TRADING STANDARDS

Fuel Quality Monitoring Programme

Test Results 2019–20

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

TRADING STANDARDS

ABOUT THIS REPORT

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DISCLAIMER

Contents

Executive Summary

The Fuel Quality Monitoring Programme (**the Programme)** is administered by Trading Standards which is an operational unit within the Ministry of Business, Innovation and Employment.

Trading Standards (**TS**) maintains a comprehensive programme of sampling and assessing the quality of retail fuel in New Zealand and monitoring its compliance with the specifications set out in the relevant Engine Fuel Specifications Regulations (**the Regulations**). Currently, the Regulations made in 2011 and amended on 2 October 2017, are in force[1].

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

A key element of the Programme is to sample and test the quality of fuels as they are sold to consumers, *i.e.* sampling is done from dispenser nozzles at the retail point of sale.

The sampling and testing programme is undertaken independently of the Fuel Industry and being focussed on retail sales, it complements the extensive sampling and testing that the Fuel Industry itself carries out at various stages during the manufacture and supply processes. This provides confidence to consumers and all stakeholders around the quality and composition of petrol, diesel and biofuels.

This report is intended to give an overview of the results of the Programme from 1 July 2019 to 30 June 2020. It is a technical report that provides useful information for fuel industry stakeholders and researchers. During this period fuel samples were collected and tested from 72 of the approximately 1,200 fuel service stations in New Zealand (including 59 routine sample sets as well as ad hoc samples e.g. samples taken following a complaint) as well as from some commercial sites and storage terminals.

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

There were no instances when a petrol or diesel sample would have been identified as non-compliant according to the requirements of the Regulations. All results were recognised to be compliant.

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

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1 http::://www.legislation.govt.nz/regulation/public/2011/0352/latest/DLM4044701.html

Introduction

MBIE has national regulatory responsibility for a number of infrastructure areas that are fundamental to consumer protection, supporting consumer and business confidence and facilitating domestic and international trade.

TS is responsible for administering a number of these areas[2], including Fuel Quality Monitoring (FQM) which is focused on maintaining a programme to monitor and ensure the quality and compliance of New Zealand's retail fuel supply with the Regulations.

In the fuel quality monitoring area, activities include:

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

These activities and the Programme are funded from a proportion of the *Petroleum or engine fuel monitoring levy* that is supplied in accordance with the Energy (Petrol, Engine Fuel, and Gas) Levy Regulations 2017[3].

This report sets out the results of the Programme from 1 July 2019 to 30 June 2020.

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

The key principles and structure of the Programme remain the same as in previous years. References to legislation related to engine fuel quality may be found on the Ministry website or in previous FQM Programme annual reports for the period from 2008 to 2019.

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

Any non-compliance or abnormalities identified through testing were subject to analysis and follow-up investigation by TS. The focus of any investigation is to confirm the validity of the results, identify any potential issues and implement an appropriate and timely response if required. Attention is also given to ensuring the underlying cause of any non-compliance is understood and remedied to prevent recurrence.

The samples were collected from 11 designated regional areas nationwide (see following Table) serviced by specific fuel supply terminals. The samples were taken from various fuel service stations according to a plan based on a statistical model which takes into account each retail fuel company's market share in that area. In total, 59 sample sets were collected from retail sites and each set included samples of regular and premium grade petrol and a sample of diesel.

2 http://www.tradingstandards.govt.nz
3 http://www.legislation.govt.nz/regulation/public/2019/0139/latest/LMS212394.html

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

Terminal/Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Whangarei	0	1	1	1	0	1	0	0	1	0	0	0	5
Auckland	2	0	0	0	3	3	0	2	2	0	0	0	12
Mt Maunganui	2	2	1	2	1	2	3	2	0	0	0	0	15
New Plymouth	0	0	0	0	1	0	0	0	0	0	0	0	1
Napier	0	0	1	1	0	0	0	0	0	0	0	0	2
Wellington	0	2	1	2	1	1	1	0	0	0	0	0	8
Nelson	1	0	1	1	0	0	0	0	0	0	0	0	3
Lyttelton	1	1	1	0	0	0	3	1	0	0	0	0	7
Timaru	0	1	1	0	0	0	0	1	0	0	0	0	3
Dunedin	0	0	0	0	0	1	0	1	0	0	0	0	2
Bluff	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	7	7	7	7	6	8	7	7	3	0	0	0	59

Through a period of three months, April to June, sampling of fuel was suspended due to a national lockdown in response to the COVID-19 pandemic. During this period there was also a significant reduction in the quantity of fuel supplied nationally. Normal levels of supply and sampling were resumed from the month of July which relates to the next reporting year.

Additional resources were also allocated to projects focused on investigating specific issues. In particular, a previous project that focused on dry vapour pressure in petrol was continued in response to detection of non-compliant samples during previous years. Vapour pressure is measured as an important indicator of volatility of petrol which is critical to the operation of spark ignition engines with respect to both performance and emissions. The presence of ethanol or other oxygenates may affect these properties and, as a result, performance and emissions as well.

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

A limited number of additional tests were added to the routine list of tests conducted. This included a test on appearance for diesel which is not specified in the Regulations. This testing was added to the routine list of diesel properties tested to assess the level and nature of the potential presence of water and other contaminants that can be visually assessed.

A number of retail sites in New Zealand offer ethanol blended petrol with an ethanol content from 70% to 85% labelled as E85. There are flexible-fuel vehicles on roads in New Zealand which are able to use E85 so since 2017 a testing schedule for E85 has been included in the Regulations.

Alongside the routine sampling and testing of fuel, TS checks 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 and thereby the owner's operating expenses. TS plans to continue keeping this local site management focus in the coming year and work with the fuel supply companies to ensure that they maintain 'best practice' and follow proper procedures as specified in their quality management systems to ensure that quality and composition of fuel is maintained throughout the supply chain.

The results of subsequent testing of fuel samples have been reported in accordance to 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 allows for results fall slightly outside the specified limits.

Conclusion

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

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

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)

The test method ASTM D2699[5] is prescribed in the Regulations for definition of RON while the test method ASTM D2700[6] is prescribed for definition of MON.

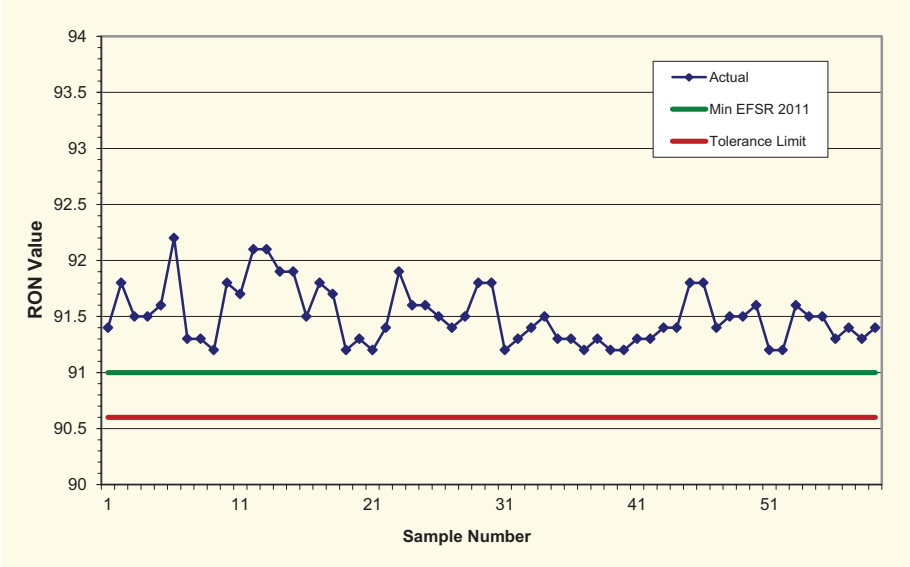
RON 91

In total, 59 samples of regular petrol were collected and all of them tested for RON. Fig. 1a below shows the testing results for RON.

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

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

Figure 1a: Test Results for Petrol RON 91, Year 2019-20

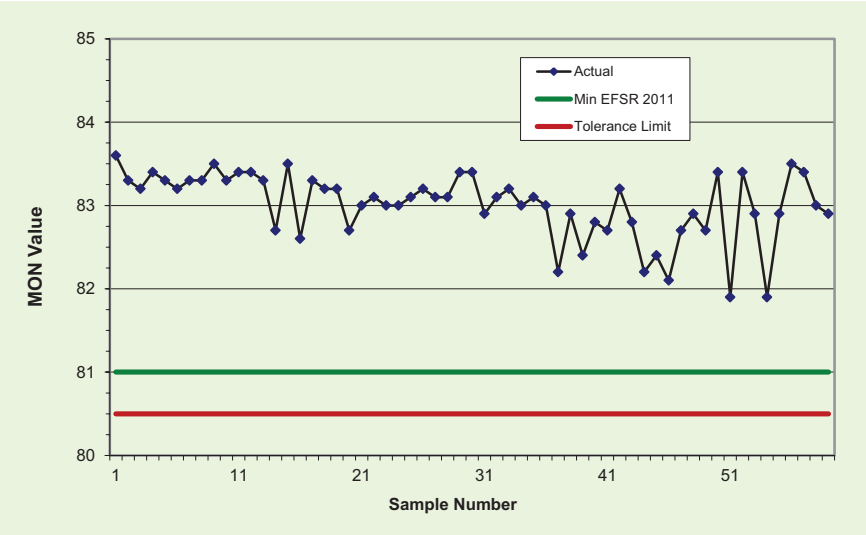


5 ASTM D2699–19 *Standard Test Method for Research Octane Number of Spark-Ignition Engine Fuel.* Here and further in footnotes, the test method's version is shown that was current in the period of testing.
6 ASTM D2700-18a *Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel.*

All samples of regular petrol were tested for MON. Fig. 1b below shows the testing results for MON.

All samples were found to be above the minimum specification limits of 81.0 for MON.

Figure 1b: Test Results for Regular Petrol MON, Year 2019-20



RON 95

In total, 45 samples of premium grade petrol were tested for RON 95.

All samples except one were found to be on or above the minimum specification limit of 95.0 for RON. Sample 18 was found to be on the specification limit.

An exception was Sample 21 which was initially found to be 94.9, *i.e.* below the specification limit of 95.0 although within the test tolerance limit *i.e.* above 94.6. The repeated test returned the same figure of 94.9, with the reproducibility condition obviously satisfied, R=0.7. Therefore Sample 21 was interpreted as compliant. The relevant figure for MON was above the minimum limit.

The same number of samples of petrol with RON 95 were tested for MON. All samples were found to have MON on or above the minimum specification limit of 85.0 for premium petrol.

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

Figure 2a: Test Results for Petrol RON 95, Year 2019-20

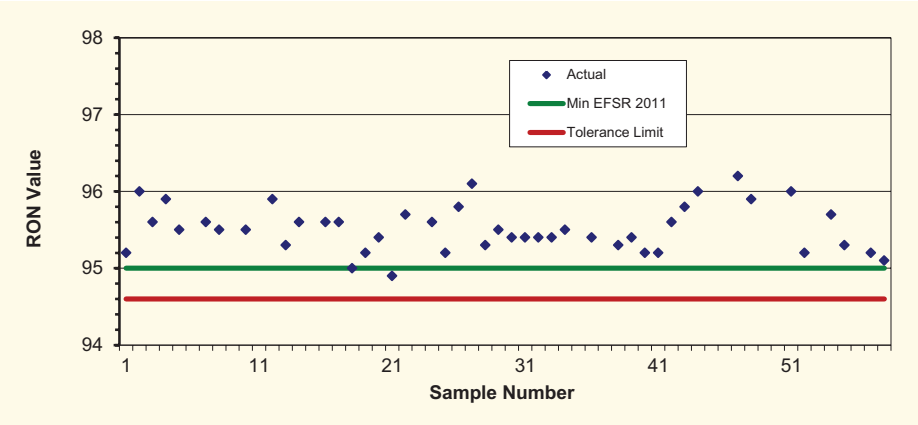
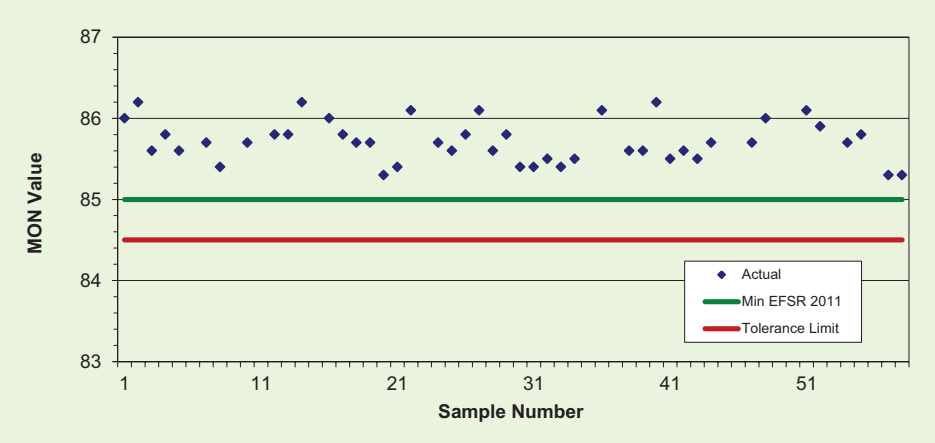


Figure 2b: Test Results for MON, Premium Petrol RON 95, Year 2019-20



RON 98

No minimum value is specified in the Regulations for premium petrol with RON 98. This fuel is advertised as having properties that are superior or in addition to the regulated limits. In particular, with an "advertised RON 98 minimum" which is referred to in Fig. 3a, it must conform, according to Section 11 of the Regulations with regard to those advertised properties when tested using the test methods specified in Schedule 1 in the Regulations.

