TRADING STANDARDS

Fuel Quality Monitoring Programme

Test Results 2023–24

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

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ISSN 2253-170X (Print)
ISSN 2253-1718 (Online)

Publication Date: 23 October 2024

Cover photo: *Lyttelton Harbour, New Zealand*

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Executive Summary

The purpose of this report is to provide an overview of the sampling and testing results of the Fuel Quality Monitoring Programme from 1 July 2023 to 30 June 2024.

This technical report is intended to provide information to stakeholders and researchers in the fuel industry. It does not provide policy advice, solutions, or recommendations. It also does not include any information regarding the complaints received by Trading Standards (TS) or any incidents that have occurred in the fuel industry.

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

Trading Standards maintains a comprehensive programme to sample and assess the quality of retail fuel in New Zealand and monitor compliance with the Engine Fuel Specifications Regulations 2011 (**the Regulations or EFSR**). The Regulations have been in force since 1988, and the latest version was introduced in 2011, with subsequent amendments in 2017 and 2022.

The Programme's primary focus is to monitor the quality of the fuel supplied to consumers nationwide by retail fuel companies. 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, marine fuels, and biofuels such as biodiesel and ethanol.

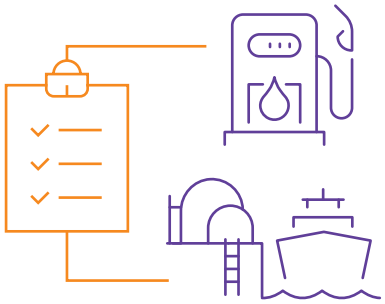
Since August 2022, Maritime New Zealand (Maritime NZ) and TS have operated a joint programme to monitor marine fuel quality, aligning with New Zealand's obligations under Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL).

The Programme collects samples of automotive fuel mainly from dispenser nozzles at the retail point of sale to assess the quality of fuel sold to consumers. Marine fuel supplied in New Zealand is sampled at storage terminals as well as at the time of bunkering. Further, in collaboration with Maritime NZ, the Programme collects samples of marine fuel used on board ships arriving in the country.

The Programme is independent of the Fuel Industry and focused on retail sales. It complements the sampling and testing the Fuel Industry carries out throughout the supply and distribution processes. It provides confidence to consumers and all stakeholders of the quality and composition of petrol, diesel, and marine fuels.

During the reported period, 630 fuel samples were collected from approximately 1,300 fuel service stations, commercial sites, and storage terminals throughout Aotearoa New Zealand. These include 396 routine samples, 167 non-routine samples taken in response to complaints and enquiries, biofuels, and 67 marine fuel samples. 18 additional samples are not included in this report as they were collected and tested for specific properties in response to certain projects or complaints.

Retail Sites Sampled	181
Routine Samples	396
Non-routine Samples	167
Marine Samples Tested by Maritime NZ	40
Marine Samples Tested by Trading Standards	27
Total Fuel Samples Reported	630



Fuel Type	Number of Samples included in this report	Number of Samples not reported
RON 91	175	6
RON 95	136	6
RON 98 and above	47	0
Diesel	186	6
Ethanol 100	1	0
MGO	43	0
VLSFO	24	0
Total	**630**	**18**

After conducting a comprehensive analysis of the samples and test results during the reported period, Trading Standards can confirm that overall, the fuel sold in New Zealand complied with the specified regulations and met the required quality standards.

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

Tel: 0508 627 774 or **Email:** tradingstandards@mbie.govt.nz

Fuel Quality Monitoring Programme

Background

MBIE is the Government's lead business-facing agency. Our contribution to improving the well-being of New Zealanders is summarised in our purpose, to grow New Zealand for all.

Trading Standards, a business unit of MBIE, ensures that New Zealanders receive fuel with accurate measurements and high-quality standards. TS maintains and administers the Fuel Quality Monitoring Programme to achieve the latter. This Programme monitors the quality of automotive and marine fuel in New Zealand and makes sure it complies with the Regulations.[1]

In the fuel quality monitoring area, activities include:

- checking fuel quality through routine sampling and targeted projects, as well as responding to complaints and emerging issues
- investigating consumer and trader complaints and responding to enquiries
- advising on and facilitating improvement of the 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 solid and effective relationships (as the lead regulator) with fuel companies, retailers, and stakeholders in NZ and abroad
- representing New Zealand on international standards committees relating to fuel quality
- collaborating with Maritime NZ to ensure the effective regulation of marine fuel standards.

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

The Programme's main objective is to verify the quality of fuels sold to retail consumers by directly collecting samples from dispenser nozzles at the point of sale. To ensure any non-conformance is identified, TS employs a statistical sampling method with an acceptable probability. The Regulations specify limits for several critical properties of premium and regular petrol grades, diesel, and biofuels such as biodiesel and ethanol blends, and marine fuels.

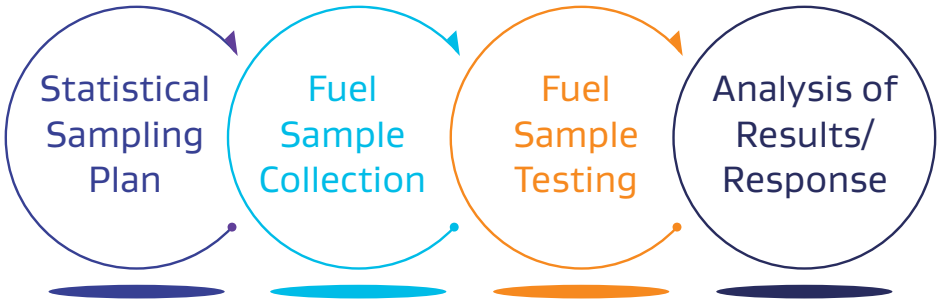
On 26 May 2022, New Zealand acceded to MARPOL Annex VI, and it came into force for New Zealand on 26 August 2022. To comply with it, new marine fuel quality regulations were included in the Engine Fuel Specifications Regulations 2011 which came into effect in August 2022 and new Marine Protection Rules Part 199 (Prevention of air pollution from ships) also came into force progressively from August 2022[2]. Marine fuel sampling occurs under a regime similar to the current fuel quality monitoring of automotive fuel, extending the overall scope to marine fuel and increasing the volume of testing samples.

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 annual reports.[3]

Funding of the Programme

The activities of TS and the Programme currently receive funding from a portion of the *Petroleum or Engine Fuel Monitoring Levy (PEFML)*, as mandated by the Energy (Petrol, Engine Fuel, and Gas) Levy Regulations 2017.[4] During the reported period, marine fuel sampling and testing done by TS was funded through a limited appropriation increase, and sustainable funding for this activity from the 2025/2026 financial year is currently being confirmed.

Methodology



During the reported period, TS was responsible for overseeing the collection of fuel samples, their testing in an accredited laboratory, and analysing the results. In cases where non-compliance or abnormalities were detected during testing, further analysis and investigation were conducted by TS. The main goal of these investigations was to confirm the accuracy of the results, identify any potential issues, and take appropriate action if necessary. Additionally, efforts were also made to understand and address the underlying causes of any non-compliance to prevent future occurrences.

2 https://www.maritimenz.govt.nz/rules/all-rules/marine-protection-rules-part-199/
3 https://fuelquality.tradingstandards.govt.nz/about-us/fuel-quality-monitoring-annual-reports/
4 https://www.legislation.govt.nz/regulation/public/2017/0147/latest/whole.html#DLM7296652

Sampling

Samples were collected from 11 regional areas across the country, serviced by specific fuel supply terminals listed in the table below. The collection was based on a statistical model that considered the market share of each retail fuel company in each area.

A total of 181 sets of samples were collected from various retail sites, with 123 sites sampled as part of routine procedures and the remaining sites sampled for reasons such as non-routine procedures, complaints or specific projects.

Most of the sample sets consisted of regular petrol, premium petrol, and diesel samples. There were some sites where premium petrol was not available during the sample collector visits. There were also instances where four samples were collected from a single site, including two samples of premium petrol with RON 95 and RON 98 or higher.

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

Terminal/Month	Jul 23	Aug 23	Sep 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar 24	Apr 24	May 24	Jun 24	Total
Whangarei	4	2	0	3	1	1	0	0	1	0	0	0	**12**
Auckland	3	10	5	2	6	3	0	4	3	4	2	0	**42**
Mt Maunganui	5	2	2	6	3	1	1	4	4	4	2	0	**34**
New Plymouth	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Napier	3	1	0	2	0	0	2	1	0	0	0	0	**9**
Wellington	1	2	0	1	2	0	2	2	5	1	0	2	**18**
Nelson	1	1	3	1	1	0	1	1	0	0	0	1	**10**
Lyttelton	2	3	3	2	0	2	0	1	0	8	0	0	**21**
Timaru	0	2	0	1	2	1	0	1	1	2	0	0	**10**
Dunedin	1	1	1	3	2	0	2	1	1	1	0	0	**13**
Bluff	2	2	4	0	2	0	1	1	0	0	0	0	**12**
TOTAL	**22**	**26**	**18**	**21**	**19**	**8**	**9**	**16**	**15**	**20**	**4**	**3**	**181**

Fuel supply terminals in Aotearoa New Zealand

Total number of regional samples collected

Seasons in the Regulations

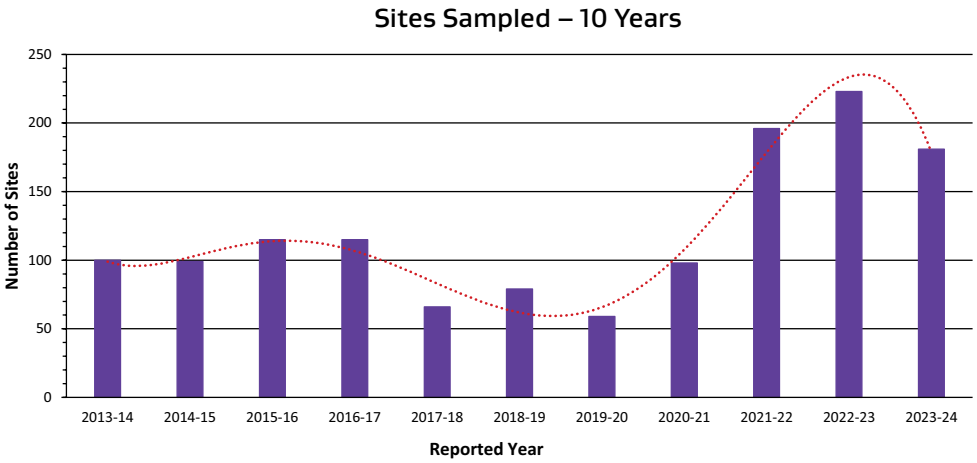
SCHEDULE 1 – PETROL

Summer	1 December - 31 March
Autumn	1 April - 31 May
Winter	1 June - 31 August
Spring	1 September - 30 November

SCHEDULE 2 – DIESEL

Summer	15 October - 14 April
Winter	15 April - 14 October

In recent years, TS has significantly increased the number of sites sampled for monitoring. The number of sites sampled per year has increased from approximately 100 sites between 2012 and 2017 to an average of 200 sites between 2021 and 2024. However, between 2017 to 2021, the number of sites sampled declined to below 100 sites. The funding allocated to TS for running the Programme increased in 2021 to meet the requirements of BS EN 14274 for the purpose of fuel quality monitoring systems (FQMS). In addition to that, marine fuel sampling and testing has expanded the scope of work carried out by TS.



Test Methods

The programme conducted tests in accordance with the Regulations. The results of subsequent testing of fuel samples have been reported based on their relevant specification limits outlined in the Regulations. ISO Standard 4259[5] provides testing tolerances that allow for results to fall slightly beyond the specified limits but still within the acceptable levels, which is the tolerance limit. There are testing tolerances set out according to the precision parameters identified in the relevant test methods.

Additional tests not yet specified in the Regulations, such as silver strip corrosion in petrol, and microbial content and appearance for diesel, were added to the routine list. The latter was added to assess the level and nature of the potential presence of water and other contaminants that can be visually assessed.

Monitoring diesel for microbial content and appearance was emphasized due to potential risks to diesel engines. The presence of microbial content in fuel is a highly contentious topic, as discussed in the Microbial Content section of the report.

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

Wet Stock Management

Alongside the routine sampling and testing of fuel, TS monitors local wet stock management processes and procedures at 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), minimising fuel contamination *e.g.,* from water ingress, monitoring stock levels and maximising 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 will continue to work with the fuel supply companies to ensure adherence to 'best practice' and proper procedures outlined in their quality management systems to ensure that quality and composition of fuel is maintained throughout the supply chain.

Marine Fuel Sampling

Marine fuel sampling and testing, which is part of the joint programme between TS and Maritime NZ, was conducted for the second time this year. The programme aimed to test the sulphur content and various quality parameters of fuel onboard ships arriving into and sold in in Aotearoa New Zealand.

All samples were found to be compliant with the requirements of MARPOL Annex VI.

Conclusion

The Programme has confirmed that the engine fuel supplied in New Zealand during the reported period was of good quality, appropriate for its intended use, and met the performance and quality standards outlined in the Regulations.

By analysing data from previous years, we can assume that the proportion of non-compliant fuel across terminals and brands remains relatively constant. Otherwise, the system would need to factor in specific high-risk areas, possible sources of non-compliance, or unique circumstances that could make certain areas more likely to have fuel that doesn't meet specifications.

As with previous reports, the source of the samples remains anonymous in order to protect the commercial sensitivity of this information.

Petrol

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

Octane rating or grade measures a fuel's ability to resist auto-ignition, which can lead to engine noise (known as knock) and, in severe cases, engine damage. It is essential to note that octane rating also impacts engine efficiency, emissions, and influences engine design. Therefore, octane rating stands out as one of the most critical properties of gasoline. To ensure proper engine operation, optimal fuel efficiency, and reduced emissions, it is necessary to use fuel with the octane rating recommended in the vehicle owner's manual.[6]

The test method ASTM D2699[7] is prescribed in the Regulations for definition of RON while the test method ASTM D2700[8] is prescribed for definition of MON.

RON 91

In total, 175 samples of regular petrol were tested for RON and were above the minimum specification limit 91.

169 samples of regular petrol were tested for MON, and the results were above the minimum specification limits of 81.0 for MON.

Fig. 1a and Fig. 1b below show the testing results for RON and MON respectively.

Here and below:

- The abbreviation 'EFSR' stands for the specification limit prescribed in the Regulations.
- Each individual result is independent from others although they are connected in the graphs for ease of interpretation.

