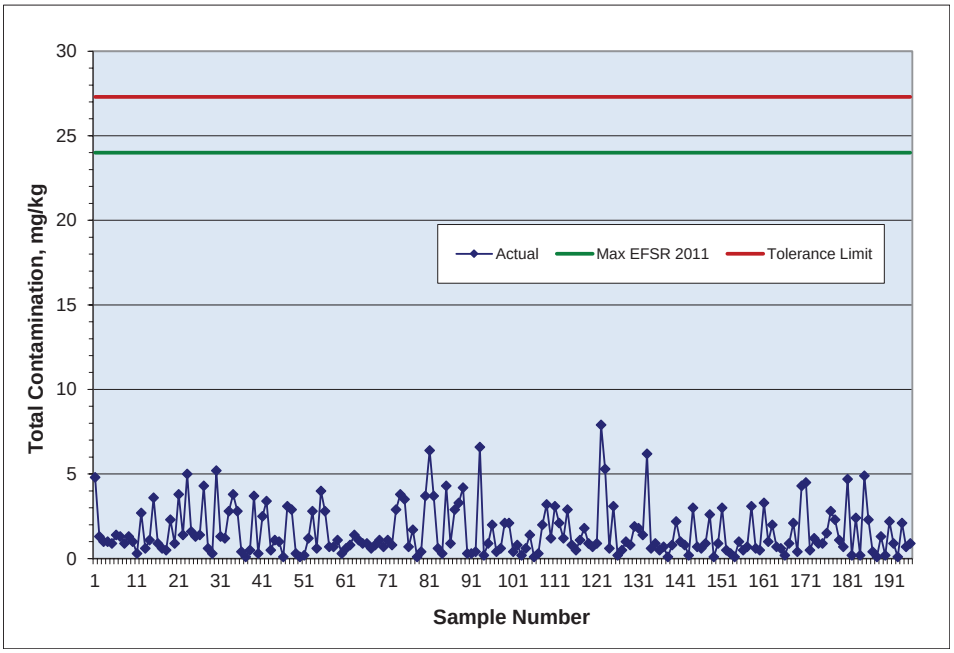


29 BS EN ISO 12937:1961, BS 1960-438:1961. *Petroleum products. Determination of content. Coulometric Karl Fischer titration method.*

Total Contamination

All 196 samples were found to be below the maximum limit of 24 mg/kg specified in the Regulations (Fig. 18) with all actual figures below 8 mg/kg. The tolerance limit identified for the test method ASTM D6217[30] is 27.3 mg/kg.