This advertised limit is also enforceable under the provisions of the Fair Trading Act 1986 in relation to possible mis-description. On that basis it is also deemed that the actual figures of RON must not be lower than 98.

For premium petrol with RON 98, a minimum limit for MON is neither specified in the Regulations nor advertised. In the absence of a specified minimum limit for MON the limit for premium petrol has been used as a benchmark.

In total, 13 samples of petrol with advertised RON 98 were collected and tested. Fig. 3a below shows the testing results for RON.

All samples with the advertised RON of 98.0 were found to be above or on the advertised minimum limit.

No minimum MON is specified for premium petrol with RON 98. All samples were found to have MON above the specification limit of 85.0 for premium petrol. Fig. 3b below shows the testing results for MON.

Figure 3a: Test Results for Petrol RON 98, Year 2019-20

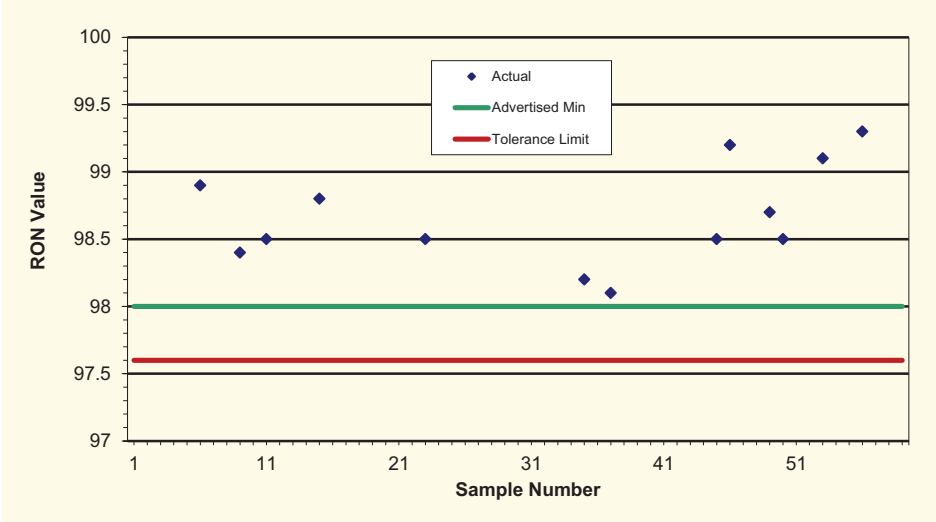
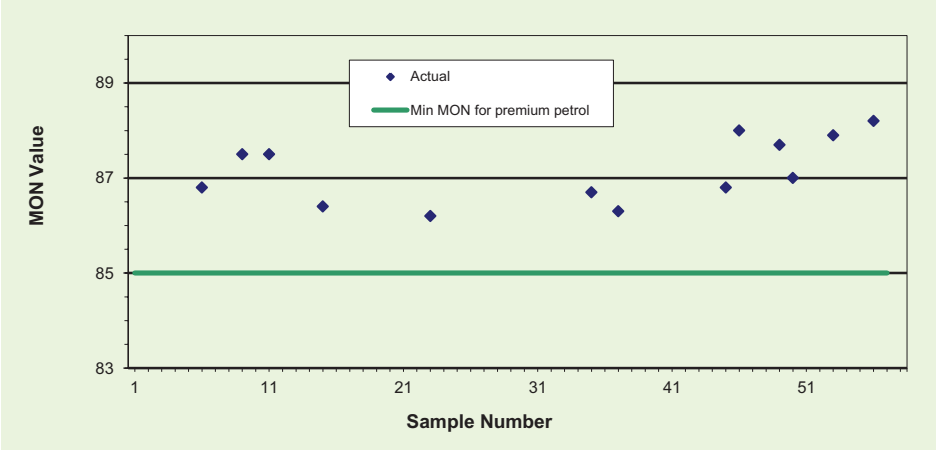


Figure 3b: Test Results for MON, Premium Petrol RON 98, Year 2019-20



Evaporation Percentage

The test method ASTM D86[7] is prescribed in the Regulations for the definition of the volume percentage of evaporated petrol at the three fixed temperatures: at 70ºC, 100ºC and 150ºC. There are three categories for evaporation percentage limits in the Regulations: E70, E100 and E150. These categories are analysed below separately for regular petrol (RON 91) and for premium petrol (RON 98 data is included with RON 95 data).

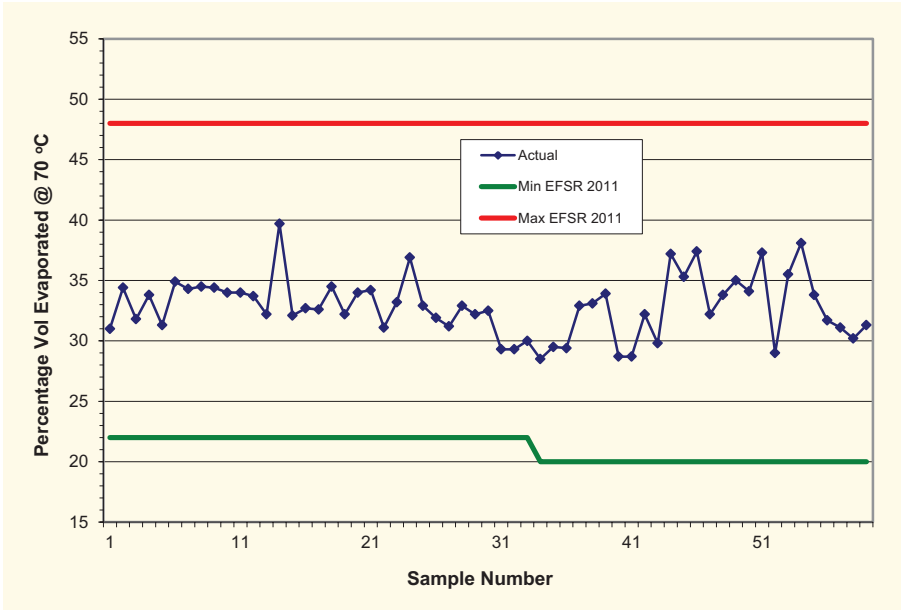
RON 91

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 59 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 2019-20



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

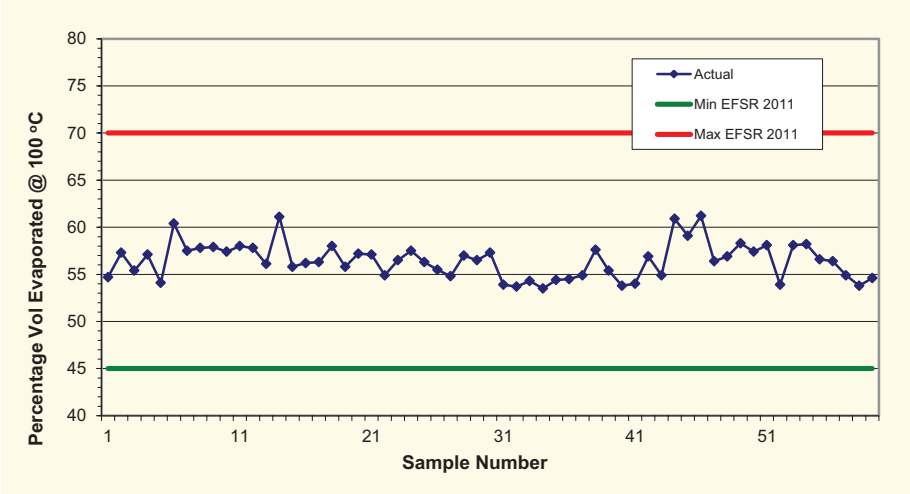
7 ASTM D86-20a *Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure.*

Percentage Volume Evaporated at 100°C

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

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

Figure 4b: Test Results for E100, RON 91, Year 2019-20

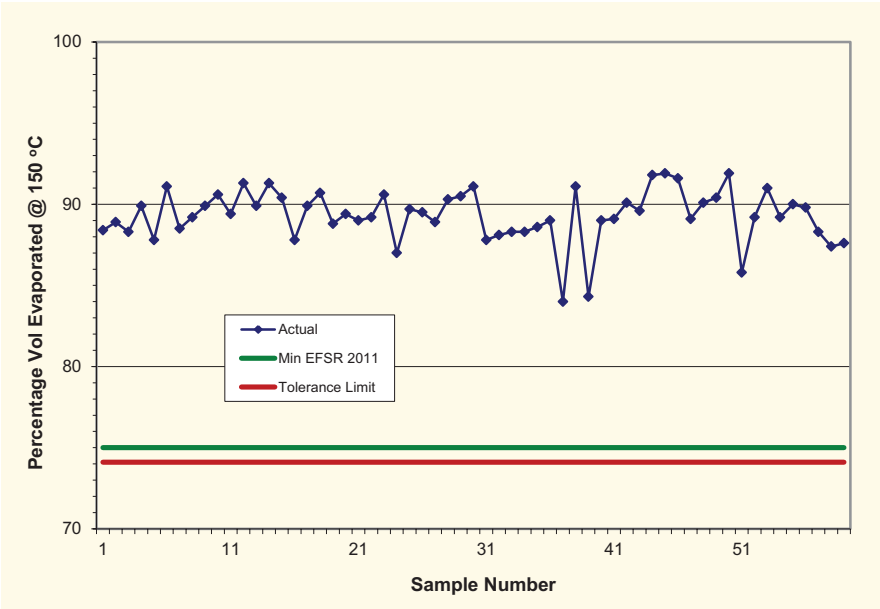


Percentage Volume Evaporated at 150°C

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

No maximum is prescribed by the Regulations for this property.

Figure 4c: Test Results for E150, RON 91, Year 2019-20



RON 95 & 98

Percentage Volume Evaporated at 70°C

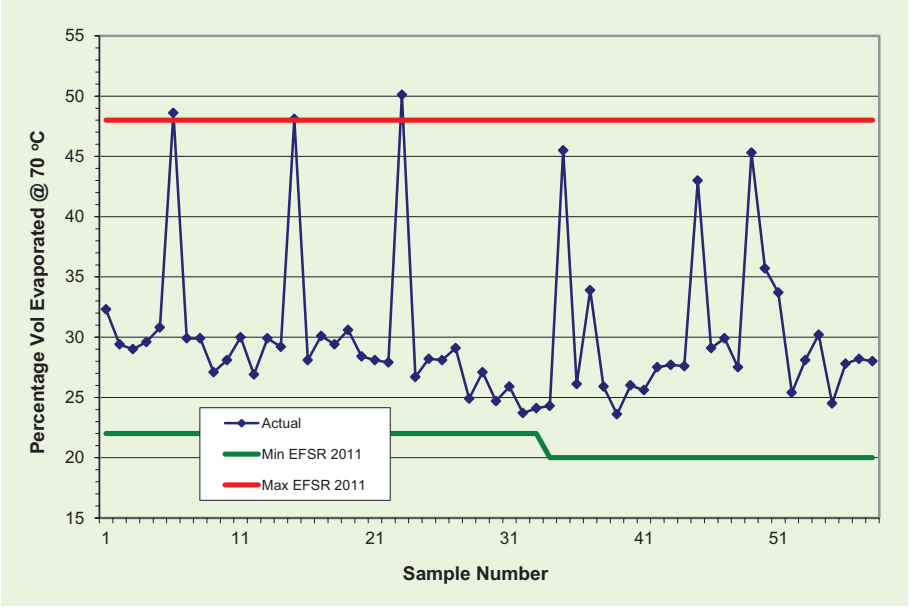
For premium petrol not containing ethanol, as in case of regular petrol, the minimum specification limit is 22% (a minimum of 20% E70 permitted for the summer season – see Footnote 1 in Schedule 1, the Regulations) and maximum specification limit is 48% while the minimum tolerance limit is 20.5% (18.5%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

The majority of results were found to be within the specification limits of 22% to 48% with the exception of a number of ethanol blended samples. According to the Regulations (Footnote 2 in Schedule 1), the maximum allowed percentage of volume evaporation at 70ºC (E70) is increased by 1% per each 1% volume of ethanol in the blend.

Four E70 results for premium petrol samples with ethanol (Fig. 5a) were found above the level of 48% however they were well within the specified limits for the relevant ethanol content, in particular, samples 6, 15 and 23 were allowed to be up to 57%.