6 *Worldwide Fuel Charter,* Gasoline and Diesel 6th Ed., 2019, p.14
7 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.
8 ASTM D2700-19 *Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel*

Figure 1a: Test Results for RON, RON 91, Year 2023-24

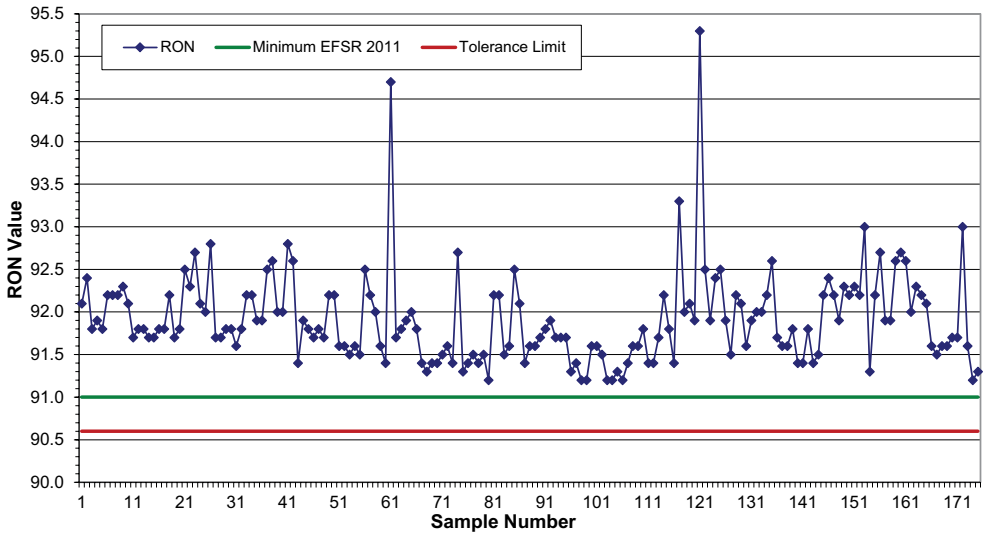
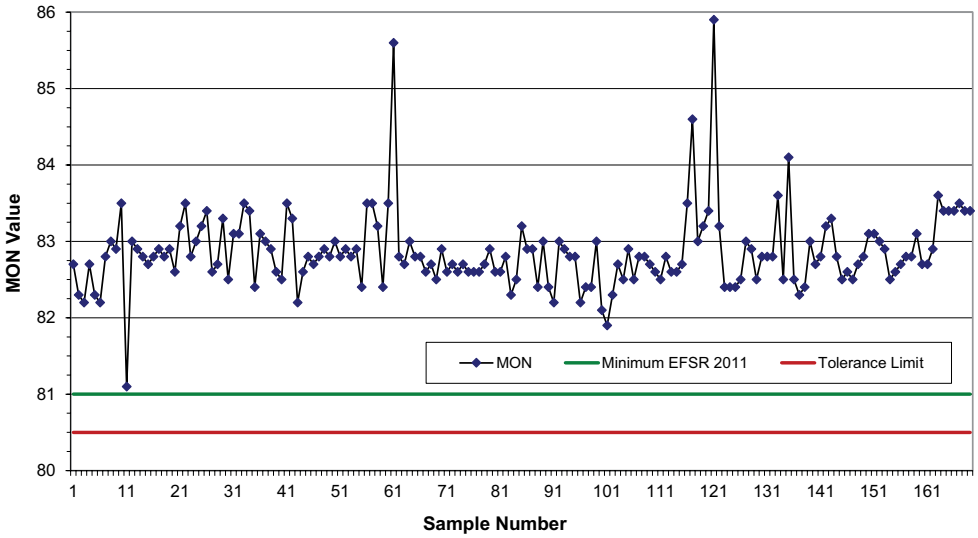


Figure 1b: Test Results for MON, RON 91, Year 2023-24



RON 95

In total, 136 samples of premium grade petrol were tested for RON 95. All samples met the minimum specification limit of 95.0 for RON, except two samples which were both collected from the same site. When tested, the initial sample had a RON result of 93.5. A follow-up sample was collected from a different pump at the same fuel station which confirmed that the petrol had a RON of 93.5. After the issue had been identified and resolved, the final sample set collected from the site confirmed that the resulting RON value was above the minimum limit of 95.0.

132 samples of premium petrol with RON 95 were tested for MON. All samples met the minimum specification limit of 85.0 for MON, except the same samples which had a RON of 93.5 above.

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

Figure 2a: Test Results for RON, RON 95, Year 2023-24

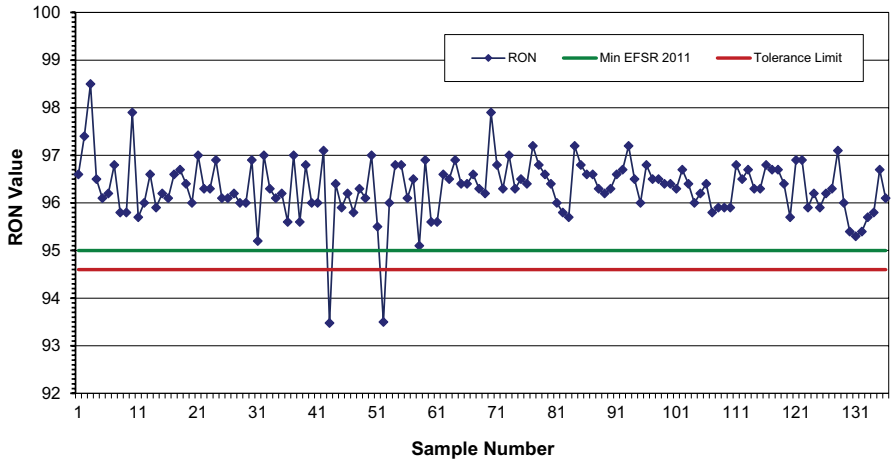
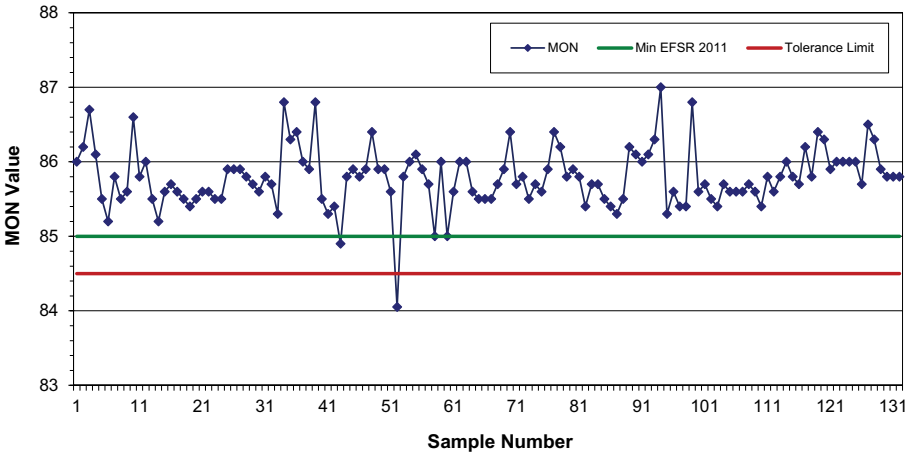


Figure 2b: Test Results for MON, RON 95, Year 2023-24



RON 98 & ABOVE

No specific minimum value of RON is specified in the Regulations for premium petrol sold in the retail market with an advertised RON above 95. This type of fuel is promoted as having properties that exceed the regulated limits. Specifically, the advertised "RON 98" mentioned in Figure 3a must comply with Section 11 of the Regulations when tested according to the methods specified in Schedule 1 of the Regulations. Under the Fair Trading Act 1986, the advertised limit can be enforced if there is a misrepresentation. Consequently, it can be inferred that the actual RON figures must be equal to or higher than 98 or, as advertised, equal to or higher than 100.

There is no specified minimum limit for MON in the Regulations or in the advertising of premium petrol with an advertised RON of 98 or higher. Therefore, the limit for premium petrol is used as a benchmark. A total of 47 samples of petrol with an advertised RON of 98 and higher were collected and tested. All samples with a RON of 98 or higher were found above the limit.

No specific minimum MON is specified for premium petrol with a RON above 95. In total, 45 samples were tested and found to have an MON above the specification limit of 85.0 for premium petrol.

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

Figure 3a: Test Results for RON, RON 98 & above, Year 2023-24

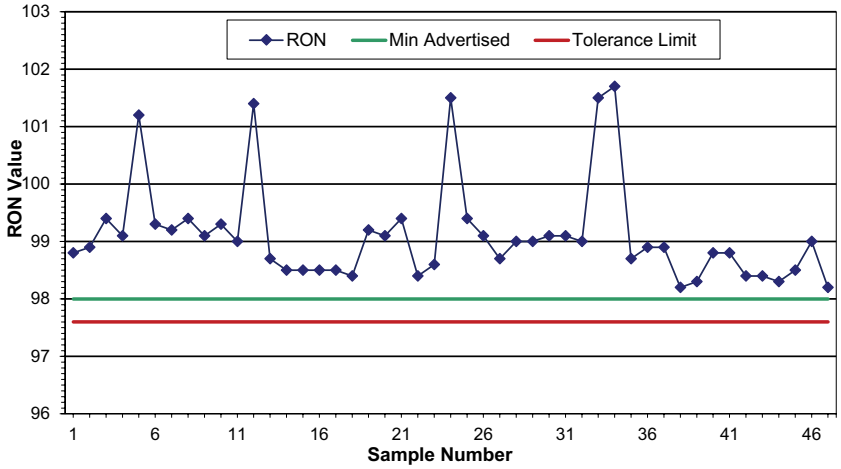
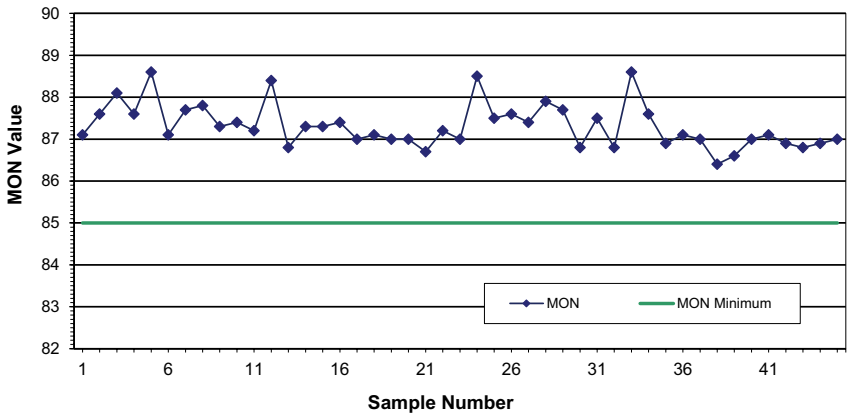


Figure 3b: Test Results for MON, RON 98 & above, Year 2023-24



Evaporation Percentage

The test method ASTM D86[9] is prescribed in the Regulations for the definition of the volume percentage of evaporated petrol at the three fixed temperatures: at 70°C, 100°C and 150°C. 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).

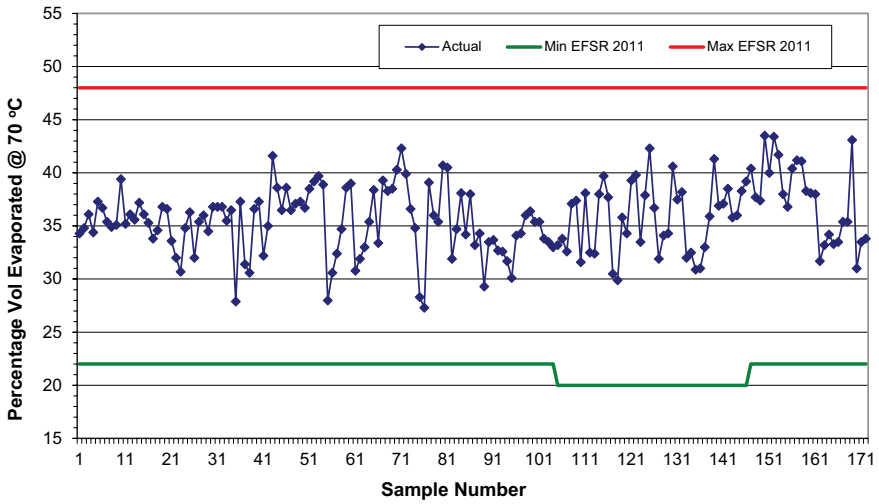
RON 91

Percentage Volume Evaporated at 70°C

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

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

Figure 4a: Test Results for E70, RON 91, Year 2023-24



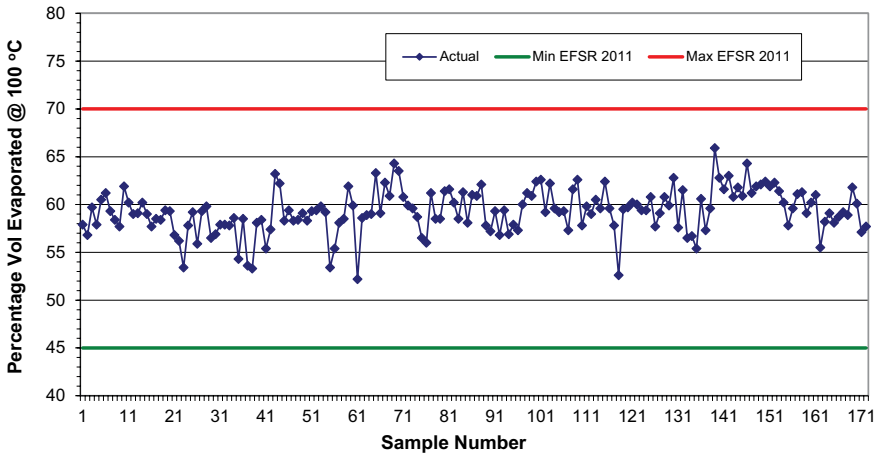
9 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*

Percentage Volume Evaporated at 100°C

All 172 samples were found to be within the specification limits from 45% to 70%.

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

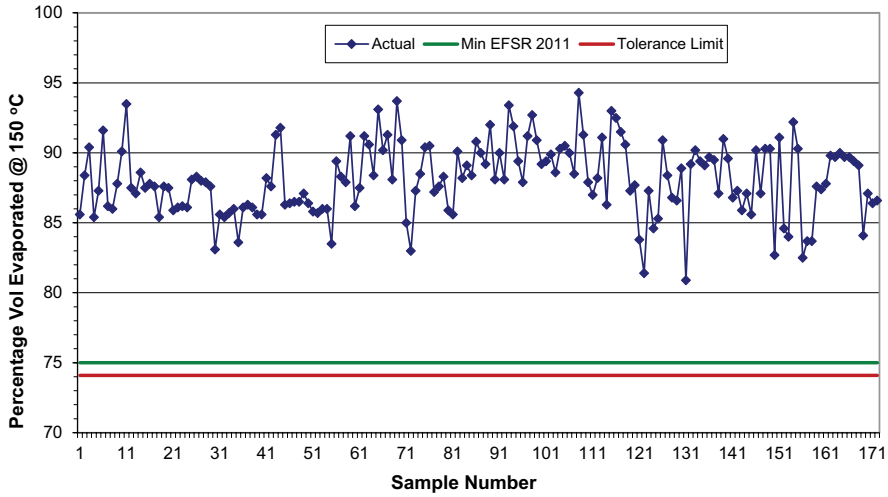
Figure 4b: Test Results for E100, RON 91, Year 2023-24



Percentage Volume Evaporated at 150°C

All 172 samples were found to be above the minimum specification limit of 75%. The minimum tolerance limit is 74.1% (see Fig. 4c). No maximum limit is prescribed by the Regulations for this property.

Figure 4c: Test Results for E150, RON 91, Year 2023-24



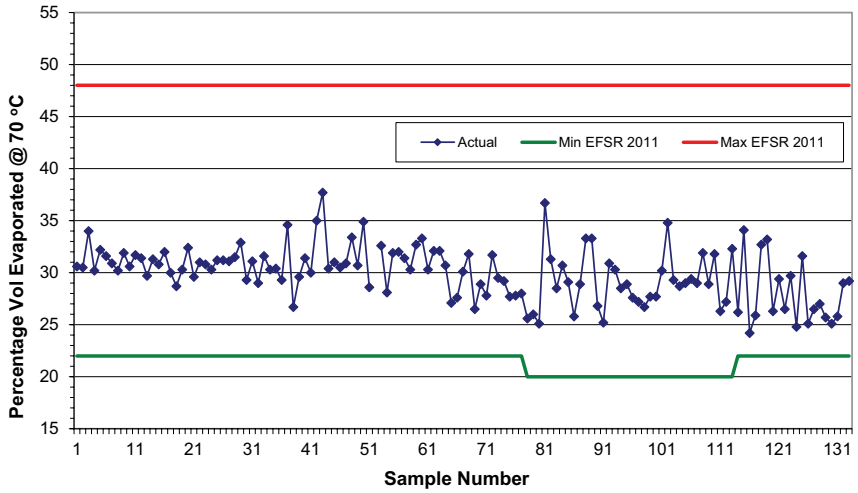
RON 95

Percentage Volume Evaporated at 70°C

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

All 132 samples were found to be within the prescribed specification limits with the minimum limit of 22% at all seasons including the summer period when the specified minimum limit for E70 is permitted to be 20% (see Fig. 5a).

Figure 5a: Test Results for E70, RON 95, Year 2023-24

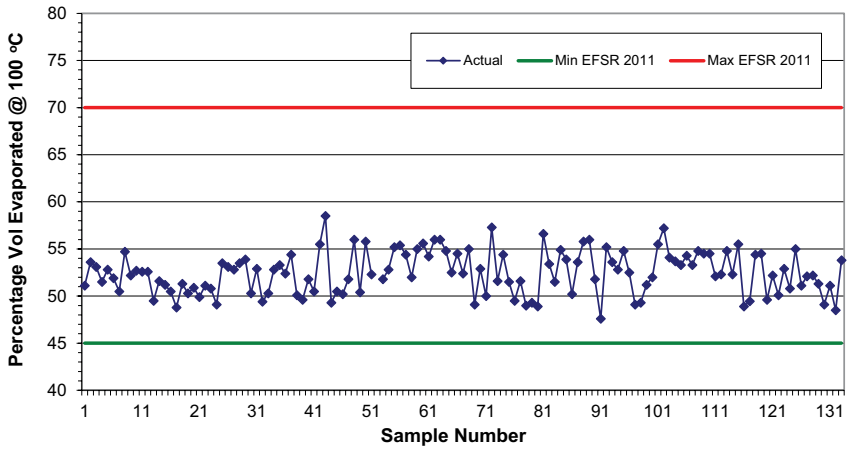


Percentage Volume Evaporated at 100°C

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

As in case of regular petrol, the tolerance limits are 43.8% and 70.9% respectively (not shown in Fig 5b).

