Results of Proficiency Test
Liquefied Propane and
Total Sulfur in LPG
October 2021

Organized by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

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1 INTRODUCTION

Since 2009 the Institute for Interlaboratory Studies (iis) organizes a proficiency scheme for the analysis of Liquefied Propane every year. From 2017 onwards a proficiency scheme for the analysis of Sulfur (total) in LPG is also organized every year. During the annual proficiency testing program 2021/2022 it was decided to continue the round robin for both the analysis of Liquefied Propane and for the analysis of Sulfur (total) in LPG.

Because iis has limited gas-handling facilities in place to prepare gas samples, a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up for the Liquefied Propane PT (iis21S03P) and a co-operation with Nippon Gases (Belgium) was set up for the Sulfur (total) in LPG PT (iis21S03S). Both EffecTech and Nippon Gases are fully equipped and have experience in the preparation of gas mixtures.

In the interlaboratory studies for Liquefied Propane 56 laboratories in 32 different countries and for Sulfur (total) in LPG 38 laboratories in 26 different countries registered for participation. See appendix 2 for the number of participants per country. In this report the results of the proficiency tests Liquefied Propane and Sulfur (total) in LPG are presented and discussed. This report is also electronically available through the iis website www.iisnl.com.

2 SET UP

The Institute for Interlaboratory Studies (iis) in Spijkenisse, the Netherlands, was the organizer of this proficiency test (PT). In this proficiency test the participants received, depending on the registration, one or two samples, see table below.

PT	Sample ID	Size	Purpose
iis21S03P	#21200	1L	Composition and Physical properties
iis21S03S	#21201	5L	Total Sulfur

Table 1: samples in Liquefied Propane and in Sulfur (total) in LPG PTs

The limited cylinder sizes are chosen to optimize sample stability, cylinder costs, transport and handling costs.
Participants were requested to report rounded and unrounded test results. The unrounded test results were preferably used for statistical evaluation.

2.1 QUALITY SYSTEM

The Institute for Interlaboratory Studies in Spijkenisse, the Netherlands, has implemented a quality system based on ISO/IEC17043:2010. This ensures strict adherence to protocols for sample preparation and statistical evaluation and 100% confidentiality of participant's data. Feedback from the participants on the reported data is encouraged and customer's satisfaction is measured on regular basis by sending out questionnaires.
EffecTech is accredited in conformance with ISO/IEC17043:2010 by UKAS (no. 4719) and ISO17025:2017 by UKAS (no. 0590). Nippon Gases is accredited in conformance with ISO 9001:2015.

2.2 PROTOCOL

The protocol followed in the organization of this proficiency test was the one as described for proficiency testing in the report 'iis Interlaboratory Studies: Protocol for the Organisation, Statistics and Evaluation' of June 2018 (iis-protocol, version 3.5). This protocol is electronically available through the iis website www.iisnl.com, from the FAQ page.

2.3 CONFIDENTIALITY STATEMENT

All data presented in this report must be regarded as confidential and for use by the participating companies only. Disclosure of the information in this report is only allowed by means of the entire report. Use of the contents of this report for third parties is only allowed by written permission of the Institute for Interlaboratory Studies. Disclosure of the identity of one or more of the participating companies will be done only after receipt of a written agreement of the companies involved.

2.4 SAMPLES

For the PT on Liquefied Propane a batch of 61 uniquely coded 1L cylinders with an artificial Liquefied Propane mixture was prepared and tested for homogeneity by EffecTech (Uttoxeter, United Kingdom) in conformance with ISO guide 35 and ISO17025 (job 21/0973). Each cylinder (with dip tube device) was filled with approximately 200 grams of Liquefied Propane mixture and labelled #21200. Every cylinder in the batch was analyzed using replicate measurements. The within bottle and between bottle variations were assessed in accordance with ISO Guide 35. This evaluation showed that all between bottle variations were small compared to the uncertainties on the reference values on each component.

The calculated repeatabilities were calculated per component and compared with 0.3 times the corresponding reproducibility of the reference test method in agreement with the procedure of ISO13528, Annex B2 in the next table.

	r (observed) in %mol/mol	0.3 x R (D2163:14(2019)) in %mol/mol
Ethane	0.0040	0.0618
Propane	0.0439	1.2611
Propene	0.0037	0.0632
iso-Butane	0.0196	0.0651
n-Butane	0.0118	0.0472
1-Butene	0.0020	0.0192
iso-Butene	0.0011	0.0162
n-Pentane	0.0054	0.0250

Table 2: homogeneity test results of subsamples #21200

The calculated repeatabilities were in agreement with 0.3 times the corresponding reproducibility of the reference test method. Therefore, homogeneity of the subsamples was assumed.

For the PT on Sulfur (total) in LPG a batch of 39 uniquely coded 5L cylinders (with dip tube device) was prepared and tested for homogeneity by Nippon Gases (Belgium) in conformance with ISO9001 (ref. nr. 428,863,001; order nr. 322799 – Round Robin). Each cylinder was filled with approximately 1500 grams of LPG and spiked with Dimethyl Sulfide (DMS) and labelled #21201.

The repeatability of the determination of Total Sulfur was calculated and compared with 0.3 times the reproducibility of the reference test method in agreement with the procedure of ISO13528, Annex B2 in the next table.

	Total Sulfur in mg/kg
r (observed)	1.5
reference test method	ASTM D6667:14(2019)
0.3 x R (ref. test method)	3.3

Table 3: evaluation of the repeatability of subsamples #21201

The calculated repeatability was in agreement with 0.3 times the reproducibility of the reference test method. Therefore, homogeneity of the subsamples was assumed.

Depending on the registration of the participant the appropriate set of PT samples was sent on September 22, 2021. An SDS was added to the sample package.

2.5 STABILITY OF THE SAMPLES

EffecTech (Uttoxeter, United Kingdom) and Nippon Gases (Belgium) declare that the prepared gas cylinders have a shelf life of at least 6 months. This is sufficient for the proficiency testing purposes.

2.6 ANALYZES

The participants were requested to determine on sample #21200: Ethane, Propane, Propene, iso-Butane, n-Butane, 1-Butene, iso-Butene, n-Pentane, iso-Pentane, Molar Mass, Relative Density at 60/60°F, Absolute and Relative Vapor Pressure at 100°F, Absolute and Relative Vapor Pressure at 40°C, Motor Octane Number (MON), Ideal Gross Heating Value and Ideal Net Heating Value at 14.696 psia and 60°F.
The participants were requested to determine Total Sulfur on sample #21201.

It was explicitly requested to treat the samples as if they were routine samples and to report the test results using the indicated units on the report form and not to round the test results, but report as much significant figures as possible. It was also requested not to report ‘less than’ test results, which are above the detection limit, because such test results cannot be used for meaningful statistical evaluations.