As in the case with regular petrol (see above), all samples were found to be within the prescribed specification limits with the minimum limit of 22% at all seasons including the summer period when the specified minimum limit for E70 is permitted to be 20%.

Figure 5a: Test Results for E70, RON 95 & 98, Year 2019-20

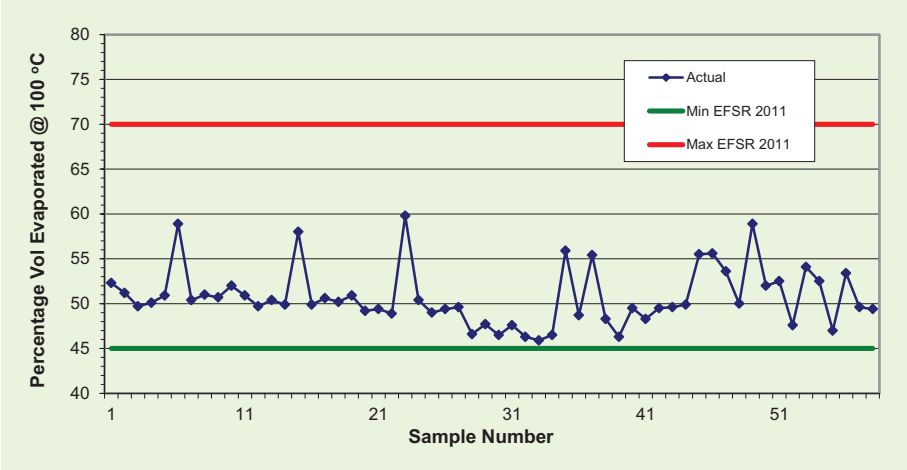


Percentage Volume Evaporated at 100°C

All samples were found to be within the specification limits from the minimum of 45% to the maximum of 70%. Sample 33 was found to be the lowest, 45.9%.

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

Figure 5b: Test Results for E100, RON 95 & 98, Year 2019-20

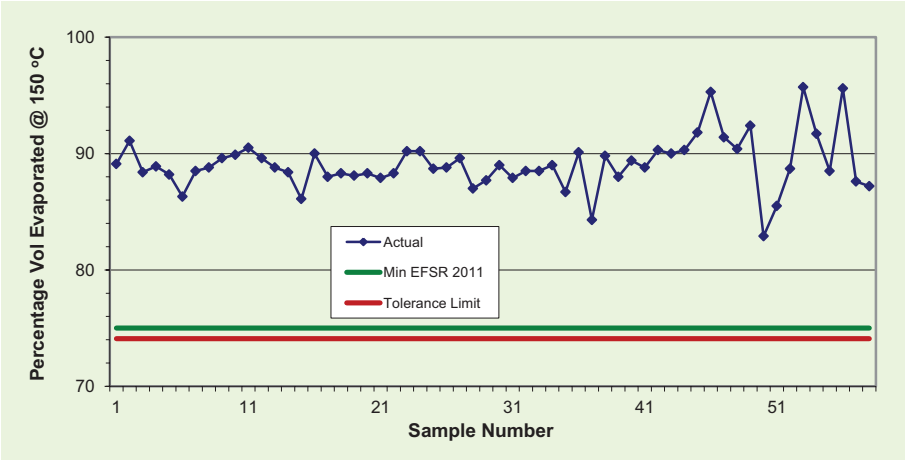


Percentage Volume Evaporated at 150°C

All samples were found to be well above the minimum specification limit of 75%. As in case of regular petrol, the minimum tolerance limit is 74.1%.

No maximum is prescribed by the Regulations for this parameter. All samples were found to be well above 80% (Fig. 5c).

Figure 5c: Test Results for E150, RON 95 & 98, Year 2019-20

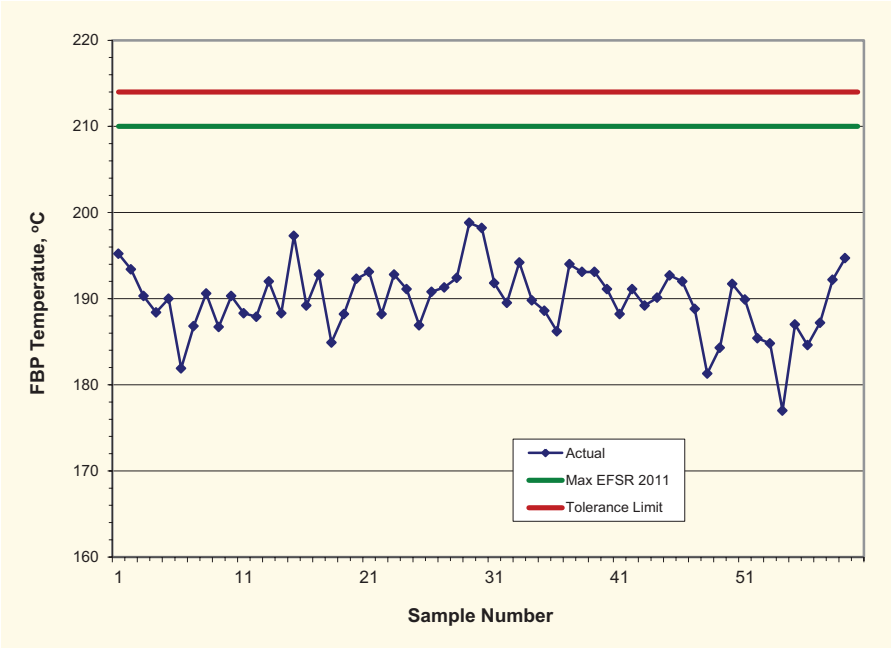


Final Boiling Point (FBP)

The test method ASTM D86[8] is prescribed in the Regulations for distillation end point (or 'final boiling point') in petrol.

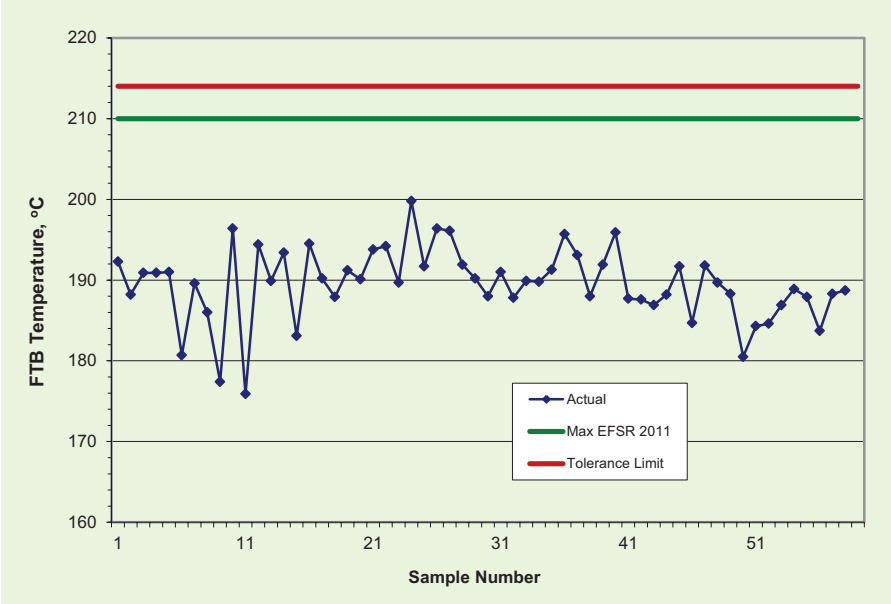
All samples were found to be within the specification maximum limit of 210ºC for both regular and premium grades (Fig.6). The tolerance limit is 214ºC. The highest figure for final boiling point was found to not exceed 200ºC.

Figure 6a: Test Results for Final Boiling Point, RON 91, Year 2019-20



The highest figure for final boiling point for premium petrol was also found to not exceed 200ºC.

Figure 6b: Test Results for Final Boiling Point, RON 95 & 98, Year 2019-20



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

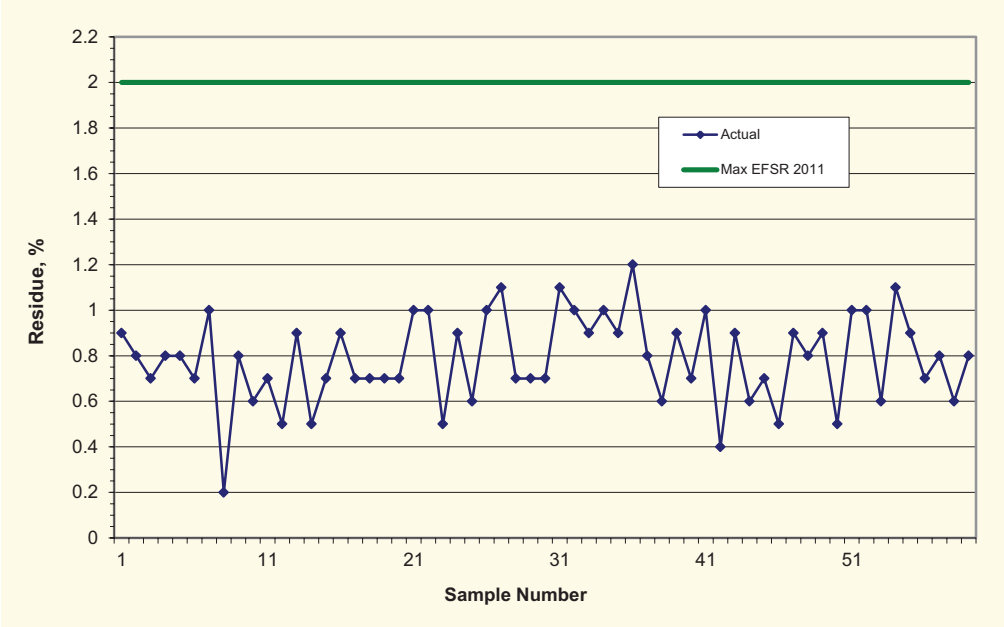
Residue

All samples were found to be well within the limits for both regular and premium grades (Fig. 7).

Distillation residue, according to the standard ASTM D86[9] 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 well below the specified maximum limit of 2% volume.

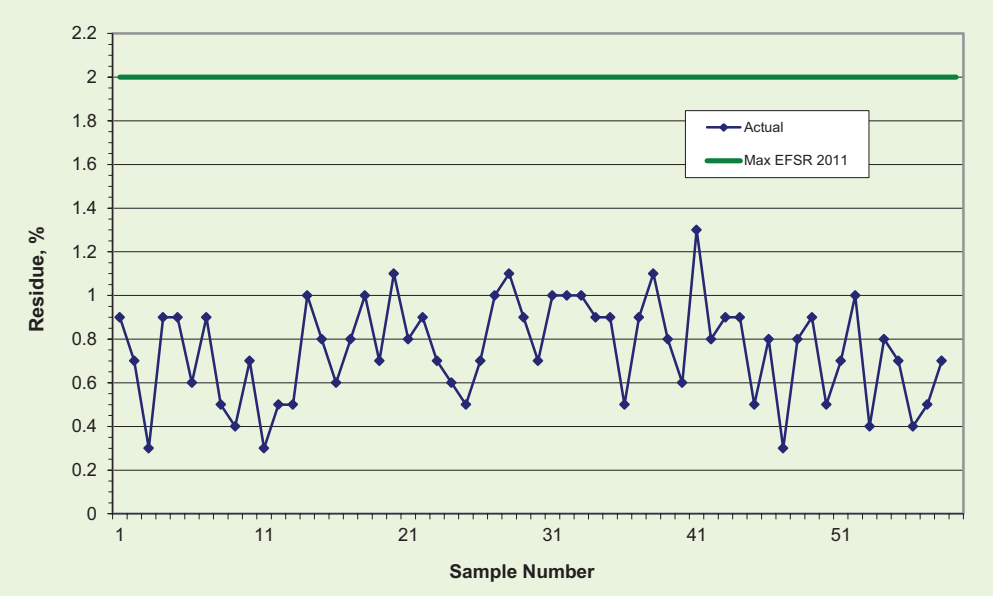
All results for regular petrol were found to be not higher than 1.2%.

Figure 7a: Test Results for Residue, RON 91, Year 2019-20



All results for premium petrol were found to be not higher than 1.3%.

Figure 7b: Test Results for Residue, RON 95 & 98, Year 2019-20



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

Dry Vapour Pressure Equivalent

The test method ASTM D5191[10] 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 they definitely complied with the Regulations in all other areas.

For the period of summer in Schedule 1 (season definitions in Section 5, the Regulations) from 1 December to 31 March inclusive, the lowest maximum limit of pressure 65 kPa is prescribed for Auckland and Northland. This is shown on the Fig. 8 by a 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

In some periods, a number of samples were initially found to be above the lowest maximum at the time. However, they were subsequently found to be within the specification limits for their region and season.

Samples 38, 39, and 53, were found to be in the range from 65.1 kPa to 66.9 kPa within the maximum limit of 75 kPa for summer in South Island.

RON 95 & 98

All samples were found to be within the specification limits for premium petrol (Fig. 8b). However, as in the case with regular petrol, in various periods, some samples (six in total) were initially found to be above the lowest maximum at the time, *i.e.* they were found to be compliant due to their regional maxima.