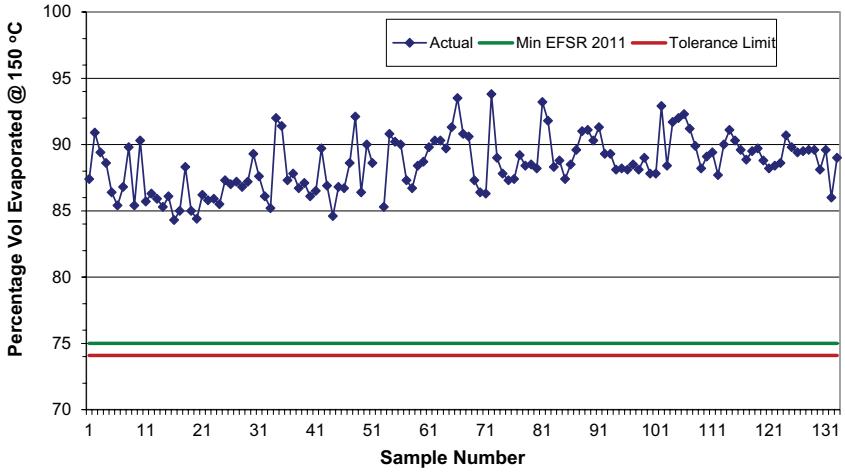
Figure 5b: Test Results for E100, RON 95, Year 2023-24



Percentage Volume Evaporated at 150°C

All samples were found to be above the minimum specification limit of 75% (Fig. 5c). As in case of regular petrol, 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 2023-24



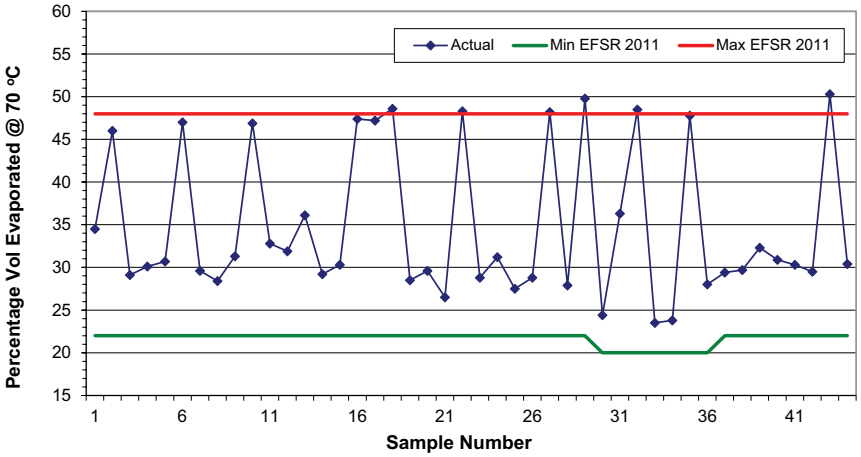
RON 98 & ABOVE

Percentage Volume Evaporated at 70°C

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

Most results were found to be within the specification limits of 22% to 48% except for 6 ethanol blended samples. According to the Regulations (Footnote 2 in Schedule 1), the maximum allowed percentage of volume evaporation at 70°C (E70) is increased by 1% per each 1% volume of oxygenates in the blend. Results for these 6 samples were between 48.2% and 50.3% with ethanol content.

Figure 6a: Test Results for E70, RON 98 & above, Year 2023-24

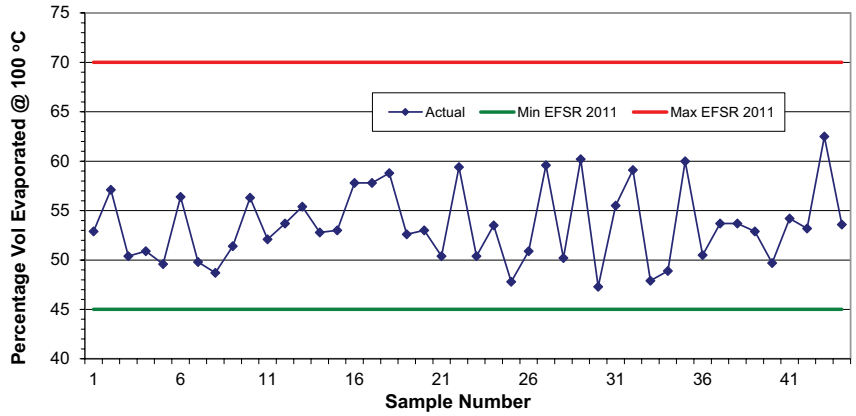


Percentage Volume Evaporated at 100°C

All samples were found to be within the specification limits from the minimum of 45% to the maximum of 70% (Fig 6b).

As in case of regular petrol, 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 2023-24

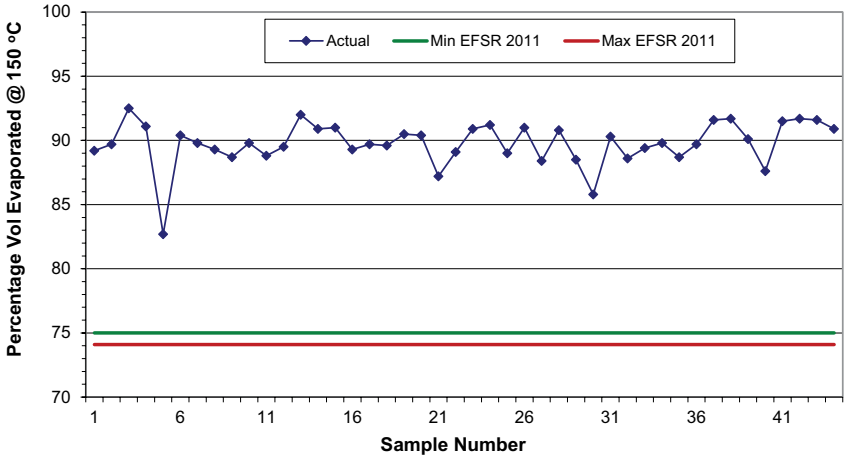


Percentage Volume Evaporated at 150°C

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

As in case of regular petrol, 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 2023-24



Final Boiling Point (FBP)

The test method ASTM D86[10] is prescribed in the Regulations for distillation end point (or 'final boiling point') in petrol.

All samples were found to be within the specification maximum limit of 210°C for both regular and premium grades (Fig.7). The maximum tolerance limit is 214°C.

Figure 7a: Test Results for Final Boiling Point, RON 91, Year 2023-24

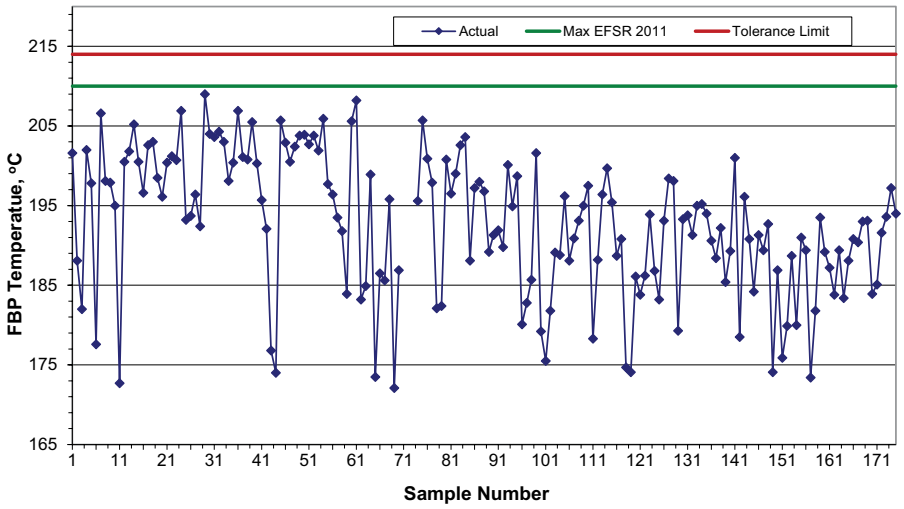
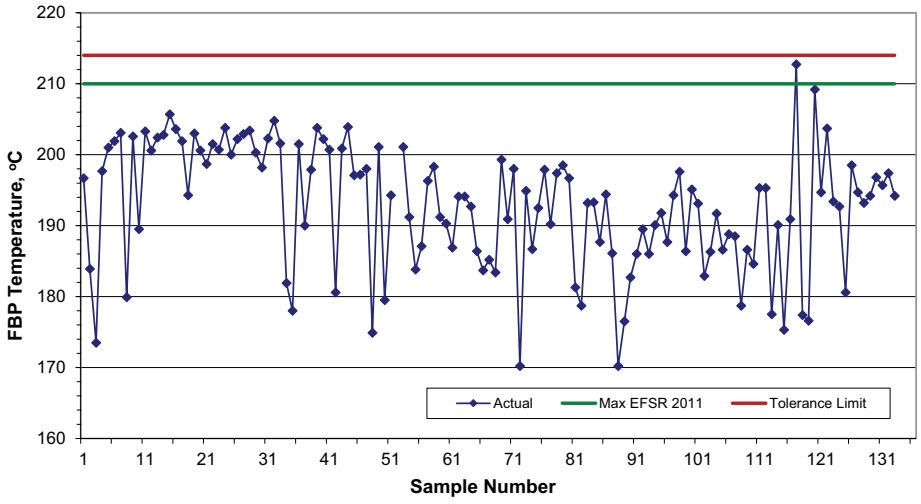
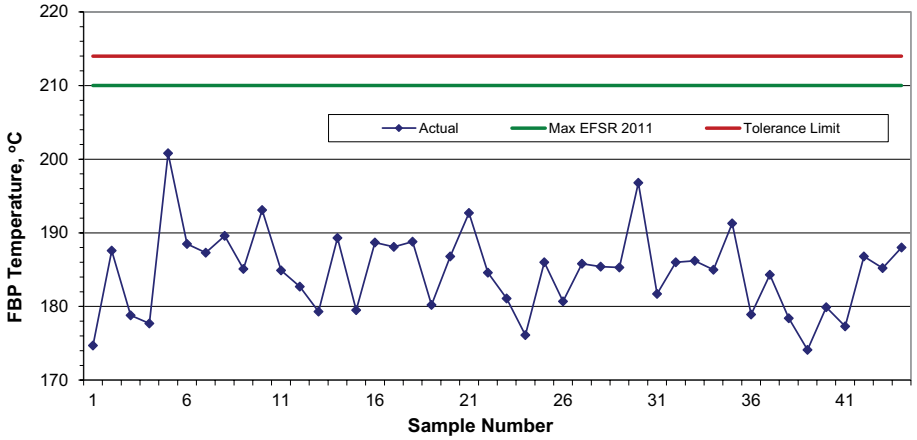


Figure 7b: Test Results for Final Boiling Point, RON 95, Year 2023-24



10 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 2023-24



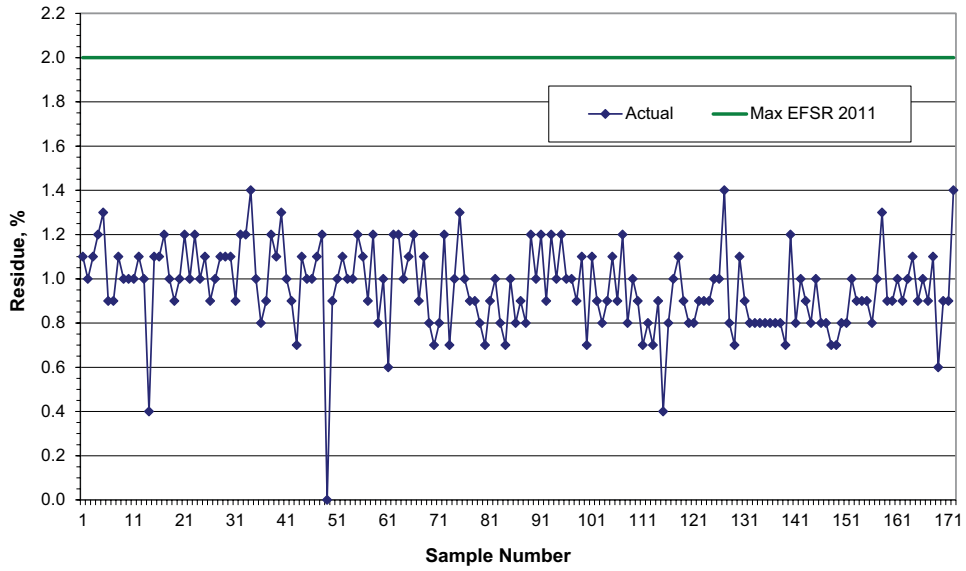
Residue

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[11] is usually expected to be within a certain range and serves primarily for indication of the correct running of the distillation process. This is one of the process control parameters and as such residue, is not something that can be measured for repeatability and reproducibility that could be listed 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 less than 1.4%.

Figure 8a: Test Results for Residue, RON 91, Year 2023-24



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

Figure 8b: Test Results for Residue, RON 95, Year 2023-24

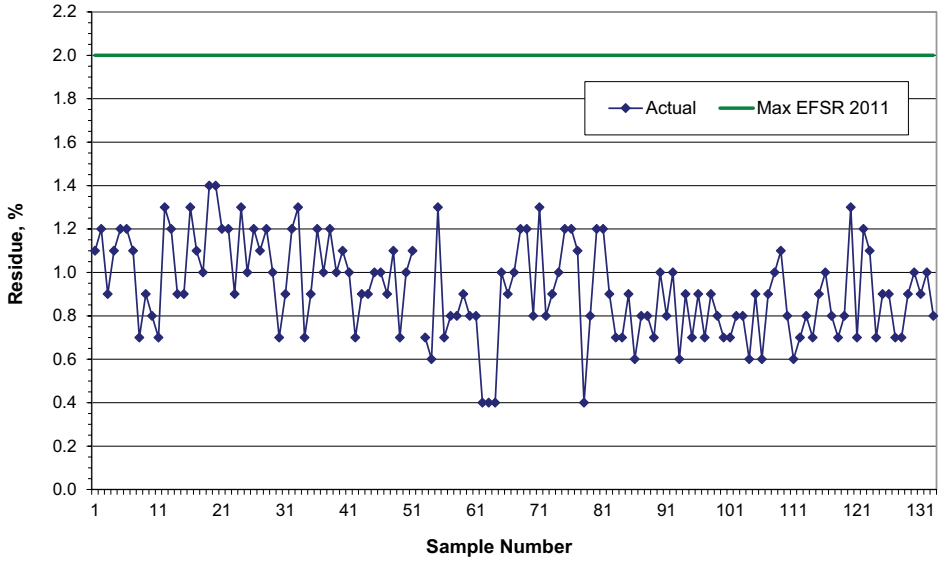
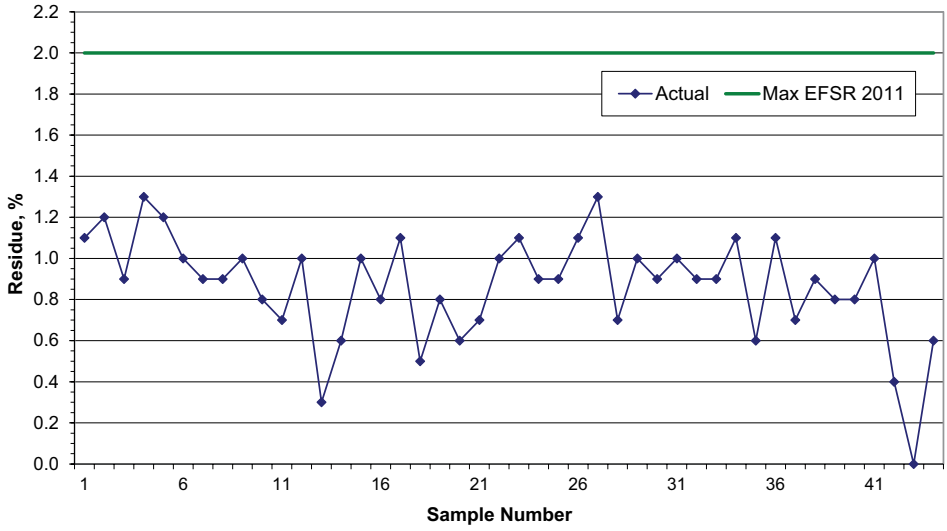


Figure 8c: Test Results for Residue, RON 98 & above, Year 2023-24



Dry Vapour Pressure Equivalent

The test method ASTM D5191[12] 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

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

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).