Figure 18: Test Results for Total Contamination, Diesel, Year 2021-22



30 ASTM D6217-18 *Standard Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration.*

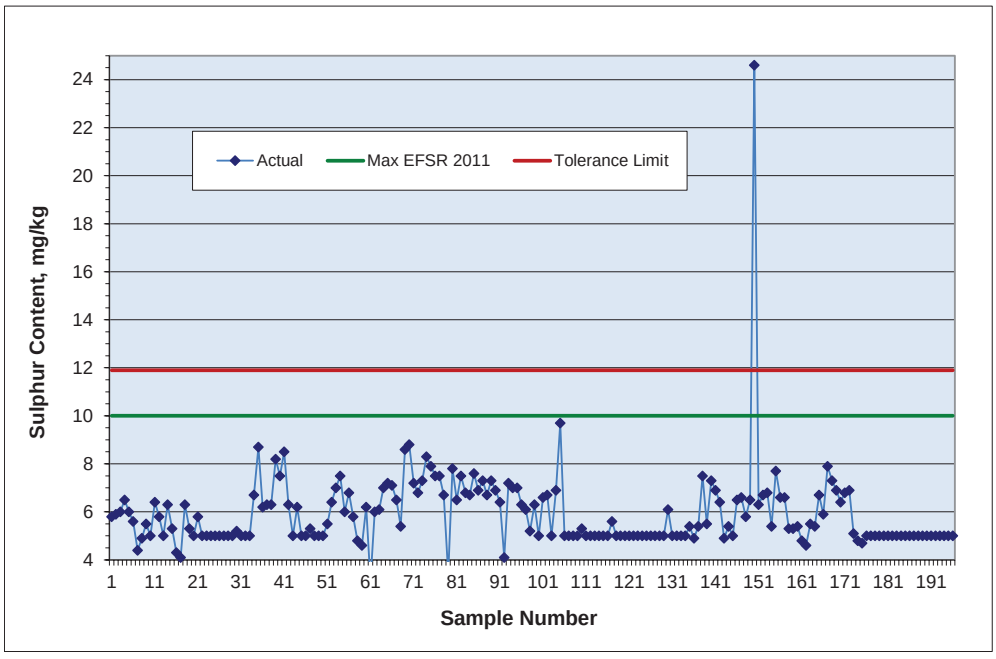
Sulphur

Sulphur content is tested in accordance with IP 497[31] or ASTM D5453[32] methods as prescribed in the Regulations. There are two different tolerance limits identified for the two methods: 11.8 mg/kg for IP497:2019 and 11.9 mg/kg for ASTM D5453-19a (only the tolerance limit for ASTM D5453-19a is shown on Fig.19).

Out of 196 tested samples 195 were found to be below the maximum limit of 10 mg/kg specified in the Regulations (Fig. 19). Sample 150 was found to be out of specification with an average result of 23.5 mg/kg with the actual figures received being 24.2 and 22.9 mg/kg. The testing laboratory issued a certificate of non-conformance for this sample based on results received by the ASTM D5453 test method. An additional test by an alternative method, IP 497, returned a result of 25.6 mg/kg which corroborated the two earlier results. Upon investigation, it was found that the fuel retail company treated the product as that for marine use. According to Footnote 10 of the October 2017 Regulations, that were current at the time of sampling, 'the limit for sulphur does not apply to sale for marine use'. However, it was noted to the retail company that the fuel was accessible by road transport users and therefore was expected to be compliant with the specifications set out in Schedule 2 of the Regulations. Further investigation of possible causes did not reveal a supply source of diesel that would have appeared to be out of specification. The batches supplied soon before the sampling in question, according to the certificates of quality demonstrated by their wholesale supplier, all had sulphur content below 10 mg/kg.

The sample was recognised as non-compliant based on the fact that it was accessible by road transport users. It was advised to the company involved that an uncertainty in the Regulations related to the marine use of diesel will be rectified. In the amended Regulations that have been in force since 26 August 2022, it is stipulated that marine fuel oil sold by retail sale must have properties that conform to the limits specified in Schedule 2. Sulphur content in another sample taken from the same site after the above amendment in the Regulations came into effect was found to be on specification.

Figure 19: Test Results for Sulphur, Diesel, Year 2021-22



31 IP 497 ISO 20884:2019 *Petroleum products — Determination of sulfur content of automotive fuels — Wavelength-dispersive X-ray fluorescence spectrometry*.

32 ASTM D5453-19a *Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence*.

Cloud Point

Cloud Point (CP) of diesel is the temperature at which the heaviest paraffins start to precipitate and form wax crystals; the fuel becomes 'cloudy'.[33] CP is tested in accordance with ASTM D5773[34] as prescribed in the Regulations.