The following five samples were found to be above the lowest maximum in the summer period. Samples: 36, 42 to 44, and 54, which were found to be in the range from 65.9 kPa to 68.5 kPa, were well within the maximum limit of 75 kPa for summer in South Island.

Next, sample 40 which was found to be 67.9 kPa, was within the maximum limit of 70 kPa for summer in the rest of North Island region.

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

Figure 8a: Test Results for DVPE, RON 91, Year 2019-20

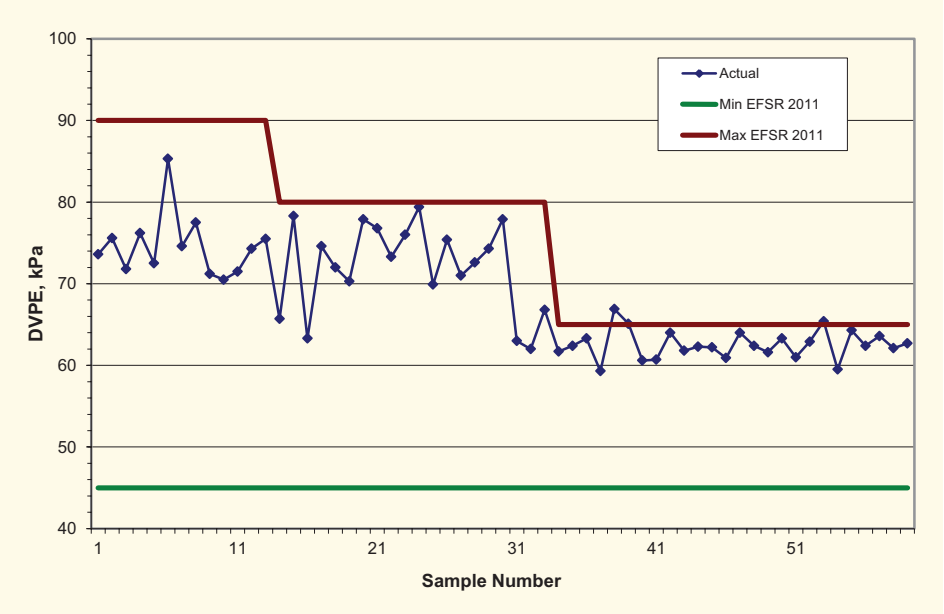
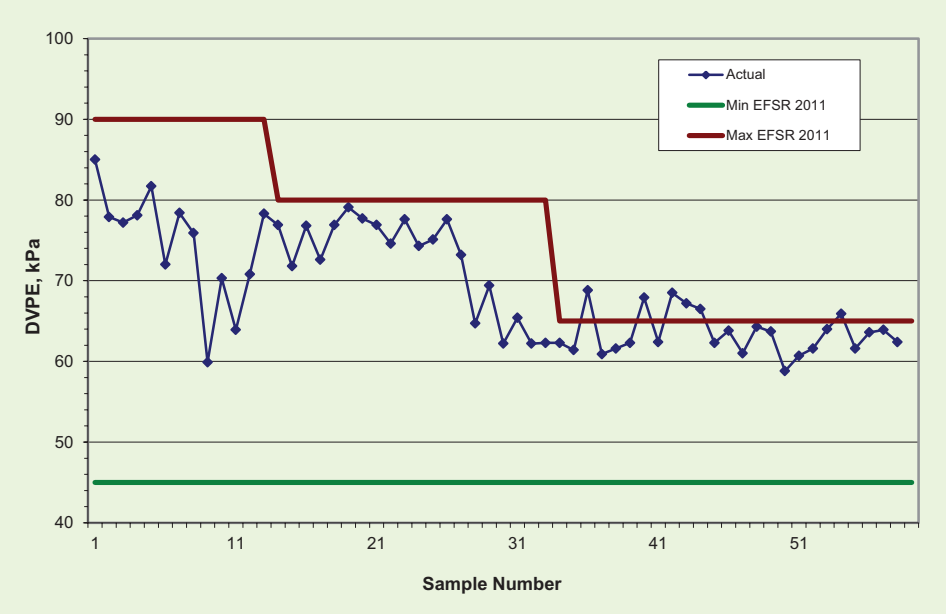


Figure 8b: Test Results for DVPE, RON 95 & 98, Year 2019-20



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)

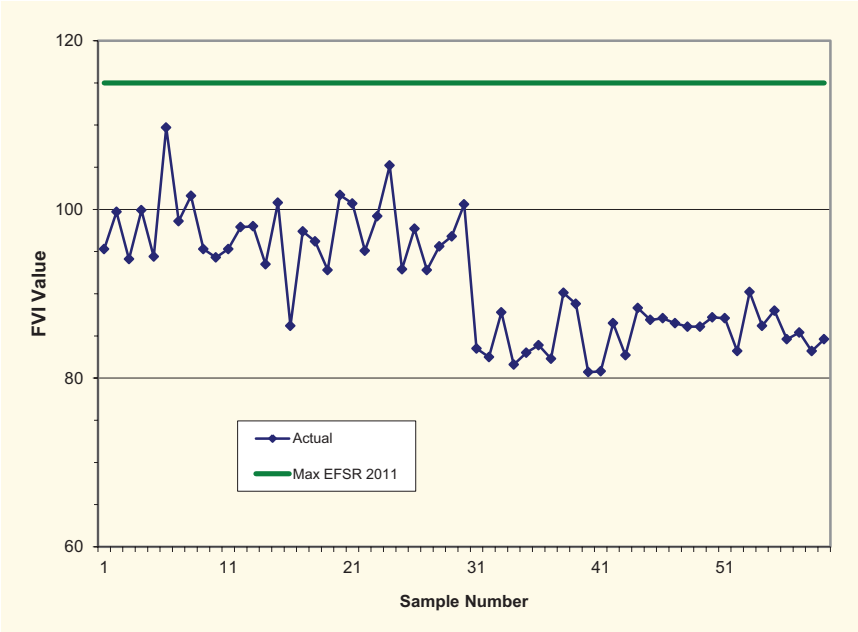
FVI serves as an indicator of the hot running performance (the tendency for vapour lock).

No definition of the FVI value is given in the related ASTM Standards prescribed in the Regulations (D86 and D5191[11]) and as a consequence 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 well within the specification maximum limit of 115.0, with the maximum value of 107.9 for sample 6.

Figure 8c: Results for Flex. Vol. Index, RON 91, Year 2019-20

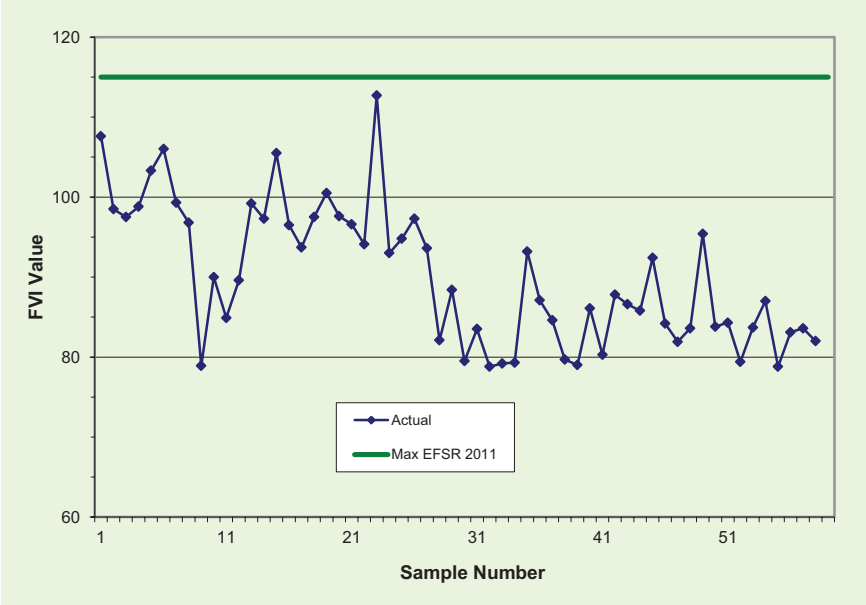


11 ASTM D5191 - 20 *Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method).*

RON 95 & 98

All samples of premium petrol were found to be within the specification maximum limit of 115.0, with the largest values of 112.7 for sample 23.

Figure 8d: Results for Flex. Vol. Index, RON 95 & 98, Year 2019-20



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.[12]

The scope of the test method IP 497[13] 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[14] 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.9 by a red line).

RON 91

All 59 samples tested for sulphur for regular petrol were found to be within the prescribed maximum limit. Sample 6 was found to be the largest with the figure of 7.8 mg/kg.

RON 95 & 98

All results for premium petrol were found to be within the prescribed maximum limit not exceeding 10 mg/kg. Sample 24 was found to be the largest with the figure of 7.6 mg/kg.

12 *Worldwide Fuel Charter,* 6th Ed., 2019, p.17.
13 IP497 EN ISO 20884:2019 *Petroleum products - Determination of sulfur content of automotive fuels. Wavelength-dispersive X-ray fluorescence spectrometry.*
14 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.*

Figure 9a: Test Results for Sulphur, RON 91, Year 2019-20

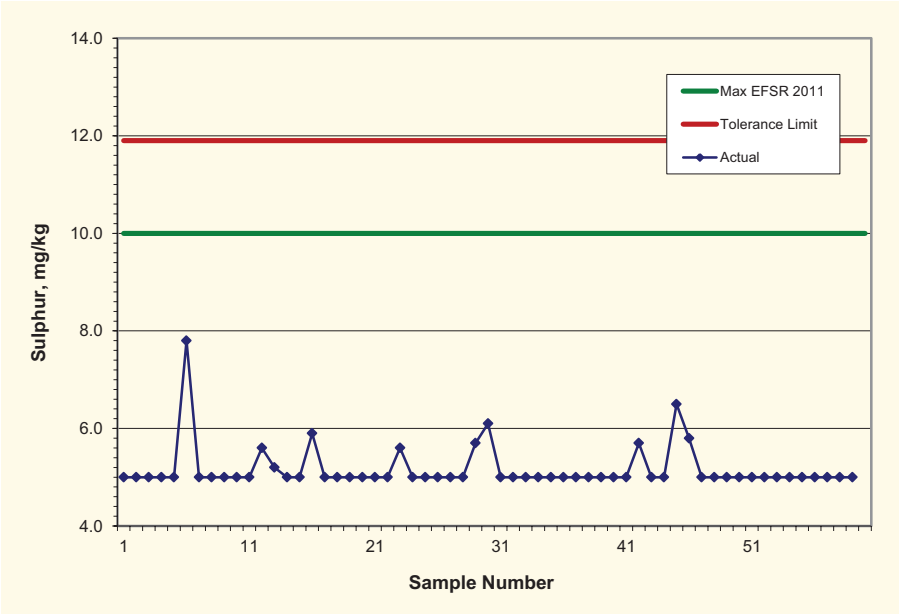
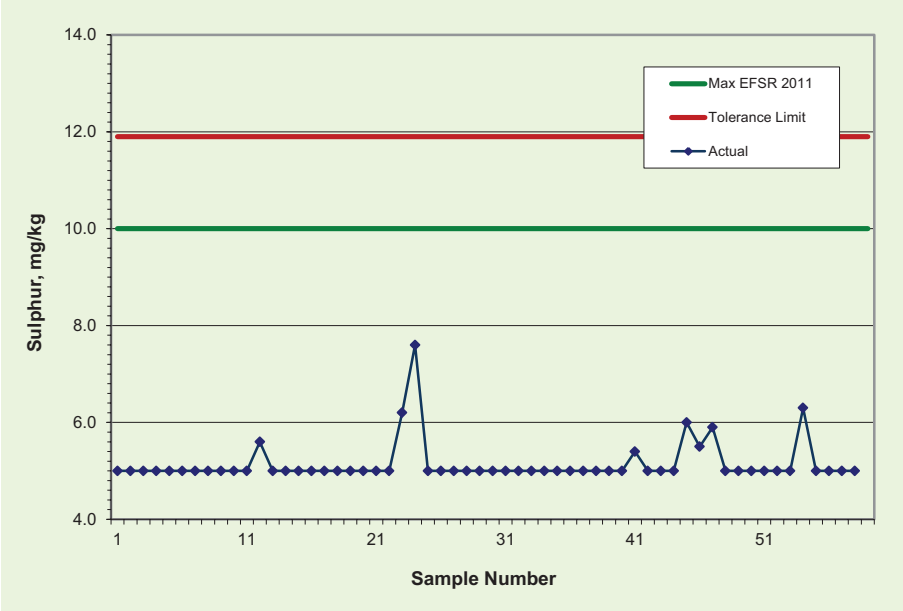


Figure 9b: Test Results for Sulphur, RON 95 & 98, Year 2019-20



Benzene and Total Aromatics

The test method ASTM D5580[15] is prescribed in the Regulations for aromatic compounds including benzene.