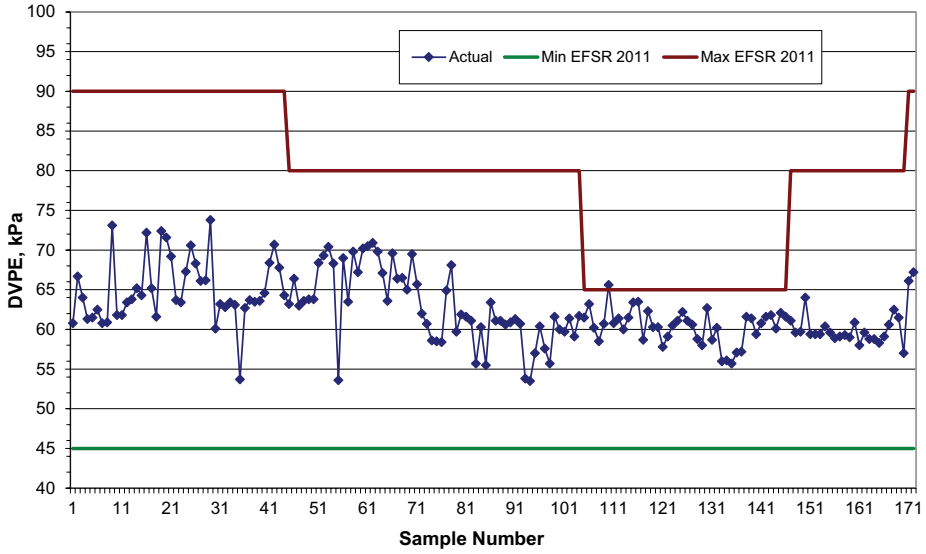
Each sample within the relevant season which appeared to be above the lowest maximum limit line was individually analysed.

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

RON 91

One sample which appears to be above the lowest maximum limit in the graph, is within the maximum limit for its region and season. Specifically, the sample which had results above the limit of 65 kPa in the figure 9a, was within the maximum limit of 75 kPa for summer in the South Island region.

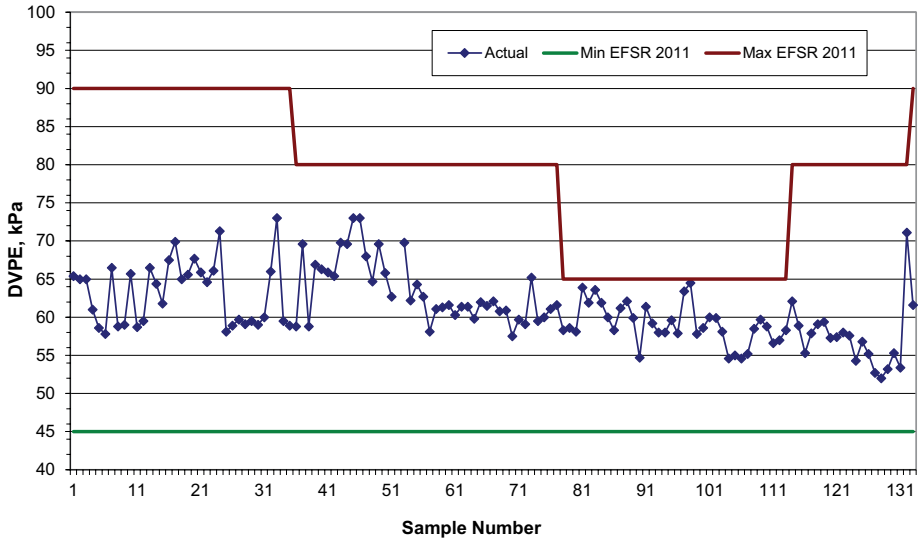
Figure 9a: Test Results for DVPE, RON 91, Year 2023-24



RON 95

All 132 samples were found to be within the specification limits for premium petrol (Fig. 9b).

Figure 9b: Test Results for DVPE, RON 95, Year 2023-24

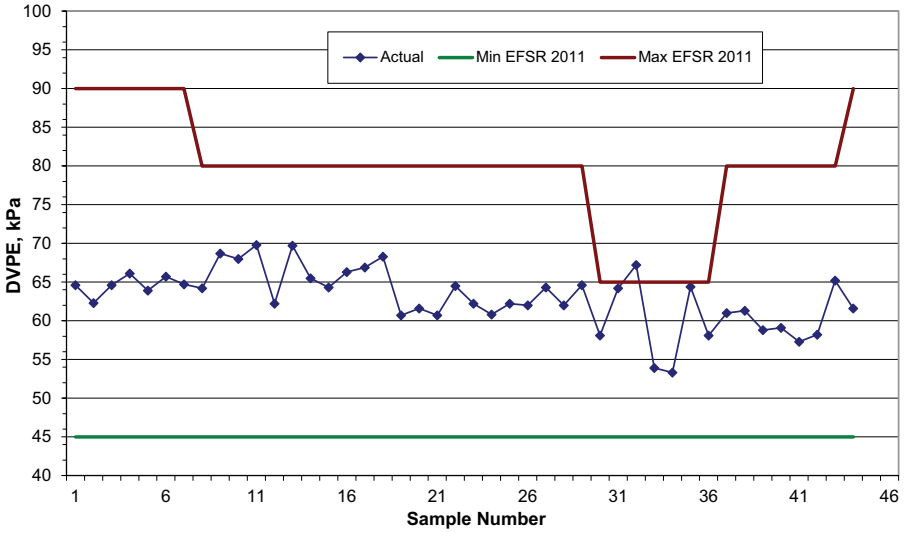


RON 98 & ABOVE

All 45 samples were found to be within the specification limits for premium petrol RON 98 and above (Fig. 9c).

One sample which appears to be above the lowest maximum limit in the graph, is within the maximum limit for its region and season. Specifically, the sample which had results above the limit of 65 kPa in the figure 9c, was within the maximum limit of 70 kPa for summer in the rest of the North Island region.

Figure 9c: Test Results for DVPE, RON 98 & above, Year 2023-24



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)

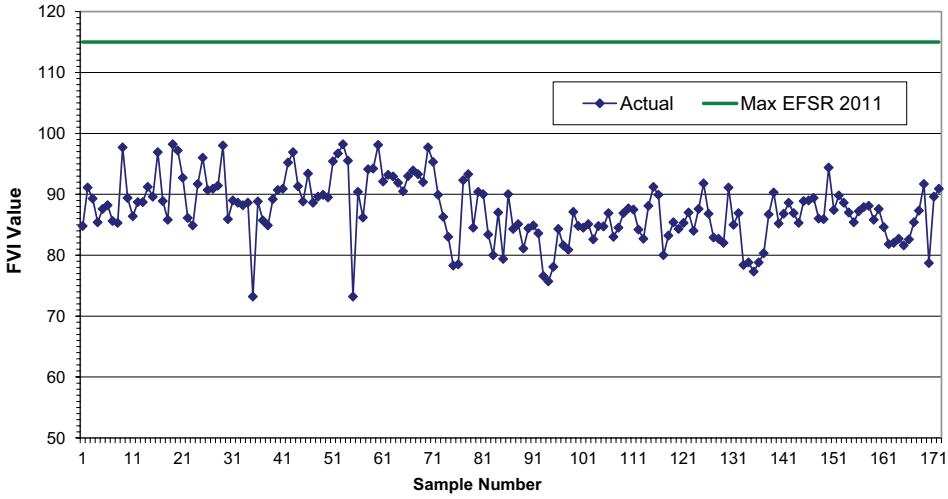
FVI serves as an indicator of the hot running performance (the tendency for vapour lock).

No definition of the FVI value is given in the related ASTM Standards prescribed in the Regulations (D86 and D5191[13]) 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 within the specification maximum limit of 115.0 (Fig 9d).

Figure 9d: Results for Flex. Vol. Index, RON 91, Year 2023-24

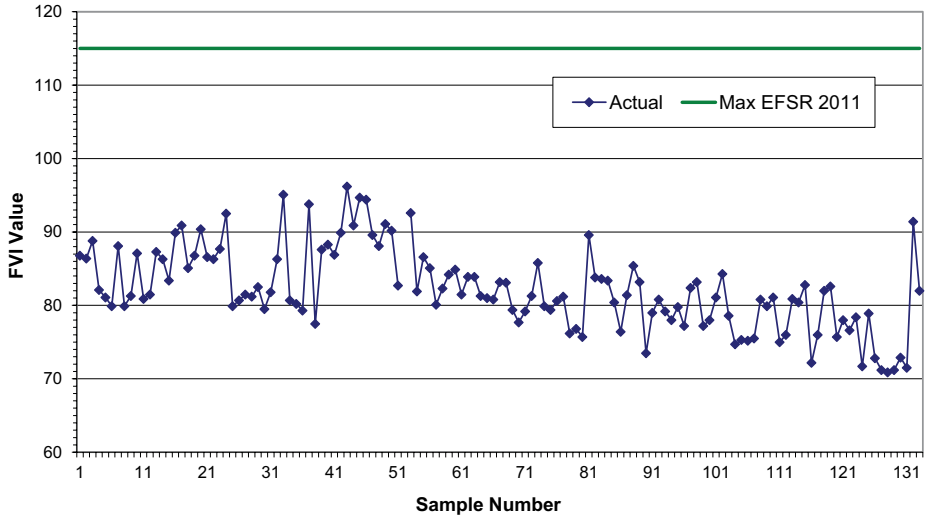


13 ASTM D5191 - 20 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)*

RON 95

All samples of premium petrol were found to be within the specification maximum limit of 115.0 (Fig 9e).

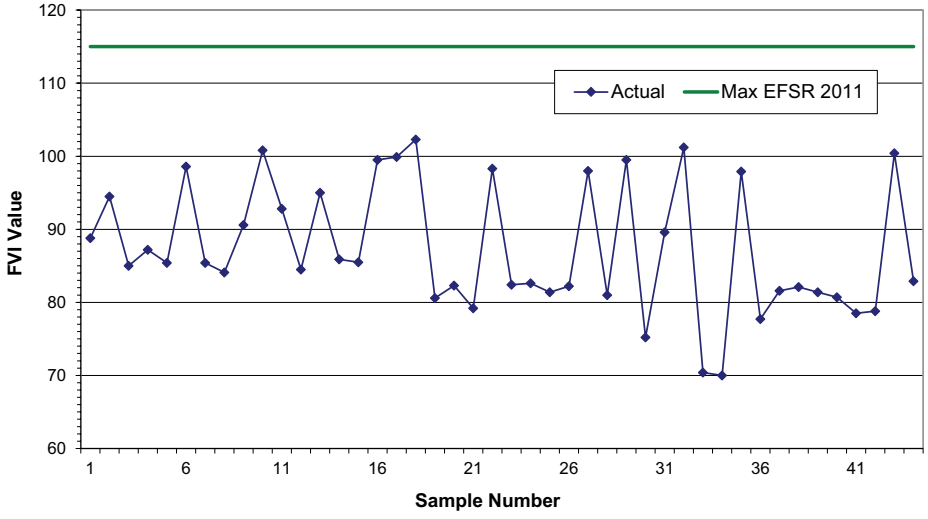
Figure 9e: Results for Flex. Vol. Index, RON 95, Year 2023-24



RON 98 & ABOVE

All samples of premium petrol were found to be within the specification maximum limit of 115.0 (Fig 9f).

Figure 9f: Results for Flex. Vol. Index, RON 98 & above, Year 2023-24



Sulphur

Sulphur has a significant impact on vehicle emissions by reducing the efficiency of catalysts. Sulphur also adversely affects heated exhaust gas oxygen sensors.[14]

New Zealand aligns with the European Union's specification limit which is a maximum of 10 mg/kg. It is referred to as 'sulphur free petrol' and has the lowest sulphur content in the world. This low sulphur level ensures that other regulated vehicle emissions remain low, and that the longevity of vehicle emissions sensors is maintained.

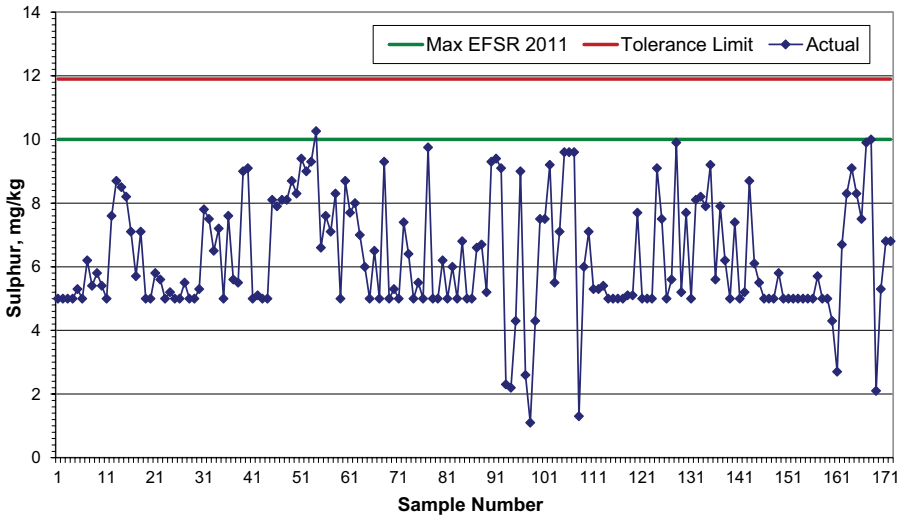
The scope of the test method IP 497[15] prescribed in the Regulations is from 5 to 60 mg/kg. Accordingly, the lowest testing result by this method is 5 mg/kg where the actual figures were found to be on or below this indicative level at the specified maximum limit since 1 July 2018 of 10 mg/kg with the tolerance limit of 11.8 mg/kg.

The ASTM standard D5453[16] 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 (shown on the Fig.10 by a red line).

RON 91

All 172 samples tested for sulphur in regular petrol were found to be within the prescribed maximum limit, except for one sample. This sample initially tested at 11.1 mg/kg, but subsequent repeated tests yielded results of 10.7 mg/kg and 9.0 mg/kg. The average result of 10.3 mg/kg falls within the tolerance limit of 11.9 mg/kg and is therefore reported as such.

Figure 10a: Test Results for Sulphur, RON 91, Year 2023-24

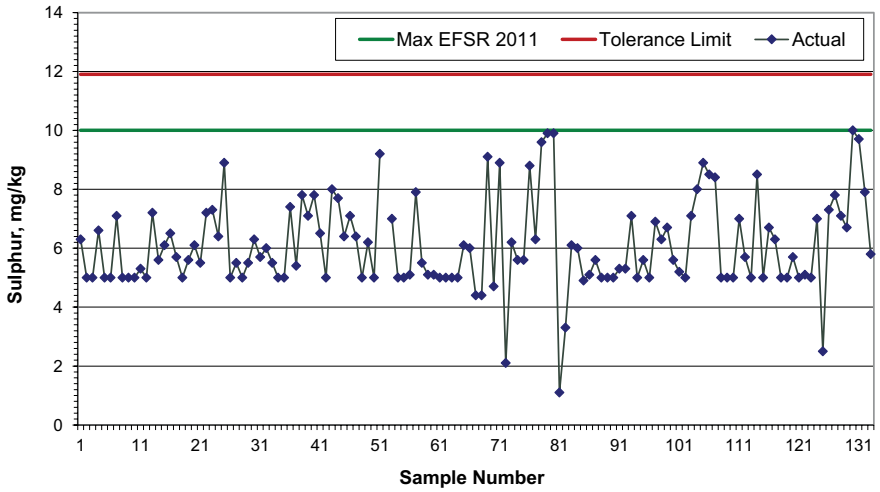


14 *Worldwide Fuel Charter,* 6th Ed., 2019, p.17
15 IP497 EN ISO 20884:2019 *Petroleum products - Determination of sulfur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry*
16 ASTM D5453–19a *Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, 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 within the prescribed maximum limit of 10 mg/kg.