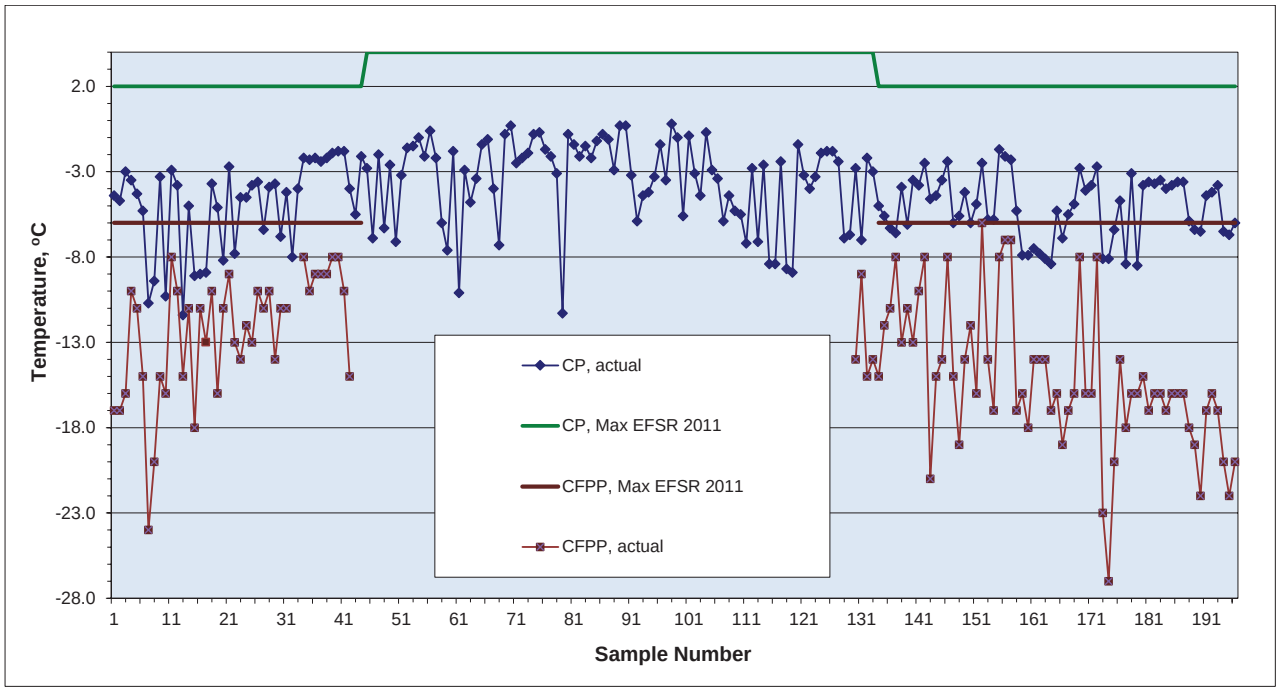
The cumulative results for CP are presented below by combining the lowest prescribed maximum limits for each season in one graph (Fig.20). Generally, results below the lowest maximum limit established for an area are compliant with the Regulations in all other areas.

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 the 'pedestal' on the graph in Fig.20, 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. The tolerance limits are 3.4°C and 5.4°C, respectively, for the specified limits of +2°C and +4°C.

All 196 samples were found to be below the lowest maximum limit within the relevant seasons.

Figure 20: Test Results for Cloud Point and Cold Filter Plugging Point, Diesel, Year 2021-22



33 *Worldwide Fuel Charter,* 6th Ed., 2019, p.81.
34 ASTM D5773-20 *Standard Test Method for Cloud Point of Petroleum Products (Constant Cooling Rate Method).*

Cold Filter Plugging Point

Cold Filter Plugging Point (CFPP) of diesel is the lowest temperature at which the fuel can pass through the filter in a standardised filtration test. CFPP is tested in accordance with IP 309[35] as prescribed in the Regulations. The CFPP test was developed from vehicle operability data. CFPP is defined only for the winter season, from 15 April to 14 October inclusive with the maximum limit of –6ºC and the tolerance limit of –5ºC.

