TRADING STANDARDS

Fuel Quality Monitoring Programme

Test Results 2022–23

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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Executive Summary

The purpose of this report is to provide an overview of the sampling and testing results of the Fuel Quality Monitoring Programme (the Programme) from 1 July 2022 to 30 June 2023.

This technical report is intended to provide valuable information to stakeholders and researchers in the fuel industry. It does not provide policy advice, solutions, or recommendations.

The Fuel Quality Monitoring 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 Aotearoa New Zealand and monitoring its compliance with the Engine Fuel Specifications Regulations (**the Regulations or EFSR**). The Regulations made in 2011 and amended on 2 October 2017 and then on 26 August 2022 are currently in force.

The Programme's primary focus is to monitor the quality of the fuel sold nationwide by the 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, and biofuels such as biodiesel and ethanol.

Additionally, since August 2022, the Programme also includes reporting on the quality of marine fuel, as Maritime New Zealand (Maritime NZ) and TS are operating a joint programme to monitor marine fuel quality. This fulfills some of New Zealand's obligations after acceding to Annex VI of the International Maritime Organization Convention for the Prevention of Pollution from Ships (MARPOL) in 2022. For the first time, this report includes a section on marine fuel that provides additional information and discussion.

The Programme collects samples of automotive fuel 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. It complements the sampling and testing the fuel industry carries out throughout the manufacturing and supply processes. It provides confidence to consumers and all stakeholders around the quality of petrol, diesel and marine fuels.

During the reported period, 747 fuel samples were collected from approximately 1,300 fuel service stations, commercial sites and storage terminals and from ships throughout Aotearoa New Zealand. These include 515 routine samples and 173 ad-hoc samples taken in response to complaints and enquiries, biofuels, and 59 marine fuel samples. A few 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	223
Routine Samples Tested	515
Ad-hoc Samples Tested	173
Marine Samples Tested	59
Total Fuel Samples Tested	747

Fuel Type	Number of Samples included in this report	Number of Samples not reported
RON 91	207	12
RON 95	176	5
RON 98 and above	47	2
Diesel	216	17
Ethanol 100	6	0
MGO	27	1
VLSFO	26	5
Total	**705**	**42**

Based on the thorough analysis of the samples and tests conducted during the covered period, it is confirmed that the engine fuel sold in Aotearoa New Zealand met the specified regulations and was of good quality.

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

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

Introduction

The Ministry of Business, Innovation and Employment (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 Aotearoa New Zealand for all.

Trading Standards (TS), a business unit under the Market Integrity branch of MBIE, maintains and administers the Fuel Quality Monitoring Programme, ensuring that consumers of Aotearoa New Zealand have access to fuel of the highest quality. This Programme monitors the quality of automotive and marine fuel in Aotearoa 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 Aotearoa New Zealand on international standards committees relating to fuel quality.

The Programme is primarily funded by a portion of the *Petroleum or Engine Fuel Monitoring Levy (PEFML)*, which is provided in compliance with the Energy (Petrol, Engine Fuel, and Gas) Levy Regulations 2017[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. Throughout the period of this report, marine fuel sampling and testing were funded by PEFML and Crown-funding with the expectation from the Government that this portion would be funded by Maritime Levies.

The primary objective of the Programme is to verify the standard of fuels that are being sold to retail consumers by directly collecting samples from dispenser nozzles at the point of sale. To ensure that 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.

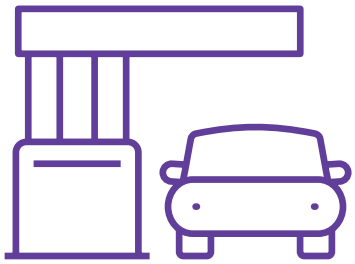
1 http://www.tradingstandards.govt.nz
2 https://www.legislation.govt.nz/regulation/public/2017/0147/latest/whole.html#DLM7296652

The key principles and structure of the automotive fuel component 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]

TS oversaw the collection of fuel samples during this period. An accredited laboratory tested the samples, and TS subsequently analysed the results. If any non-compliance or abnormalities were detected during testing, TS conducted further analysis and investigation. The main goal of these investigations are to confirm the accuracy of the results, identify any potential issues, and take appropriate action if necessary. Additionally, efforts were focused on understanding and addressing the underlying cause of any non-compliance to prevent future occurrences.

The samples were collected from 11 regions across the country serviced by specific fuel supply terminals, as listed in the table below. The sampling criteria were supported by a statistical model that took into consideration the location and market share of each retail fuel outlet.

A total of 223 sets of samples were collected from various retail sites. 164 sites were sampled based on the statistical model, the rest of the sites were sampled in response to various reasons e.g., complaints, projects, etc. which in total accounted for more than 17% of the retail sites in Aotearoa New Zealand.



17%
Retail sites sampled for monitoring

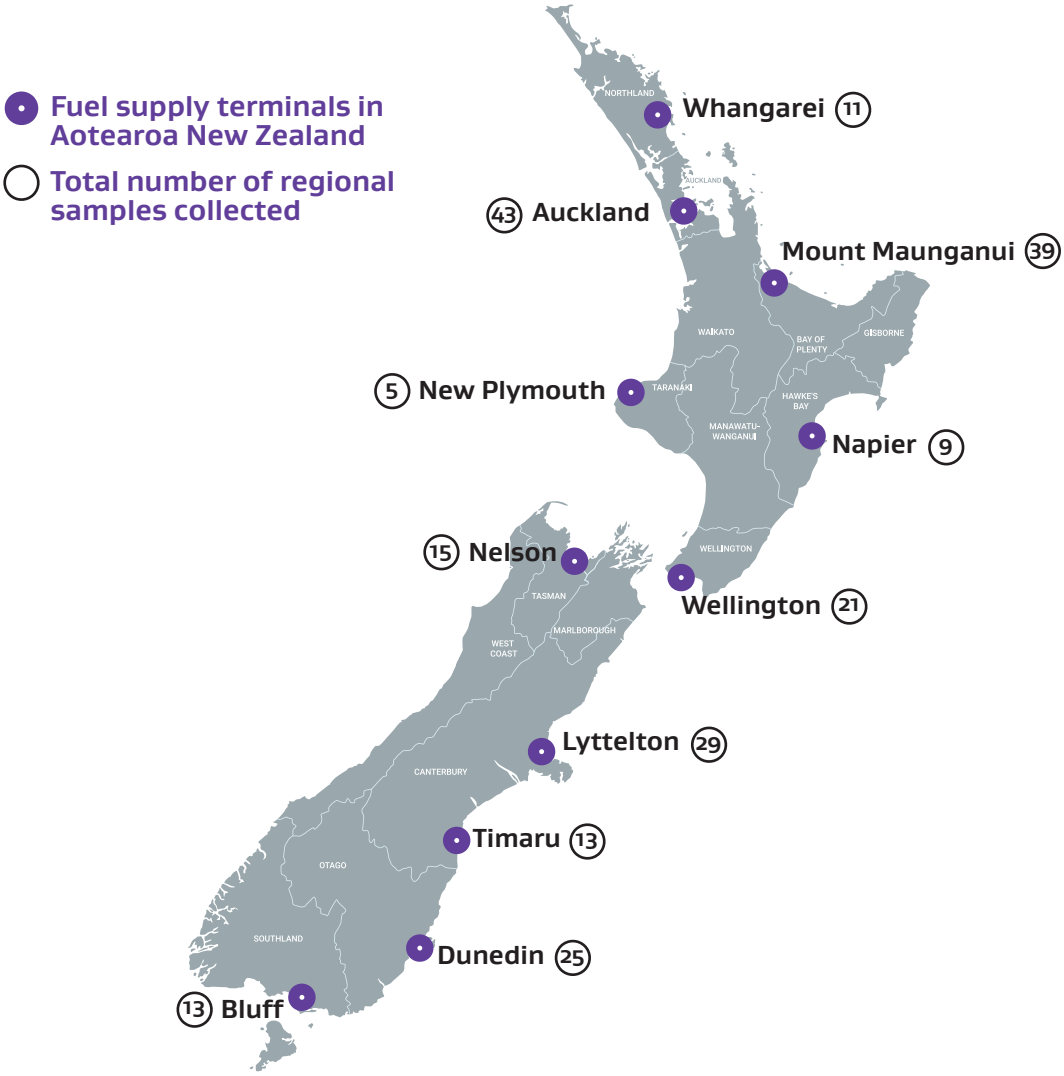
12.6%
Retail sites sampled based on a statistical model

Most of the sets contained regular petrol, premium-grade petrol, and diesel samples. At some sites, premium petrol was not available during sample collector visits. However, on certain occasions, four samples were collected from a single site, including two samples for premium petrol with RON 95 and RON 98 or higher.

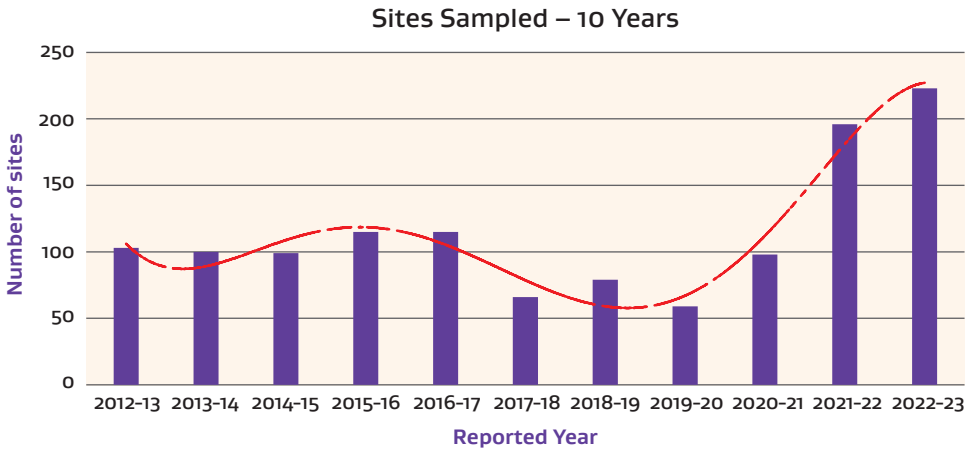
The regional distribution of fuel 'sample sets' is shown in the table below:

Terminal/Month	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	Total
Whangarei	0	1	0	2	0	1	1	0	1	4	0	1	11
Auckland	3	4	5	3	2	1	4	8	5	3	2	3	43
Mt Maunganui	4	7	2	4	5	3	3	2	4	0	3	2	39
New Plymouth	0	0	1	1	0	1	0	2	0	0	0	0	5
Napier	3	1	0	0	0	1	0	0	2	0	1	1	9
Wellington	0	1	1	4	2	2	1	2	1	2	3	2	21
Nelson	2	0	2	1	1	1	2	1	1	2	1	1	15
Lyttelton	4	1	4	1	1	1	1	2	2	3	5	4	29
Timaru	2	1	1	0	3	0	0	1	0	1	3	1	13
Dunedin	2	2	1	3	2	2	0	3	3	2	2	3	25
Bluff	0	1	1	2	1	0	2	0	2	2	2	0	13
TOTAL	20	19	18	21	17	13	14	21	21	19	22	18	223

3 http://fuelquality.tradingstandards.govt.nz/about-us/fuel-quality-monitoring-annual-reports/



In recent years, TS has significantly increased the number of sites being sampled for monitoring. During the period of 2012-2021 an average of 92 sites were sampled yearly, but during the period of 2021-23, the number of sites significantly increased with the highest number of sites, 223, being sampled in 2022-23.



A few additional tests were included in the regular list of tests conducted as with previous years. These included a test on silver strip corrosion in petrol, and tests on microbial content and appearance for diesel. The latter test was added to the routine list of tests for diesel properties to evaluate the quantity and nature of water and other contaminants that can be visually assessed.

While microbial content and appearance for diesel are not specified in the Regulations, TS places a strong emphasis on monitoring them as they pose potential risks to diesel engines. It is acknowledged that microbial content in fuel is a contentious issue (see Microbial Content section).

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 fuel supply companies to ensure that they maintain 'best practice' and follow proper procedures as specified in their quality management systems to ensure that quality is maintained 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. Otherwise, the system would require taking into account specifically elevated risks, particular sources of possible non-compliance and/or unique circumstances which would distinct some areas as more prone to appear out of specification.

The results of subsequent testing of fuel samples have been reported in accordance with their relevant specification limits set out in the Regulations. In accordance with the provisions of ISO Standard 4259[4], there are tolerances set out under the testing regime which allow for results to fall slightly outside the specified limits.

Marine fuel sampling and testing was included in the programme for the first time this year jointly run by TS and Maritime NZ. Samples of fuel sold in and used on ships arriving in Aotearoa New Zealand were tested for sulphur content and a number of other quality related parameters.

CONCLUSION

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

In this report, in-line with prior editions, sample sources remain anonymous, due to the commercially sensitive nature of this information.

4 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*

Petrol

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

Octane rating or grade is a measure of the fuel's ability to resist auto-ignition, which can cause objectionable engine noise (*i.e.,* knock) and, in severe cases, engine damage. Importantly, octane rating also affects engine efficiency and emissions and constrains engine design. These issues make octane rating among the most important properties of gasoline. Achieving proper engine operation, good fuel efficiency and reduced emissions requires the use of fuel with the octane rating recommended in the vehicle owner's manual.[5]

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.

RON 91

In total, 207 samples of regular petrol were collected, all of these were tested for RON and were within minimum specification limit 91. Sample 75 was found to be on the specification limit for RON.

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

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.