To get comparable test results a detailed report form and a letter of instructions are prepared. On the report form the reporting units are given as well as the reference test methods (when applicable) that will be used during the evaluation. The detailed report form and the letter of instructions are both made available on the data entry portal www.kpmd.co.uk/sgs-iis/. The participating laboratories are also requested to confirm the sample receipt on this data entry portal. The letter of instructions can also be downloaded from the iis website www.iisnl.com.

3 RESULTS

During five weeks after sample dispatch, the test results of the individual laboratories were gathered via the data entry portal www.kpmd.co.uk/sgs-iis/. The reported test results are tabulated per determination in appendix 1 of this report. The laboratories are presented by their code numbers.

Directly after the deadline, a reminder was sent to those laboratories that had not reported test results at that moment. Shortly after the deadline, the available test results were screened for suspect data. A test result was called suspect in case the Huber Elimination Rule (a robust outlier test) found it to be an outlier. The laboratories that produced these suspect data were asked to check the reported test results (no reanalyzes). Additional or corrected test results are used for data analysis and the original test results are placed under 'Remarks' in the result tables in appendix 1. Test results that came in after the deadline were not taken into account in this screening for suspect data and thus these participants were not requested for checks.

3.1 STATISTICS

The protocol followed in the organization of this proficiency test was the one as described for proficiency testing in the report ‘iis Interlaboratory Studies: Protocol for the Organisation, Statistics and Evaluation’ of June 2018 (iis-protocol, version 3.5).
For the statistical evaluation the *unrounded* (when available) figures were used instead of the rounded test results. Test results reported as ‘<…’ or ‘>…’ were not used in the statistical evaluation.

First, the normality of the distribution of the various data sets per determination was checked by means of the Lilliefors-test, a variant of the Kolmogorov-Smirnov test and by the calculation of skewness and kurtosis. Evaluation of the three normality indicators in combination with the visual evaluation of the graphic Kernel density plot, lead to judgement of the normality being either ‘unknown’, ‘OK’, ‘suspect’ or ‘not OK’. After removal of outliers, this check was repeated. If a data set does not have a normal distribution, the (results of the) statistical evaluation should be used with due care.

The assigned value is determined by consensus based on the test results of the group of participants after rejection of the statistical outliers and/or suspect data.

According to ISO13528 all (original received or corrected) results per determination were submitted to outlier tests. In the iis procedure for proficiency tests, outliers are detected prior to calculation of the mean, standard deviation and reproducibility. For small data sets, Dixon (up to 20 test results) or Grubbs (up to 40 test results) outlier tests can be used. For larger data sets (above 20 test results) Rosner's outlier test can be used. Outliers are marked by D(0.01) for the Dixon's test, by G(0.01) or DG(0.01) for the Grubbs' test and by R(0.01) for the Rosner's test. Stragglers are marked by D(0.05) for the Dixon's test, by G(0.05) or DG(0.05) for the Grubbs' test and by R(0.05) for the Rosner's test. Both outliers and stragglers were not included in the calculations of averages and standard deviations.

For each assigned value the uncertainty was determined in accordance with ISO13528. Subsequently the calculated uncertainty was evaluated against the respective requirement based on the target reproducibility in accordance with ISO13528. In this PT, the criterion of ISO13528, paragraph 9.2.1. was met for all evaluated tests, therefore, the uncertainty of all assigned values may be negligible and need not be included in the PT report.

Finally, the reproducibilities were calculated from the standard deviations by multiplying them with a factor of 2.8.

3.2 GRAPHICS

In order to visualize the data against the reproducibilities from literature, Gauss plots were made, using the sorted data for one determination (see appendix 1). On the Y-axis the reported test results are plotted. The corresponding laboratory numbers are on the X-axis. The straight horizontal line presents the consensus value (a trimmed mean). The four striped lines, parallel to the consensus value line, are the +3s, +2s, -2s and -3s target reproducibility limits of the selected reference test method. Outliers and other data, which were excluded from the calculations, are represented as a cross. Accepted data are represented as a triangle.

Furthermore, Kernel Density Graphs were made. This is a method for producing a smooth density approximation to a set of data that avoids some problems associated with histograms. Also, a normal Gauss curve (dotted line) was projected over the Kernel Density Graph (smooth line) for reference. The Gauss curve is calculated from the consensus value and the corresponding standard deviation.

3.3 Z-SCORES

To evaluate the performance of the participating laboratories the z-scores were calculated. As it was decided to evaluate the performance of the participants in this proficiency test (PT) against the literature requirements (derived from e.g. ISO or ASTM test methods), the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation in this interlaboratory study.

The target standard deviation was calculated from the literature reproducibility by division with 2.8. In case no literature reproducibility was available, other target values were used, like Horwitz or an estimated reproducibility based on former iis proficiency tests.

When a laboratory did use a test method with a reproducibility that is significantly different from the reproducibility of the reference test method used in this report, it is strongly advised to recalculate the z-score, while using the reproducibility of the actual test method used, this in order to evaluate whether the reported test result is fit-for-use.

The z-scores were calculated according to:

$z_{(target)}$ = (test result - average of PT) / target standard deviation

The $z_{(target)}$ scores are listed in the test result tables in appendix 1.

Absolute values for z<2 are very common and absolute values for z>3 are very rare. Therefore, the usual interpretation of z-scores is as follows:

	|z|	< 1	good
1 <	|z|	< 2	satisfactory
2 <	|z|	< 3	questionable
3 <	|z|		unsatisfactory

4 EVALUATION

Some problems were encountered with the dispatch of the samples due to COVID-19 pandemic. Therefore, the reporting time on the data entry portal was extended with another week.
For the Liquefied Propane PT (iis21S03P) five participants reported after the extended reporting date and six participants did not report any test results. Not all participants were able to report test results for all requested tests.
In total 50 participants reported 617 numerical test results. Observed were 45 outlying test results, which is 7.3%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.
For the Sulfur in LPG PT (iis21S03S) four participants reported after the extended reporting date and six participants did not report any test results. In total 32 participants reported 32 numerical test results. Observed were 2 outlying test results, which is 6.3%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.

Not all data sets proved to have a normal Gaussian distribution. These are referred to as “not OK” or “suspect”. The statistical evaluation of these data sets should be used with due care, see also paragraph 3.1.

4.1 EVALUATION PER SAMPLE AND PER TEST

In this section the reported test results are discussed per sample and per test. The test methods which were used by the various laboratories were taken into account for explaining the observed differences when possible and applicable. These test methods are also in the tables together with the original data. The abbreviations, used in these tables, are explained in appendix 3.