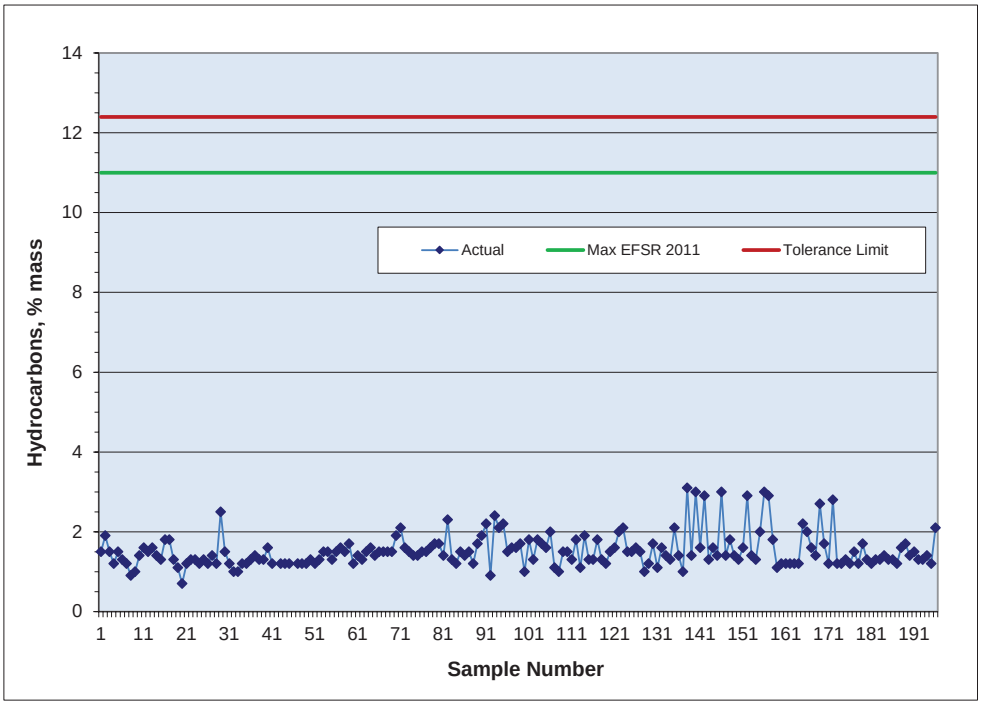
The test results for CFPP are set out on the same graph as that for CP (Fig.20). All samples were found to be below the maximum limit specified in the Regulations.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons are tested in accordance with IP 391[36] as prescribed in the Regulations.

All 196 tested samples were found to be below the maximum limit of 11% with the tolerance limit of 12.4%. All results were found to be below 4%.

Figure 21: Test Results for Polycyclic Aromatic Hydrocarbons, Diesel, Year 2021-22



35 BS EN 116:2015, BS 1960-309:2015 *Diesel and domestic heating fuels. Determination of cold filter plugging point. Stepwise cooling bath method.*

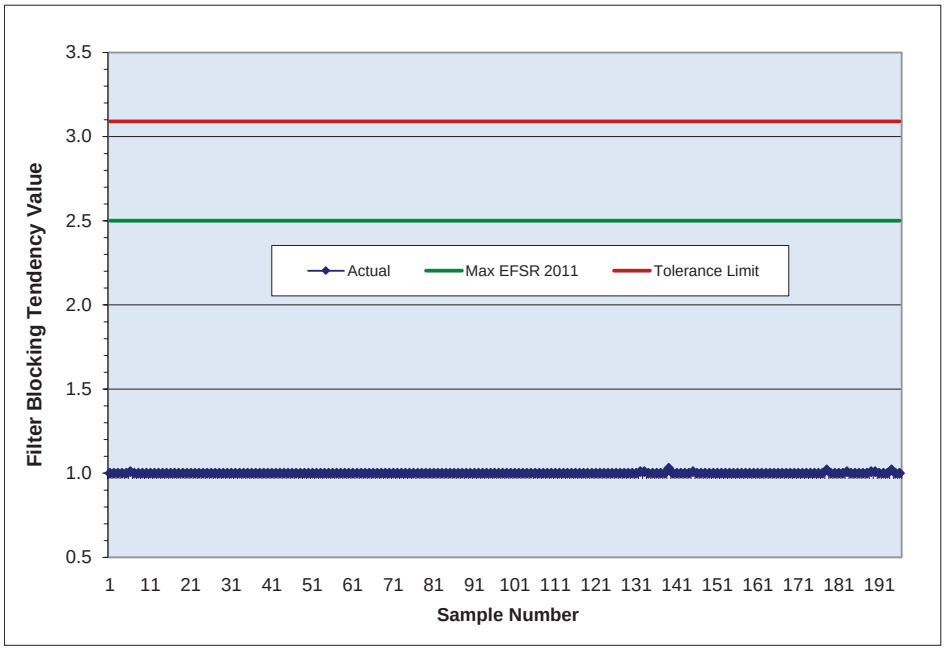
36 BS EN 12916:2019 *Petroleum products. Determination of aromatic hydrocarbon types in middle distillates. High performance liquid chromatography method with refractive index detection.*

Filter Blocking Tendency

Filter blocking tendency can be tested in accordance with IP 387[37] or ASTM D2068[38] as prescribed in the Regulations.