5 *Worldwide Fuel Charter,* Gasoline and Diesel 6th Ed., 2019, p.14.
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.*

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

Figure 1a: Test Results for RON, RON 91, Year 2022-23

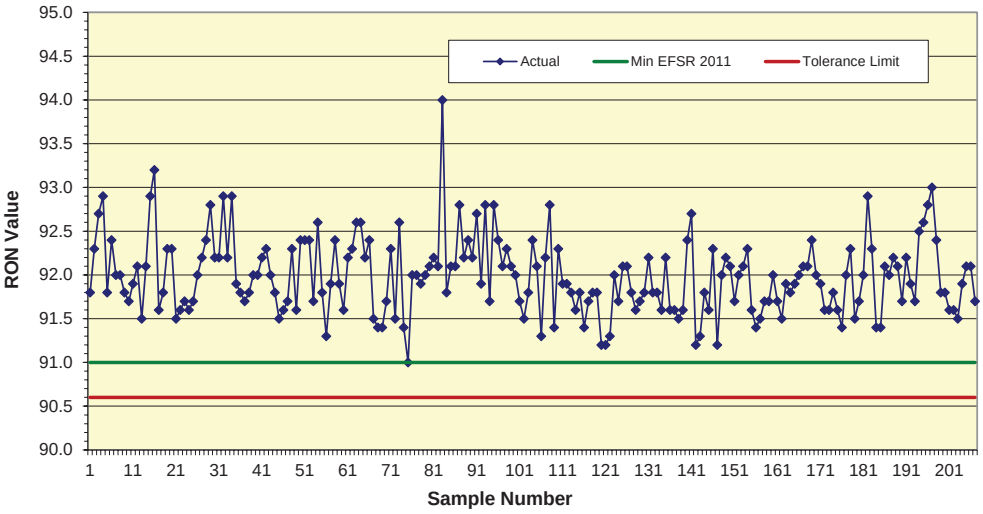
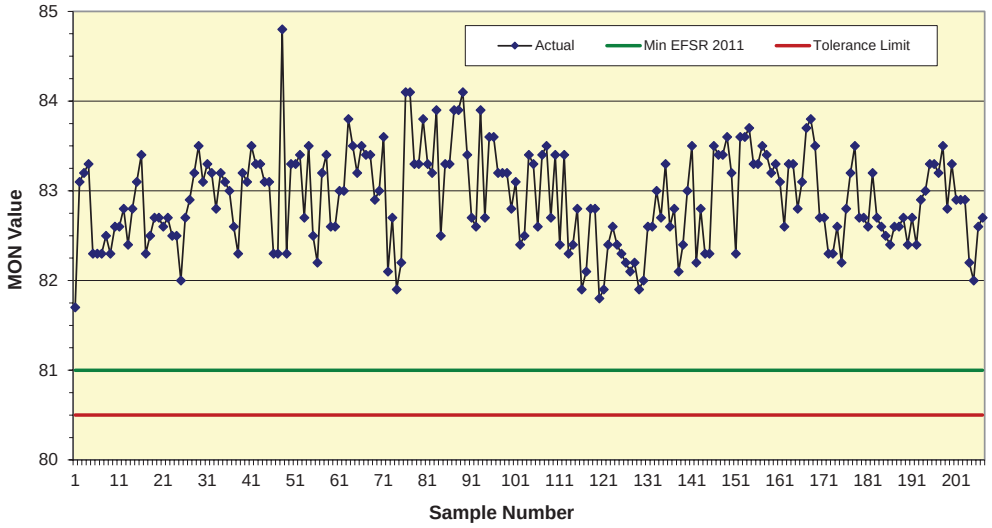


Figure 1b: Test Results for MON, RON 91, Year 2022-23



RON 95

In total, 176 samples of premium grade petrol were tested for RON 95. All samples met the minimum specification limit of 95.0 for RON. The same number of samples of petrol with RON 95 were tested for MON.

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

Figure 2a: Test Results for RON, RON 95, Year 2022-23

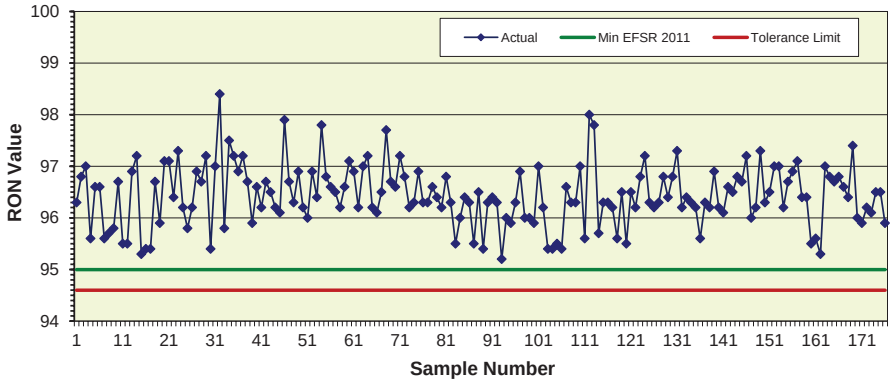
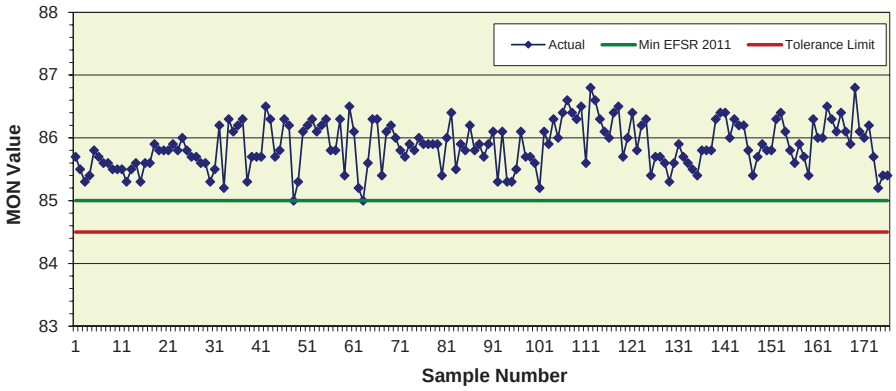


Figure 2b: Test Results for MON, RON 95, Year 2022-23



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, 47 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 at the advertised minimum limit or higher.

No minimum MON is specified for premium petrol with RON above 95. All samples were found to have MON above the specification 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 shown in the graph for RON.

Figure 3a: Test Results for RON, RON 98 & above, Year 2022-23

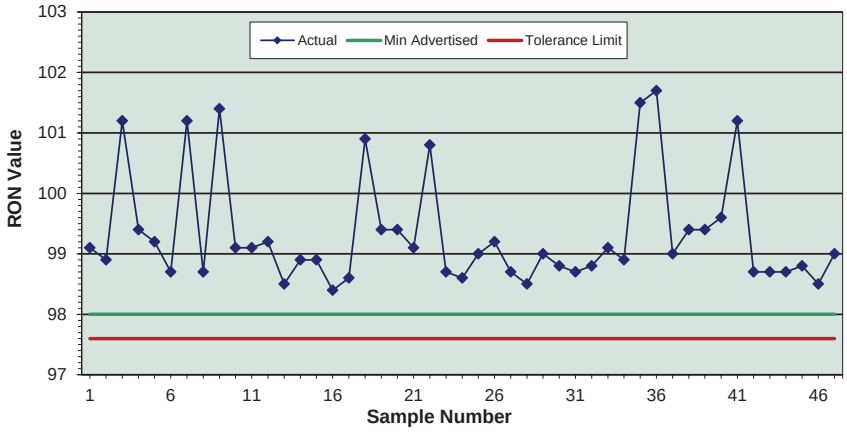
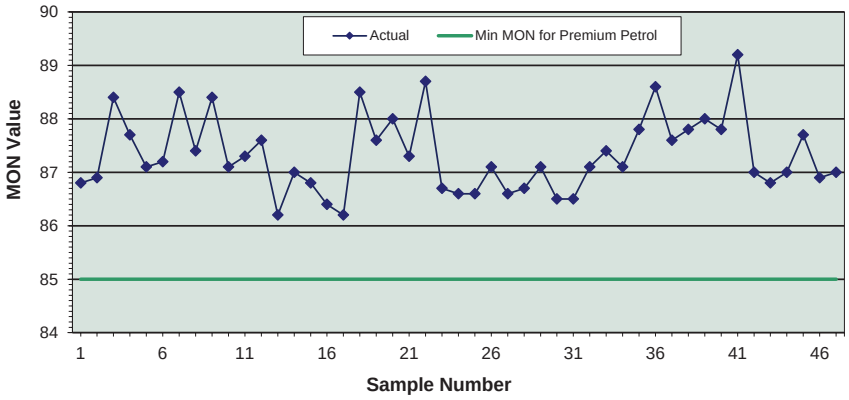


Figure 3b: Test Results for MON, RON 98 & above, Year 2022-23



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 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).

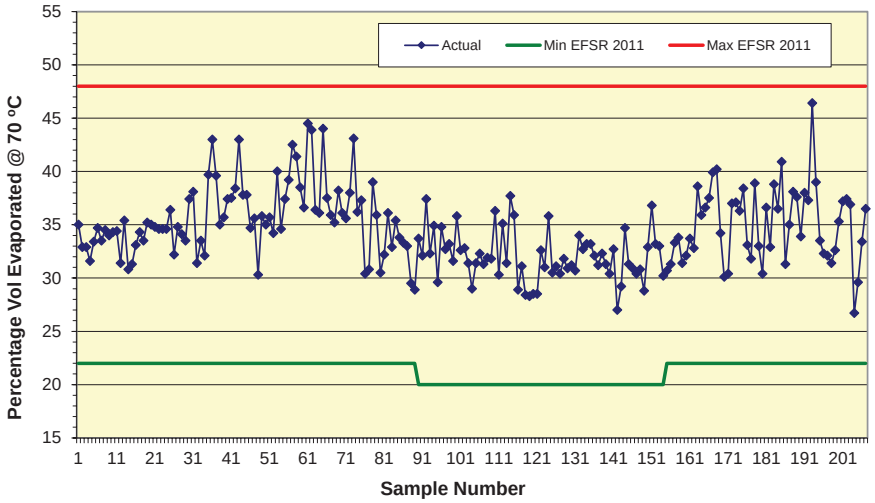
RON 91

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 207 samples were found to be within the prescribed specification limits above the minimum limit of 22% during 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 2022-23



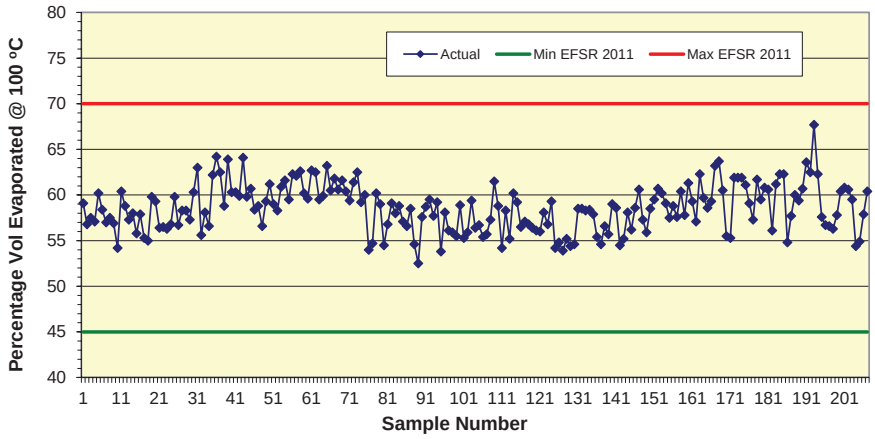
8 ASTM D86-20b *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure.*

Percentage Volume Evaporated at 100°C

All 207 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).

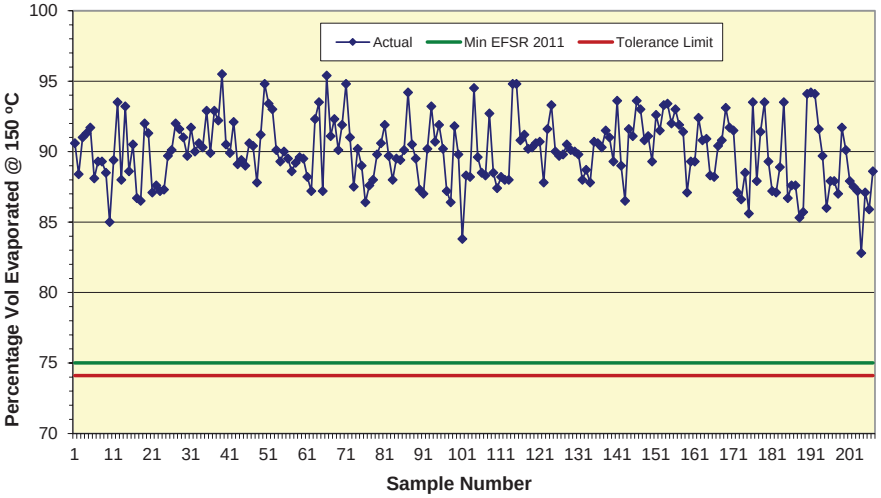
Figure 4b: Test Results for E100, RON 91, Year 2022-23



Percentage Volume Evaporated at 150°C

All 207 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 2022-23



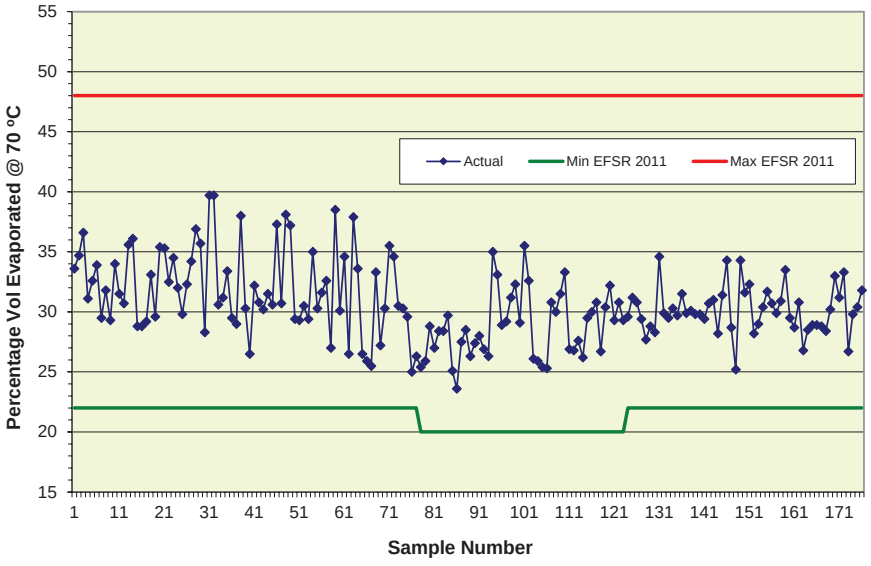
RON 95

Percentage Volume Evaporated at 70°C

For premium petrol not containing ethanol, as in 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 176 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 2022-23

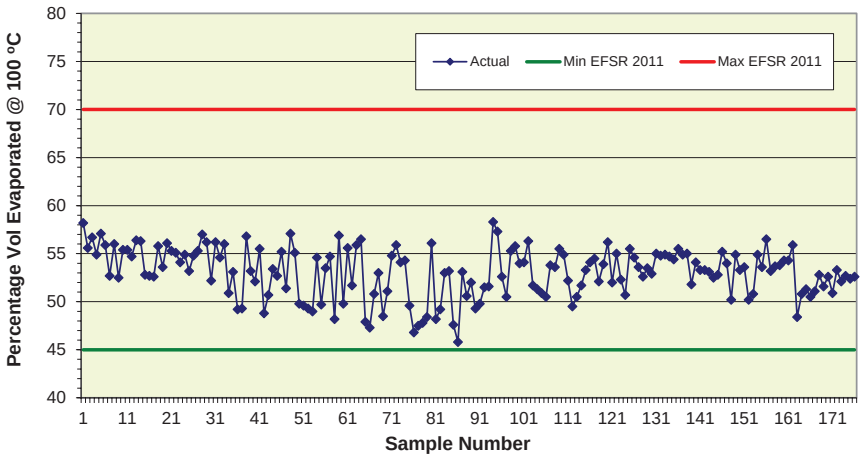


Percentage Volume Evaporated at 100°C

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

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

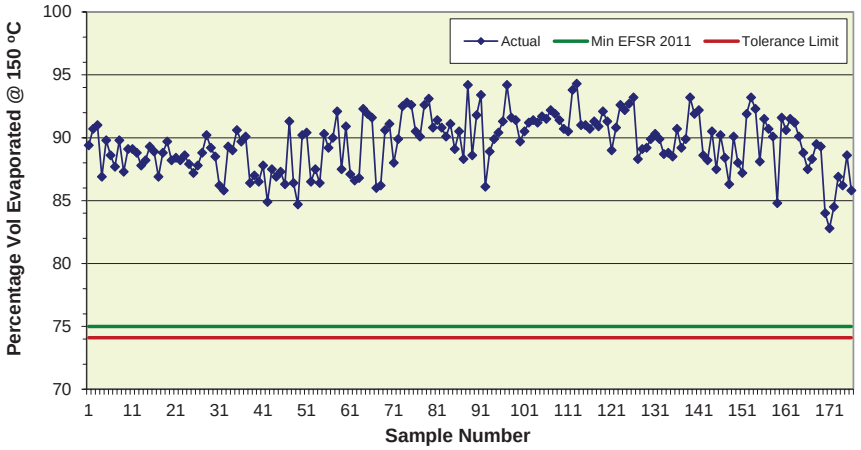
Figure 5b: Test Results for E100, RON 95, Year 2022-23