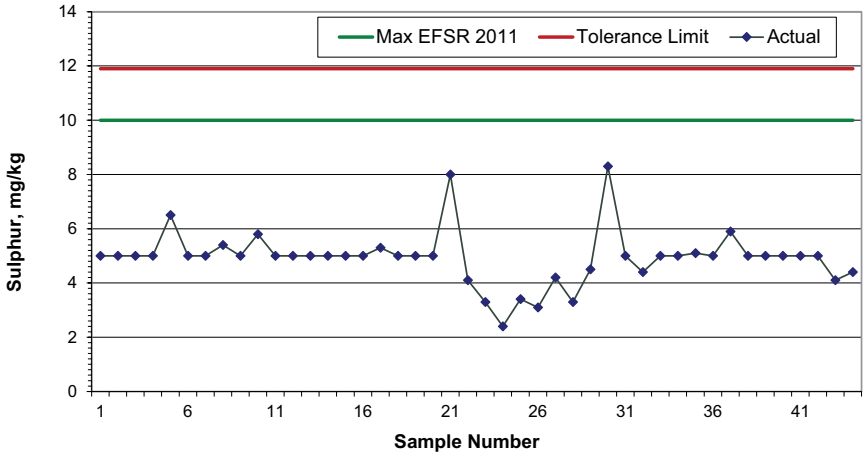
Figure 10b: Test Results for Sulphur, RON 95, Year 2023-24



RON 98 & ABOVE

All 44 results for premium petrol 98 and above were found to be within the prescribed maximum limit not exceeding 8.3 mg/kg.

Figure 10c: Test Results for Sulphur, RON 98 & above, Year 2023-24



Benzene and Total Aromatics

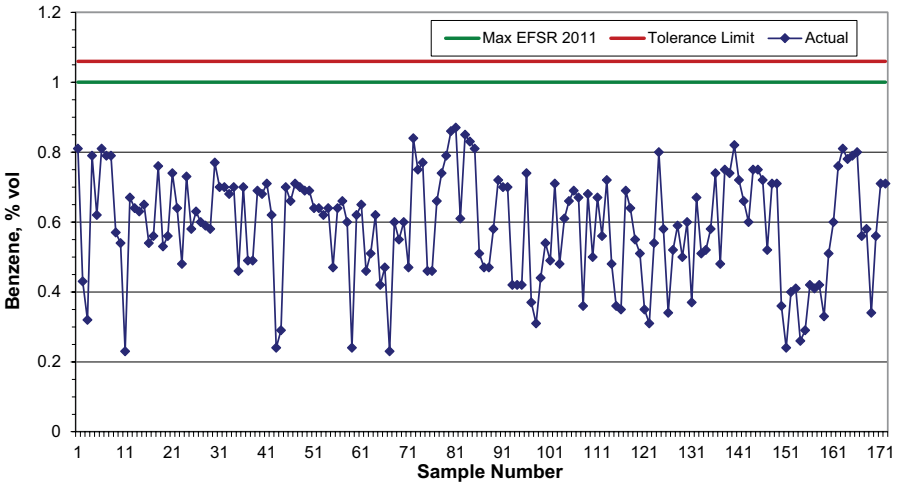
The test method ASTM D5580[17] is prescribed in the Regulations for aromatic compounds including benzene.

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

RON 91

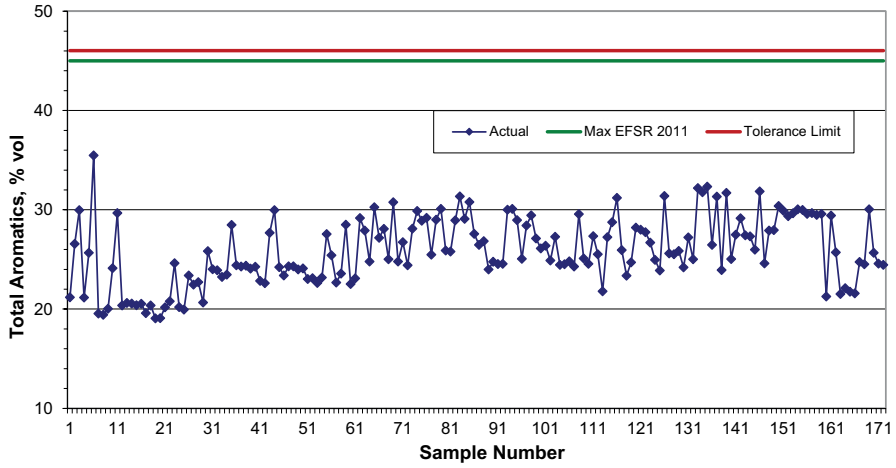
All 172 results tested for benzene content in regular petrol were found to be below 1% with the largest figure of 0.96% (Fig.11a).

Figure 11a: Test Results for Benzene, RON 91, Year 2023-24



All results of total aromatics were found to be within the prescribed limit with the largest figure of 42.85% (Fig. 11b).

Figure 11b: Test Results for Total Aromatics, RON 91, Year 2023-24

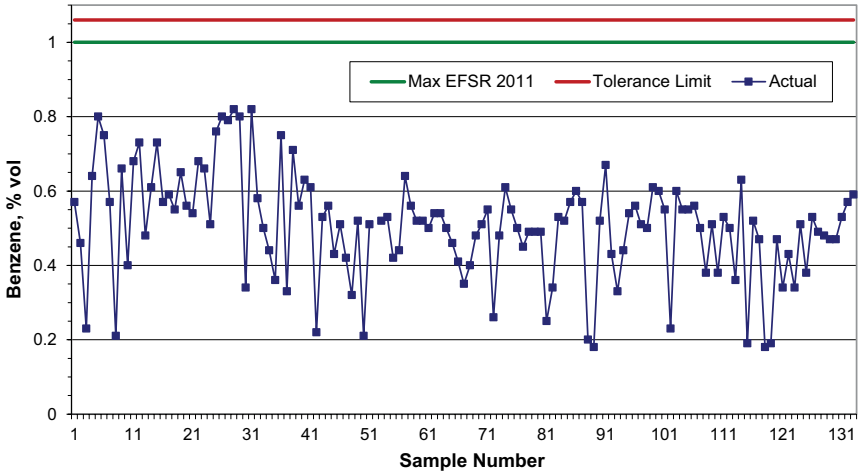


17 ASTM D5580-21 *Standard Standard Test Method for Determination of Benzene, Toluene, Ethylbenzene, p/m-Xylene, o-Xylene, C9 and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography*

RON 95

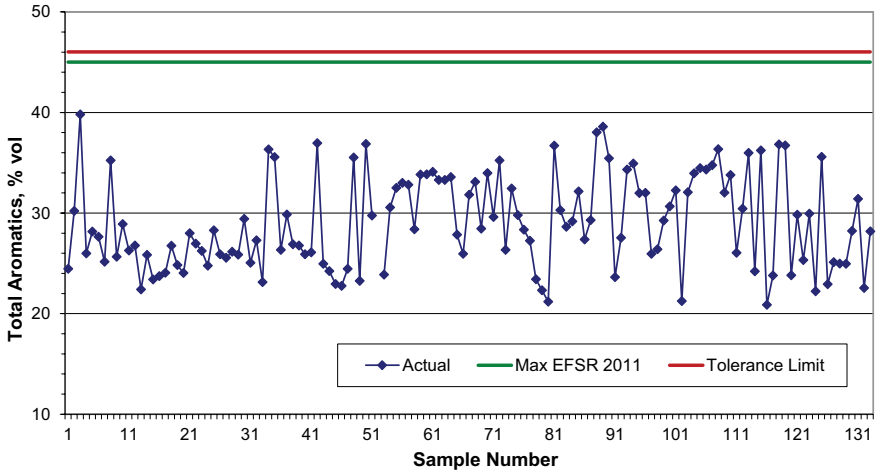
All 132 samples of premium petrol tested for benzene were found to be within the prescribed maximum limit for benzene (Fig 11c).

Figure 11c: Test Results for Benzene, RON 95, Year 2023-24



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

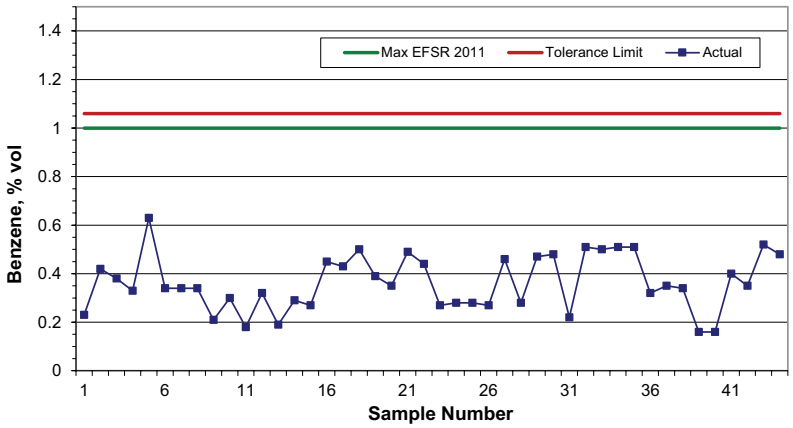
Figure 11d: Test Results for Total Aromatics, RON 95, Year 2023-24



RON 98 & ABOVE

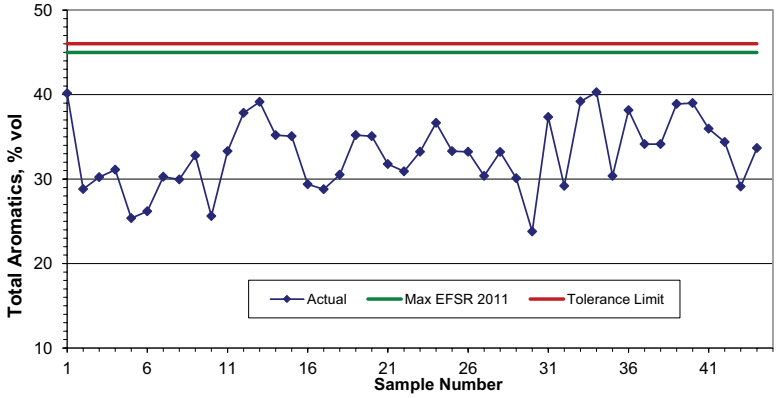
All 45 samples of premium petrol RON 98 and above tested for benzene were found to be within the prescribed maximum limit for benzene (Fig 11e).

Figure 11e: Test Results for Benzene, RON 98 & above, Year 2023-24



For premium petrol RON 98 and above, all results on total aromatics were found to be within the maximum limit of 45% (Fig. 11f).

Figure 11f: Test Results for Total Aromatics, RON 98 & above, Year 2023-24



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 the 'pool average aromatics content in petrol' was collected from four fuel retail companies that imported petrol during the reported period. The collected results were found to be within the required limits. However, due to the commercial sensitivity of the calculation process, the actual results are not included in this report.

Olefins

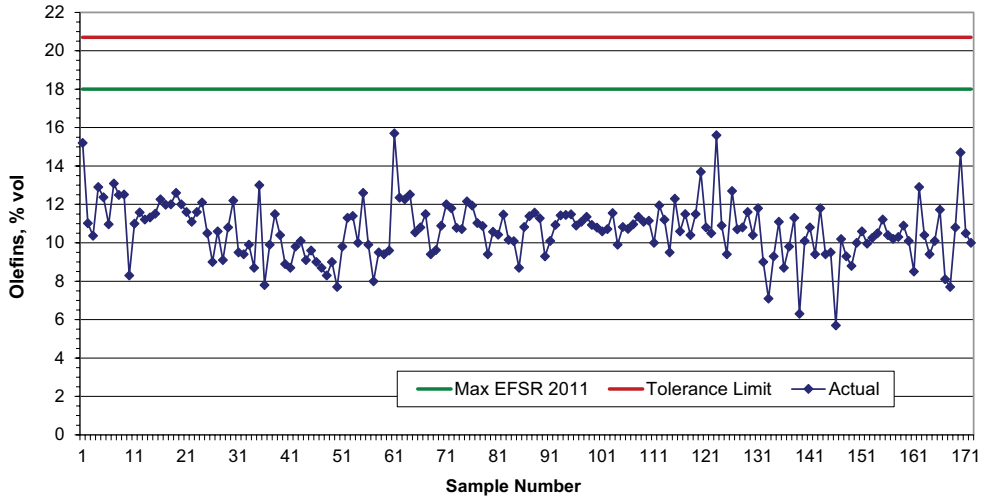
The test methods ASTM D1319[18] and ASTM D6839[19] are prescribed in the Regulations for olefins content.

Majority of samples were tested by D6839; all samples were found to be within the specification maximum limit of 18% vol with the tolerance limit of 19.6% for D6839 and 20.7% for D1319.

RON 91

For regular petrol, all the results were found to be below the specified maximum limit of 18% (Fig. 12a).

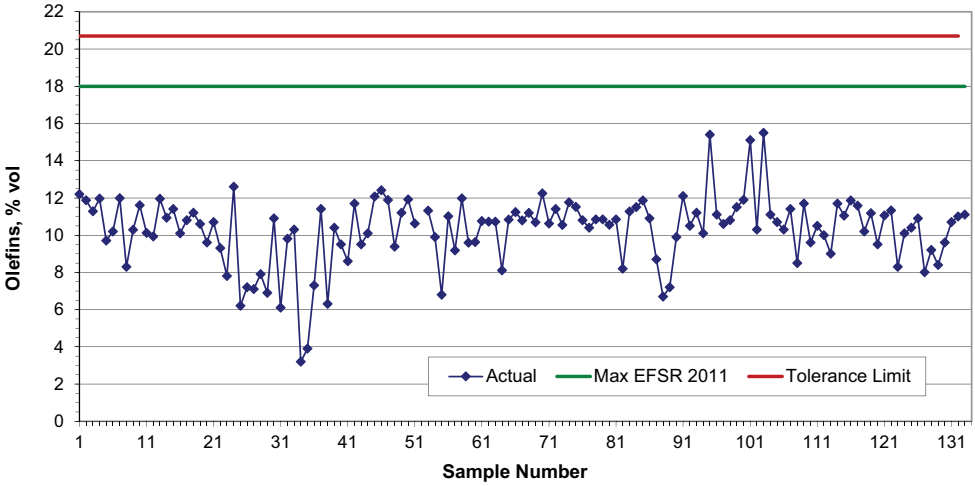
Figure 12a: Test Results for Olefins, RON 91, Year 2023-24



RON 95

For premium petrol RON95, all the results were found to be below the specified maximum limit of 18% (Fig. 12b).

Figure 12b: Test Results for Olefins, RON 95, Year 2023-24



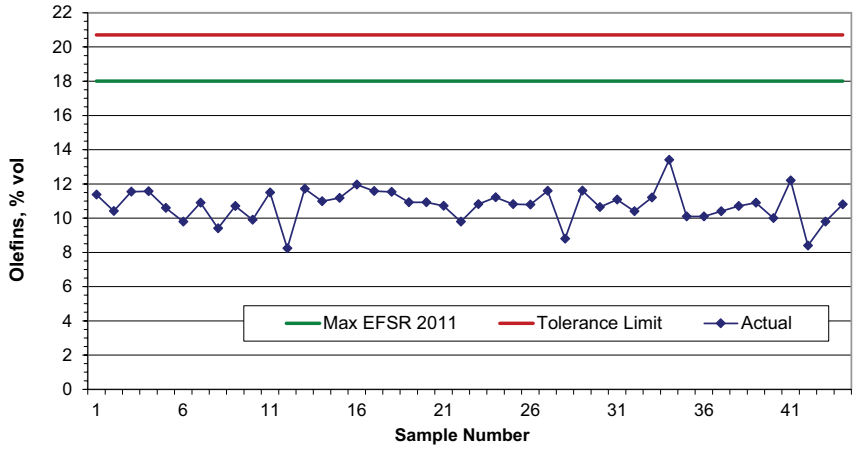
18 ASTM D1319-20a *Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption*

19 ASTM D6839-18 *Standard Test Method for Hydrocarbon Types, Oxygenated Compounds, and Benzene in Spark Ignition Engine Fuels by Gas Chromatography*

RON 98 & ABOVE

For premium petrol RON98 and above, all the results were found to be below the specified maximum limit of 18% (Fig. 12c).