All 196 samples were found to be below the specified maximum limit of 2.5 with the tolerance limit of 3.09.

Figure 22: Filter Blocking Tendency, Diesel, Year 2021-22



37 IP 387:2017 *Determination of filter blocking tendency*.
38 ASTM D2068-20 *Standard Test Method for Determining Filter Blocking Tendency*.

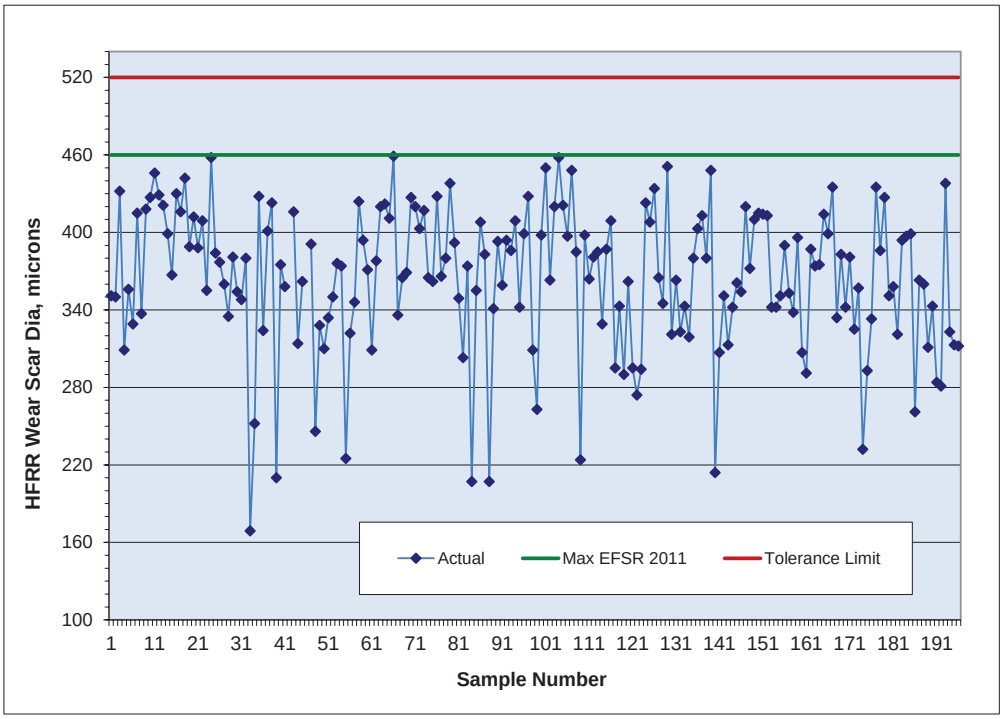
Lubricity

Lubricity is identified as a diameter of the wear scar produced on an oscillating ball from contact with a stationary plate immersed in the fluid and is tested in accordance with IP 450[39] as prescribed in the Regulations.

The diameter is measured in microns. The specified maximum limit is 460 µm, with the tolerance limit of 520 µm.

All 196 samples were found to be below the specified maximum limit. A few samples were found to be close to the specified limit: Sample 24 of 458 µm, Sample 67 of 459 µm, and Sample 104 which was initially found to be on the limit of 460 µm but when retested achieved a result of 456 µm. This resulted in an average of 458 µm.

Figure 23: Test Results for Lubricity, Diesel, Year 2021-22



39 IP 450:2020 *Diesel fuel – Assessment of lubricity using the high-frequency reciprocating rig (HFRR) – Part 1: Test method (ISO 12156-1:2018); BS 2000-450:2000 Methods of test for petroleum and its products. Diesel fuel. Assessment of lubricity using the high-frequency reciprocating rig (HFRR). Test method.*