In the iis PT reports ASTM methods are referred to with a number (e.g. D2163) and an added designation for the year that the method was adopted or revised (e.g. D2163:14). If applicable, a designation in parentheses is added to designate the year of reapproval (e.g. D2163:14(2019)). In the test results tables of appendix 1 only the method number and year of adoption or revision (e.g. D2163:14) will be used.

Because the majority of the participating laboratories used ASTM D2163 as test method for the determination of the Propane Composition, it was decided to use the reproducibilities of this test method as target reproducibilities, and to mention the reproducibilities of EN27941 (identical to IP405 and ISO7941) for reference only. In ASTM D2163 no reproducibilities of 1-Butene and iso-Butene are mentioned, the reproducibilities of n-Butane were used to calculate the reproducibilities of these two components.

Two laboratories (467 and 1213) reported deviating test results for many of the gas composition test results. At least four of the nine test results were statistical outliers. As the nine test results are not independent it was decided to exclude the remaining reported test results of these laboratories for the statistical evaluation (inclusive the reported test results for the parameters calculated from the measured Gas Composition).

sample #21200

Total of the composition results: The sum of the test results of the composition per laboratory was calculated by iis. The total of this sum should be 100% because the composition test results are requested as normalized. Two calculated results were found to be significantly different than 100. It was decided to exclude these test results from labs 1040 and 1603 for all statistical evaluations.

Ethane: The determination of this component was not problematic. One statistical outlier was observed and four other test results were excluded. The calculated reproducibility after rejection of the suspect data is in full agreement with the requirements of ASTM D2163:14(2019) and in agreement with EN27941:93(liq).

Propane: The determination of this component was not problematic. No statistical outliers were observed but four test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and EN27941:93(liq).

Propene: The determination of this component was not problematic. Four statistical outliers were observed and three other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and EN27941:93(liq).

iso-Butane: The determination of this component may be problematic depending on the test method used. Two statistical outliers were observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the requirements of ASTM D2163:14(2019) but is in agreement with EN27941:93(liq).

n-Butane: The determination of this component may be problematic depending on the test method used. Four statistical outliers were observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the requirements of ASTM D2163:14(2019) but is in agreement with EN27941:93(liq).

1-Butene: The determination of this component was not problematic. Four statistical outliers were observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and EN27941:93(liq).

iso-Butene: The determination of this component was not problematic. Two statistical outliers were observed and three other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14(2019) and EN27941:93(liq).

n-Pentane: The determination of this component may be problematic depending on the test method used. Two statistical outliers were observed and three other test results were excluded. The calculated reproducibility after rejection of the suspect data is not at all in agreement with the requirements of ASTM D2163:14e1(2019) but is in agreement with the requirements of EN27941:93(liq).

iso-Pentane: The determination of this component may not be problematic. Most of the laboratories agreed that the amount of iso-Pentane was below 0.01 %mol/mol, therefore no z-scores were calculated.

Molar Mass: This calculated parameter may not be problematic. One statistical outlier was observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is in line with the reproducibility calculated by iis using the published molecular masses obtained from ASTM D2421:21e1 over all reported component concentrations (0.13 vs. 0.14 g/mol).

Relative Density at 60/60°F: This calculated parameter may be problematic. No statistical outliers were observed but two test results were excluded. The calculated reproducibility after rejection of the suspect data is larger than the reproducibility calculated by iis using the published relative density factors obtained from ASTM D2598:21 over all reported component concentrations (0.0012 vs. 0.0009).

Abs. Vapor Pres. at 100°F: As the reported results calculated via ISO8973 and ASTM D2598 are not identical, it was decided to evaluate the test results for both methods separately. The calculated parameters may be problematic depending on the test method used.
One statistical outlier was observed in the ISO8973 test results and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is smaller than the reproducibility calculated by iis using

the published vapor pressure factors obtained from ISO8973:97(amd.1-20) over all reported component concentrations (1.37 vs. 1.77 psi).
In the ASTM D2598 test results one statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is larger than the reproducibility calculated by iis using the published vapor pressure factors obtained from ASTM D2598:21 over all reported component concentrations (2.54 vs. 1.65 psi).

Rel. Vapor Pres. at 100°F: As the reported results calculated via ISO8973 and ASTM D2598 are not identical, it was decided to evaluate the test results for both methods separately. The calculated parameters may be problematic depending on the test method used.
No statistical outliers were observed in the ISO8973 test results but one test result was excluded. The calculated reproducibility after rejection of the suspect data is larger than the reproducibility calculated by iis using the published vapor pressure factors obtained from ISO8973:97(amd.1-20) over all reported component concentrations (2.05 vs. 1.78 psi).
In the ASTM D2598 test results three statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is smaller than the reproducibility calculated by iis using the published vapor pressure factors obtained from ASTM D2598:21 over all reported component concentrations (0.38 vs. 1.65 psi).

Abs. Vapor Pres. at 40°C: This calculated parameter may not be problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is smaller than the reproducibility calculated by iis using the published vapor pressure factors obtained from ISO8973:97(amd.1-20) over all reported component concentrations (10.0 vs. 12.8 kPa).

Rel. Vapor Pres. at 40°C: This calculated parameter may not be problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is in line with the reproducibility calculated by iis using the published vapor pressure factors obtained from ISO8973:97(amd.1-20) over all reported component concentrations (12.0 vs. 12.8 kPa).

MON: As the reported results calculated via EN589 and ASTM D2598 are not identical, it was decided to evaluate the test results for both methods separately. The calculated parameters may be problematic.
Three statistical outliers were observed in the EN589 test results and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is larger than the reproducibility calculated by iis using the published vapor pressure factors obtained from EN589:18 over all reported component concentrations (0.11 vs. 0.03).
In the ASTM D2598 test results one statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is larger than the reproducibility calculated by iis using the published vapor pressure

factors obtained from D2589:21 over all reported component concentrations (0.69 vs. 0.11).

Ideal Gross Heating Value at 14.696 psia / 60°F: This calculated parameter may not be problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is in line with the reproducibility calculated by iis using the published Ideal Gross Heating Values obtained from ASTM D3588:98(2017)e1 over all reported component concentrations (5.91 vs. 6.35 kJ/mol).

Ideal Net Heating Value at 14.696 psia / 60°F: This calculated parameter may not be problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is in line with the reproducibility calculated by iis using the published Ideal Gross Heating Values obtained from ASTM D3588:98(2017)e1 over all reported component concentrations (5.52 vs. 5.96 kJ/mol).

sample #21201

Total Sulfur: The determination of this component was problematic. Two statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the requirements of ASTM D6667:21.