Percentage Volume Evaporated at 150°C

All samples were found to be above the minimum specification limit of 75% (Fig. 5c). As in 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 2022-23



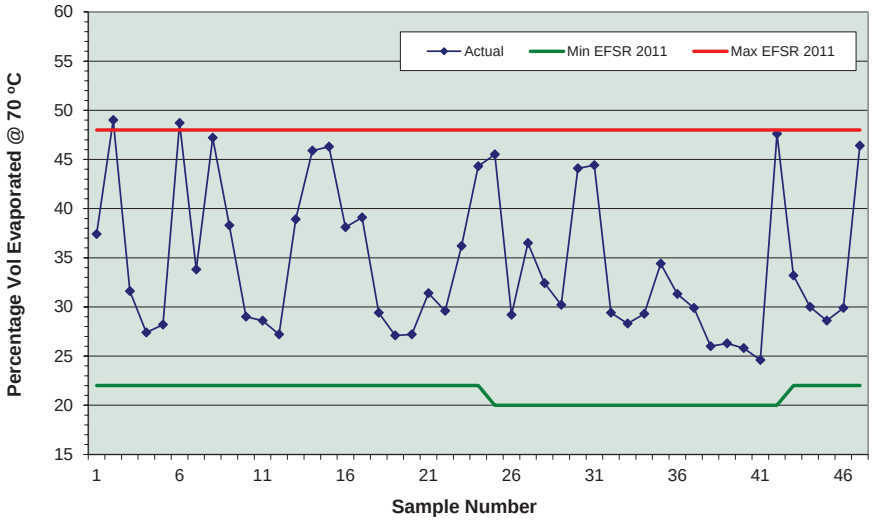
RON 98 & ABOVE

Percentage Volume Evaporated at 70°C

For premium petrol not containing ethanol, as in 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 two 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 samples 2 and 6 were 49% and 48.7% with ethanol content, respectively, were 9.18% to 9.01%.

Figure 6a: Test Results for E70, RON 98 & above, Year 2022-23

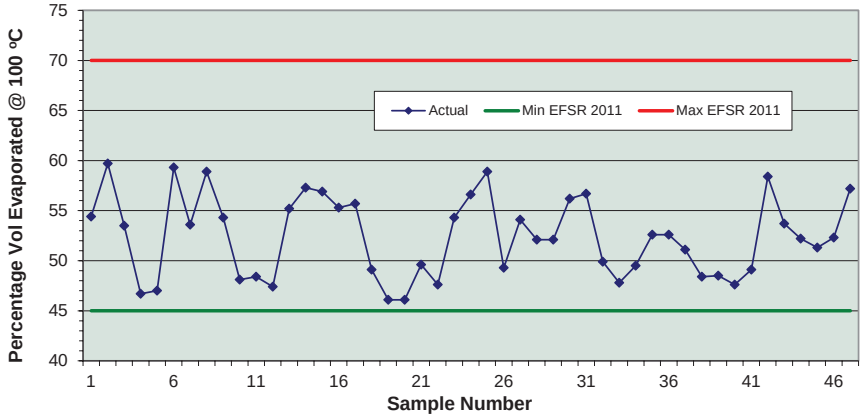


Percentage Volume Evaporated at 100°C

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

As in 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 2022-23

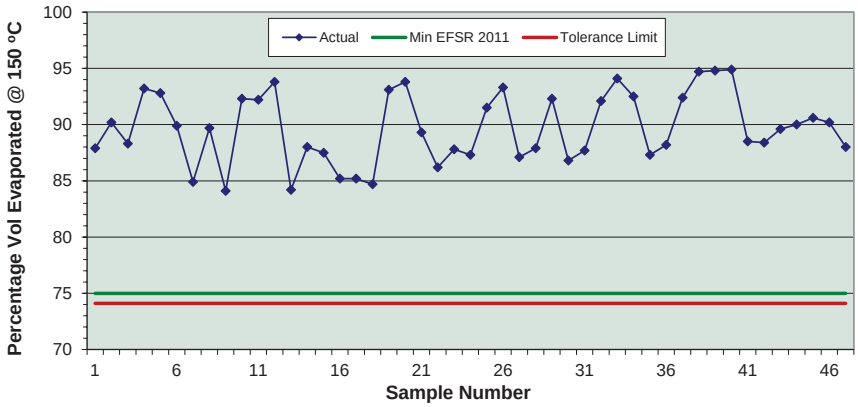


Percentage Volume Evaporated at 150°C

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

As in 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 2022-23



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 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 2022-23

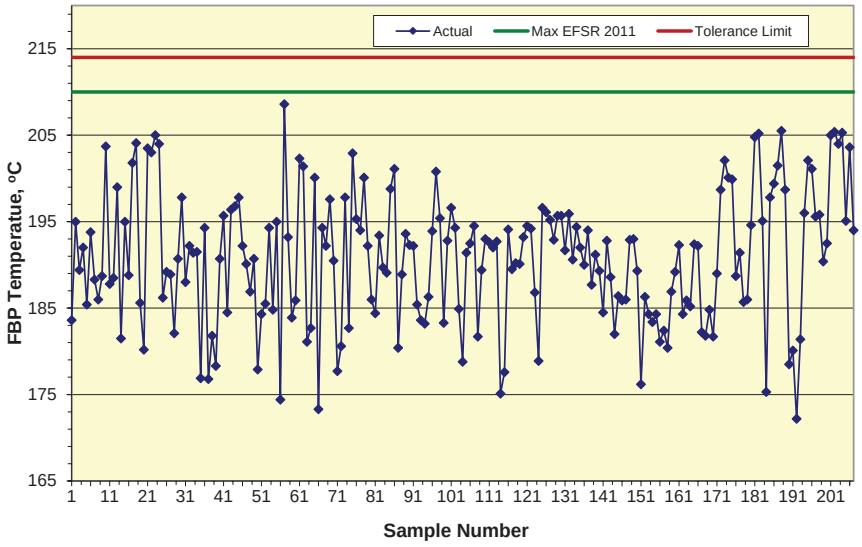
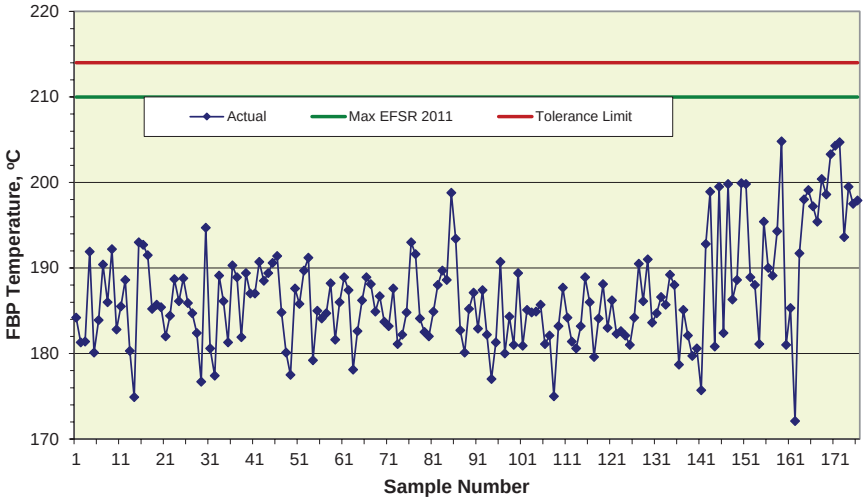
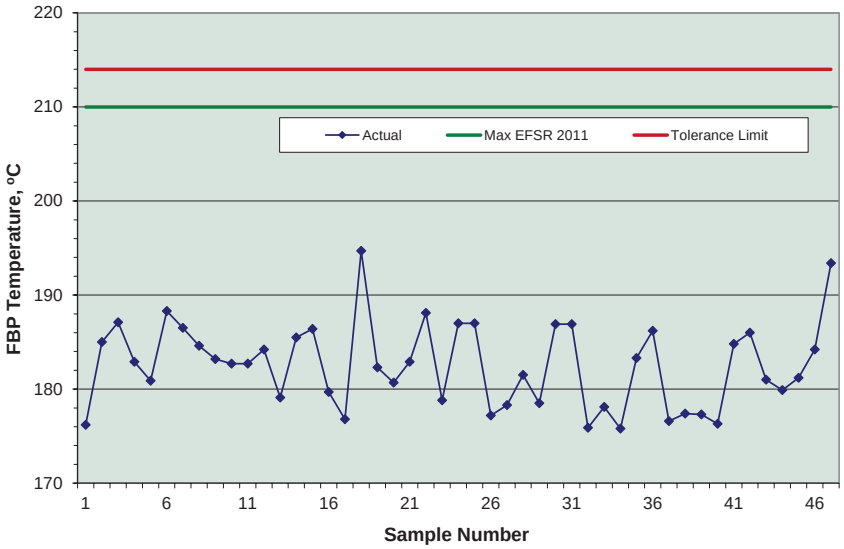


Figure 7b: Test Results for Final Boiling Point, RON 95, Year 2022-23



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 2022-23



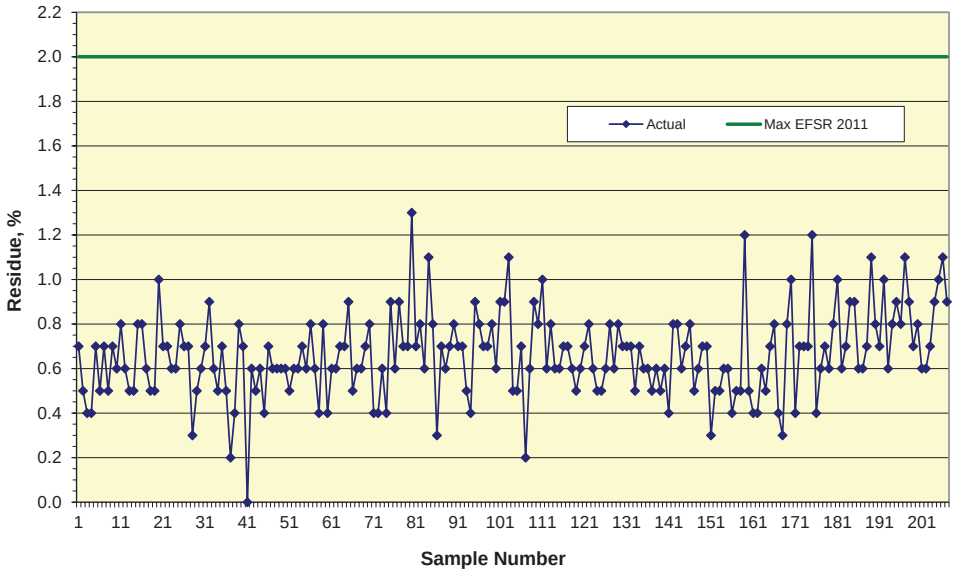
Residue

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 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 1.3%.

Figure 8a: Test Results for Residue, RON 91, Year 2022-23



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

Figure 8b: Test Results for Residue, RON 95, Year 2022-23

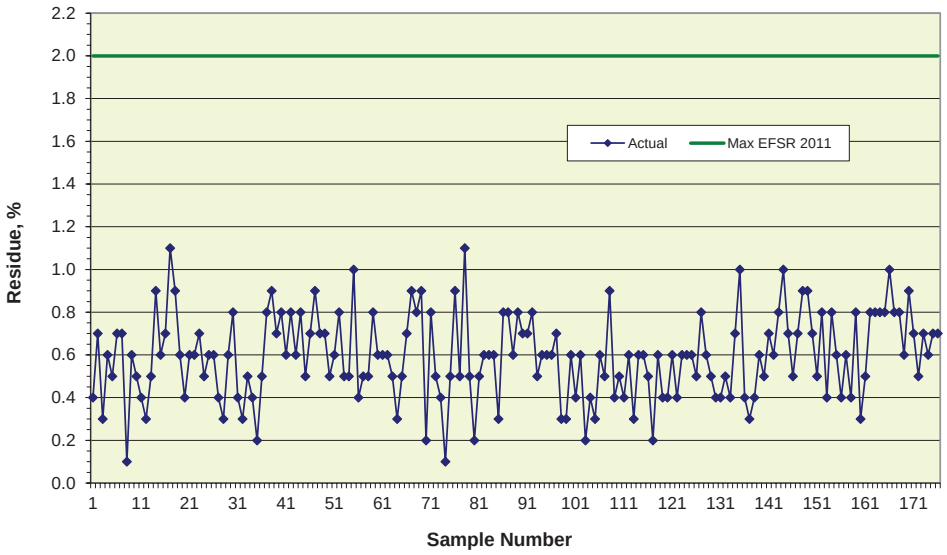
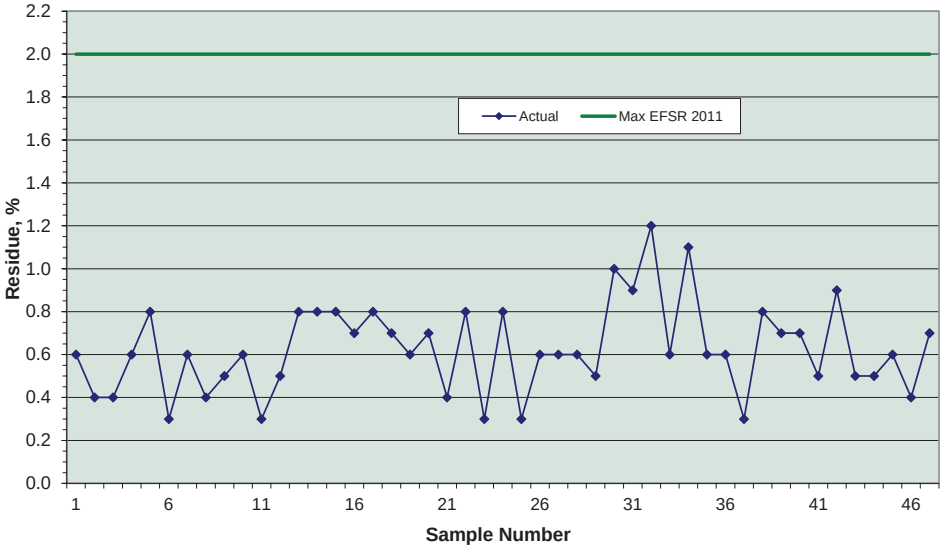


Figure 8c: Test Results for Residue, RON 98 & above, Year 2022-23



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).