Figure 12c: Test Results for Olefins, RON 98 & above, Year 2023-24



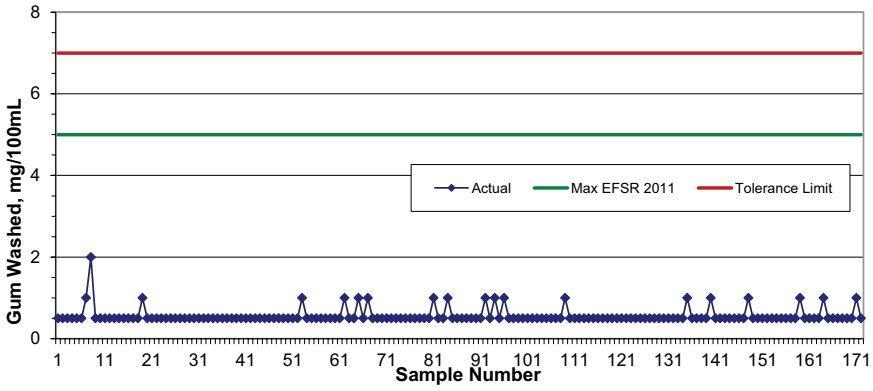
Existent Gum (solvent washed)

The threshold of the test method ASTM D381[20] prescribed in the Regulations is 0.5 mg/100mL. Accordingly, the lowest line of testing results as prescribed by this method is 0.5 mg/100mL where the actual figures were found to be on or below this indicative level at the specified maximum limit of 5 mg/100mL. The tolerance limit is 7.0 mg/100mL.

RON 91

For regular petrol, all 172 results were found to be within the maximum specification limit of 5 mg/100mL. (Fig. 13a).

Figure 13a: Test Results for Gum, RON 91, Year 2023-24

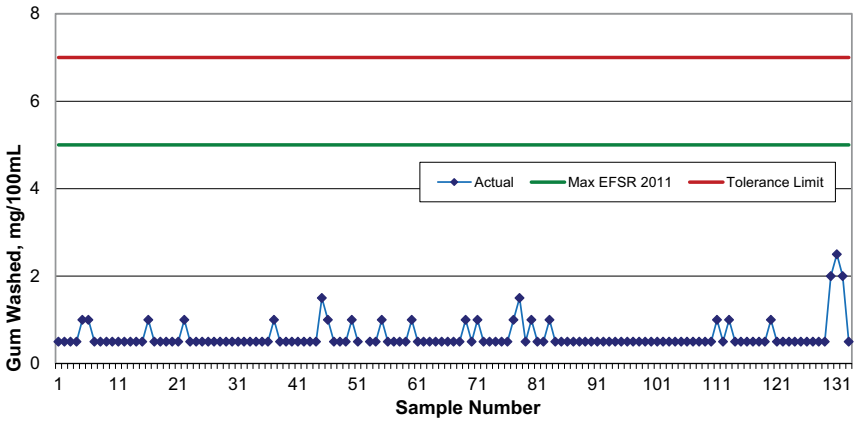


20 ASTM D381-19 *Standard Test Method for Gum Content in Fuels by Jet Evaporation*

RON 95

For premium petrol RON 95, all results were found to be within maximum specification limit as well (Fig. 13b).

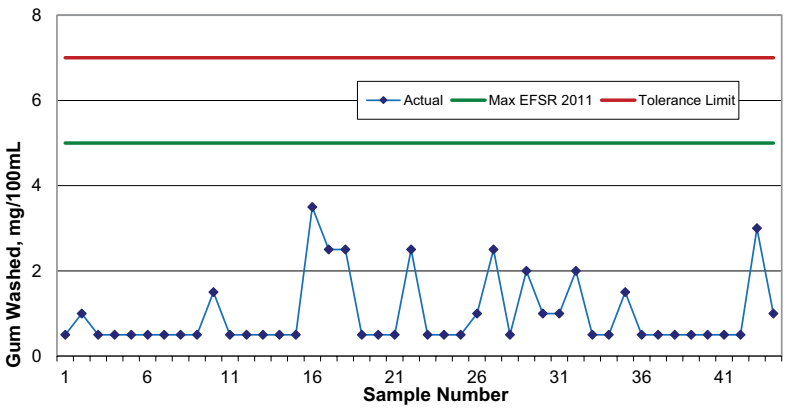
Figure 13b: Test Results for Gum, RON 95, Year 2023-24



RON 98 & ABOVE

For premium petrol RON 98 & above, all results were also found to be within maximum specification limit (Fig. 13c).

Figure 13c: Test Results for Gum, RON 98 & above, Year 2023-24



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 such contaminants 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[21]. For phosphorus, this is done by means of an initial identification of its presence on the threshold of resolution by the specified method[22]. These tests' results have not been included in this report as they were usually found to be below the threshold and within the specification limits.

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

Further, 23 samples of regular petrol and 25 samples of premium petrol were tested for copper strip corrosion[23] and 13 samples for oxidation stability[24]; all of them were found to be compliant.

5 samples of petrol with an advertised RON 100+ were tested this year. All results were found to be within the specifications of Schedule 1 in the Regulations.

SUMMARY OF PETROL TEST RESULTS

There was one instance when a petrol sample was found to be non-compliant with the Regulations.

All samples met the minimum specification limit of 95.0 for RON, except for two samples collected from the same site. When the sample was tested for RON, it was found to have a value of 93.5, which is below the minimum value of 95.0. A follow-up sample from a different pump at the same fuel station confirmed this result.

The two relevant MON results were also below the specified minimum limit; one was within the tolerance limit, and the other was non-compliant.

An investigation revealed a configuration error in a blending dispenser as the cause of the issue. The retail site complied with all instructions from Trading Standards. After the issue had been identified and resolved, the final sample set confirmed that the RON value was above the minimum limit of 95.0 through repeated testing.

In addition, 57 regular petrol samples and 55 premium petrol samples were tested for silver strip corrosion. This test helps to detect the presence of active sulphur. The results were acceptable, even though the Regulations have not specified the test method yet. The significance of this test was realised after the active sulphur contamination incident in 2017-18 (refer to the Report for the year 2018-19).

Inclusion of silver strip corrosion test for petrol into the Regulations is under consideration by the Ministry and stakeholders.

21 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)*
22 ASTM D3231–18 *Standard Test Method for Phosphorus in Gasoline*
23 ASTM D130-19 *Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test*
24 ASTM D525-12a (2019) *Standard Test Method for Oxidation Stability of Gasoline (Induction Period Method)*

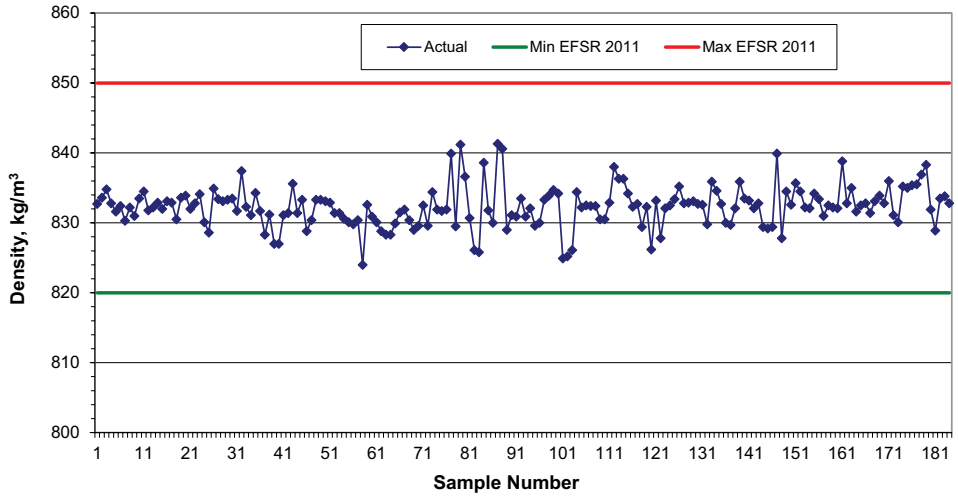
Diesel

Density

Density of diesel at 15°C can be tested according to ASTM D1298[25] or ASTM D4052[26] prescribed in the Regulations. Respectively, there are two pairs of tolerance limits identified using the two methods for the minimum limit of 820 kg/m^3 and for the maximum limit of 850 kg/m^3.

All 184 samples were found to be within the specification limits (Fig 14).

Figure 14: Test Results for Density, Diesel, Year 2023-24



25 ASTM D1298-17 *Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method*

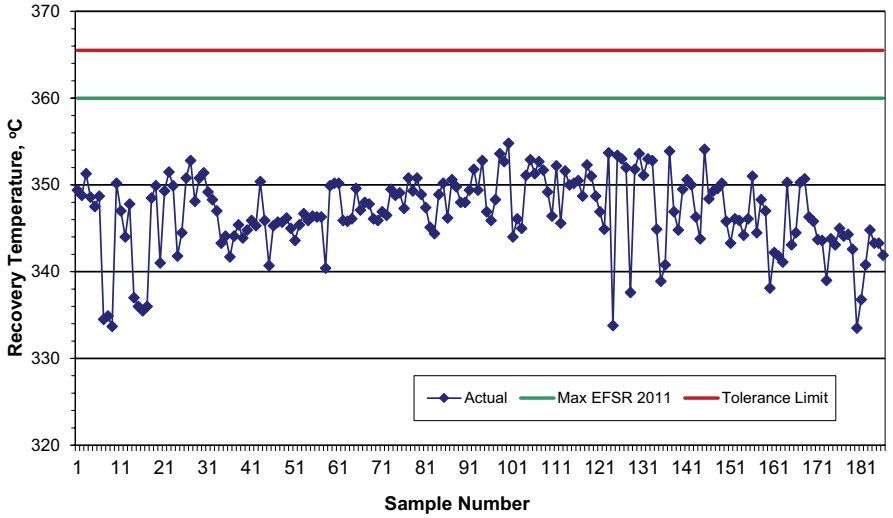
26 ASTM D4052-18a *Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter*

Distillation

The Distillation test means definition of temperature (°C) at which 95% volume recovered. The temperature should be tested by ASTM D86[27] prescribed in the Regulations.

All 186 samples were found to be below the specification maximum limit of 360°C for distillation at 95% volume recovered (T95) at the tolerance limit of 365.5°C. There is no prescribed minimum limit for this property.

Figure 15: Test Results for Distillation 95% Vol Recovered, Diesel, Year 2023-24



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[28]

The cetane index, according to ASTM D4737[29] 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.

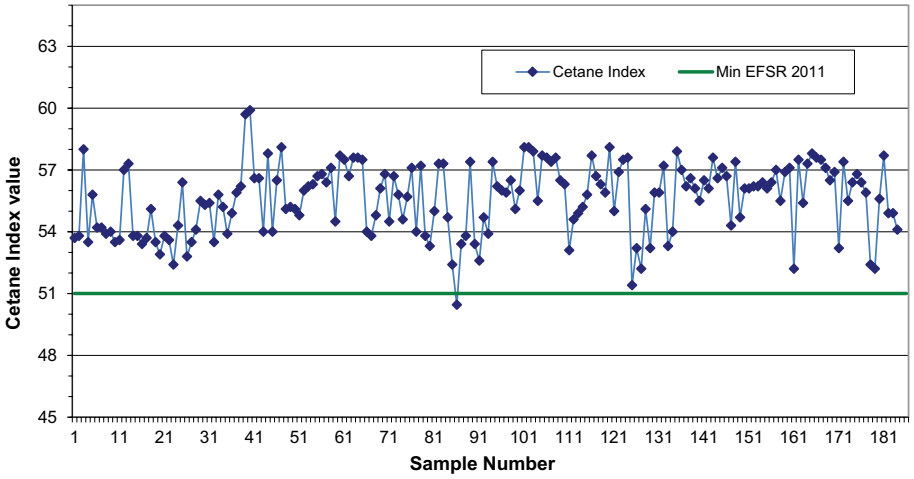
Since the reproducibility for cetane index is not defined in the ASTM D4737, it is impossible to exactly define a tolerance limit. However, the Standard specifies that 'the expected error of prediction of Procedure A will be less than ±2 cetane numbers for 65% of the distillate fuels evaluated'. On these grounds, an estimate for the tolerance limit would be derived as 50.2.

27 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure*
28 *Worldwide Fuel Charter.* 6th Ed., 2019, p.64
29 AASTM D4737-21 *Standard Method for Calculated Index by Four Variable Equation*

183 samples were found to be above the minimum specification limit of 51 (Fig.16).

One sample was found to be below the specification limit. The cetane index was found to be out of specification, with an average result (50.7 and 50.2) of 50.5, which falls within the estimated tolerance limit.

Figure 16: Test Results for Cetane Index, Diesel, Year 2023-24



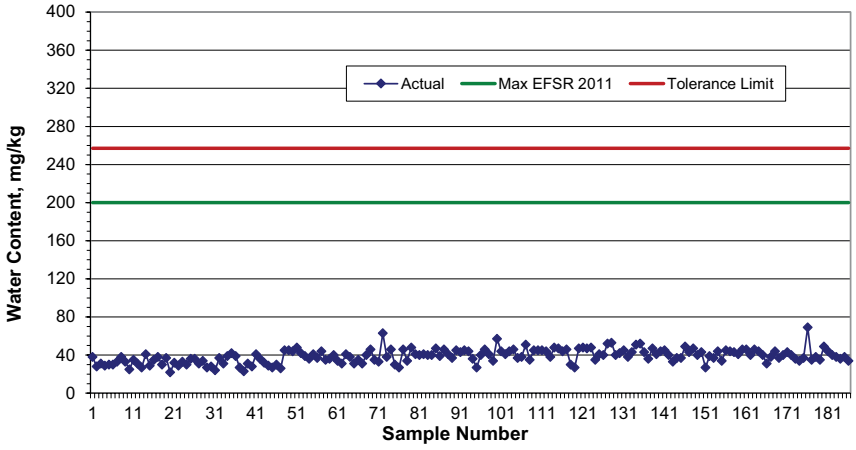
Water

The test for water content is done according to IP438[30] which determines the total water present in diesel sample held either in solution or in solution and free water.

Water is soluble to some extent in hydrocarbons. The amount of water that is held in solution will be dependent on the temperature and the composition of the hydrocarbon. At typical ambient temperatures in New Zealand the expected concentration of water dissolved in diesel, is around 30 to 40 mg/kg.

The water content in all the tested samples were found to be within the specification limit of 200 mg/kg at the tolerance limit of 257 mg/kg.

Figure 17: Test Results for Water in Diesel, Year 2023-24

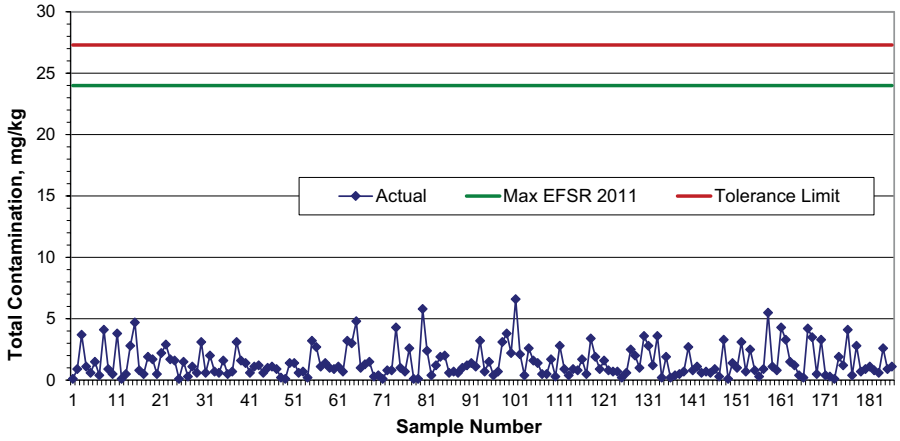


30 BS EN ISO 12937:1961, BS 1960-438:1961. *Petroleum products. Determination of content. Coulometric Karl Fischer titration method*

Total Contamination

All 186 samples were found to be below the maximum limit of 24 mg/kg specified in the Regulations (Fig. 18) with actual figures below 5 mg/kg. The tolerance limit for D6217[31] is 27.3 mg/kg.