4.2 PERFORMANCE EVALUATION FOR THE GROUP OF LABORATORIES

A comparison has been made between the reproducibility as declared by the reference test method and the reproducibility as found for the group of participating laboratories. The number of significant test results, the average, the calculated reproducibility (2.8 * standard deviation) and the target reproducibility derived from literature reference test methods (in casu ASTM test methods) are presented in the next table.

Component	unit	n	average	2.8 * sd	R(D2163)
Ethane	%mol/mol	45	0.449	0.181	0.191
Propane	%mol/mol	46	94.31	0.81	4.20
Propene	%mol/mol	43	0.626	0.065	0.209
iso-Butane	%mol/mol	46	2.044	0.279	0.220
n-Butane	%mol/mol	44	1.399	0.197	0.160
1-Butene	%mol/mol	44	0.188	0.034	0.065
iso-Butene	%mol/mol	45	0.127	0.032	0.054
n-Pentane	%mol/mol	45	0.798	0.205	0.085
iso-Pentane	%mol/mol	38	<0.01	n.e.	n.e.

Table 4: reproducibilities of the composition of sample #21200

Parameter	unit	n	average	2.8 * sd	R(all calc)*
Molar Mass	g/mol	28	44.76	0.13	0.14
Rel. Density at 60/60°F		31	0.5109	0.0012	0.0009
Abs. VP at 100°F ISO/IP	psi	10	187.51	1.37	1.77
Abs. VP at 100°F D2598	psi	6	183.61	0.23	1.65
Rel. VP at 100°F ISO/IP	psi	11	172.58	2.05	1.78
Rel. VP at 100°F D2598	psi	8	168.85	0.38	1.65
Abs. VP at 40°C	kPa	22	1331	10	13
Rel. VP at 40°C	kPa	22	1230	12	13
MON EN589		13	95.16	0.11	0.03
MON D2598		7	96.51	0.69	0.11
IGHV D3588	kJ/mol	9	2251	6	6
INHV D3588	kJ/mol	9	2072	6	6

Table 5: reproducibilities of calculated parameters on sample #21200 using one set of factors.

*) calculated by iis using all reported component concentrations

Component	unit	n	average	2.8 * sd	R(lit)
Total Sulfur	mg/kg	30	35.2	13.6	11.0

Table 6: reproducibility of Sulfur on sample #21201

Without further statistical calculations it can be concluded that for several components there is a good compliance of the group of participating laboratories with the relevant reference test method. The problematic components have been discussed in paragraph 4.1.

4.3 COMPARISON OF THE PROFICIENCY TEST OF OCTOBER 2021 WITH PREVIOUS PTS

	October 2021	October 2020	October 2019	October 2018	October 2017
Number of reporting laboratories	50	43	46	44	47
Number of test results	617	550	574	495	536
Number of statistical outliers	45	35	48	20	30
Percentage of statistical outliers	7.3%	6.4%	8.4%	4.0%	5.6%

Table 7: comparison with previous proficiency tests on Liquefied Propane only

	October 2021	October 2020	October 2019	October 2018	October 2017
Number of reporting laboratories	32	28	13	15	8
Number of test results	32	28	13	15	8
Number of statistical outliers	2	4	0	1	1
Percentage of statistical outliers	6.3%	14.3%	0%	6.7%	12.5%

Table 8: comparison with previous proficiency tests on Sulfur in LPG only

In proficiency tests, outlier percentages of 3% - 7.5% are quite normal.

The performance of the determinations of the proficiency tests was compared against the requirements of the reference test methods. The conclusions are given in the following tables.

Component	October 2021	October 2020	October 2019	October 2018	October 2017
Ethane	+/-	+	+	++	++
Propane	++	++	++	++	++
Propene	++	++	++	++	++
iso-Butane	-	-	+	-	+/-
n-Butane	-	-	+/-	--	-
1-Butene	+	--	++	+	++
iso-Butene	+	-	+	+	++
n-Pentane	--	(--)	+/-	-	-
iso-Pentane	n.e.	n.e.	n.a.	n.a.	n.a.

Table 9: comparison determinations on Liquefied Propane against the reference test methods

**) results in brackets should be used with due care

Component	October 2021	October 2020	October 2019	October 2018	October 2017
Total Sulfur	-	-	+	-	+

Table 10: comparison determinations on Sulfur in LPG against the reference test method

The following performance categories were used:

- ++ : group performed much better than the reference test method
- + : group performed better than the reference test method
- +/- : group performance equals the reference test method
- - : group performed worse than the reference test method
- -- : group performed much worse than the reference test method
- n.e. : not evaluated

5 DISCUSSION

The consensus values as determined in this PT are compared with the average values from the homogeneity testing by EffecTech (Uttoxeter, United Kingdom) in the following table. From this comparison it is clear that the consensus values as determined in this PT are in line with the values as determined during the preparation of the gas cylinders.

Parameter	EffecTech in %mol/mol	Average PT in %mol/mol	Difference in %mol/mol	z-score
Ethane	0.504	0.449	0.054	0.79
Propane	94.466	94.306	0.160	0.11
Propene	0.633	0.626	0.007	0.09
iso-Butane	1.981	2.044	-0.063	-0.81
n-Butane	1.348	1.399	-0.051	-0.89
1-Butene	0.182	0.188	-0.005	-0.23

Parameter	EffecTech in %mol/mol	Average PT in %mol/mol	Difference in %mol/mol	z-score
iso-Butene	0.126	0.127	-0.001	-0.07
n-Pentane	0.760	0.798	-0.037	-1.22

Table 11: comparison of consensus values with values determined by EffecTech

In principle no additional variation should be introduced when applying a calculation on the reported component concentrations. However, in practice a significant additional uncertainty is added in most cases. See the differences between the values from the test results as reported by the participating laboratories (each using its own calculation procedure) and the values as calculated by iis using one calculation procedure for each set of laboratory test results (see table 5).

Different test methods for the calculation of the Vapor Pressure do exist. Specification EN589 refers to ISO8973 for the calculation of Vapor Pressure. In ISO8973 (identical to IP432) the Vapor Pressure is calculated from the mole fraction per component and a Vapor Pressure factor of that component. In ASTM D2598 the Vapor Pressure is calculated from the liquid volume percentage per component and a Vapor Pressure factor of that component.
For the MON, the calculation in Annex B from specification EN589 is used by iis on a molar basis, while ASTM D2598 describes the calculation of MON on a liquid volume basis.
Also, the selection of the tables for the component factors to be used for the calculations may cause additional uncertainty.