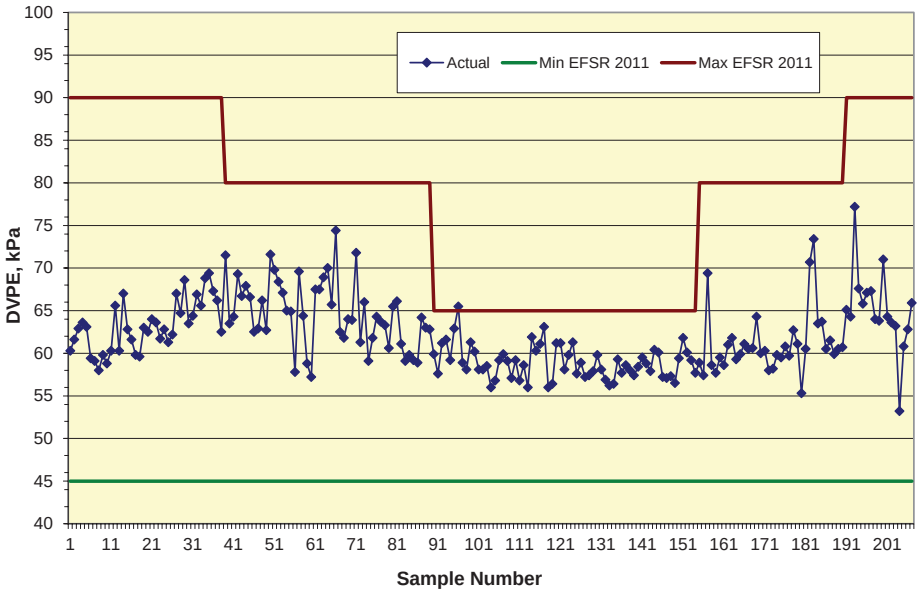
Each individually analysed sample, taken within the relevant season, appeared to be above the lowest maximum limit.

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

RON 91

In some periods, one sample was initially found to be above the lowest maximum at the time. However, the sample subsequently found to be within the specification limits for their region and season. The sample which had results above the limit of 65 kPa in the figure 9a, was found to be within the maximum limit of 70 kPa for summer in the rest of North Island.

Figure 9a: Test Results for DVPE, RON 91, Year 2022-23

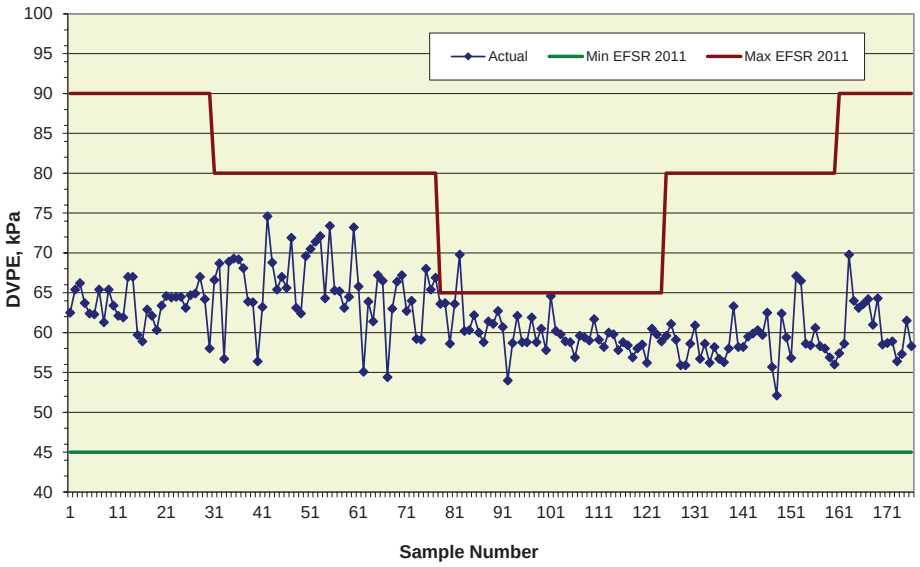


11 ASTM D5191-20 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method).*

RON 95

All 176 samples, except for one, were found to be within the specification limits for premium petrol (Fig. 9b). The sample was initially found to be above the lowest maximum in the summer period with actual result 69.8 kPa which was within the maximum limit of 70 kPa for summer in rest of the North Island.

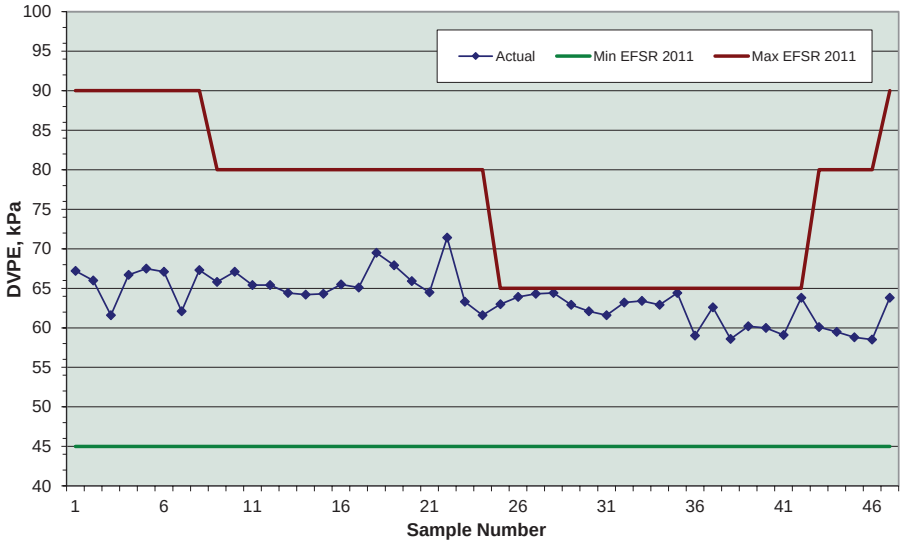
Figure 9b: Test Results for DVPE, RON 95, Year 2022-23



RON 98 & ABOVE

All 47 samples were found to be within the specification limits for premium petrol RON 98 and above (Fig. 9c).

Figure 9c: Test Results for DVPE, RON 98 & above, Year 2022-23



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)

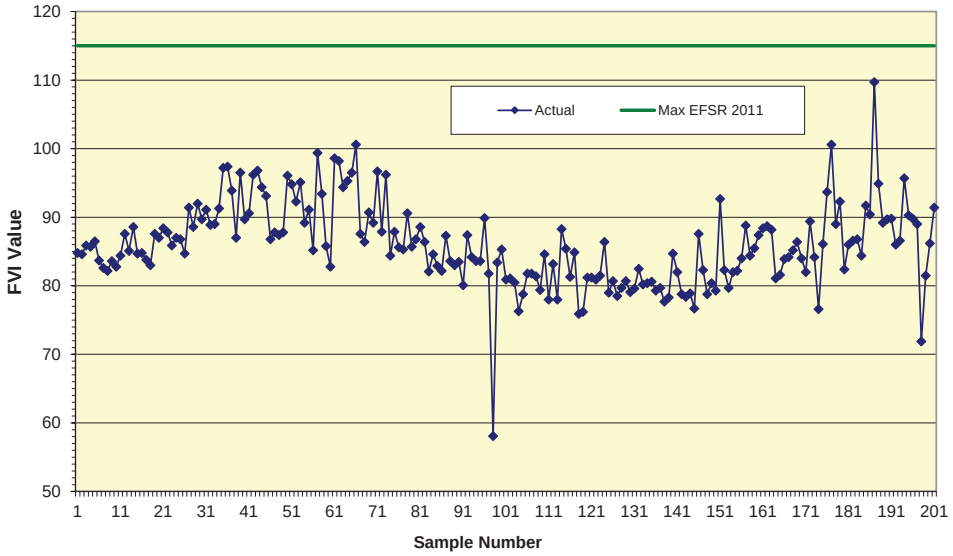
FVI serves as an indicator of the hot running performance (the tendency for vapour lock).

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 within the specification maximum limit of 115.0, with the maximum value of 109.7 (Fig 9d).

Figure 9d: Results for Flex. Vol. Index, RON 91, Year 2022-23

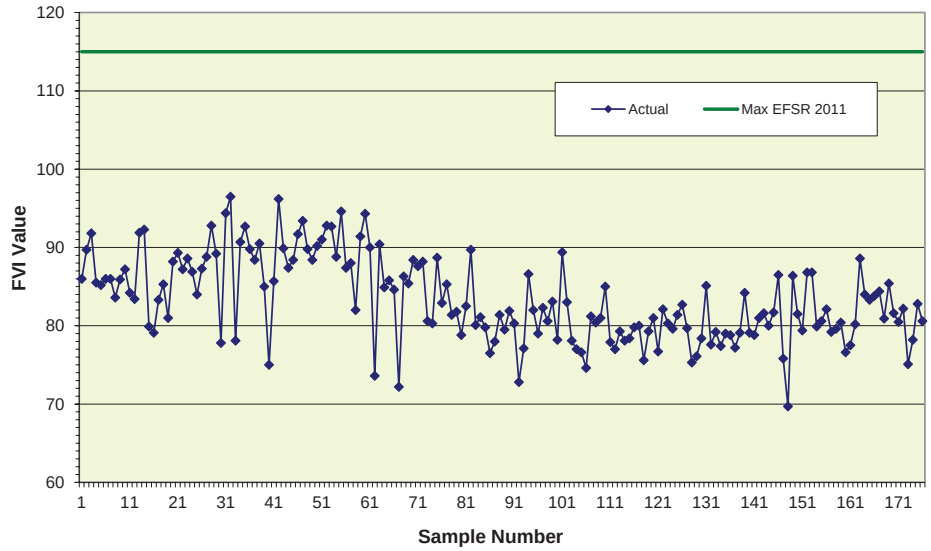


12 ASTM D5191 - 20 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method).*

RON 95

All samples of premium petrol were found to be within the specification maximum limit of 115.0, with the maximum value of 96.5.

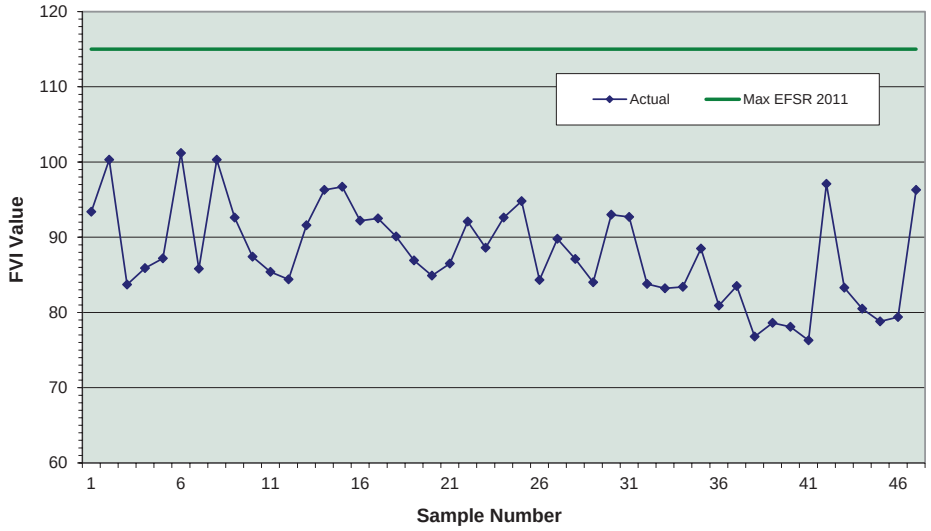
Figure 9e: Results for Flex. Vol. Index, RON 95, Year 2022-23



RON 98 & ABOVE

All samples of premium petrol were found to be within the specification maximum limit of 115.0, with the maximum value of 101.2.

Figure 9f: Results for Flex. Vol. Index, RON 98 & above, Year 2022-23



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

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]

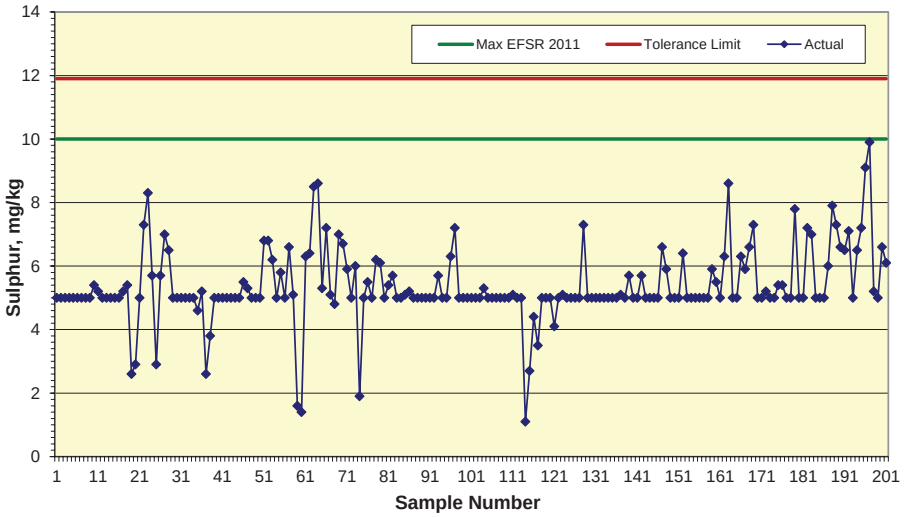
The scope of the test method IP 497[14] prescribed in the Regulations is from 5 to 60 mg/kg. Accordingly, the lowest testing result by this method is 5 mg/kg where the actual figures were found to be on or below this indicative level at the specified maximum limit since 1 July 2018 of 10 mg/kg with the tolerance limit of 11.8 mg/kg.

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

RON 91

All 202 samples tested for sulphur for regular petrol were found to be within the prescribed maximum limit, with the largest value of 9.9 mg/kg.

Figure 10a: Test Results for Sulphur, RON 91, Year 2022-23



13 *Worldwide Fuel Charter,* 6th Ed., 2019, p.17.

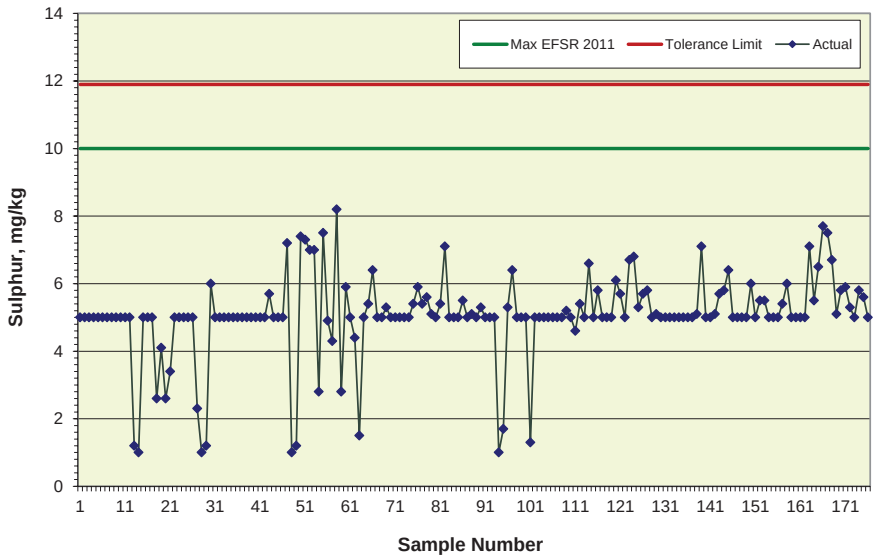
14 IP497 EN ISO 20884:2019 *Petroleum products - Petroleum products - Determination of sulfur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry.*

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 176 results for premium petrol were found to be within the prescribed maximum limit of 10 mg/kg, with the largest value of 8.2 mg/kg.