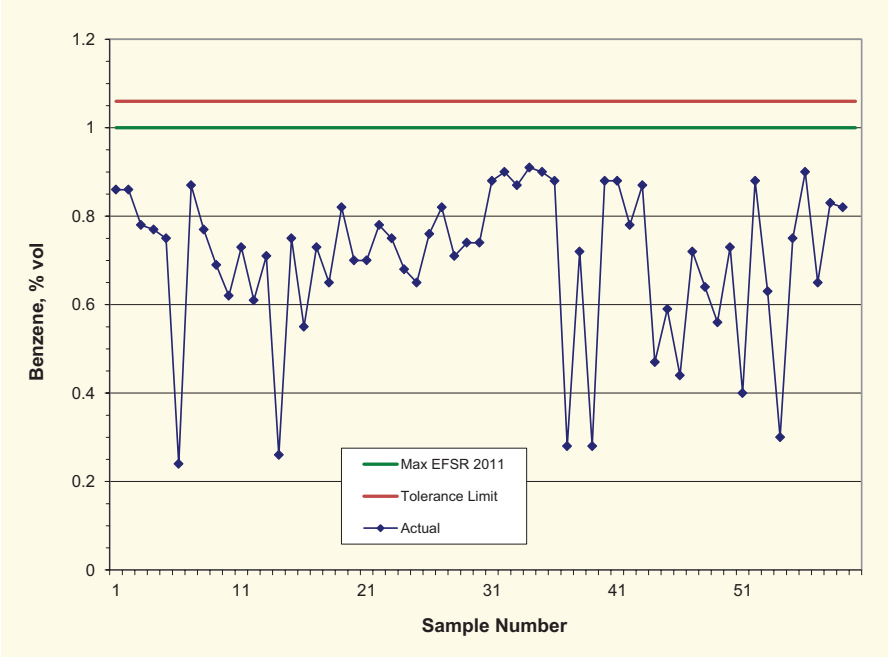
All samples were found to be within the prescribed maximum limits, for both benzene (maximum 1% vol) and total aromatic compounds (45% vol maximum cap) for regular as well as premium grade of petrol with the tolerance limits, respectively, of 1.06% for benzene and of 46.03% for the maximum cap in total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

RON 91

All 59 results tested for benzene content in regular petrol were found to be below 0.95% with the largest figure of 0.91% for Sample 34 (Fig.10a).

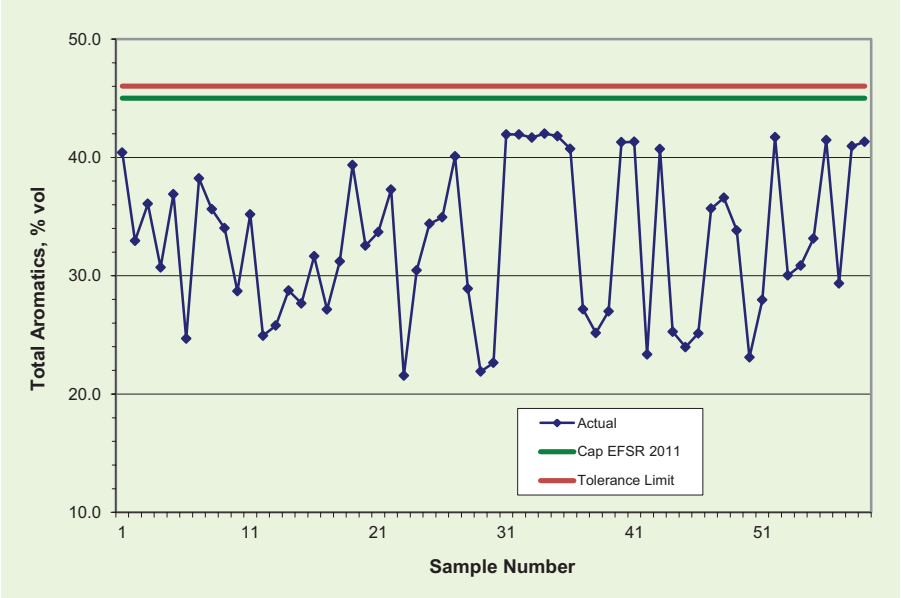
All 59 results of total aromatics were found to be within the prescribed limit. Sample 34 was found to be the largest with a figure of 42.01% (Fig. 10b).

Figure 10a: Test Results for Benzene, RON 91, Year 2019-20



15 ASTM D5580-15(2020) *Standard Test Method for Determination of Benzene, Toluene, Ethylbenzene, p/m-Xylene, o-Xylene, C9 and Heavier Aromatics, and Total Aromatics in Finished Gasoline by Gas Chromatography.*

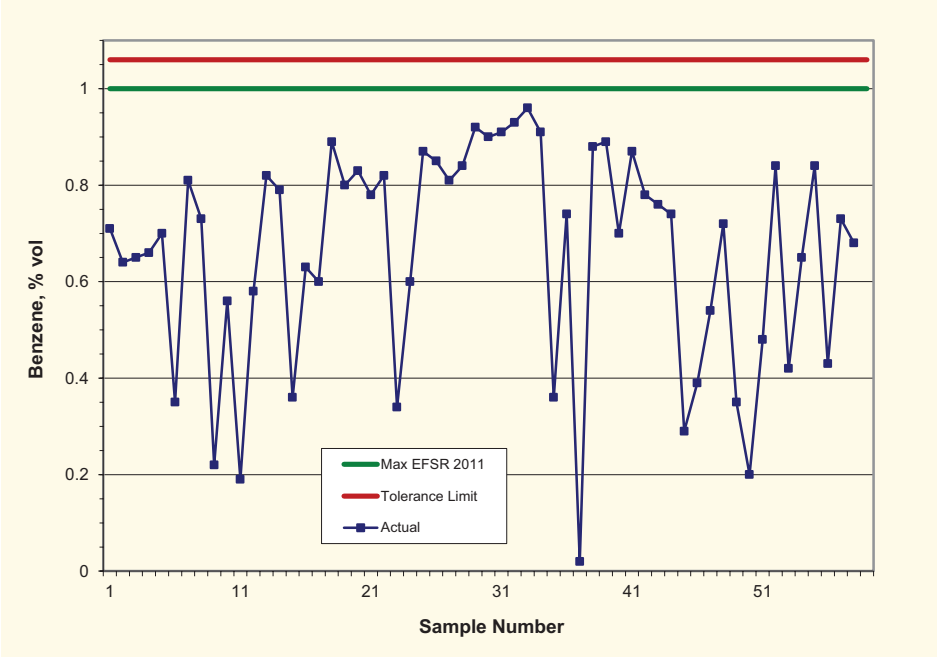
Figure 10b: Test Results for Total Aromatics, RON 91, Year 2019-20



RON 95 & 98

All 58 samples of premium petrol tested for benzene were found to be well within the prescribed maximum limit for benzene with the largest result for sample 33 which was found to be 0.96%.

Figure 10c: Test Results for Benzene, RON 95 & 98, Year 2019-20

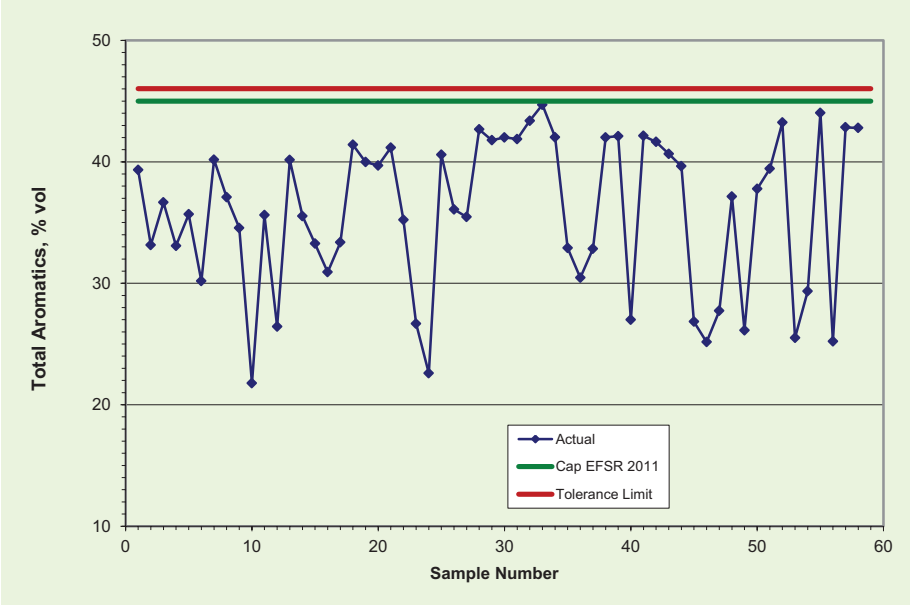


For premium petrol, all 58 results on total aromatics were found to be within the maximum limit of 45% with the largest result of 44.70% also for sample 33 (Fig. 10d).

According to Section 19 of the Regulations, actual amounts of petrol which were produced or imported, must be considered in order 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 and from The New Zealand Refining Company Ltd for the one year period ending on 30 June 2020. 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.

Figure 10d: Test Results for Total Aromatics, RON 95 & 98, Year 2019-20



Olefins

The test methods ASTM D1319[16] and ASTM D6839[17] are prescribed in the Regulations for olefins content. All samples were tested by D6839 and found to be within the specification maximum limit of 18% vol with the tolerance limit of 20.7% for D1319 and 19.6%.

RON 91

For regular petrol, all results were found to be below 16% (Fig. 11a) with the largest result of 15.02% for sample 50.

RON 95 & 98

For premium petrol, all results were found to be below 16% (Fig. 11b) with the largest result of 15.32% for sample 9.

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

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

Figure 11a: Test Results for Olefins, RON 91, Year 2019-20

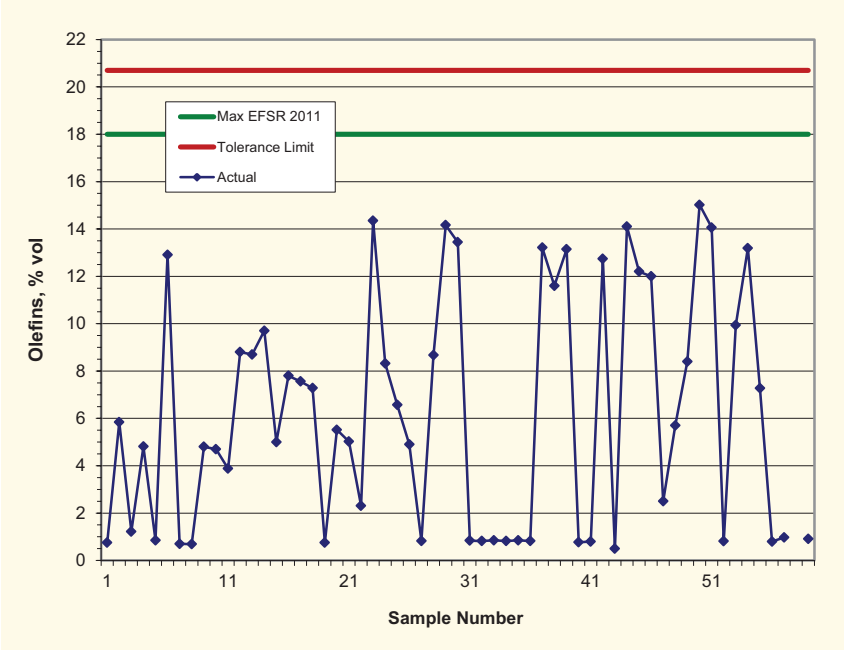
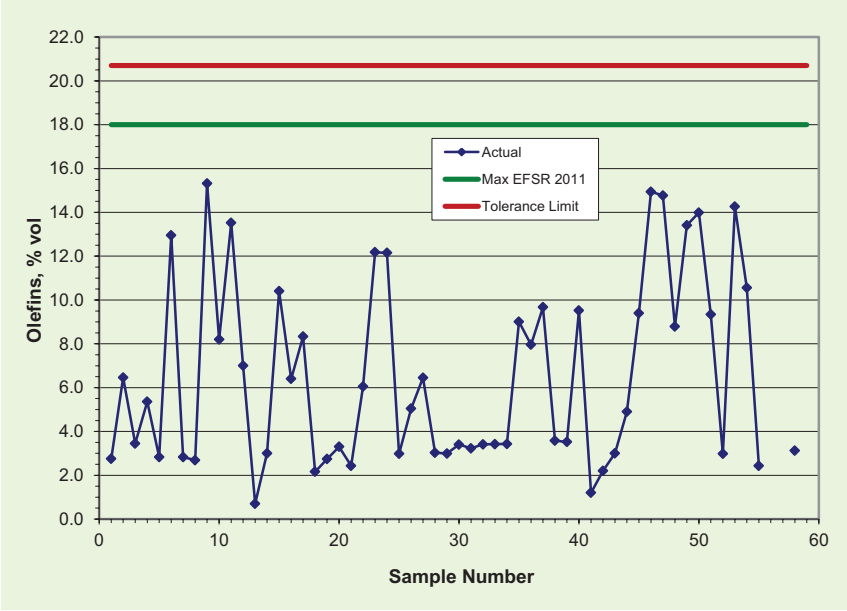


Figure 11b: Test Results for Olefins, RON 95 & 98, Year 2019-20



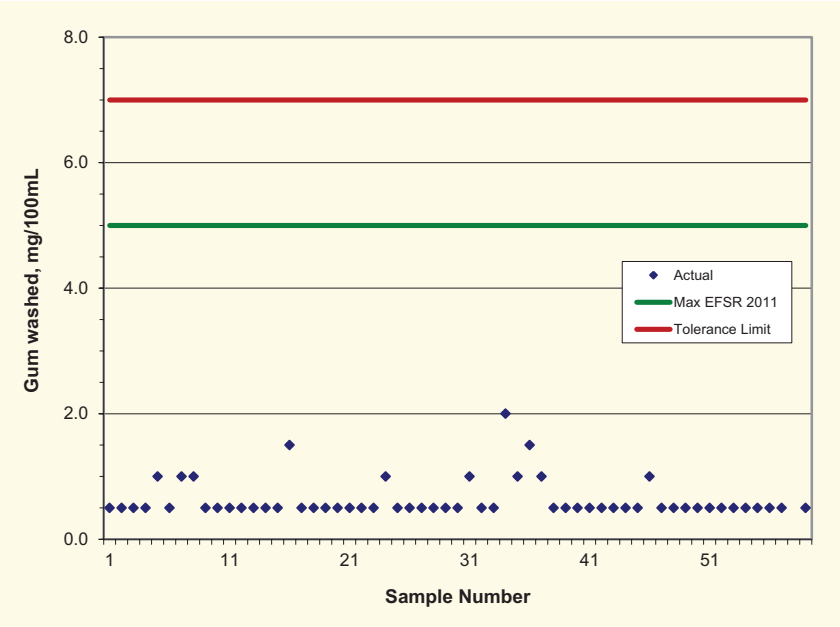
Existent Gum (solvent washed)

The threshold of the test method ASTM D381[18] 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.