It is remarkable to see that the results for Vapor Pressure from the ASTM D2598 calculation are significantly lower than the results from the ISO8973/IP432 calculation.
The observed difference is caused by a difference in the VP factor of Ethane. ASTM (Subcommittee D02.H) commented (lit. 13):

"*The vapor pressure of ethane in D2598 was revised a few times prior to 2002. The current value, 611 psi, has remained the same for the last ten years. The revision of ethane was done because components in LPG blends do not necessarily behave as ideal gases. In particular, properties of ethane and ethylene appear to differ from ideality. Factors for these two components have been modified from 'ideal gas' values to make the calculated vapor pressure results more closely approximate actual measured vapor pressures of LPG blends. (i.e. D1267). Chapter 2 of Fuels and Lubricants Handbook (George Totten, © 2003), states that calculated vapor pressure were found to be biased high relative to experimental vapor pressure measured by D1267 for high ethane samples in earlier versions of D2598*".

APPENDIX 1

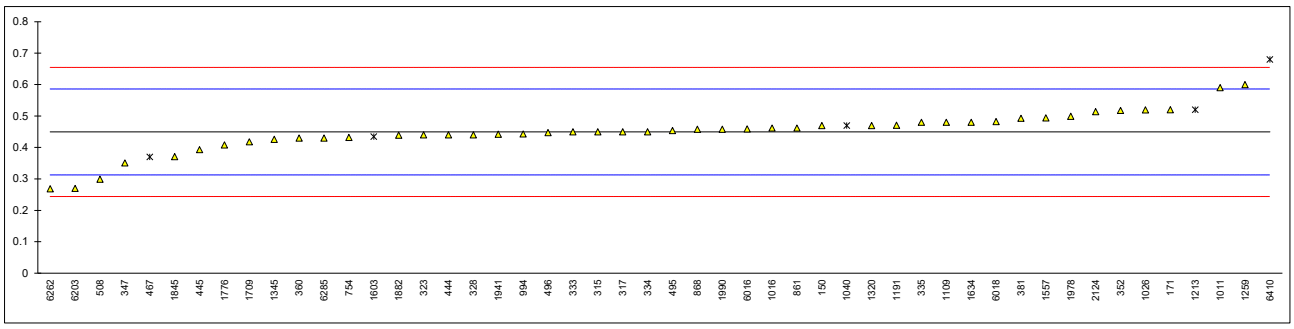
Total of reported (normalized) hydrocarbon composition test results; results in %mol/mol

lab	method	iis calculated	remarks
150	D2163	100.01	
171	D2163	99.99	
315	D2163	100.00	
317	D2163	100.00	
323	D2163	100.01	
328	D2163	100.00	
333	D2163	100.00	
334	D2163	100.00	
335	D2163	100.00	
347	D2163	100.00	
352	EN27941	100.06	
360	EN27941	100.00	
381	EN27941	100.00	
444	D2163	100.00	
445	D2163	100.00	
467	D2163	99.99	
495	D2163	100.00	
496	D2163	100.00	
508	D2163	100.00	
529		-----	
562		-----	
754	D2163	100.00	
861	D2163	100.00	
868	D2163	100.00	
970		-----	
994	D2163	99.98	
1011	ISO7941	99.99	
1016	ISO7941	100.00	
1026	ISO7941	100.00	
1040	DIN51619	**100.49**	Not 100%
1109	IP405	100.00	
1191	IP473	100.00	
1213	D2163	100.02	
1259	EN27941	99.90	
1320	D2163	99.99	
1345	D2163	100.00	
1557	EN27941	100.00	
1603	In house	**99.04**	Not 100%, reported: Sample contains 0,9630 %mol/mol Helium
1634	ISO7941	100.00	
1709	D2163	100.00	
1746		-----	
1776	EN27941	100.00	
1845	D2163	100.00	
1882	EN27941	100.00	
1941	EN27941	100.00	
1978	D2163	100.00	
1990	IP473	100.00	
2124	D2163	100.00	
6016	GOST10679	100.00	
6018	EN27941	99.99	
6193		-----	
6203	EN27941	100.00	
6262	D2163	100.00	
6285	EN27941/ISO7941/DIN51619	100.00	
6410	D2163	100.00	
6411		-----	

Determination of Ethane on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.47		0.30	
171	D2163	0.52		1.03	
315	D2163	0.45		0.01	
317	D2163	0.45		0.01	
323	D2163	0.44		-0.14	
328	D2163	0.44		-0.14	
333	D2163	0.45		0.01	
334	D2163	0.45		0.01	
335	D2163	0.48		0.45	
347	D2163	0.351		-1.44	
352	EN27941	0.5176	C	1.00	first reported 0.9911
360	EN27941	0.43		-0.28	
381	EN27941	0.493		0.64	
444	D2163	0.440		-0.14	
445	D2163	0.393		-0.82	
467	D2163	0.37	ex	-1.16	see paragraph 4.1
495	D2163	0.454		0.07	
496	D2163	0.447		-0.03	
508	D2163	0.29925		-2.20	
529		-----		-----	
562		-----		-----	
754	D2163	0.432		-0.25	
861	D2163	0.462		0.18	
868	D2163	0.458		0.13	
970		-----		-----	
994	D2163	0.4429		-0.09	
1011	ISO7941	0.59		2.06	
1016	ISO7941	0.462		0.18	
1026	ISO7941	0.51946	C	1.03	first reported 0.9977
1040	DIN51619	0.47	ex	0.30	see paragraph 4.1
1109	IP405	0.48		0.45	
1191	IP473	0.47089		0.31	
1213	D2163	0.52	ex,C	1.03	first reported 0.01. See paragraph 4.1
1259	EN27941	0.6		2.20	
1320	D2163	0.47		0.30	
1345	D2163	0.426		-0.34	
1557	EN27941	0.494		0.65	
1603	In house	0.4347	ex	-0.21	see paragraph 4.1
1634	ISO7941	0.48		0.45	
1709	D2163	0.418241		-0.46	
1746		-----		-----	
1776	EN27941	0.408		-0.61	
1845	D2163	0.371		-1.15	
1882	EN27941	0.4392		-0.15	
1941	EN27941	0.442		-0.11	
1978	D2163	0.4995		0.73	
1990	IP473	0.458		0.13	
2124	D2163	0.5141		0.95	
6016	GOST10679	0.4589		0.14	
6018	EN27941	0.4823		0.48	
6193		-----		-----	
6203	EN27941	0.27		-2.62	
6262	D2163	0.2684		-2.65	
6285	EN27941/ISO7941/DIN51619	0.43		-0.28	
6410	D2163	0.6801	R(0.05)	3.37	
6411		-----		-----	