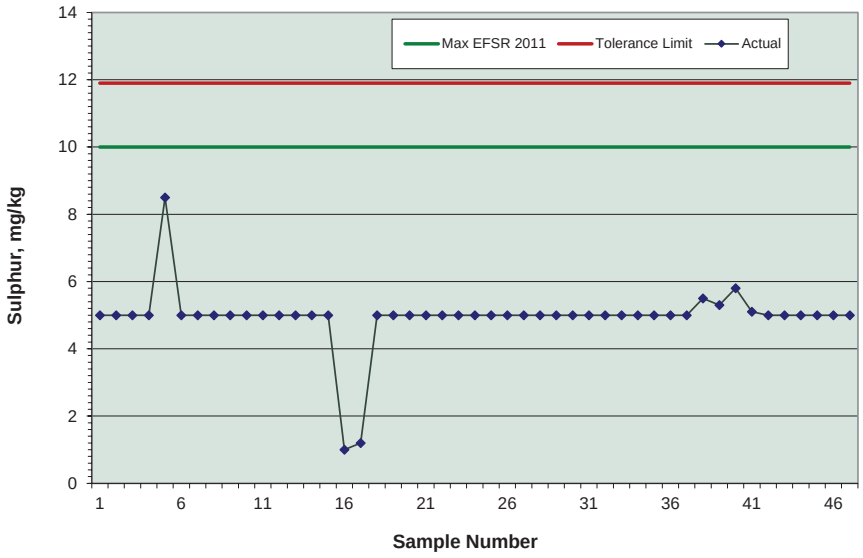
Figure 10b: Test Results for Sulphur, RON 95, Year 2022-23



RON 98 & ABOVE

All 47 results for premium petrol 98 and above were found to be within the prescribed maximum limit not exceeding 8.5 mg/kg.

Figure 10c: Test Results for Sulphur, RON 98 & above, Year 2022-23



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

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

Figure 11a: Test Results for Benzene, RON 91, Year 2022-23

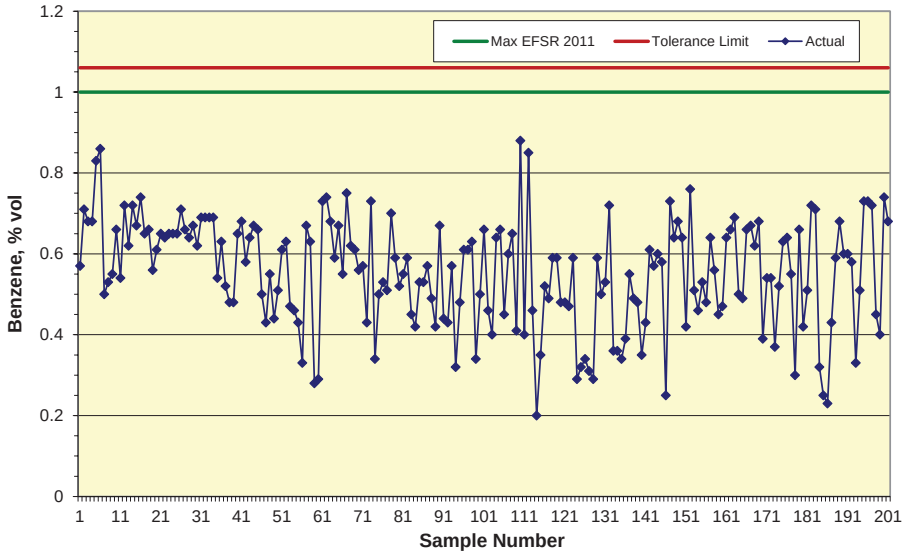
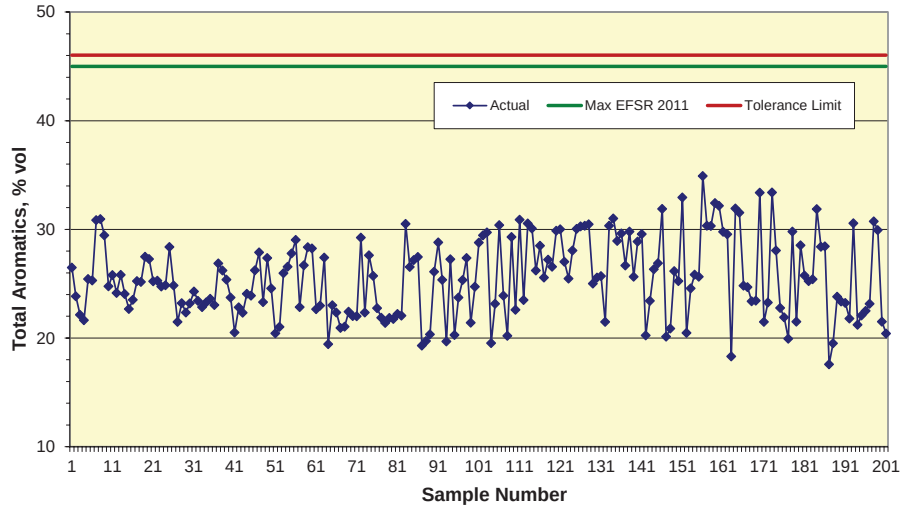


Figure 11b: Test Results for Total Aromatics, RON 91, Year 2022-23



16 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 176 samples of premium petrol tested for benzene were found to be within the prescribed maximum limit for benzene with the largest result for a sample reported as 0.79%.

For premium petrol, all results on total aromatics were found to be within the maximum limit of 45% with the largest result of 39.69% (Fig. 11d).

Figure 11c: Test Results for Benzene, RON 95, Year 2022-23

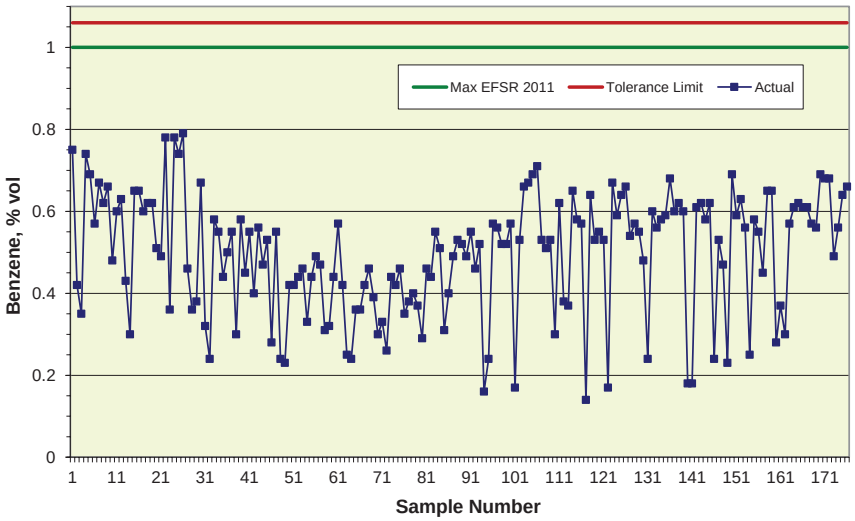
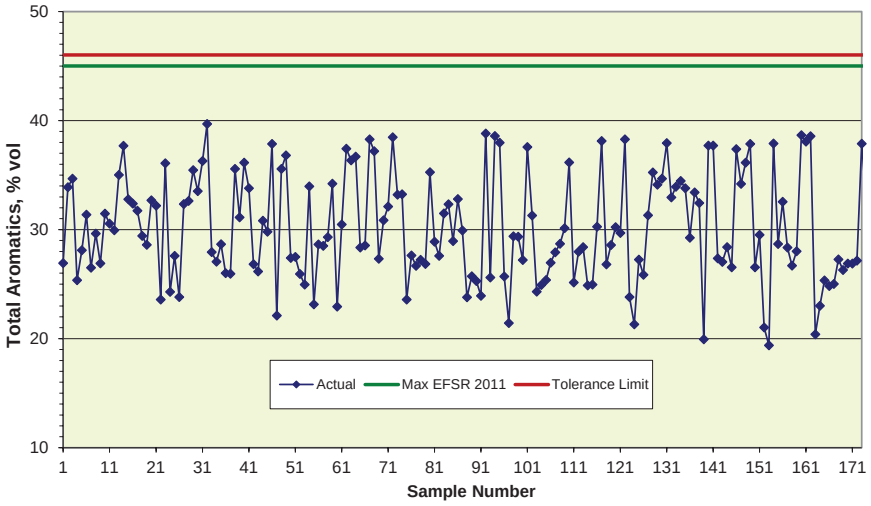


Figure 11d: Test Results for Total Aromatics, RON 95, Year 2022-23



RON 98 & ABOVE

All 47 samples of premium petrol RON 98 and above tested for benzene were found to be within the prescribed maximum limit for benzene with the largest result for a sample reported as 0.65%.

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

Figure 11e: Test Results for Benzene, RON 98 & above, Year 2022-23

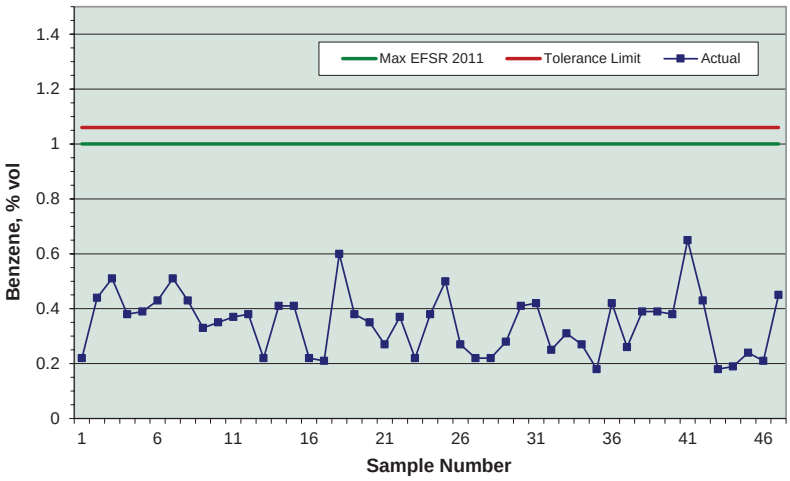
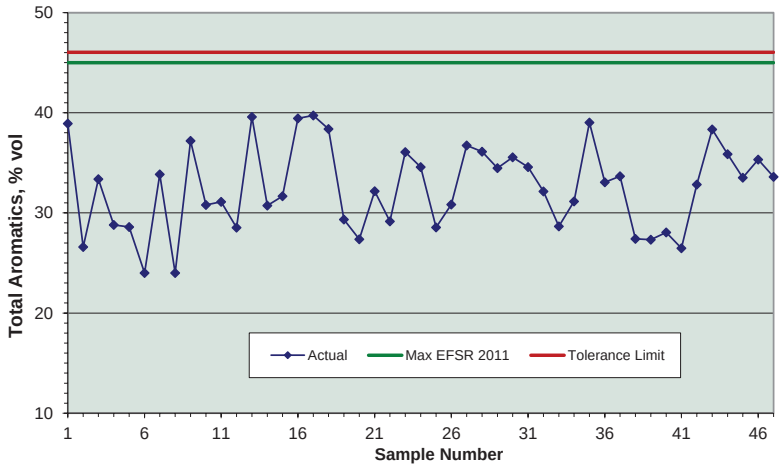


Figure 11f: Test Results for Total Aromatics, RON 98 & above, Year 2022-23



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 2023. The actual results were found to be within the required limits. Due to the commercial sensitivity of the calculation process, the actual results were not included in this report.

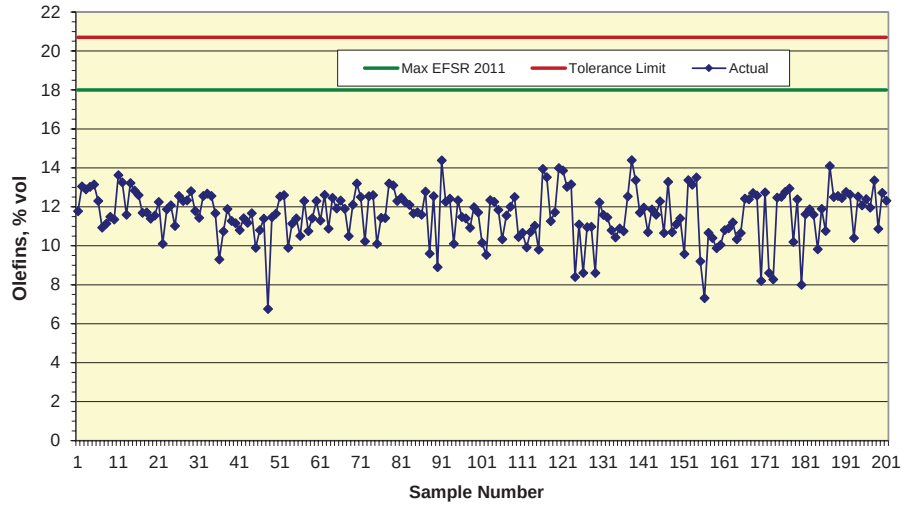
Olefins

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

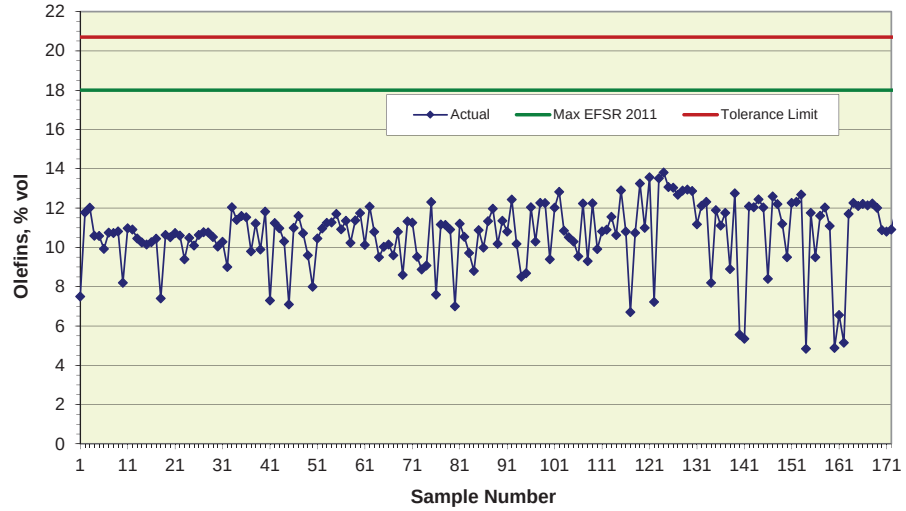
Figure 12a: Test Results for Olefins, RON 91, Year 2022-23