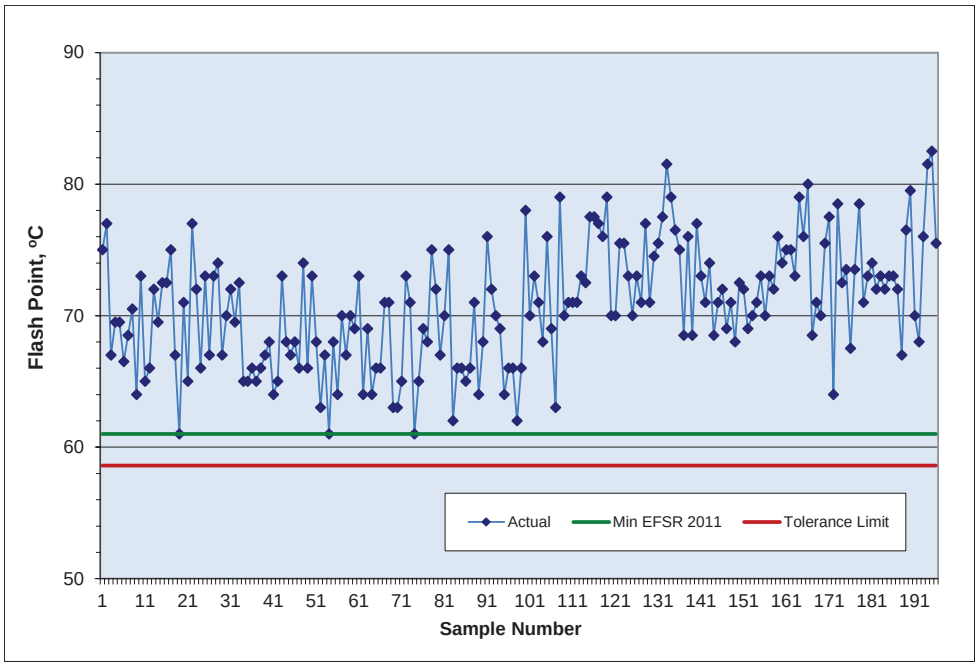
Flash Point

Flash point is tested in accordance with ASTM D93[40] as prescribed in the Regulations.

All 196 samples were found to be on or above the specified minimum limit of 61°C. Samples 19, 54 and 74 had results on the minimum limit of 61°C.

The tolerance limit is 58.6°C (Fig 24). A repeat test of Sample 19 returned the same result of 61°C. Samples 54 and 74 did not undergo repeated testing.