For regular petrol, all results were found to be not higher than 2.0 mg/100mL (Fig. 12a).

RON 91

Figure 12a: Test Results for Gum, RON 91, Year 2019-20

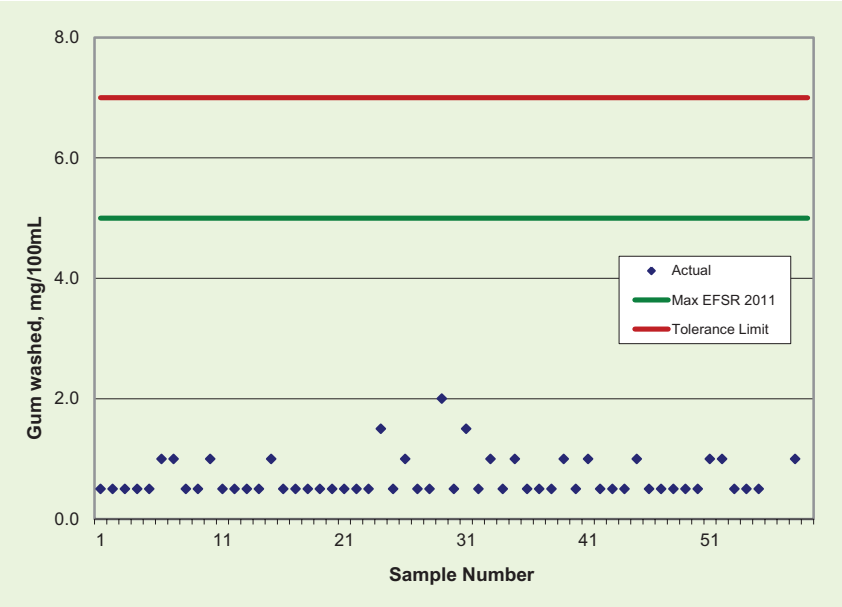


18 ASTM D381-19 *Standard Test Method for Gum Content in Fuels by Jet Evaporation.*

RON 95 & 98

For premium petrol, all results were also found to be not higher than 2.0 mg/100mL (Fig. 12b).

Figure 12b: Test Results for Gum, RON 95 & 98, Year 2019-20



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[19]. For phosphorus, this is done by means of an initial identification of its presence on the threshold of resolution by the specified method[20]. These tests' results have not been included in this report as they were usually found to be below the threshold and well within the specification limits.

The ethanol content in petrol blends was also tested and found to be within the specified limit. All results for samples with ethanol content up to 10%[21], are discussed below in the Biofuel section.

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

Finally, a number of 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.

19 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).*
20 ASTM D3231–18 *Standard Test Method for Phosphorus in Gasoline.*
21 ASTM D4815-15b (2019) *Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C1 to C4 Alcohols in Gasoline by Gas Chromatography.*
22 ASTM D130-18 *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).*

Summary for Petrol Test Results

There was one instance when the test result was found to be on the specification limit; this was one result for RON in petrol 95.

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

However, there was one test result for RON of premium petrol that was found to be below the minimum specified limit according to the Regulations. The sample was initially found to be 94.9, *i.e.* below the specification limit of 95.0 although within the test tolerance limit *i.e.* above 94.6. The repeated test returned the same figure of 94.9, with the reproducibility condition satisfied. Therefore the sample was interpreted as compliant. The relevant figure for MON was above the minimum limit.

Finally, 25 samples of regular petrol as well as 25 samples of premium petrol were tested for silver strip corrosion[24] which is not yet listed in the Regulations but has become important since the sulphur contamination incident in 2017-18 (see Report for yr. 2018-19). All tested samples returned results that would be recognised as compliant according to the established international practices.

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

24 ASTM D7667-10(2015) *Standard Test Method for Determination of Corrosiveness to Silver by Automotive Spark-Ignition Engine Fuel - Thin Silver Strip Method.*

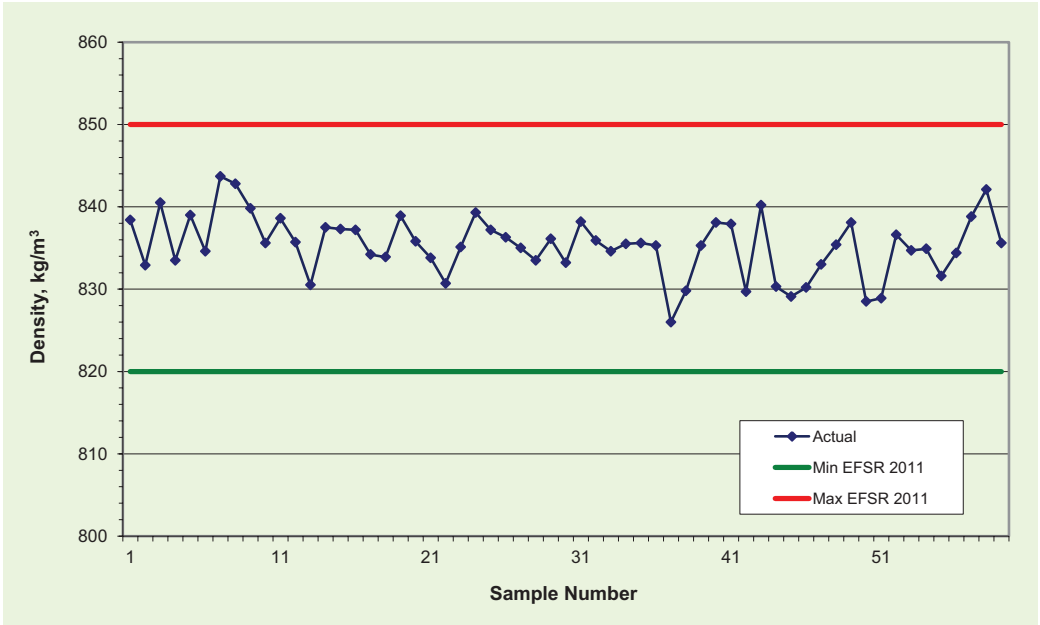
Diesel

Density

Density of diesel at 15ºC 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 59 results were found to be well within the specification limits with the minimum figure of 826.0 kg/m^3 for Sample 37 at the minimum tolerance limit of 819.3 kg/m^3 and the maximum figure of 843.7 kg/m^3 for Sample 7 at the maximum tolerance limit of 850.7 kg/m^3 (defined for ASTM D1298-17).

Figure 13: Test Results for Density, Diesel, Year 2019-20



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

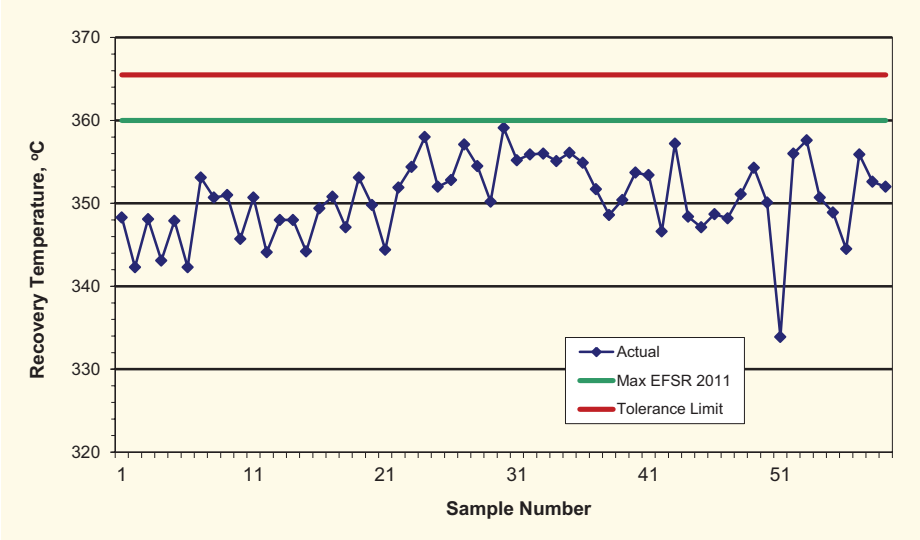
The Distillation test means definition of temperature (ºC) at which 95% volume recovered. The temperature should be tested by ASTM D86[27] prescribed in the Regulations.

All 59 samples were found to be below the specification maximum limit of 360ºC for distillation at 95% volume recovered (T95) at the tolerance limit of 365.5ºC.

Sample 30 was found to be the highest with the actual figure of 359.1ºC.

Sample 51 was found to be the lowest with the actual figure of 333.9ºC although there is no prescribed minimum limit for this property.

Figure 14: Test Results for Distillation 95% Vol Recovered, Diesel, Year 2019-20



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

Cetane Index

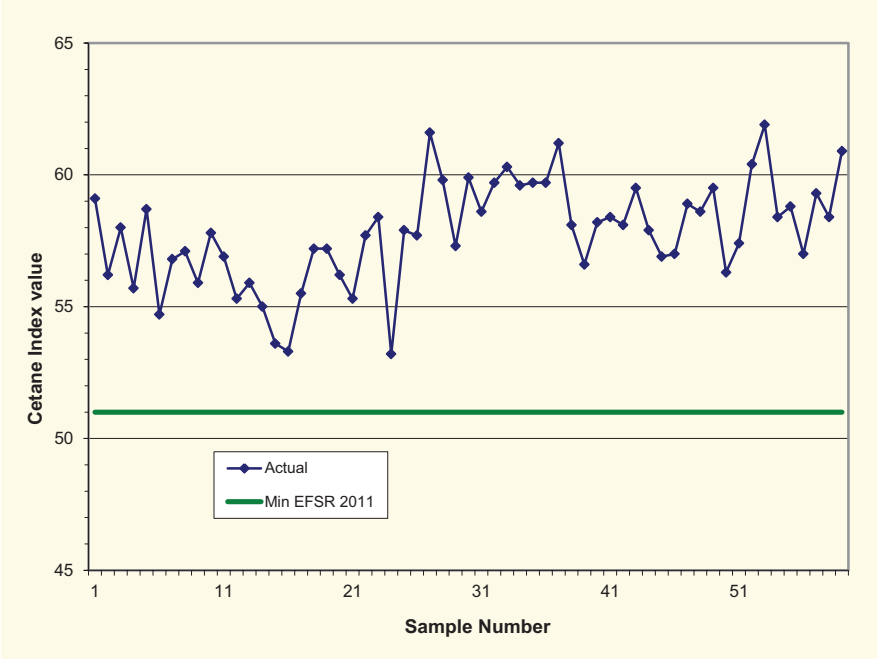
Cetane is a measure of the compression ignition behaviour of a diesel fuel; higher cetane levels enable quicker ignition. Cetane influences cold startability, exhaust emissions and combustion noise. In general, higher cetane enables improved control of ignition delay and combustion stability, especially with modern diesels which use high amounts of exhaust gas recirculation.[28]

The cetane index is not tested for but calculated from certain measured fuel properties it is designed to approximate the natural cetane.[27] The cetane index, according to ASTM D4737[29] prescribed in the Regulations, is calculated from density and distillation recovery temperature measurements. The calculated cetane index is a tool for estimating cetane number when a test engine for determining cetane number is not available and/or cetane improvers are not used.