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 2022-23

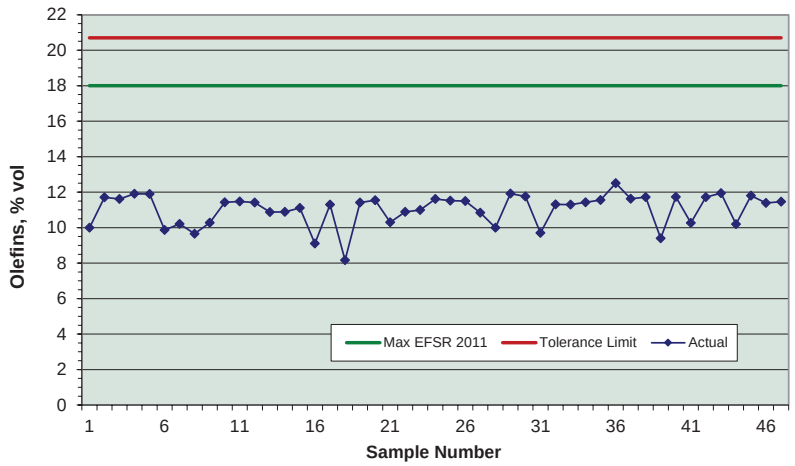


17 ASTM D1319-20a *Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption.*
18 ASTM D6839-18 *Standard Test Method for Hydrocarbon Types, Oxygenated Compounds, and Benzene in Spark Ignition Engine Fuels by Gas Chromatography.*

RON 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 2022-23



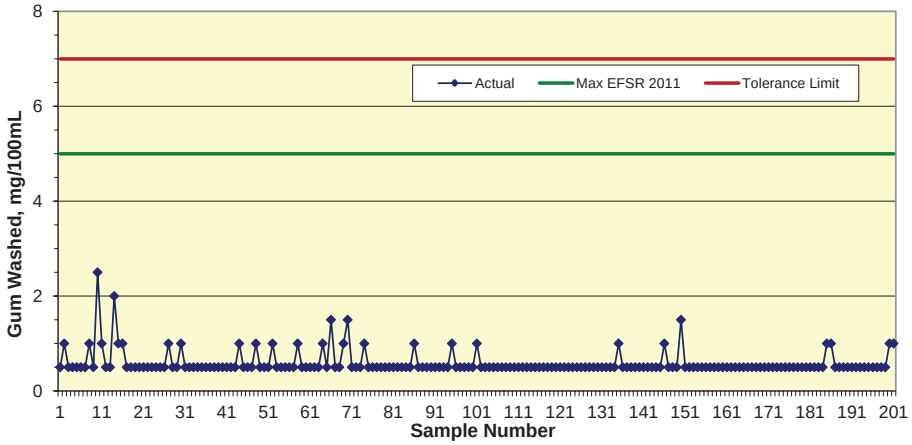
Existent Gum (solvent washed)

The threshold of the test method ASTM D381[19] 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 202 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 2022-23

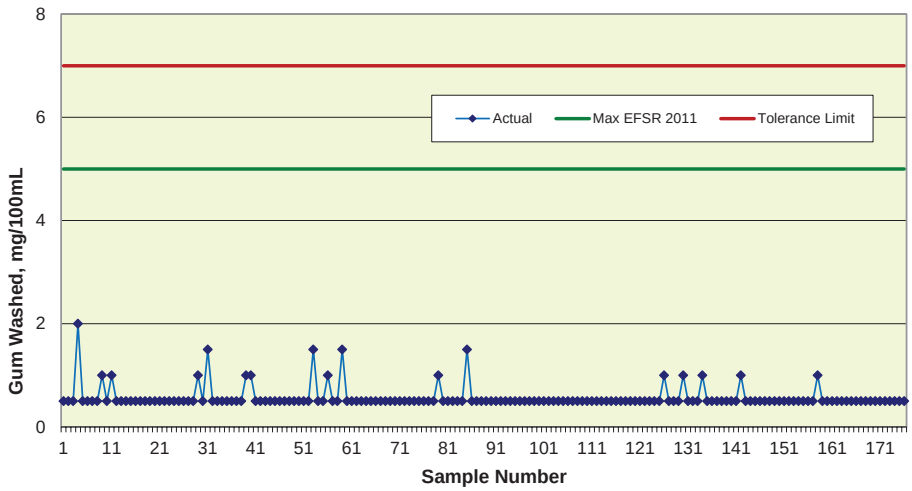


19 ASTM D381-19 *Standard Test Method for Gum Content in Fuels by Jet Evaporation.*

RON 95

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

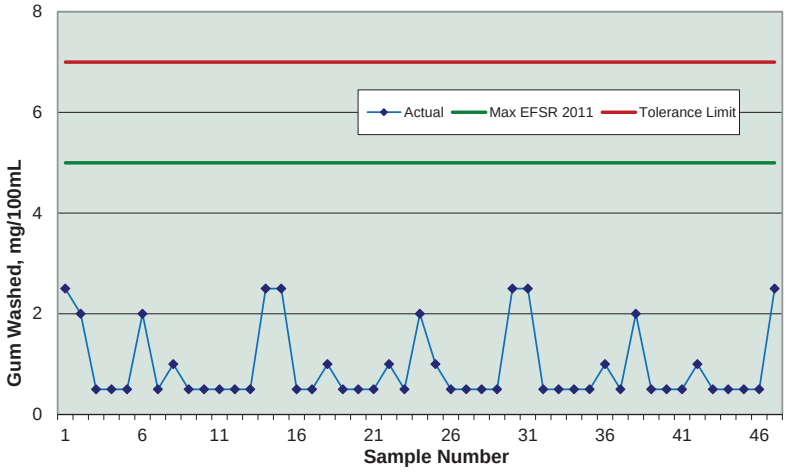
Figure 13b: Test Results for Gum, RON 95, Year 2022-23



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 2022-23



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[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 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, 31 samples of regular petrol and 37 samples of premium petrol were tested for copper strip corrosion[22] and 17 samples for oxidation stability[23]; all of them were found to be compliant.

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

SUMMARY OF 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.

One test result for RON of regular petrol was found to be on the minimum specified limit according to the Regulations. The sample was accepted as compliant without repeated testing.

In addition, 64 samples of regular petrol and 74 samples of premium petrol were tested for silver strip corrosion, to detect the presence of active sulphur, and the results were acceptable, although the test method is not yet stipulated in the Regulations. The importance of this test was recognised after the active sulphur contamination incident in 2017-18 (see Report for yr. 2018-19).

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

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).*

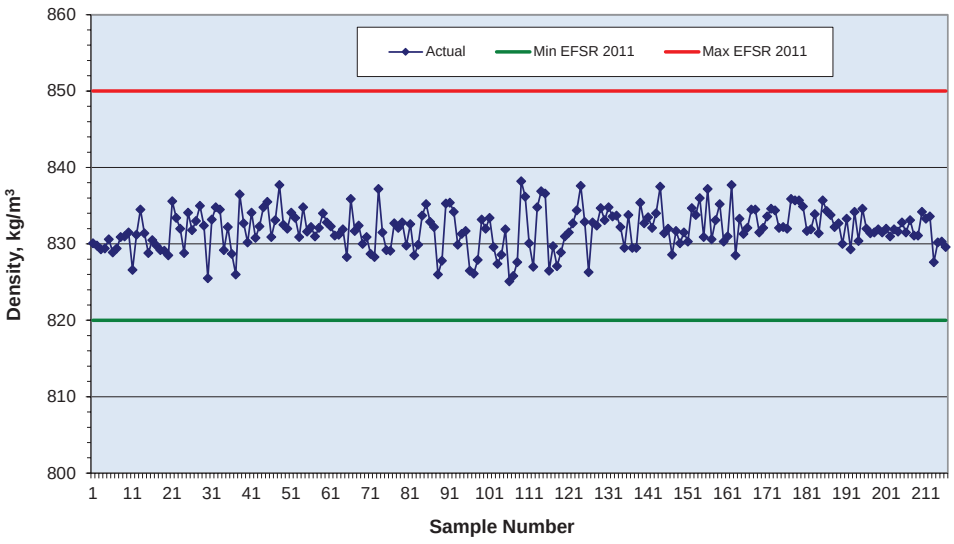
Diesel

Density

The density of diesel at 15°C can be tested according to ASTM D1298[24] or ASTM D4052[25] prescribed in the Regulations. Respectively, there are two pairs of tolerance limits identified using the two methods for the minimum limit of 820 kg/m³ and for the maximum limit of 850 kg/m³.

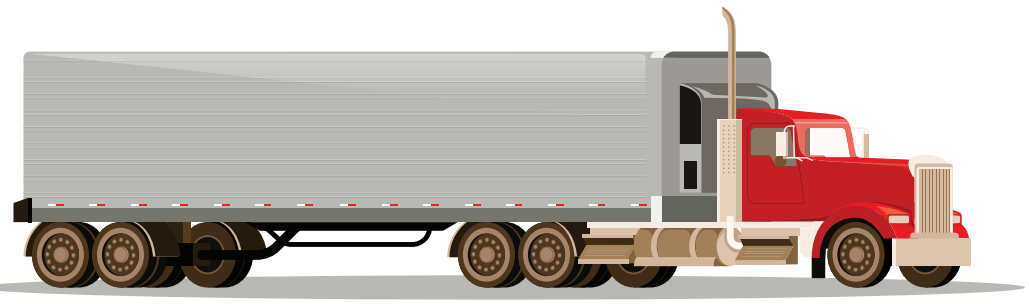
All 216 samples were found to be within the specification limits (Fig 14).

Figure 14: Test Results for Density, Diesel, Year 2022-23



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*.



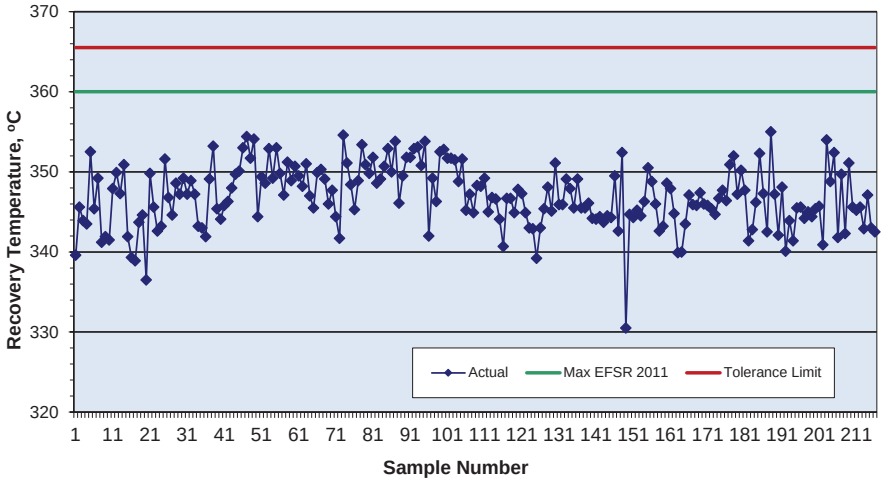
Distillation

The Distillation test means definition of temperature (°C) at which 95% volume recovered. The temperature should be tested by ASTM D86[26] prescribed in the Regulations.

All 216 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.

The highest actual figure was 358.1°C and the lowest actual figure was 334°C although there is no prescribed minimum limit for this property.

Figure 15: Test Results for Distillation 95% Vol Recovered, Diesel, Year 2022-23



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]

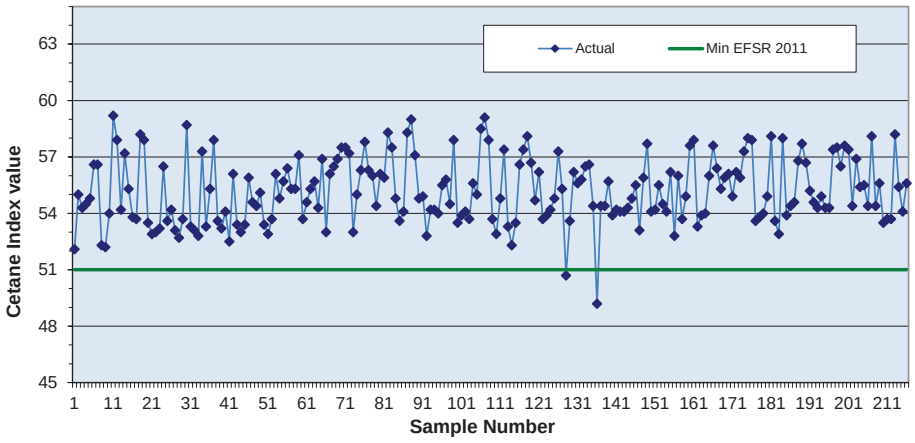
The cetane index, according to ASTM D4737[28] prescribed in the Regulations, is not tested for but calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine for determining cetane number is not available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

214 samples out of 216 tested were found to be above the minimum limit of 51 (Fig.16). Sample 128 with actual results of 50.7 was within the estimated tolerance limit.

One sample 136 was found to be below the estimated tolerance limit. Sample 136 was diesel sold by retail sale where the cetane index was found to be out of specification with the average of the results (49.2 and 49.2) by two operators is 49.2. The testing laboratory issued a certificate of non-conformance for this sample. Further investigation revealed that the certificate of quality that was accompanying a wholesale supply of the relevant shipment of diesel had listed figures of cetane index as well as cetane number which were, respectively, recorded as 48.8, 48.6, 48.0 and 51.4, 51.3, 51.2. This combination of two figures is permissible by the Regulations: the limits of 47 for the minimum cetane index at the minimum cetane number of 51. Therefore, Sample 136 was finally accepted as compliant.

Figure 16: Test Results for Cetane Index, Diesel, Year 2022-23



27 *Worldwide Fuel Charter.* 6th Ed., 2019, p.64.
28 AASTM D4737-21 *Standard Method for Calculated Index by Four Variable Equation.*

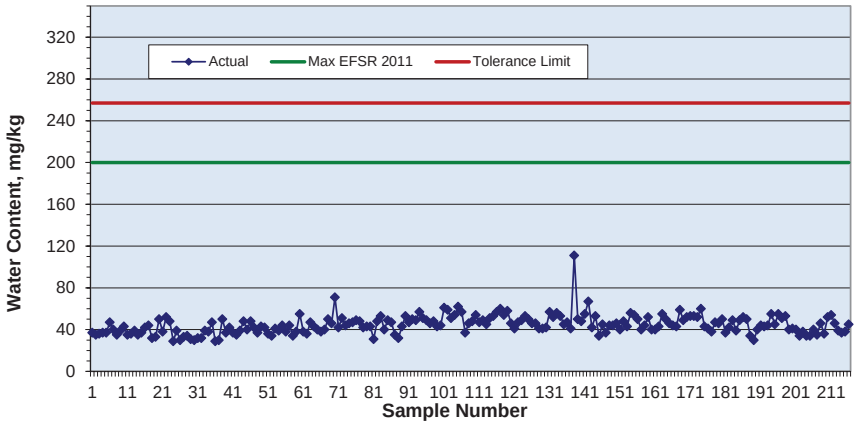
Water

The test for water content is done according to IP438[29] 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 Aotearoa 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 2022-23

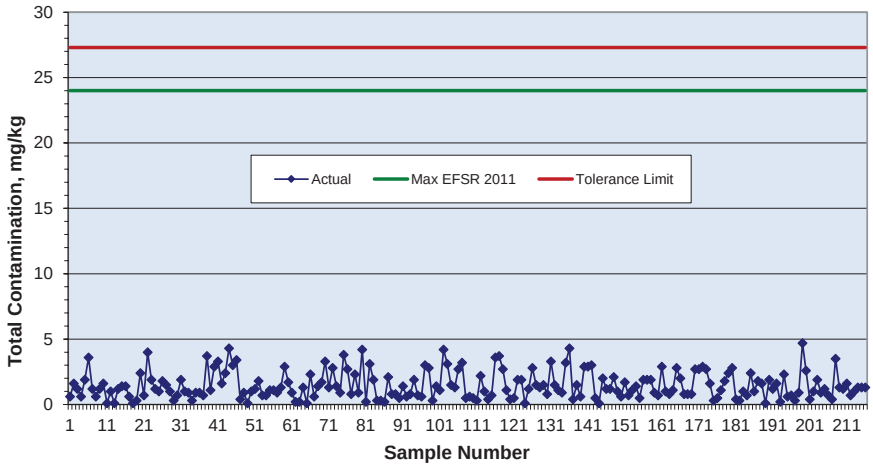


29 BS EN ISO 12937:1961, BS 1960-438:1961. *Petroleum products. Determination of content. Coulometric Karl Fischer titration method.*

Total Contamination

All 216 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[30] is 27.3 mg/kg.