normality	not OK
n	45
outliers	1 + 4ex
mean (n)	0.4494
st.dev. (n)	0.06478
R(calc.)	0.1814
st.dev.(D2163:14)	0.06837
R(D2163:14)	0.1914
compare	
R(EN27941:93(liq))	0.2976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0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
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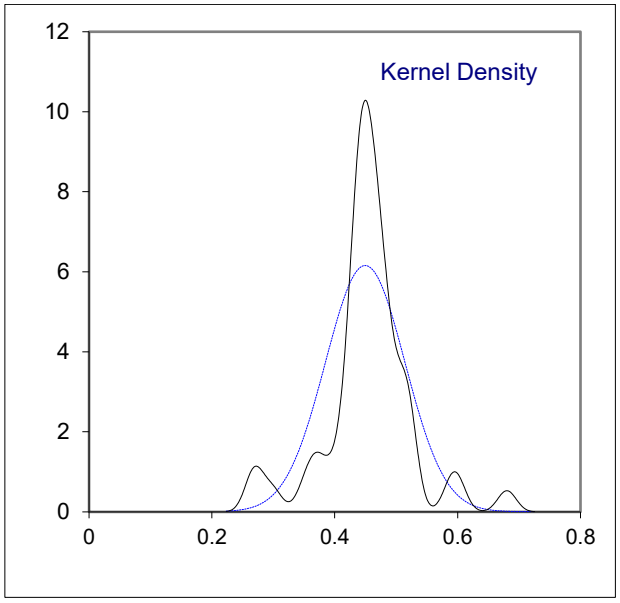
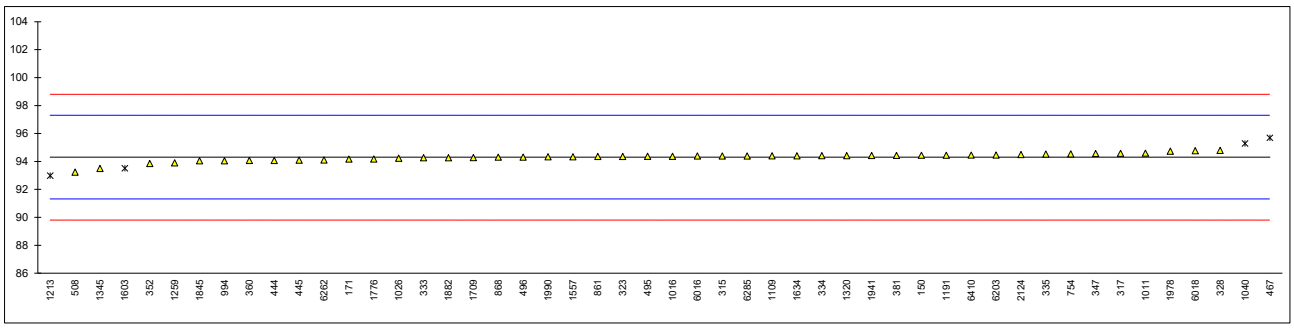

Kernel Density
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8

Determination of Propane on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	94.44		0.09	
171	D2163	94.17		-0.09	
315	D2163	94.39		0.06	
317	D2163	94.58		0.18	
323	D2163	94.36		0.04	
328	D2163	94.79		0.32	
333	D2163	94.26		-0.03	
334	D2163	94.41		0.07	
335	D2163	94.53		0.15	
347	D2163	94.565		0.17	
352	EN27941	93.8481	C	-0.31	first reported 93.0854
360	EN27941	94.07		-0.16	
381	EN27941	94.43		0.08	
444	D2163	94.072		-0.16	
445	D2163	94.097		-0.14	
467	D2163	95.69	ex	0.92	see paragraph 4.1
495	D2163	94.364		0.04	
496	D2163	94.317		0.01	
508	D2163	93.23387		-0.72	
529		-----		-----	
562		-----		-----	
754	D2163	94.541		0.16	
861	D2163	94.358		0.03	
868	D2163	94.308		0.00	
970		-----		-----	
994	D2163	94.0514		-0.17	
1011	ISO7941	94.59		0.19	
1016	ISO7941	94.373		0.04	
1026	ISO7941	94.2275	C	-0.05	first reported 93.7940
1040	DIN51619	95.29	ex	0.66	see paragraph 4.1
1109	IP405	94.40		0.06	
1191	IP473	94.44227		0.09	
1213	D2163	92.98	ex,C	-0.88	first reported 56.10. See paragraph 4.1
1259	EN27941	93.9		-0.27	
1320	D2163	94.41		0.07	
1345	D2163	93.503		-0.54	
1557	EN27941	94.340		0.02	
1603	In house	93.5120	ex	-0.53	see paragraph 4.1
1634	ISO7941	94.40		0.06	
1709	D2163	94.275832		-0.02	
1746		-----		-----	
1776	EN27941	94.174		-0.09	
1845	D2163	94.051		-0.17	
1882	EN27941	94.2640		-0.03	
1941	EN27941	94.421		0.08	
1978	D2163	94.7372		0.29	
1990	IP473	94.339		0.02	
2124	D2163	94.4923		0.12	
6016	GOST10679	94.3855		0.05	
6018	EN27941	94.7680		0.31	
6193		-----		-----	
6203	EN27941	94.46		0.10	
6262	D2163	94.1027		-0.14	
6285	EN27941/ISO7941/DIN51619	94.39		0.06	
6410	D2163	94.4577		0.10	
6411		-----		-----	

normality	not OK
n	46
outliers	0 + 4ex
mean (n)	94.3063
st.dev. (n)	0.28771
R(calc.)	0.8056
st.dev.(D2163:14)	1.49949
R(D2163:14)	4.1986
compare	
R(EN27941:93(liq))	1.0146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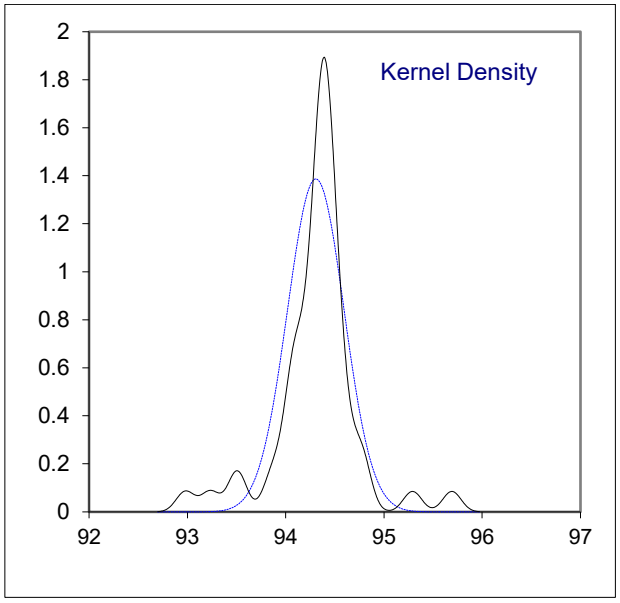
102
100
98
96
94
92
90
88
86
1213 508 1345 1603 352 1259 1845 994 360 444 445 6262 171 1778 1026 333 1882 1709 868 496 1990 1557 861 323 495 1016 6016 315 6285 1109 1634 334 1320 1941 381 150 1191 6410 6203 2124 335 754 347 317 1011 1978 6018 328 1040 467