All 59 tested samples were found to be above the minimum limit of 51 (Fig.15).

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. Sample 16 and 24 were found to be the lowest with the actual figures of 53.3 and 53.2, respectively.

Figure 15: Test Results for Cetane Index, Diesel, Year 2019-20



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

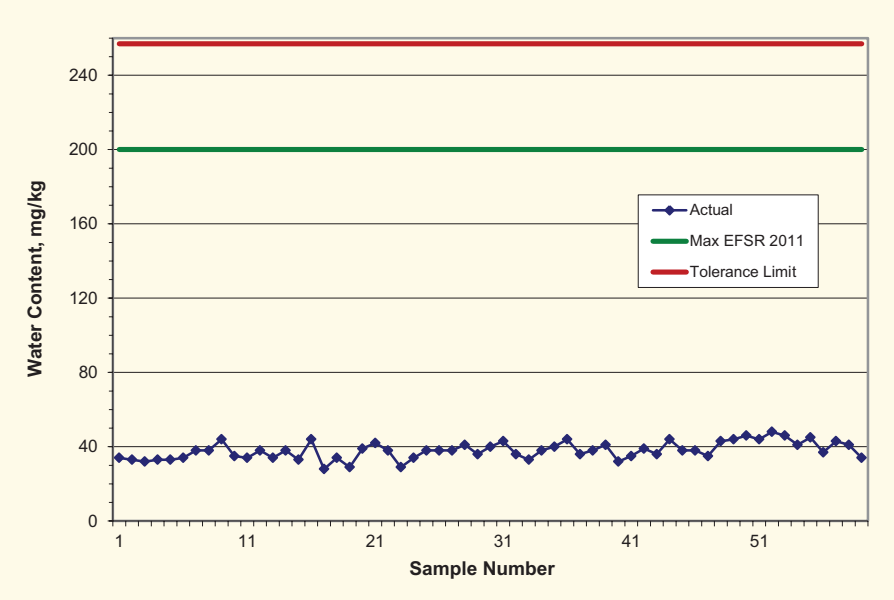
Water

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 well within the specification limit of 200 mg/kg at the tolerance limit of 257 mg/kg with actual testing results not exceeding 50 mg/kg.

Figure 16: Test Results for Water in Diesel, Year 2019-20

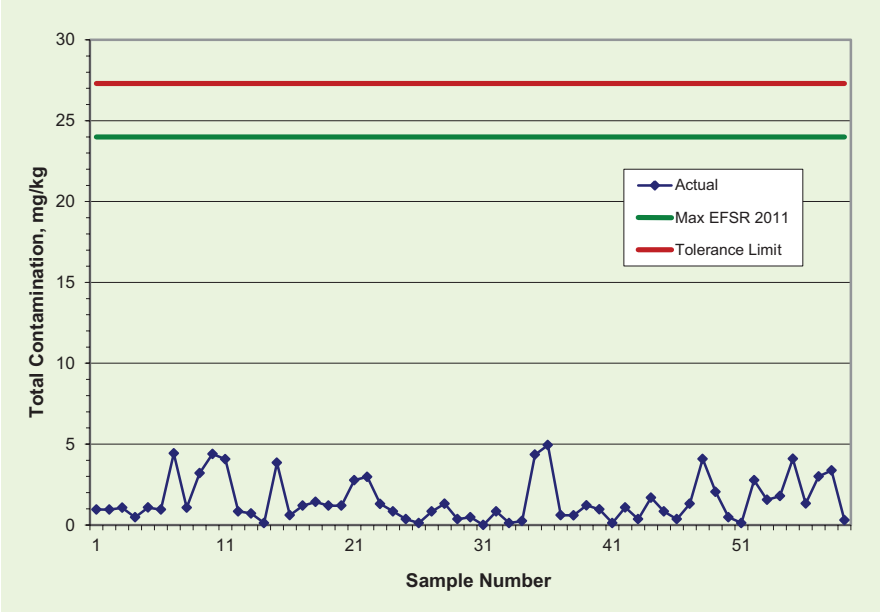


30 BS EN ISO 12937:2001, BS 2000-438:2001. *Petroleum products. Determination of content. Coulometric Karl Fischer titration method.*

Total Contamination

All 59 samples were found to be well below the maximum limit of 24 mg/kg specified in the Regulations (Fig. 17) with actual figures below 5 mg/kg. The tolerance limit for D6217[31] is 27.3 mg/kg.

Figure 17: Test Results for Total Contamination, Diesel, Year 2019-20



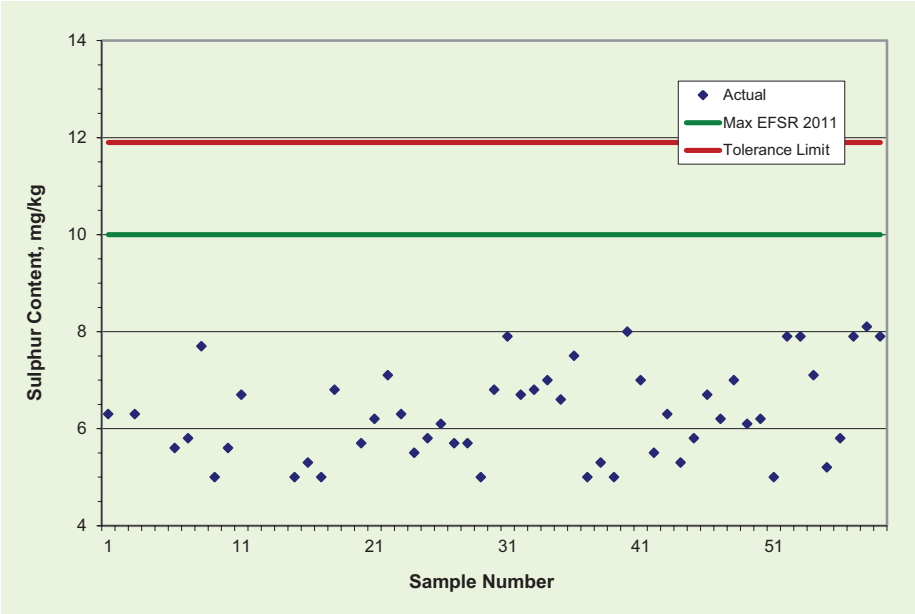
31 ASTM D6217-18 *Standard Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration*.

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.18).

All 52 tested samples were found to be below the maximum limit of 10 mg/kg specified in the Regulations (Fig. 18).

Figure 18: Test Results for Sulphur, Diesel, Year 2019-20



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 should be 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.19). Generally, if results were below the lowest maximum limit established for an area they definitely complied with the Regulations in all other areas.

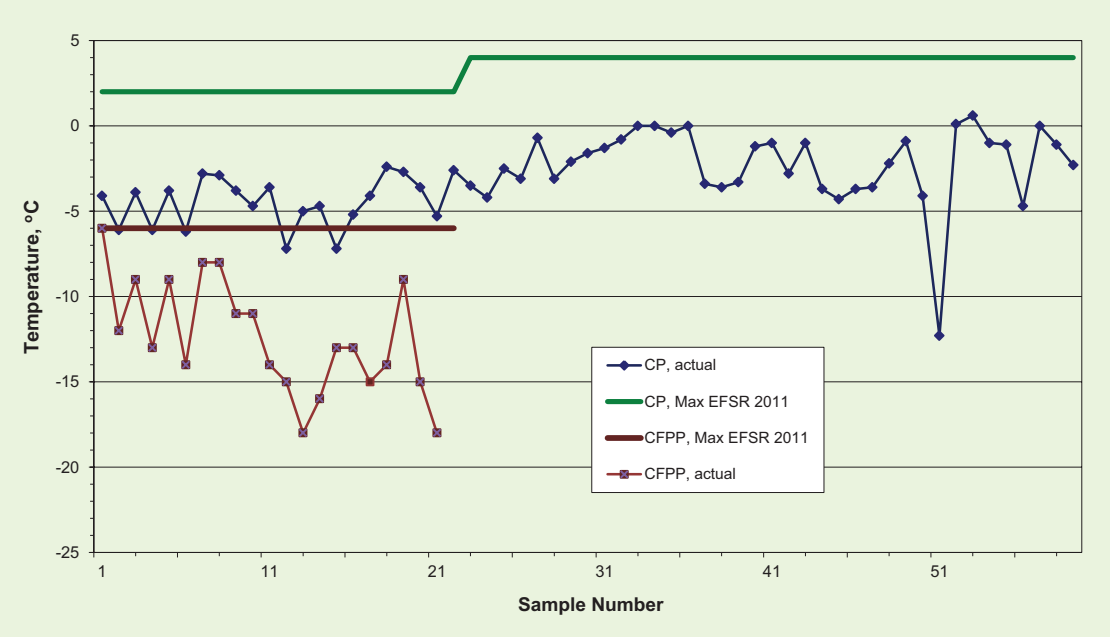
For the period of summer in Schedule 2 (season definitions in Section 5, the Regulations) from 15 October to 14 April inclusive, the lowest maximum limit of CP +4°C is prescribed for all New Zealand excluding Auckland and Northland.

The bottom line before the 'pedestal' on the graph in Fig.19, 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 59 samples appeared to be below the lowest maximum limit within the relevant seasons. Sample 18 returned the highest testing result for winter, -2.4°C, at the maximum limit of +2°C. Sample 53 returned the highest result for summer season, 0.6°C, at the maximum limit of +4°C in the rest of the North Island seasonal region.

The lowest figure for CP was found to be –12.3°C for Sample 51 from the rest of the North Island region.

Figure 19: Test Results for Cloud Point and Cold Filter Plugging Point, Diesel, Year 2019-20



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[37] 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 as long as 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 –6ºC.

The test results for CFPP are set out on the same graph as that for CP (Fig.19). This gives an advantage to see the data 'at glance' and compare the two sets where necessary.

All samples except Sample 1 were found to be below the maximum limit specified in the Regulations. Sample 1 was found to be on the maximum limit of –6ºC with the tolerance limit of –4ºC. Samples 13 and 21 were found to have the lowest CFPP of –18ºC.

It is worthwhile to note that the newly introduced norm (the delta between CFPP and CP to be below 10ºC)[35] has not been met in six instances out of 21 pairs of tests with the maximum delta of 12.7ºC for Sample 21. However, this is just an empirical rule which is not reflected in the Regulations.

In all six cases, the test results for CP and CFPP were well below the specified maximum limits.

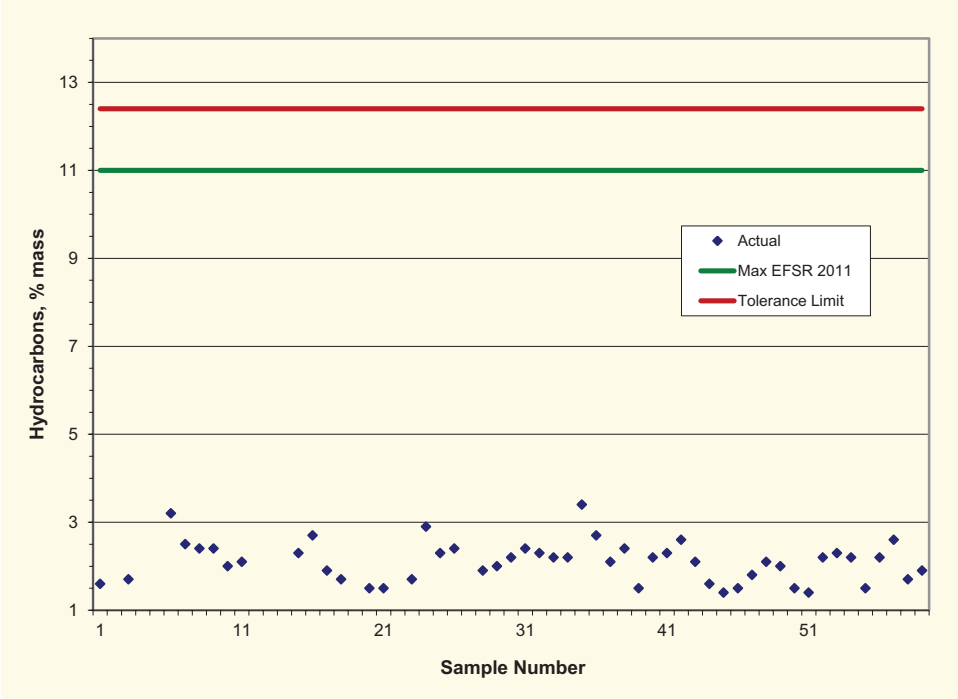
36 *Worldwide Fuel Charter,* 6th Ed., 2019, p.81.
37 BS EN 116:2015, BS 2000-309:2015 *Diesel and domestic heating fuels. Determination of cold filter plugging point. Stepwise cooling bath method.*

Polycyclic Aromatic Hydrocarbons

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

All 51 tested samples were found to be well below the maximum limit of 11% specified in the Regulations at the tolerance limit of 12.4%. All testing results were actually found to be below 4%.