Figure 18: Test Results for Total Contamination, Diesel, Year 2022-23

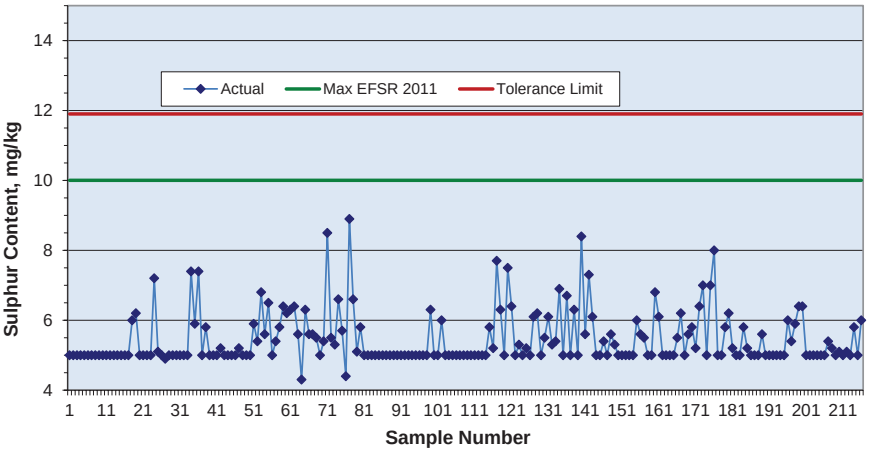


Sulphur

Sulphur content can be tested according to IP 497[31] or ASTM D5453[32] 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 216 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 2022-23



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

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 according to ASTM D5773[34] prescribed in the Regulations.

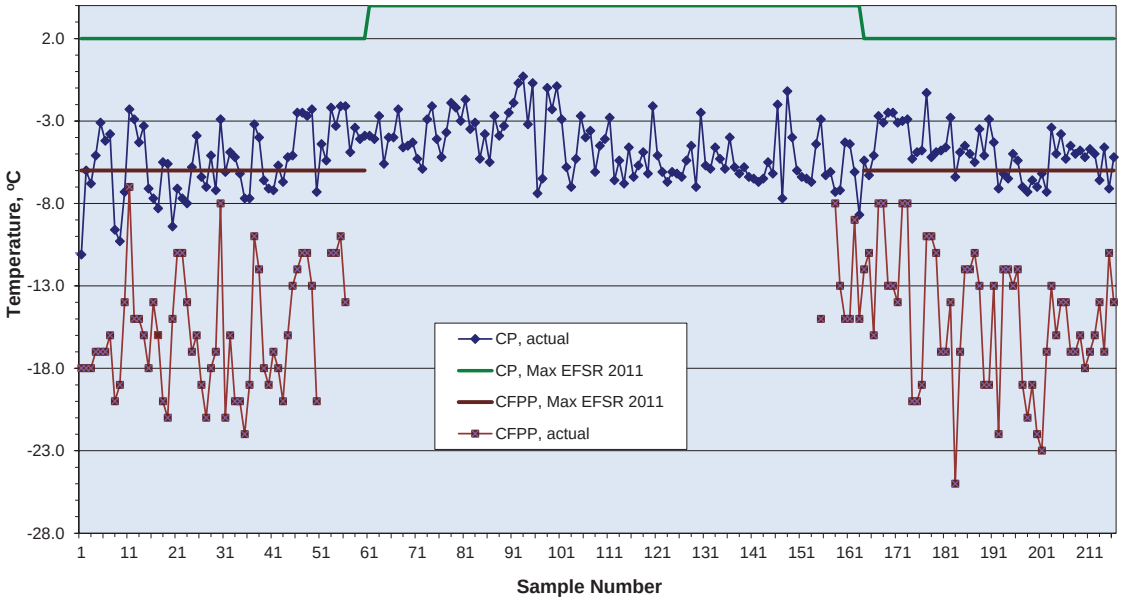
The cumulative results for CP are presented below by combining the lowest prescribed maximum limits for each season in one graph (Fig.20). Generally, results below the lowest maximum limit established for an area are complied with the Regulations in all other areas.

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 Aotearoa 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 Aotearoa 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 5.40C, respectively, for the specified limits of +2°C and +4°C.

All 216 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 2022-23



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 should be tested according to IP 309[35] 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 10oC[36]. 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.

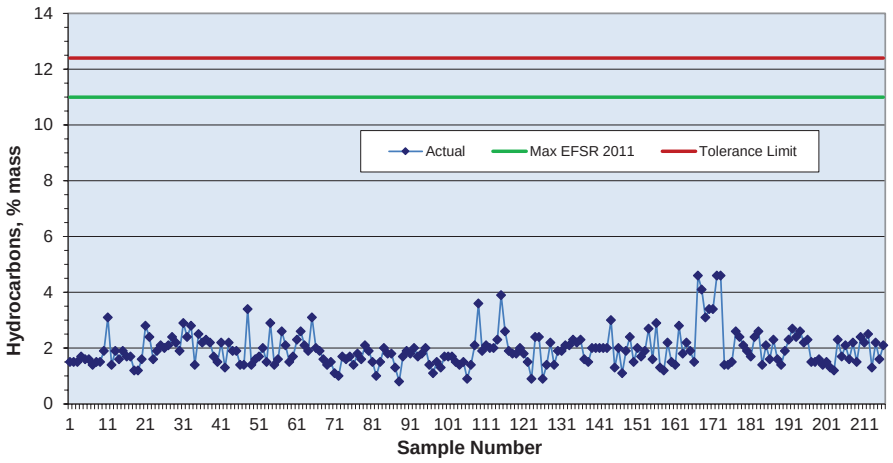
The test results for CFPP are set out on the same graph as that for CP (Fig.20). This gives an advantage to see the data 'at glance' and compare the two sets where necessary. All samples were found to be below the maximum limit specified in the Regulations.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons are tested by IP 391[37] prescribed in the Regulations.

All 216 tested samples were found to be below the maximum limit of 11% specified in the Regulations at the tolerance limit of 12.4%. All testing results were found to be below 4%.

Figure 21: Test Results for Polycyclic Aromatic Hydrocarbons, Diesel, Year 2022-23



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 Worldwide Fuel Charter, 6th Ed., 2019, p.81.

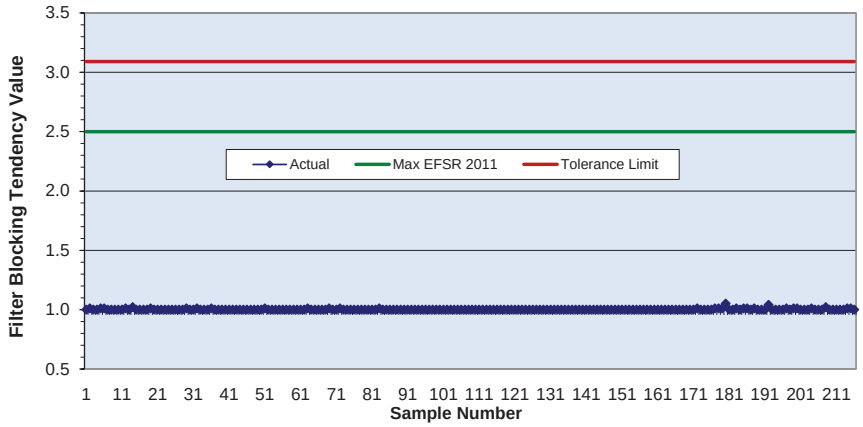
37 BS EN 12916:2019 *Petroleum products. Determination of aromatic hydrocarbon types in middle distillates. High performance liquid chromatography method with refractive index detection.*

Filter Blocking Tendency

Filter blocking tendency can be tested by IP 387[38] or ASTM D2068[39] prescribed in the Regulations.

All 216 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 2022-23



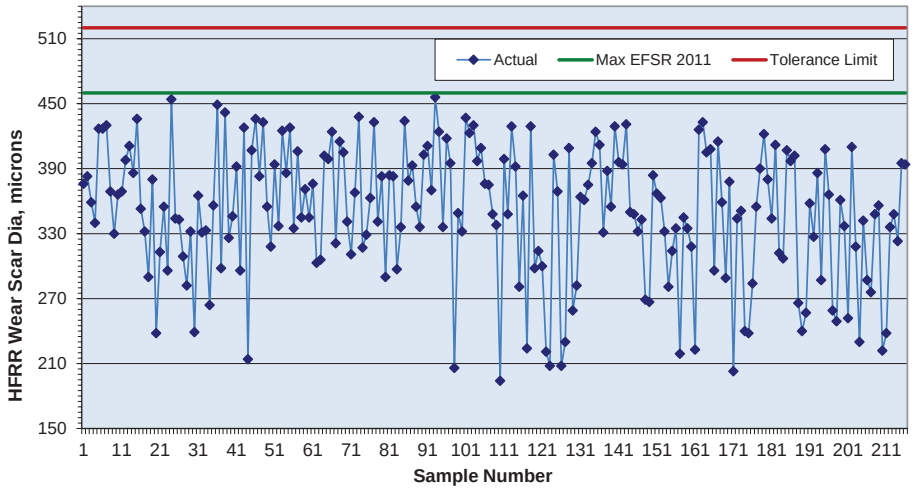
Lubricity

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[40] 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 216 samples were found to be below the specification maximum limit for the lubricity, with the largest result of 456 µm.

Figure 23: Test Results for Lubricity, Diesel, Year 2022-23



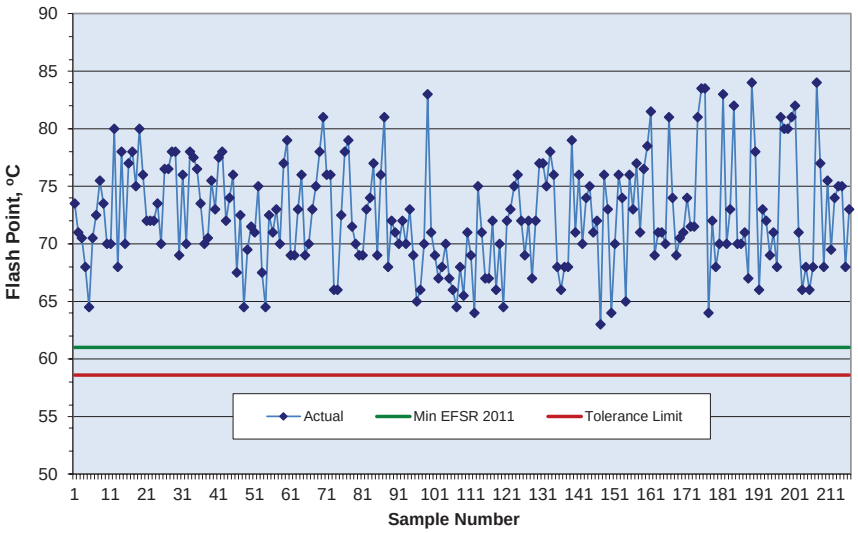
38 IP 387:2017 *Determination of filter blocking tendency.*
39 ASTM D2068-20 *Standard Test Method for Determining Filter Blocking Tendency.*
40 IP 450:2020 *Diesel fuel – Assessment of lubricity using the high-frequency reciprocating rig (HFRR) – Part 1: Test method (ISO 12156-1:2018); BS 2000-450:2000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

All 216 samples were found to be above or on the specified minimum limit of 61°C for flash point of diesel (Fig 24).

Figure 24: Test Results for Flash Point, Diesel, Year 2022-23

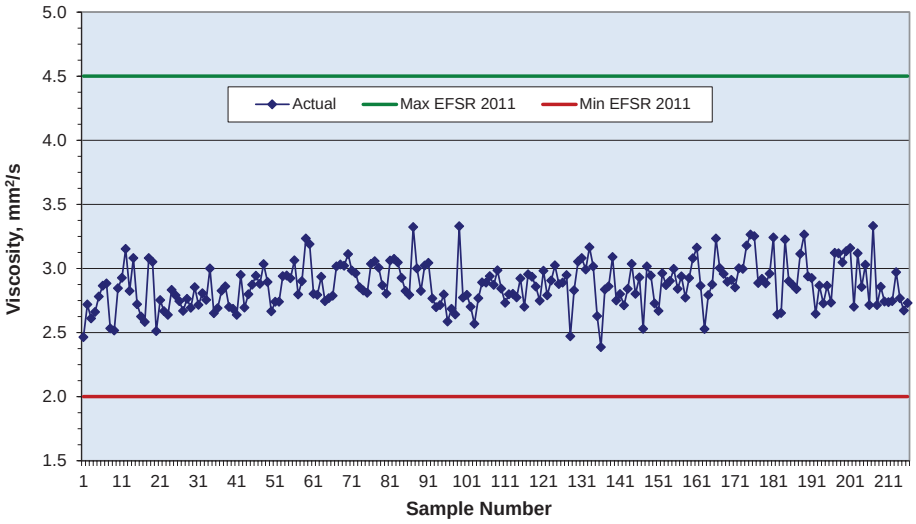


Viscosity

The viscosity is tested at 40 °C by ASTM D445[42] prescribed in the Regulations.

All 216 samples were found to be above the specified minimum limit of 2.0 mm² per second and below the specified maximum limit of 4.5 mm² per second for viscosity of diesel (Fig 25).

Figure 25: Test Results for Viscosity, Diesel, Year 2022-23



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

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

Microbial Content

In the presence of free water, hydrocarbon fuels in storage tanks support the growth of microorganisms such as bacteria, yeast, and fungi colonies, also known as microbes or 'bugs'. This water can be condensate, water entrained in imported fuel (particularly sea water), surface or ground water leaks etc. If microbes proliferate, they can block fuel filters and cause gauging problems.