Kernel Density
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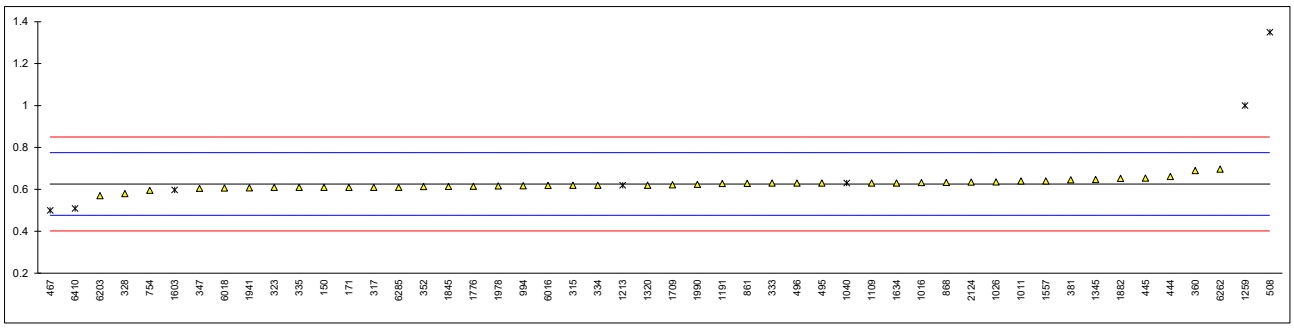
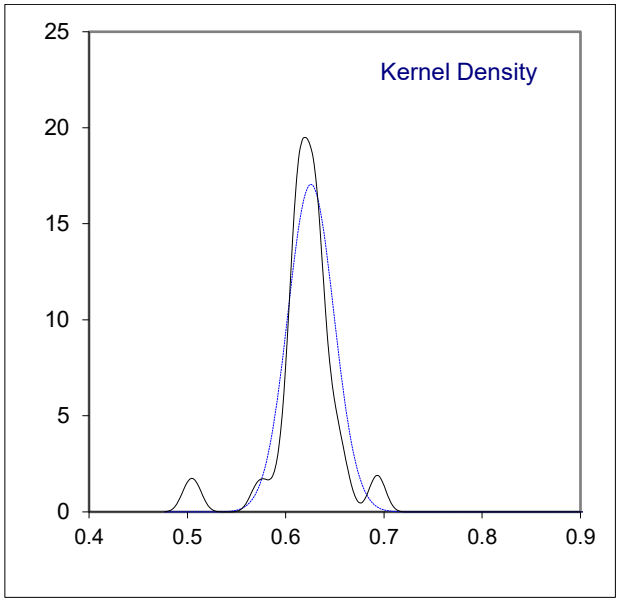
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
92
93
94
95
96
97

Determination of Propene on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.61		-0.21	
171	D2163	0.61		-0.21	
315	D2163	0.62		-0.07	
317	D2163	0.61		-0.21	
323	D2163	0.61		-0.21	
328	D2163	0.58		-0.61	
333	D2163	0.63		0.06	
334	D2163	0.62		-0.07	
335	D2163	0.61		-0.21	
347	D2163	0.605		-0.28	
352	EN27941	0.6135	C	-0.16	first reported 0.6549
360	EN27941	0.69		0.86	
381	EN27941	0.646		0.27	
444	D2163	0.662		0.49	
445	D2163	0.654		0.38	
467	D2163	0.50	R(0.01)	-1.68	
495	D2163	0.630		0.06	
496	D2163	0.630		0.06	
508	D2163	1.35003	C,R(0.01)	9.70	first reported 0.85003
529		-----		-----	
562		-----		-----	
754	D2163	0.596		-0.40	
861	D2163	0.629		0.05	
868	D2163	0.633		0.10	
970		-----		-----	
994	D2163	0.6178		-0.10	
1011	ISO7941	0.64		0.19	
1016	ISO7941	0.632		0.09	
1026	ISO7941	0.6356	C	0.13	first reported 0.6573
1040	DIN51619	0.63	ex	0.06	see paragraph 4.1
1109	IP405	0.63		0.06	
1191	IP473	0.62803		0.03	
1213	D2163	0.62	ex,C	-0.07	first reported Not Detected. See paragraph 4.1
1259	EN27941	1.0	R(0.01)	5.01	
1320	D2163	0.62		-0.07	
1345	D2163	0.647		0.29	
1557	EN27941	0.640		0.19	
1603	In house	0.5976	ex	-0.37	see paragraph 4.1
1634	ISO7941	0.63		0.06	
1709	D2163	0.621588		-0.05	
1746		-----		-----	
1776	EN27941	0.615		-0.14	
1845	D2163	0.614		-0.15	
1882	EN27941	0.6530		0.37	
1941	EN27941	0.608		-0.24	
1978	D2163	0.6169		-0.12	
1990	IP473	0.624		-0.02	
2124	D2163	0.6350		0.13	
6016	GOST10679	0.6193		-0.08	
6018	EN27941	0.6069		-0.25	
6193		-----		-----	
6203	EN27941	0.57		-0.74	
6262	D2163	0.6962		0.95	
6285	EN27941/ISO7941/DIN51619	0.61		-0.21	
6410	D2163	0.5089	R(0.01)	-1.56	
6411		-----		-----	

normality	not OK
n	43
outliers	4 + 3ex
mean (n)	0.6256
st.dev. (n)	0.02339
R(calc.)	0.0655
st.dev.(D2163:14)	0.07468
R(D2163:14)	0.2091
compare	
R(EN27941:93(liq))	0.2126

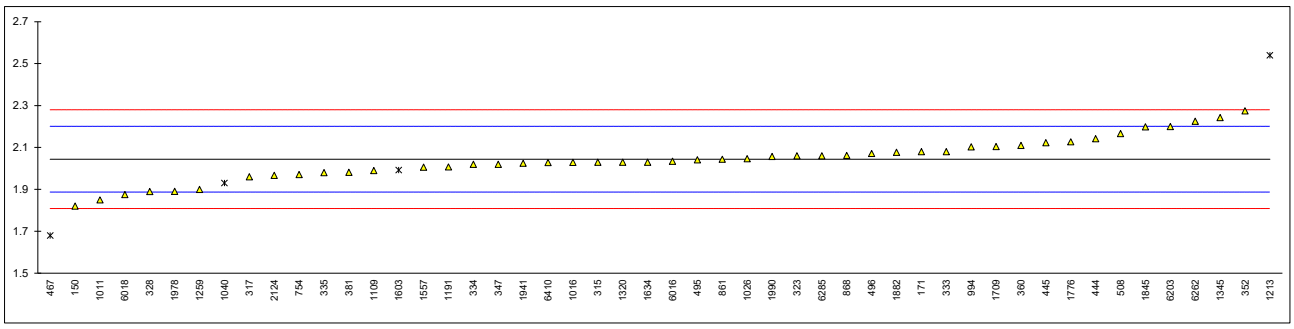

1.4
1.2
1
0.8
0.6
0.4
0.2
467 6410 6203 328 754 1603 347 6018 1941 323 335 150 171 317 6285 352 1845 1776 1978 994 6016 315 334 1213 1320 1709 1990 1191 861 333 496 495 1040 1109 1634 1016 868 2124 1026 1011 1557 381 1345 1882 445 444 360 6262 1259 508