Figure 18: Test Results for Total Contamination, Diesel, Year 2023-24

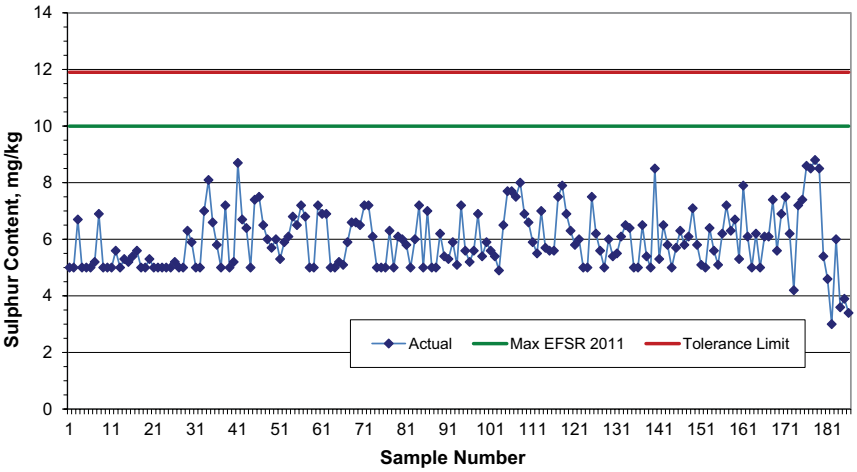


Sulphur

Sulphur content can be tested according to IP 497[32] or ASTM D5453[33] prescribed in the Regulations. Respectively, there are two slightly different tolerance limits identified for the two methods: 11.8 mg/kg for IP497:2019 and 11.9 mg/kg for D5453-19a (the latter is shown on Fig.19).

All the 186 samples tested were found to be below the maximum limit of 10 mg/kg specified in the Regulations (Fig. 19).

Figure 19: Test Results for Sulphur, Diesel, Year 2023-24



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

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

33 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'[34]. CP is tested according to ASTM D5773[35] prescribed in the Regulations.

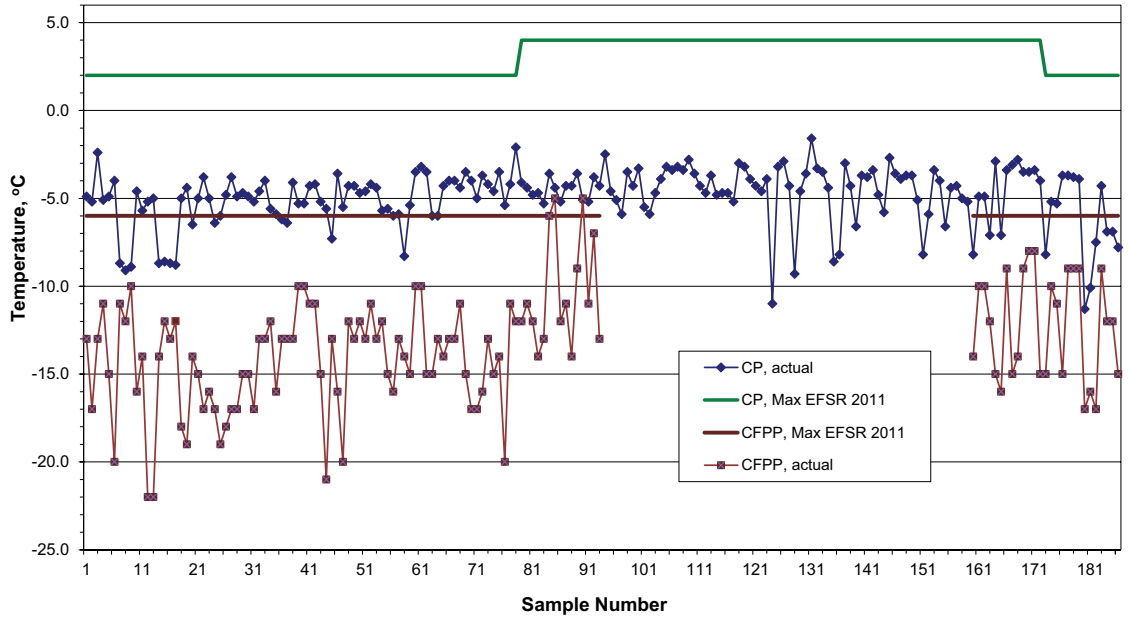
The cumulative results for CP are presented below by combining the lowest prescribed maximum limits for each season in one graph (Fig.20). Generally, results below the lowest maximum limit established for an area are complied with the Regulations in all other areas.

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 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 186 samples appeared 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 2023-24



34 *Worldwide Fuel Charter,* 6th Ed., 2019, p.81
35 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 should be tested according to IP 309[36] prescribed in the Regulations. The CFPP test was developed from vehicle operability data and demonstrates an acceptable correlation for fuels and vehicles in the market, if the delta between CFPP and CP is below 10°C[37]. CFPP is defined only for the winter season, from 15 April to 14 October inclusive, with the maximum limit of –6°C and the tolerance limit of –5°C.

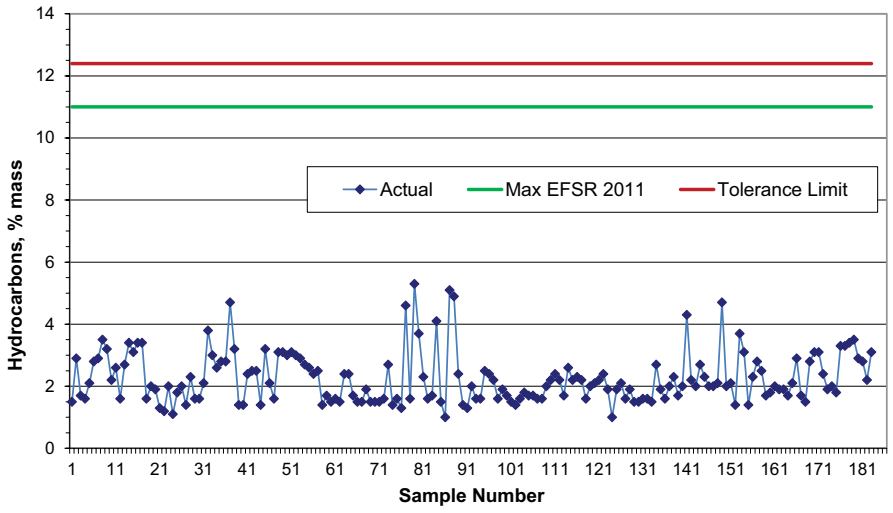
The test results for CFPP are set out on the same graph as that for CP (Fig.20). This gives an advantage to see the data 'at glance' and compare the two sets where necessary. All samples were found to be below the maximum limit specified in the Regulations. Two samples were reported above the maximum limit, but still within the tolerance limit.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons are tested by IP 391[38] prescribed in the Regulations.

All 186 tested samples were found to be below the maximum limit of 11% specified in the Regulations at the tolerance limit of 12.4%.

Figure 21: Test Results for Polycyclic Aromatic Hydrocarbons, Diesel, Year 2023-24



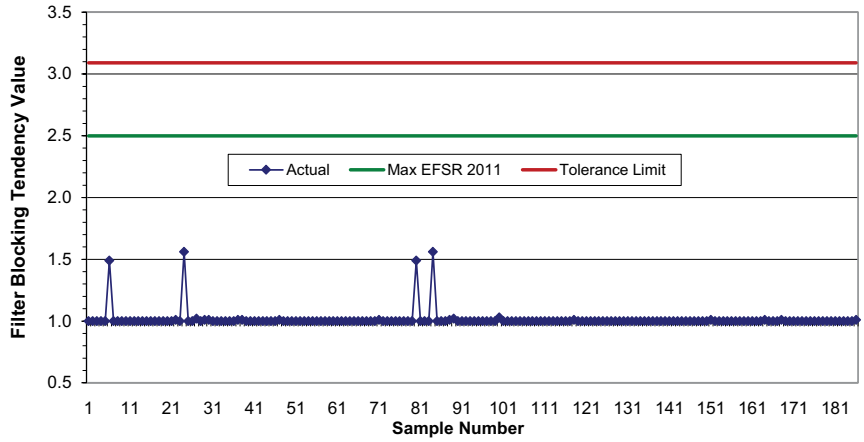
36 BS EN 116:2015, BS 1960-309:2015 *Diesel and domestic heating fuels. Determination of cold filter plugging point. Stepwise cooling bath method*
37 Worldwide Fuel Charter, 6th Ed., 2019, p.81
38 BS EN 12916:2019 *Petroleum products. Determination of aromatic hydrocarbon types in middle distillates. High performance liquid chromatography method with refractive index detection*

Filter Blocking Tendency

Filter blocking tendency can be tested by IP 387[39] or ASTM D2068[40] prescribed in the Regulations.

All 186 samples were found to be within the specified maximum limit of 2.5 for filter blocking tendency at the tolerance limit of 3.09.

Figure 22: Filter Blocking Tendency, Diesel, Year 2023-24



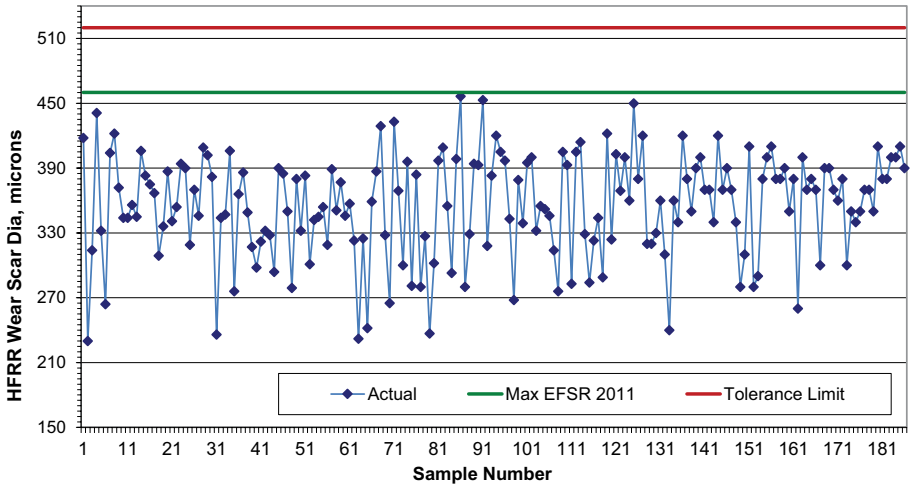
Lubricity

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 are tested by IP 450[41] prescribed in the Regulations.

The diameter is usually measured in microns: the specification maximum limit is 460 µm. The tolerance limit is 520 µm.

All 186 samples were found to be below the specification maximum limit for the lubricity.

Figure 23: Test Results for Lubricity, Diesel, Year 2023-24



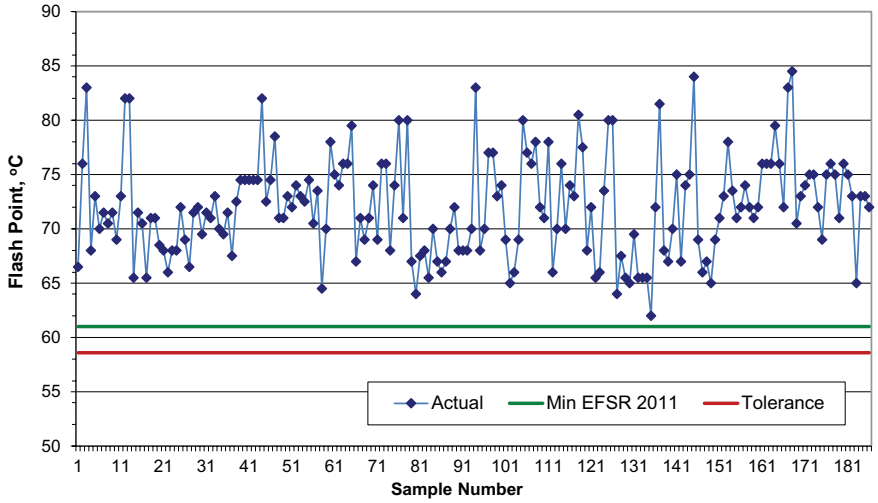
39 IP 387:2017 *Determination of filter blocking tendency*
40 ASTM D2068-20 *Standard Test Method for Determining Filter Blocking Tendency*
41 IP 450:2020 *Diesel fuel – Assessment of lubricity using the high-frequency reciprocating rig (HFRR) – Part 1: Test method (ISO 12156-1:2018); BS 2000-450:2000 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 by ASTM D93[42] prescribed in the Regulations.

All 186 samples were found to be above the specified minimum limit of 61°C for flash point of diesel (Fig 24).

Figure 24: Test Results for Flash Point, Diesel, Year 2023-24

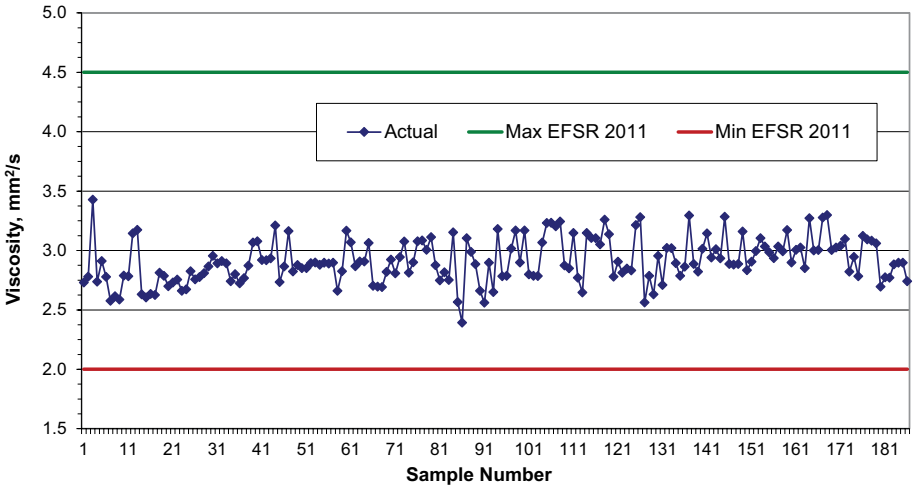


Viscosity

The viscosity is tested at 40°C by ASTM D445[43] prescribed in the Regulations.

All 186 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).

Figure 25: Test Results for Viscosity, Diesel, Year 2023-24



42 ASTM D93-20 *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*
43 ASTM D445-19a *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)*

Microbial Content

Microbial content is tested using IP 385[44], a laboratory method widely recognised internationally for measuring microbial content. Although this method is not explicitly stipulated in the Regulations, it is commonly accepted.

It should be noted that microbiological parameters present distinct challenges, and this test provides an indication of the level of contamination rather than a definitive result. It is important to recognise that the precision of microbiological analytical methods generally falls short of those used in the petroleum industry for analysing physical and chemical properties of fuels.

There are no universally recognised values which are deemed to indicate an acceptable level of microbiological content in fuels or associated water. The international guidelines[44] suggest numerical ranges and/or limit values for microbial content, widely applied for tank bottom or drain samples from storage and retail site tanks. Often the limit values are expressed as 'negligible/normal', 'moderate/ warning' and 'heavy/action' and used to trigger preventative action, remedial action and/or a more thorough investigation of a fuel system or facility, not intended as specification limit values due to its complexity. TS, in consultation with the industry, has previously adopted an approach of considering investigation in cases when microbiological content of more than 4,000 colony forming units per litre (CFU/L) is found. The factors which influence this decision include water content and appearance test results. Instances with total microbiological growth above 10,000 CFU/L are investigated further. TS is cautious and normally refers to a stringent numerical limit, as the samples tested are nozzle samples from delivery pumps.