Figure 24: Test Results for Flash Point, Diesel, Year 2021-22



40 ASTM D93-20 *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester.*

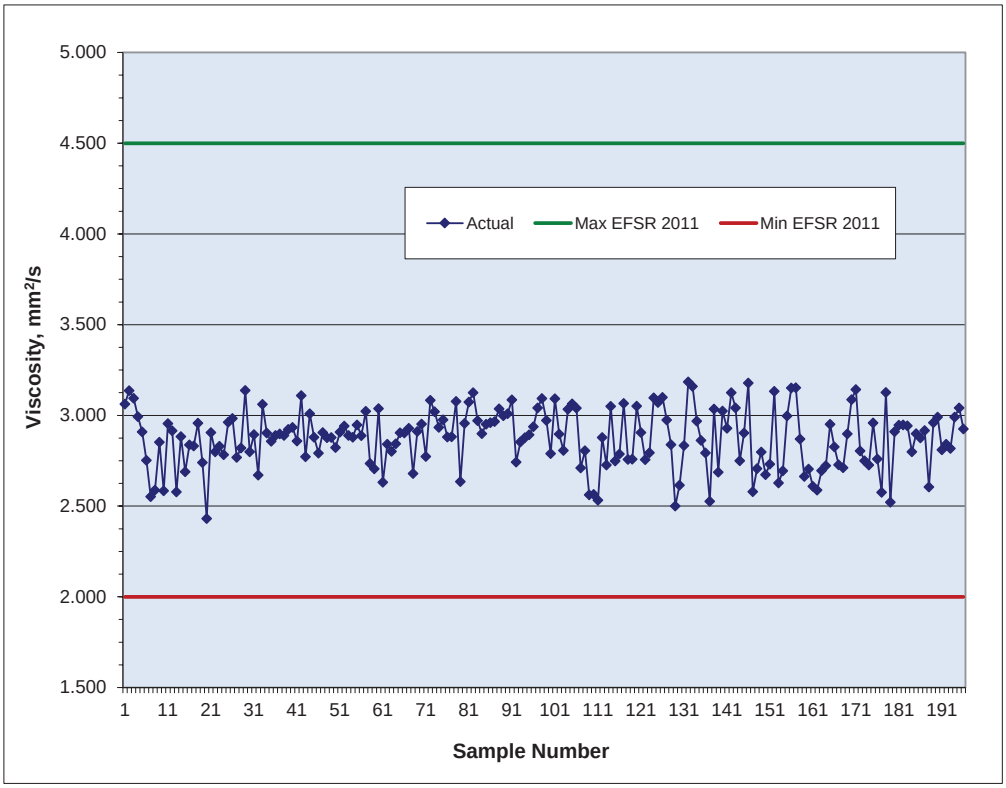
Viscosity

The viscosity is tested at 40ºC in accordance with ASTM D445[41] as prescribed in the Regulations.

All 196 samples were found to be above the specified minimum limit of 2.0 mm^2 per second and below the specified maximum limit of 4.5 mm^2 per second for viscosity of diesel (Fig 25).

The tolerance limits of 1.974 and 4.559 mm^2 per second, respectively, are not shown on Fig. 25 since their close proximity to the limits.

Figure 25: Test Results for Viscosity, Diesel, Year 2021-22



41 ASTM D445-19a *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)*.

Summary for Diesel Test Results

In five instances diesel samples were initially suspected to be non-compliant according to the requirements of the Regulations. The testing laboratory issued three Non-Conformance Certificates (NCC): one related to cetane index below the specification, and two others, for water content and sulphur content, above the relevant specifications.

The sample with a cetane index of 50.7 was found to be within the tolerance limit and therefore compliant. Additionally, two samples were found to be below the estimated tolerance limit. One of them, with an average index of 49.1, was Marine Gas Oil (MGO) that was commercially supplied marine grade fuel and therefore has a minimum cetane index of 40. The other sample was diesel sold by retail sale where the cetane index was found to be out of specification with an average result of 49.6. On investigation it was found that a wholesale supply of the relevant shipment of diesel had listed figures for the cetane index and cetane number of 47.9 and 51.7, respectively. According to the Regulations, with the minimum cetane index of 47 in combination with the minimum cetane number of 51, this sample was accepted as compliant.

One sample was found to be out of specification for water content with an average of 397 mg/kg. An additional test using the appearance test method, ASTM D4176, revealed the presence of a significant amount of free water and particulates. Remedial actions were undertaken by the fuel retail company and follow up testing confirmed the issue had been rectified. One customer claimed problems with their vehicle around the time of the initial sampling and their expenditure for the vehicle's damage repair was reimbursed by the fuel retail company.

One sample was found to be out of specification for sulphur content with an average result of 23.5 mg/kg. On investigation, it was found that the fuel retail company considered the product as that for marine use. However, the sample was recognised as non-compliant based on the fact that was supplied from a dispenser accessible to road transport users. In the amended Regulations that have been in force since 26 August 2022, it is stipulated that marine fuel oil sold by retail sale must have properties that conform to the limits specified in Schedule 2.

See more detailed explanations above in the relevant sections.

There were a number of samples which were initially found to be on the specified limit. Among those were three instances of flash point and one instance of lubricity. When repeated, one of the flash point results confirmed the initial figure of 61ºC, and a repeated lubricity test resulted in an average of 458 µm, *i.e.* below the specified limit. The other two samples with flash point on the specification limit did not undergo repeat testing.

75 out of 196 samples were tested for copper strip corrosion[42]. 43 samples were tested for carbon residue[43] and ash[44] and 34 samples were tested for oxidation stability[45]. All of these tests returned the compliant results.

Testing of diesel for appearance according to the ASTM standard D4176[46], which is not listed in the Regulations, was conducted. This was done to maintain confidence that water in bulk and/or other contamination, if present, would be identified.