Figure 20: Test Results for Polycyclic Aromatic Hydrocarbons, Diesel, Year 2019-20



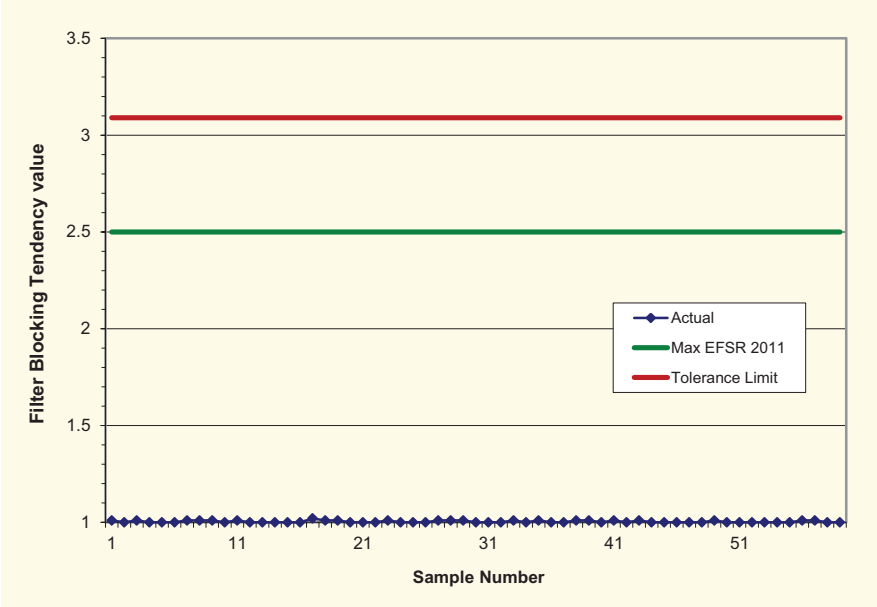
38 BS EN 12916:2019 *Petroleum products. Determination of aromatic hydrocarbon types in middle distillates. High performance liquid chromatography method with refractive index detection.*

Filter Blocking Tendency

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

All 59 samples were found to be well within the specified maximum limit of 2.5 for filter blocking tendency at the tolerance limit of 3.09. Sample 4 was found to be the largest with the actual figure just of 1.02.

Figure 21: Filter Blocking Tendency, Diesel, Year 2019-20



39 IP 387:2017 *Determination of filter blocking tendency*.
40 ASTM D2068-17 *Standard Test Method for Determining Filter Blocking Tendency*.

Lubricity

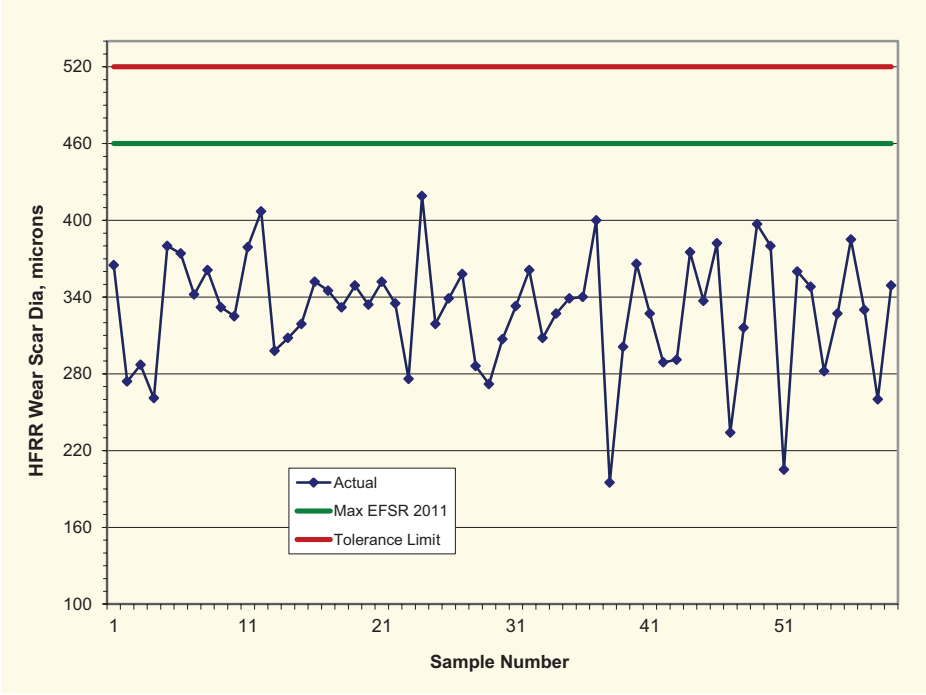
Lubricity is identified as a diameter of the wear scar produced on an oscillating ball from contact with a stationary plate immersed in the fluid and should be tested by IP 450[41] prescribed in the Regulations.

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

All 59 samples were found to be below the specification maximum limit for the lubricity.

Sample 24 was found to be the closest to the specification limit with the actual figure of 419 µm.

Figure 22: Test Results for Lubricity, Diesel, Year 2019-20



41 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.*

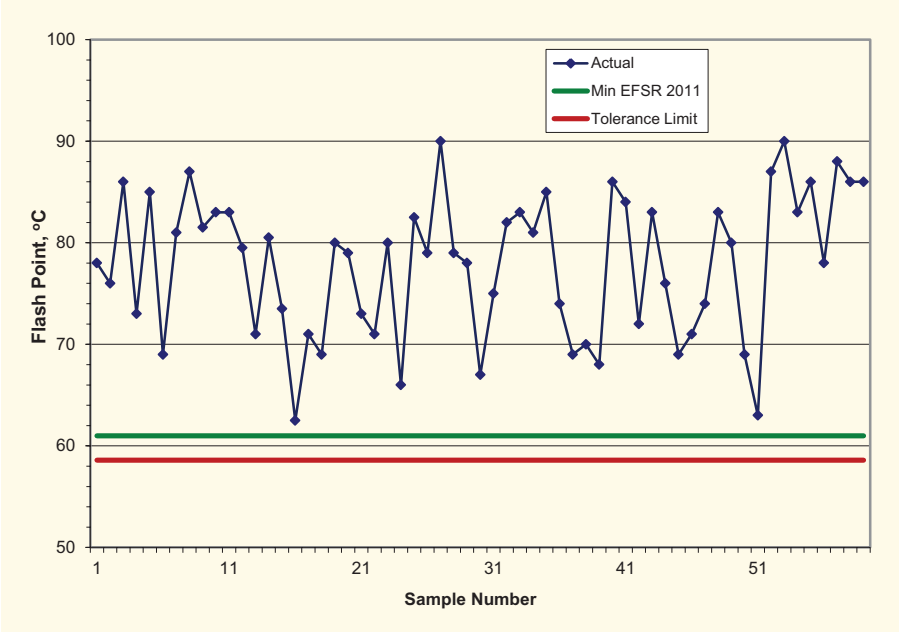
Flash Point

Flash point should be tested by ASTM D93[42] prescribed in the Regulations.

All 59 samples were found to be above the specified minimum limit of 61ºC for flash point of diesel. The tolerance limit is 58.6ºC.

Samples 16 and 51 were found to be the lowest with the actual results of 62.5 and 63.0ºC, respectively.

Figure 23: Test Results for Flash Point, Diesel, Year 2019-20



42 ASTM D93-19 *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester.*

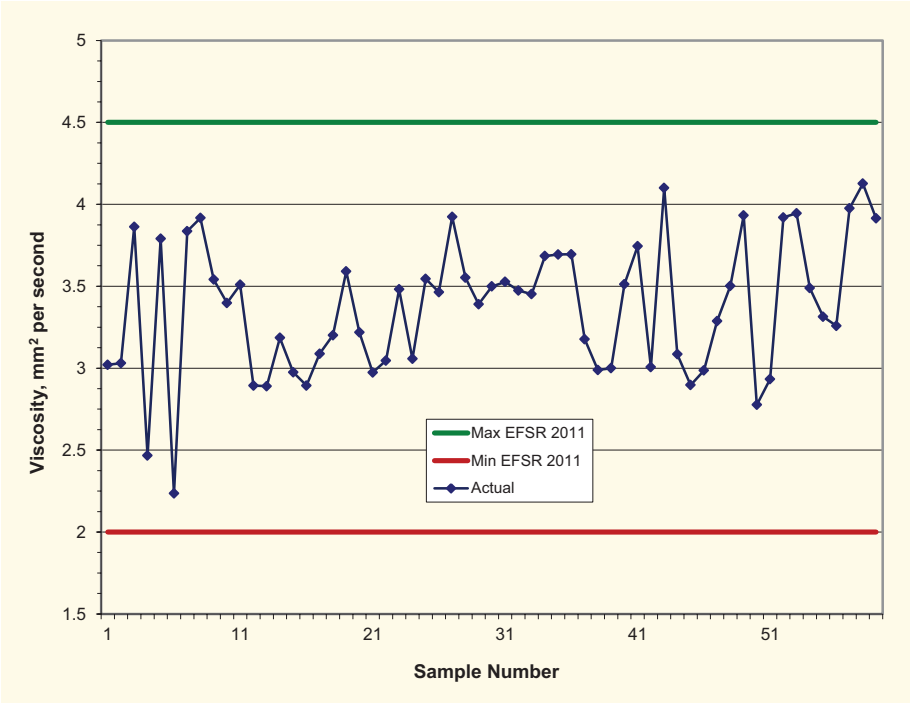
Viscosity

The viscosity should be tested at 40ºC by ASTM D445[43] prescribed in the Regulations.

All 59 samples were found to be well 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.

All test results were in the range between 2.5 and 4.0 mm^2 per second with the minimum result of 2.235 mm^2 per second for Sample 6 and the maximum result of 4.126 mm^2 per second for Samples 58. The minimum tolerance limit is 1.974 mm^2 per second and the maximum tolerance limit is 4.559 mm^2 per second (not shown on Fig.24).

Figure 24: Test Results for Viscosity, Diesel, Year 2019-20



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

Summary for Diesel Test Results

There were no instances when a diesel sample would have been identified as suspect non-compliant according to the requirements of the Regulations. All results were recognised to be compliant.

In one instance the test result was found to be on the specification limit. This is a result for cold filter plugging point in winter season.

Further, 19 out of 59 samples were tested for copper strip corrosion[44] and all of them were found to be compliant. A number of samples were tested for oxidation stability[45] and also were found to be compliant.

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

44 ASTM D130-18 *Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test*.
45 ASTM D2274-2014(2019) *Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)*.
46 ASTM D4176-14 *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 and when sampling is completed during production prior to supply.

Retail Fuel Sampling and Testing

BIODIESEL B5

This blend was tested a number of times throughout the year at retail as well as commercial sites. The product falls into the category of diesel by definition in the Regulations, with FAME (Fatty Acid Methyl Esters), *i.e.* the main component of biodiesel according to Schedule 3, content up to 5%. All samples were found compliant with the relevant specifications in the Regulations.

ETHANOL BLENDED PETROL E10

This year, a number of samples of premium petrol blended with ethanol and labelled as E10, were sampled and tested from the retail sites. All samples were found to be compliant, in particular, ethanol and oxygen content as well as dry vapour pressure, were found within the prescribed specifications, for all the samples.

ETHANOL BLENDED PETROL E85

A number of retail sites in New Zealand now offer fuel ethanol labelled as E85. This product is specified in the Schedule 1A of the Regulations since there are flexible-fuel vehicles on roads in New Zealand which are able to use E85 and the E85 dispensers have been accessible to the public throughout the period covered by this report.

This blend was tested a number of times throughout the year at retail sites and all samples were found to be compliant.

Non-Retail Fuel Sampling and Testing

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

This year, three sets of biodiesel, B100 (pure biodiesel) and relevant B10 (10% blend with mineral diesel), were sampled and tested. Biodiesel B100 was tested according to the requirements of Schedules 3 in the Regulations while B10 blend was tested according to the Regulation 17.

BIODIESEL B100

Problems with accurate measurement of FAME content remained in the focus of the testing programme. Some test results were found to be slightly below the specified minimum limit of 96.5%, e.g. two determinations of 95.8% and 96.9% under the condition of reproducibility; but all average results were found to be above the tolerance limit of 94.1%. This was seen as a reflection of the variability and tolerances around the test method as opposed to sub-standard products.

Water content was found below the specified maximum limit in all samples.

BIODIESEL B10

These blends were considered to be a final product supplied to commercial customers and therefore the properties listed in Regulation 17 were tested along with a few additional properties such as the filter blocking tendency. Filter blocking tendency is deemed to be an essential parameter for the product to be 'fit for purpose'.

A number of samples of B10 were collected either at the plant dispenser or at the non-retail point of sale. All samples were found to be fully compliant.

ETHANOL COMPONENT E100

Denatured ethanol E100 for blending with petrol, was tested from a storage terminal. Properties of duplicate samples taken from top and bottom of the storage tank were found to be fully within the specified limits.

Note: The specifications for properties of biofuels are still under review and development by the international ISO and ASTM standardisation committees. The Ministry continues to monitor and contribute to this work to ensure New Zealand has sufficient technical knowledge in this area and our perspectives and issues are represented and considered internationally.

Appendix

A Brief Glossary and Abbreviations

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