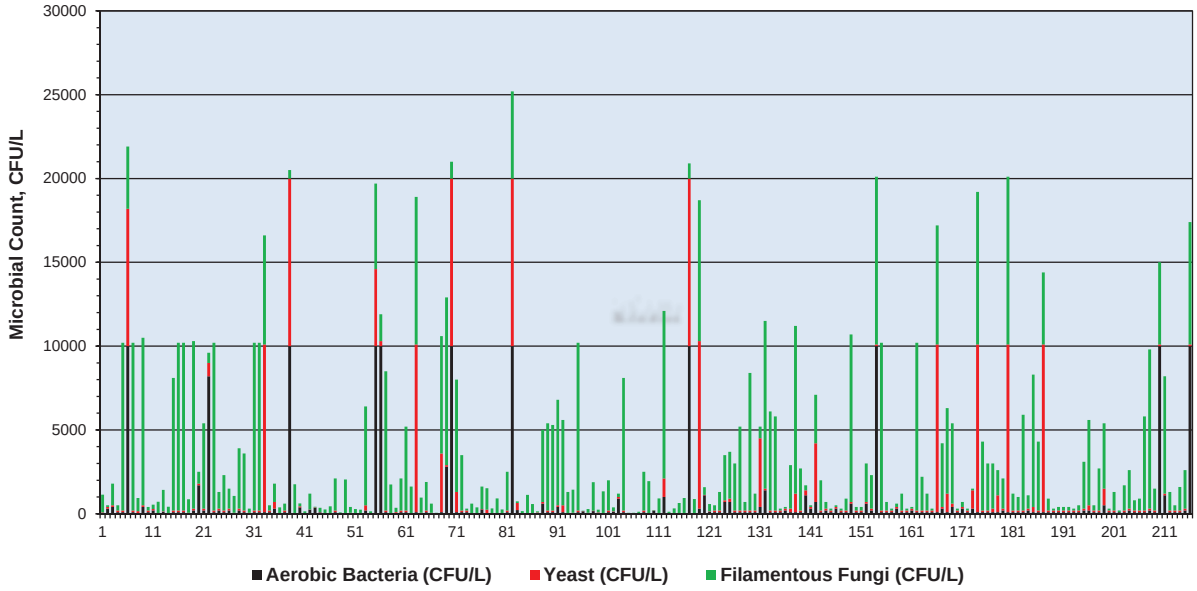
Currently, the Regulations do not include any specific requirements on microbial content due to the subjective nature of the test methods. However, as per regulation 9, diesel sold needs to be fit for common purposes.

TS is reliant on international guidelines regarding potential sources of microorganisms, as well as possible remedial strategies to prevent microbial growth. Good housekeeping, which includes regular removal of water from the underground storage tanks (UST), helps to reduce the microbial growth.

Proper vehicle maintenance by consumers, in accordance with the vehicle owner's manual, can substantially reduce microbiological proliferation and the resulting potential problems with engine performance.

Microbial content is tested according to IP 385[43] which is not stipulated in the Regulations. It is broadly recognised that microbiological parameters represent a few unique challenges, however, this is a commonly accepted international standard laboratory method to measure microbial content. The test is indicative of the extent of microbial content in a sample, not definitive. It is recognised that the precision of any microbiological analytical method will generally be considerably less than that of methods widely used in the petroleum industry for analysis of physical and chemical properties of fuels.

Figure 26: Microbial Content, Diesel, Year 2022-23



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

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 applied by the Ministry for its own 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. Investigate by further sampling and testing.
Category C	Above 10,000	Operational problem and spread of contamination likely. Investigate thoroughly.

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.

It is acknowledged that microbial testing is a subjective test and that obtaining representative samples can be challenging[45]. Accordingly, when assessing whether diesel is fit for common purposes, TS identifies the impact of microbial content on fuel quality only in rare instances.

However, TS still places a strong emphasis on monitoring microbial content as it serves as an indicator for the presence of water in fuel and poses potential risks to diesel engines and can directly or indirectly affect the quality of fuel.

While diesel is most likely to be affected by microorganisms, other fuels are also susceptible to microbial growth like blends of biofuels, aviation kerosene (not in the scope of the Programme), and heavy fuel oil (see Section on Marine Fuel).

There are other test methods such as ASTM D7978[46], technically equivalent to IP 613[47], that are under consideration for use by TS. These test methods use the same detection parameter used in IP 385. However, where, IP 385 provides separate assessment of numbers of viable aerobic bacteria and fungi, these procedures are used to quantify combined total count of viable aerobic microbial content.

As the Regulations do not include any specific requirements on microbial content, retail sites are advised to maintain good housekeeping practices. The Ministry is currently reviewing the microbial content issue and considering publishing guidelines for good housekeeping, while also striving to improve sample collection procedures and testing methodology.

44 *Guidelines for the investigation of the microbial content of liquid fuels and for the implementation of avoidance and remedial strategies.* 3rd Ed., Energy Institute, London, 2019.
45 ASTM D6469 – 20 *Standard Guide for Microbial Contamination in Fuels and Fuel System.*
46 ASTM D7978 – 14 (Reapproved 2019) *Standard Test Method for Determination of the Viable Aerobic Microbial Content of fuels and Associated Water—Thixotropic Gel Culture Method.*
47 IP 613 (2014) *Determination of the viable aerobic microbial content of fuels and associated water - Thixotropic Gel Culture Method.*

SUMMARY OF DIESEL TEST RESULTS

In one instance, a diesel sample was suspected of non-compliance due to the cetane index being below the specification limit in the Regulations. As a result, the testing laboratory issued a Non-Conformance Certificate (NCC) for that sample.

Sample 136 was found to be below the estimated tolerance limit. Sample 136 was diesel sold by retail sale where the cetane index was found to be out of specification with the average of the results (49.2 and 49.2) by two operators is 49.2. The testing laboratory issued a certificate of non-conformance for this sample. Further investigation revealed that the certificate of quality that was accompanying a wholesale supply of the relevant shipment of diesel had listed figures of cetane index as well as cetane number which were, respectively, recorded as 48.8, 48.6, 48.0 and 51.4, 51.3, 51.2. This combination of two figures is permissible by the Regulations: the limits of 47 for the minimum cetane index at the minimum cetane number of 51. Therefore, Sample 136 was finally accepted as compliant. Another sample 128 with actual results of 50.7 was within the estimated tolerance limit.

Further, 64 out of 216 samples were tested for copper strip corrosion[48] and all of them were found to be compliant. Next, 40 samples were tested for carbon residue[49] and ash[50] and, finally, 38 samples were tested for oxidation stability[51]. All these tests returned the compliant results.

Testing the appearance of diesel was conducted according to the ASTM standard D4176[52], to ensure that any water or other contamination would be identified, even though it is not listed in the Regulations. It has proven to be an effective method during investigations in response to complaints and enquiries.

48 ASTM D130-19 *Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test*.
49 BS EN ISO 10370:2014 *Petroleum products. Determination of carbon residue. Micro method*.
50 ASTM D482-19 *Standard Test Method for Ash from Petroleum Products*.
51 ASTM D2274-2014(2019) *Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)*.
52 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 covered by this report. 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, 8 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 for blending with petrol, was tested three times from a storage terminal throughout the period covered in this report. Results for duplicate samples taken from top and bottom of the storage tank were within the specified limits.

ETHANOL BLENDED PETROL E85

This product is specified in the Schedule 1A of the Regulations since there are flexible-fuel vehicles on roads in Aotearoa 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 Aotearoa New Zealand. TS is not aware of these products being sold in the market during period covered in this report.

Marine Fuels

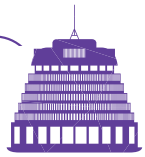
MARPOL ANNEX VI – A TIMELINE

26 May 2022

Aotearoa New Zealand acceded to MARPOL ANNEX VI.

Marine fuel quality regulations were included in the Regulations.

26 August 2022



Introduction

On 26 May 2022 Aotearoa New Zealand acceded to MARPOL Annex VI of the International Maritime Organization (IMO) Convention for the Prevention of Pollution from Ships 1973. MARPOL Annex VI entered into force for Aotearoa New Zealand on 26 August 2022. Under Annex VI, the IMO has set a limit for sulphur in fuel oil and requirements for fuel quality used on board ships[53]. This significantly reduces the amount of sulphur oxides emitted from ships and provides health and environmental benefits, particularly for people living close to Aotearoa New Zealand ports and coasts. As well as the sulphur limit, IMO sets other requirements for fuel quality to control the emissions of pollutants.

The Ministry and Maritime NZ jointly regulate the fuel quality aspects of MARPOL Annex VI, to ensure that Aotearoa New Zealand's commitment to health and environmental standards at sea is fulfilled. The agencies use a wide range of regulatory tools to achieve compliance, with a focus on the provision of information and education where appropriate.

The Ministry is responsible for regulating marine fuel sold in Aotearoa New Zealand ('shore' or 'supply' side regulatory activity) while Maritime NZ is responsible for regulating the obligations of ship operators ('ship' side regulatory activity). This includes the routine random sampling of fuel in use on ships arriving in Aotearoa New Zealand.

TS maintains a national register of local marine fuel suppliers that are categorised by port and fuel type[54]. Currently, eight companies are registered as marine fuel suppliers in New Zealand.

53 IMO Resolution MEPC.320(74) - *2019 Guidelines for consistent implementation of the 0.50% sulphur limit under MARPOL Annex VI.*

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

Properties to Test

Sulphur content is the only property directly specified in MARPOL Annex VI. This is explicitly stipulated to be not higher than 0.5 % m/m. However, there are several properties mentioned throughout MARPOL Annex VI which are specified in Schedule 5 of the EFSR 2011 and considered as the critical set to test. These 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 sets out an instruction for information to be included in Bunker Delivery Notes (BDN) provided with fuel supplied to ships 400 GT or 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 Annex VI[55].

In turn, regulation 18.3 lists desirable properties but does not specify test methods or properties to be confirmed. However, the MARPOL Annex VI requirements are traceable to the international standard ISO 8217 which is referred to in EFSR 2011 and is commonly accepted by the shipping industry worldwide. MARPOL Annex VI doesn't mention it directly, however, refers to other documents such as Safety of Life at Sea (SOLAS) and Marine Environment Protection Committee (MEPC) circulars which refer to the standard.

To ensure the analysis is complete, TS periodically tests the full list of properties listed in Table 1 (for distillates) and Table 2 (for residuals) of ISO 8217-2017. Testing is done in line with the specifications stipulated in the standard.

Further, there is an international Publicly Available Specification (PAS)[56], which is in-line with the intent of MARPOL Annex VI and has a section on the Application of ISO 8217:2017 to 0.50 mass % sulphur fuel. It has specific considerations for 0.50 mass % sulphur marine fuel which can be interpreted as guidelines on how to monitor the quality of marine fuel. This standard clarifies that 'In view of the implementation date (referring to MARPOL Annex VI), it was considered that a revision of ISO 8217:2017 was not possible in the given timeframe. As such, the best option for the industry was the development of this document.'

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 8217-2017. 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, 15 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 (Fig. 28), 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 8217-2017. Currently, there is only one supplier of VLSFO in Aotearoa New Zealand which was sampled several times throughout the period of this report. Samples were found to be compliant with the requirements of MARPOL Annex VI. In particular, the sulphur content was found to be in the range of 0.459% to 0.479% m/m (Fig. 28).

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

56 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.*

A shipment of VLSFO, categorised as RMD80, was sampled on board of a supply vessel in Marsden Point at the time it was loaded onto the vessel. Samples of VLSFO, categorised as RMD80 and RMG180, were also collected from this supply vessel at the time of bunkering to seven different ships with the gross tonnage varying from 6,264 GT (general cargo ship) to 121,878 GT (cruise ship).

All samples were found to be compliant with the requirements of MARPOL Annex VI. In particular, the sulphur content in VLSFO categorised as per Table 2 ISO 8217, was found to be in the following ranges (Fig. 28):

- 0.488% to 0.495% m/m (RMD80)
- 0.471% to 0.477% m/m (RMG180)

Deliveries were sampled by TS at the time of bunkering seven ships including a container ship, three cargo ships, vehicle carrier, passenger cruise ship and a research vessel.

In total, 11 samples were collected under TS' instruction, including one ship sampled in two instances. Of those, five samples underwent the full test according to the standard.

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

FUEL SAMPLED ONBOARD IN-USE

Marine fuel oil samples were collected from foreign flagged vessels visiting Aotearoa New Zealand ports, under MNZ's guidance. Sampling was focused on fuel oil confined in ship compartments and carried for use onboard that ship.

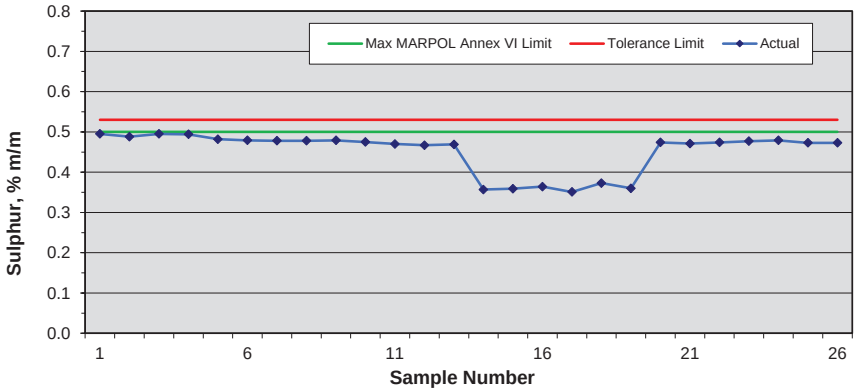
In total, 23 samples were collected from five ships with gross tonnage ranging from 24,649 GT to 73,899 GT. Of those 23 samples, six were MGO samples and the rest VLSFO. Three categories of VLSFO were identified according to Table 2 ISO 8217: RME180, RMG180 and RMG380.

Five ships were sampled by Maritime NZ including two container ships, one vehicle carrier, one bulk carrier, and one passenger cruise ship.

All samples were found to be compliant with the requirements of MARPOL Annex VI. In particular, the sulphur content in VLSFO categorised as per Table 2 ISO 8217, was found to be in the following ranges (Fig. 28):

- 0.351% to 0.479% m/m (RMG180)
- 0.478% to 0.482% m/m (RME180)
- 0.357% to 0.364% m/m (RMG380)

Figure 28: Test Results for Sulphur, MARPOL Annex VI, Year 2022-23



Water Content

According to ISO 8217, residual fuel has the maximum limit of 0.5% vol for water. Among residual fuel samples, four results were found to be above the limit with actual figures of 1.0%, 2.2%, 2.8% and 10.0%.

Microbial Content

MGO samples were tested for microbial content. Several of the samples were found to be in Category C (refer to Diesel Microbial Content section) which was confirmed by comparative testing in a separate laboratory. As a side note, most of the samples with the high microbial content were collected from onboard compartments of ships.

Contribution to the IMO

The IMO continues to develop the supporting documentation for delivering Annex VI requirements. Through our collaboration with Maritime NZ, TS provided input and feedback into the work of the IMO Sub-Committee on Pollution Prevention and Response and the IMO Marine Environment Protection (MEPC) Committee.

TS also contributed to the discussion on whether additional requirements and/or restrictions should be imposed on biofuel used for blending into marine fuel.

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.
Forecourt	The area of a petrol station where the petrol pumps are situated.
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.
UST	Underground Storage Tank
Bunkering	The transfer of fuel from land-based or floating facilities into ships' permanent tanks or connection of portable tanks to the ship's fuel supply system.
Fuel oil	Any fuel delivered to and intended for combustion purposes for propulsion or operation onboard a ship, including gas, distillate, and residual fuels.
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.
Onboard sample	A sample of fuel oil intended to be used or carried for use onboard that ship.