42 ASTM D130-19 *Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test*.
43 BS EN ISO 10370:2014 *Petroleum products. Determination of carbon residue. Micro method.*
44 ASTM D482-19 *Standard Test Method for Ash from Petroleum Products.*
45 ASTM D2274-2014(2019) *Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method).*
46 ASTM D4176-04(2019) *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 that this report covers. As in previous annual reports, the actual results are not always shown due to the commercial sensitivity of the data.

ETHANOL BLENDED PETROL E10

Twelve samples of premium petrol blended with ethanol and labelled as E10 were sampled from retail sites. All samples were found to be compliant, including for ethanol content, oxygen content, and dry vapour pressure. Results for content of ethanol blended in petrol were all found to be below the claimed 10% with the minimum volume of blended ethanol of 8.74% and the maximum volume of 9.26%.

ETHANOL COMPONENT E100

Denatured ethanol, E100 for blending with petrol, was tested three times from a storage terminal throughout the period covered in this report. All results for duplicate samples taken from top and bottom of the storage tank were found to be within the specified limits.

ETHANOL BLENDED PETROL E85

This product is specified in Schedule 1A of the Regulations as there are flexible-fuel vehicles in New Zealand which are able to use E85. However, no E85 dispensers were accessible to the public during the period covered by this report.

BIODIESEL B5 & B7

This product falls into the category of diesel by definition in the Regulations, with FAME (Fatty Acid Methyl Esters), the main component of biodiesel according to Schedule 3, content up to 5%. This product wasn't available in the market for the period covered in this report.

Diesel with FAME content up to 7%, permitted in New Zealand since October 2017, wasn't supplied either.

NON-RETAIL SAMPLING AND TESTING OF BIODIESEL

When non-retail sale products are utilised as components for retail market products, TS monitors their quality as they are categorised by the Regulations. The Ministry continues to work with the industry to help ensure understanding and development of acceptable biodiesel that meets the country's needs.

This year, one set of biodiesels, B100 (pure biodiesel) and relevant B10 (10% blend with mineral diesel), was sampled and tested. Biodiesel B100 was tested according to the requirements of Schedules 3 in the Regulations while B10 blend was tested according to Regulation 17. Biodiesel B100 was found to be on specification except for oxidation stability which was found to have an average of 5.5 hrs with the minimum specified limit being 8 hrs with the tolerance limit of 7.1 hrs. The blended biodiesel (B10) was found to be on specification including the oxidation stability test. However, the FAME content was found to be above the claimed figure of 10%, with the actual average of two results being 12.0% with a tolerance limit of 10.3%. As it was a commercial product supply, the producer was advised to inform their customers about the excessive FAME figure.

The biodiesel producer is reviewing their processes following the sampling and testing.

Appendix

A Brief Glossary and Abbreviations

ASTM	American Society for Testing and Materials
BS EN	British Standard European Norm
CEN	Comité Européen de Normalisation (*French for:* European Committee for Standardization)
ISO	International Organization for Standardization (a common short name not an acronym)
IP	Institute of Petroleum, UK
IPL	Independent Petroleum Laboratory
FAME	fatty acid methyl esters, *i.e.* the main component of biodiesel according to Schedule 3 of the Regulations
CP	cloud point of diesel *i.e.* the temperature at which the heaviest paraffins start to precipitate and form wax crystals; the fuel becomes 'cloudy'
CFPP	cold filter plugging point of diesel *i.e.* the lowest temperature at which the fuel can pass through the filter in a standardised filtration test
B100	biodiesel according to Schedule 3 of the Regulations
E85	fuel ethanol *i.e.* a blend of petrol and ethanol, containing not less than 70% and not more than 85% ethanol by volume
Cetane	a measure of the compression ignition behaviour of a diesel fuel; higher cetane levels enable quicker ignition
Octane	usually in RON (Research Octane Number) or MON (Motor Octane Number), petrol's ability to resist auto-ignition; auto-ignition can cause engine knock, which can severely damage engines: the higher the octane number the greater the fuels resistance to knock. RON is an indicator of the fuel's anti-knock performance at lower engine speed and typical acceleration conditions. MON is an indicator of the anti-knock performance under higher engine speed and higher load conditions.