The simplified guidelines developed by the Ministry for risk assessment based on the international guidelines

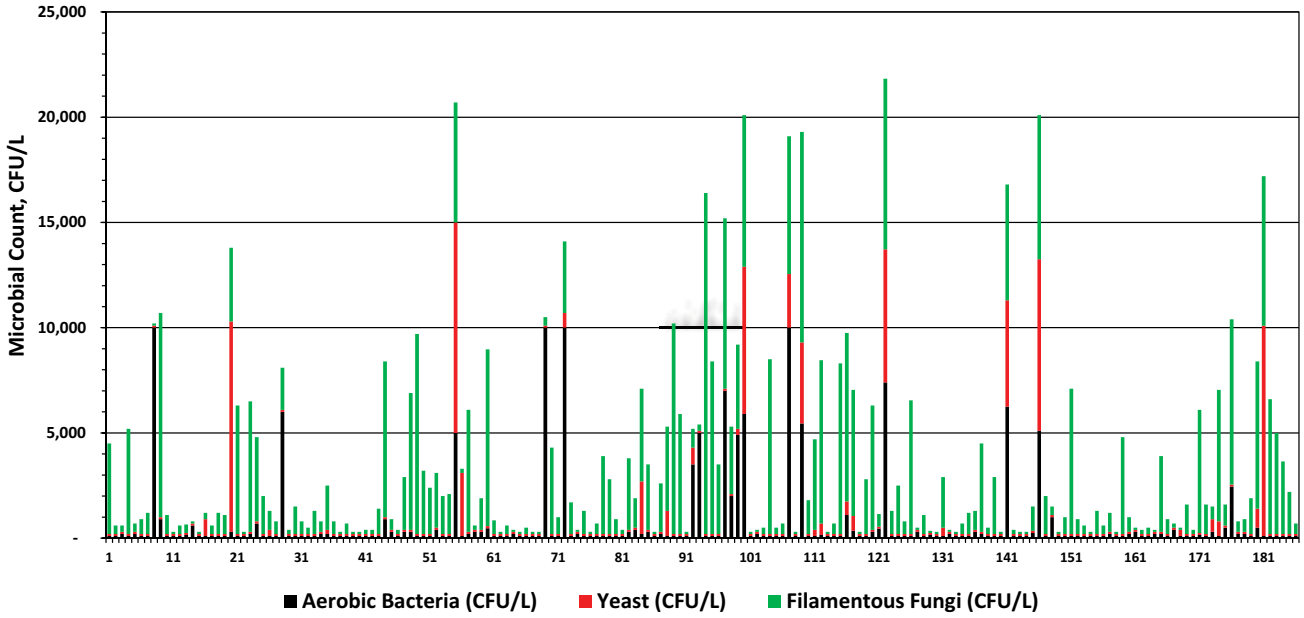
Category	Level of Microbial Growth (CFU/L)	Action
Category A	Below 4,000	Acceptable
Category B	4,000-10,000	Microbial proliferation may be occurring. If required, investigate by further sampling and testing.
Category C	Above 10,000	Operational problem and spread of contamination likely. Investigate thoroughly.

Based on the above guidelines, among the 186 sites tested for microbial contamination, several retail sites showed an exceedingly high microbial count. 133 samples were in the Category A, 36 samples were in Category B, and 17 samples were in the Category C.

It is important to note that microbiological test results alone should not be used to draw conclusions about the quality or fitness of fuel for common purposes. This is true even if the results fall under Category C, as outlined in the guidelines adopted by the Ministry.

44 IP 385:2019 (2020) *Determination of the viable aerobic microbial content of fuels and fuels components boiling below 390°C — Filtration and culture method*

Figure 26: Microbial Content, Diesel, Year 2023-24



It is acknowledged that microbial testing is a subjective test and that obtaining representative samples can be challenging[45].

Furthermore, when assessing whether diesel is fit for common purposes, TS rarely identified the impact of microbial content. However, TS still places a strong emphasis on monitoring microbial content as it serves as an indication of water presence in fuel. This poses potential risks to diesel engines and can have a direct or indirect impact on the fuel quality.

For more information on the microbial content, please refer to the microbial content section of the TS FQM Annual Report 2022-2023.

45 ASTM D6469 – 20 *Standard Guide for Microbial Contamination in Fuels and Fuel System*

SUMMARY OF DIESEL TEST RESULTS

There were no instances where a diesel sample would have been identified as noncompliant with the Regulations' requirements.

In one case, a diesel sample was deemed non-compliant with the Regulations due to a suspected issue with the cetane index falling below the required specification. However, upon further investigation, it was found that the cetane index was slightly outside the specified range but still within the estimated tolerance limit.

Further, 48 samples were tested for copper strip corrosion[46] and all of them were found to be compliant. Next, 32 samples were tested for carbon residue[47] and ash[48] and, finally, 28 samples were tested for oxidation stability[49]. All these tests returned the compliant results.

Testing of diesel for appearance according to the ASTM standard D4176[50], which is not listed in the Regulations, was continued to maintain confidence that water, and/or other contamination, if present, would be identified. Notably, the appearance test proved to be a valuable method during investigations in response to complaints and enquiries.

46 ASTM D130-19 *Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test*
47 BS EN ISO 10370:2014 *Petroleum products. Determination of carbon residue. Micro method*
48 ASTM D482-19 *Standard Test Method for Ash from Petroleum Products*
49 ASTM D2274-2014(2019) *Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)*
50 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

This year, 14 samples of premium petrol blended with ethanol and labelled as E10 were sampled from the retail sites. All samples were found to be compliant, including ethanol content, oxygen content, and dry vapour pressure. Results for content of ethanol blended in petrol were all found below the claimed 10%.

ETHANOL COMPONENT E100

Denatured ethanol E100, used to blend with petrol, was tested once from a storage terminal throughout the period covered in this report. Both the top and bottom samples were out of specification for Washed Gum content, with 6.0 mg/100mL and 6.5 mg/100mL, respectively. The maximum limit specified in the Regulations is 5.0 mg/100mL. After repeating the tests, the results were 6.0 mg/100mL and 5.5 mg/100mL. The average of the four results from the two series of tests was within the tolerance limit 6.5 mg/100mL.

ETHANOL BLENDED PETROL E85

This product is specified in the Schedule 1A of the Regulations since there are flexible-fuel vehicles on roads in New Zealand which can use E85. However, no E85 dispensers have been accessible to the public throughout the period covered by this report.

BIODIESEL B5 & B7

The B5 biodiesel falls into the category of diesel in the Regulations, with FAME (Fatty Acid Methyl Esters), *i.e.,* the main component of biodiesel according to Schedule 3, content up to 5%. The B7 biodiesel with FAME content up to 7% is permitted in New Zealand. TS is not aware of these products being sold in the market during the period covered in this report.

Lyttelton Harbour, New Zealand

Marine Fuels

Introduction

MARPOL ANNEX VI – A TIMELINE

Annex VI of the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL) came into effect in Aotearoa New Zealand on August 26, 2022. Prior to that, on May 26, 2022, Aotearoa New Zealand became a party to MARPOL Annex VI.

Under Annex VI, the International Maritime Organisation (IMO) has established a sulphur limit for fuel oil and requirements for fuel quality used on ships. This regulation significantly reduces the emission of sulphur oxides from ships and provides health and environmental benefits.

The Ministry and Maritime NZ collaborate in regulating the fuel quality aspects of MARPOL Annex VI to ensure compliance and promote information and education. The Ministry regulates marine fuel sold in Aotearoa New Zealand, while Maritime NZ regulates ship operators' obligations.

TS maintains a national register of local marine fuel suppliers that are categorised by port and fuel type[51] and regulated by the Programme. Currently, eight companies are registered as marine fuel suppliers in New Zealand.

51 https://fuelquality.tradingstandards.govt.nz/marine/register-of-marine-fuel-suppliers/

Properties to Test

There is no specific instruction in MARPOL Annex VI regarding which properties to test, except for sulphur content, which must not exceed 0.5% m/m. However, several properties mentioned throughout MARPOL Annex VI are specified in Schedule 5 of the EFSR 2011 and are considered critical. These properties include sulphur, density, viscosity, flash point, hydrogen sulphide, acid value, and cetane index for distillates or Calculated Carbon Aromaticity Index (CCAI) for residuals.

The two groups of marine fuel, distillate and residual, are defined in the Interpretation section of EFSR.

Furthermore, MARPOL Annex VI explicitly requires certain information to be included in Bunker Delivery Notes (BDN) of ships 400 GT and more:

- Density at 15°C (kg/m^3)
- Sulphur content (% m/m)
- declaration signed and certified by the fuel oil supplier's representative that the fuel oil supplied is in conformity with regulation 18.3 of the Annex VI[52].

Regulation 18.3 outlines desirable characteristics but does not provide specific test methods or properties to be verified. These requirements are based on ISO 8217[53], an international standard referenced in EFSR 2011 and widely accepted by the global shipping industry (the current report refers to the 2017 version, which was effective until May 30, 2024). Although not explicitly mentioned in MARPOL Annex VI, it refers to other documents such as Safety of Life at Sea (SOLAS) and Marine Environment Protection Committee (MEPC) circulars, which, in turn, refer to the ISO standard.

For a comprehensive analysis, TS periodically tests all the properties listed in Table 1 (for distillates) and Table 2 (for residuals) of ISO 8217.

Furthermore, there is an international Publicly Available Standard (PAS)[54], which aligns with the objectives of MARPOL Annex VI and includes a section on the Application of ISO 8217 to 0.50 mass% sulphur fuel. This standard provides specific considerations for monitoring the quality of marine fuel with a sulphur content of 0.50 mass%.

52 MARPOL Annex VI, Resolution MEPC.328(76) https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.328(76).pdf

53 ISO 8217:2024(E) *Products from petroleum, synthetic and renewable sources — Fuels (class F) — Specifications of marine fuels*

54 ISO/PAS 23263:2019 *Petroleum products — Fuels (class F) — Considerations for fuel suppliers and users regarding marine fuel quality in view of the implementation of maximum 0,50% sulfur in 2020*

Summary of Test Results

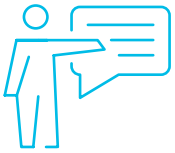
FUEL FROM AOTEAROA NEW ZEALAND SUPPLIERS

Distillate marine fuel is referred to as Marine Gas Oil (MGO) in this report and is described by a group of categories in Table 1 of ISO 8217. MGO was sampled from a number of fuel storage terminals nationwide and at the time of delivery of fuel to client ships (bunkering).

In total, 24 distillate samples were tested, in which 17 samples were tested according to the full list of properties in Table 1 as well as for microbial content. All samples were found to be compliant with the requirements of MARPOL Annex VI. In particular, the sulphur content was reported to be below 0.015% m/m, significantly lower than the 0.5% m/m stipulated in MARPOL Annex VI.

Residual marine fuel is referred to as Very Low Sulphur Fuel Oil (VLSFO) in this report and is described by a group of categories specified in Table 2 of ISO 8217. Currently, there is only one supplier of VLSFO in New Zealand which was sampled three times throughout the period of this report. Testing of properties were done in line with the specifications stipulated in ISO 8217. Samples were found to be compliant with the requirements of MARPOL Annex VI. In particular, the sulphur content was found to be 0.473% m/m, 0.451%m/m and 0.462% m/m.

Other properties were also found to be compliant with the requirements of regulation 18.3 of MARPOL Annex VI.



Deliveries were sampled by TS at the time of bunkering varieties of ships which included container ships, fish factory ships, cargo ships, vehicle carriers, passenger cruise ships, yachts, research vessels etc.

FUEL SAMPLED ONBOARD IN-USE

Samples of marine fuel oil available on-board ships that either belong to the NZ domestic fleet or arrive in NZ under flags of other nations were collected under Maritime NZ's instruction. Sampling was focused on fuel oil confined in ship compartments and carried for use on board that ship.

In total, 40 samples were collected from eleven ships. Of those 40 samples, 19 were MGO samples and the rest VLSFO. Three categories of VLSFO were identified according to Table 2 ISO 8217: RMD80, RMG180 and RMG380.

11 ships were sampled by Maritime NZ including container ships, tankers, vehicle carriers, bulk carriers, and passenger cruise ships.

All samples were found to be compliant with the requirements of MARPOL Annex VI.

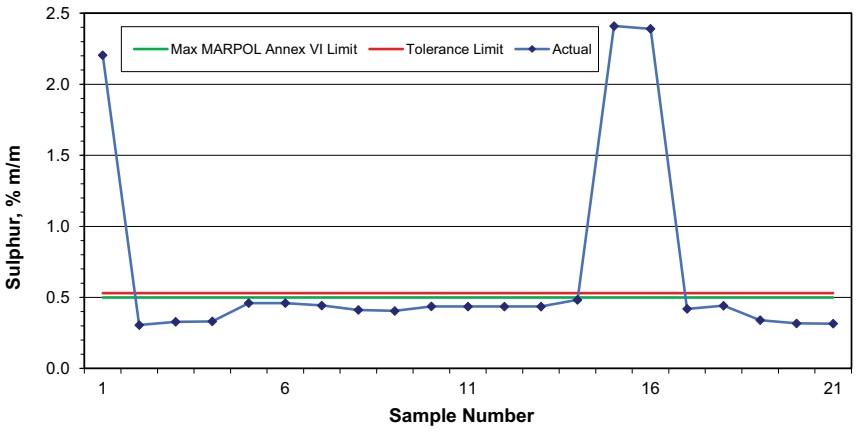
The sulphur content in VLSFO, as categorized in Table 2 of ISO 8217, was found to be compliant overall. However, there were three instances where the sulphur content exceeded the 0.5% mass limit, with results of 2.21% mass, 2.41% mass, and 2.39% mass from two different ships.

Both ships were equipped with Exhaust Gas Cleaning Systems (EGCS) certified to comply with the EGC Technical Manual Scheme B (ETM-B), which includes continuous emissions monitoring with parameter checks, as outlined in IMO Resolution.[55]

Further investigation revealed that the relevant BDNs stated sulphur contents of 2.41% mass and 2.47% mass, for these two ships, respectively. The supplied fuel has been certified for sulphur content not to exceed the specified limit of 3.5%, in accordance with regulation 4.1 of MARPOL Annex VI for ships equipped with EGCS. Furthermore, the fuel complies with regulation 18.3 of MARPOL Annex VI.

Fig. 27 The results of sulphur content testing in samples of residual fuel supplied in New Zealand as well as that collected from ships' compartments as on board in-use fuel.

Figure 27: Test Results for Sulphur, MARPOL Annex VI, Year 2023-24



ADDITIONAL RESULTS FOR BOTH SUPPLY AND SHIP SIDE SAMPLES

Water Content

According to ISO 8217, residual fuel has a maximum limit of 0.5% vol for water. Among residual fuel samples, three results were found to be above the limit with actual figures of 14.9%, 3.7%, and 5.4%.

Microbial Content

MGO samples were also tested for microbial content. Ten samples were found to be in Category C (refer to Diesel Microbial Content section of the report) which was confirmed by comparative testing in a separate laboratory. Notably, most samples with the high microbial content were collected from ship compartments: eight from on board in-use and only two from New Zealand suppliers.

55 IMO Resolution MEPC.259 (68) 2015 Guidelines for the Approval and Survey of Exhaust Gas Cleaning Systems

Overlooking Central Business District, Auckland

Appendix

A Brief Glossary and Abbreviations

ASTM	American Society for Testing and Materials
BS EN	British Standard European Norm
B100	Biodiesel according to Schedule 3 of the Regulations
Bunkering	The transfer of fuel from land-based or floating facilities into ships' permanent tanks or connection of portable tanks to the fuel supply system.
CEN	Comité Européen de Normalisation (*French for:* European Committee for Standardization).
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.
Cetane	A measure of the compression ignition behaviour of a diesel fuel; higher cetane levels enable quicker ignition.
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'.
Engine fuel	Any gaseous or liquid fuel that can be used as a fuel for engines, and includes biofuel, diesel, petrol (which is called motor spirit in the Excise and Excise-equivalent Duties Table (as defined in section 5(1) of the Customs and Excise Act 2018)), synthetic fuel, and blends of these.
Exhaust Gas Cleaning System (EGCS)	An EGCS, or exhaust scrubber, is type of machinery that removes particulate matter and harmful emissions, such as SOx, from exhaust gases. Washwater from an open loop exhaust scrubber may be discharged into the sea where this is allowable. Residue from a closed loop exhaust scrubber must be stored on board until it can be disposed of via port reception facilities on land. A hybrid exhaust scrubber can be switched from open to closed loop mode. Washwater or residue must be discharged or disposed of according to the hybrid scrubber mode used.
E85	Fuel ethanol *i.e.,* a blend of petrol and ethanol, containing not less than 70% and not more than 85% ethanol by volume.
FAME	Fatty acid methyl esters, *i.e.,* the main component of biodiesel according to Schedule 3 of the Regulations.
FQMS	Fuel Quality Monitoring Systems

Gross tonnage (GT)	The gross tonnage calculated in accordance with the tonnage measurement regulations contained in Annex I to the International Convention on Tonnage Measurements of Ships, 1969, or any successor Convention.
In-use sample	A sample of fuel oil in use on a ship.
IP	Institute of Petroleum, UK
ISO	International Organization for Standardization (a common short name not an acronym.
Marine fuel oil	Any fuel delivered to and intended for combustion purposes for propulsion or operation on board a ship, including gas, distillate, and residual fuels.
MARPOL	The International Convention for the Prevention of Pollution from Ships, 1973. MARPOL is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes.
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.
On board sample	A sample of fuel oil intended to be used or carried for use on board that ship.
UST	Underground Storage Tank