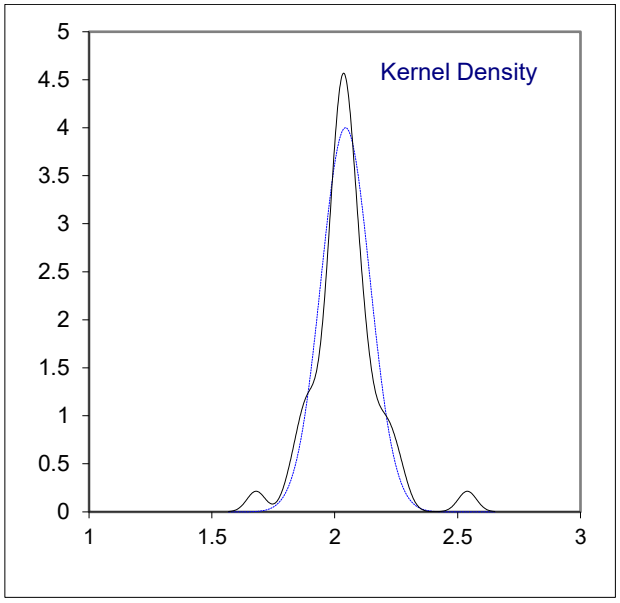

Kernel Density
25
20
15
10
5
0
0.4
0.5
0.6
0.7
0.8
0.9

Determination of iso-Butane on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.82		-2.86	
171	D2163	2.08		0.46	
315	D2163	2.03		-0.18	
317	D2163	1.96		-1.07	
323	D2163	2.06		0.20	
328	D2163	1.89		-1.96	
333	D2163	2.08		0.46	
334	D2163	2.02		-0.31	
335	D2163	1.98		-0.82	
347	D2163	2.02		-0.31	
352	EN27941	2.2746	C	2.94	first reported 2.2367
360	EN27941	2.11		0.84	
381	EN27941	1.982		-0.79	
444	D2163	2.142		1.25	
445	D2163	2.123		1.01	
467	D2163	1.68	R(0.05)	-4.64	
495	D2163	2.041		-0.04	
496	D2163	2.071		0.34	
508	D2163	2.16682		1.56	
529		-----		-----	
562		-----		-----	
754	D2163	1.971		-0.93	
861	D2163	2.044		0.00	
868	D2163	2.062		0.23	
970		-----		-----	
994	D2163	2.1031		0.75	
1011	ISO7941	1.85		-2.47	
1016	ISO7941	2.029		-0.19	
1026	ISO7941	2.0469	C	0.04	first reported 2.0720
1040	DIN51619	1.93	ex	-1.45	see paragraph 4.1
1109	IP405	1.99		-0.69	
1191	IP473	2.00695		-0.47	
1213	D2163	2.54	C,R(0.01)	6.32	first reported 0.06
1259	EN27941	1.9		-1.84	
1320	D2163	2.03		-0.18	
1345	D2163	2.243		2.54	
1557	EN27941	2.006		-0.49	
1603	In house	1.9920	ex	-0.66	see paragraph 4.1
1634	ISO7941	2.03		-0.18	
1709	D2163	2.104330		0.77	
1746		-----		-----	
1776	EN27941	2.127		1.06	
1845	D2163	2.198		1.96	
1882	EN27941	2.0769		0.42	
1941	EN27941	2.025		-0.24	
1978	D2163	1.8905		-1.96	
1990	IP473	2.057		0.16	
2124	D2163	1.9666		-0.99	
6016	GOST10679	2.0337		-0.13	
6018	EN27941	1.8751		-2.15	
6193		-----		-----	
6203	EN27941	2.20		1.99	
6262	D2163	2.2248		2.30	
6285	EN27941/ISO7941/DIN51619	2.06		0.20	
6410	D2163	2.0281		-0.20	
6411		-----		-----	

normality	OK
n	46
outliers	2 + 2ex
mean (n)	2.0441
st.dev. (n)	0.09970
R(calc.)	0.2792
st.dev.(D2163:14)	0.07844
R(D2163:14)	0.2196
compare	
R(EN27941:93(liq))	0.3849

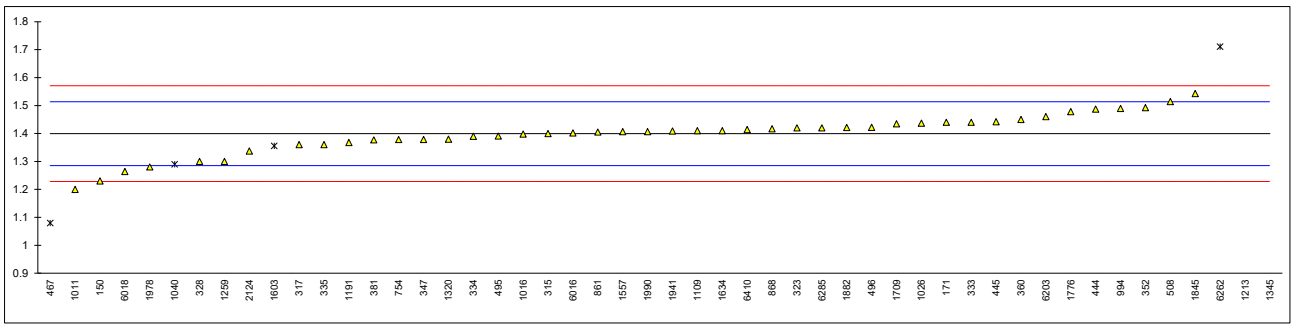

2.7
2.5
2.3
2.1
1.9
1.7
1.5
467 150 1011 6018 328 1978 1259 1040 317 2124 754 335 381 1109 1603 1557 1191 334 347 1941 6410 1016 315 1320 1634 6016 495 861 1026 1990 323 6285 868 496 1882 171 333 994 1709 360 445 1776 444 508 1845 6203 6262 1345 352 1213

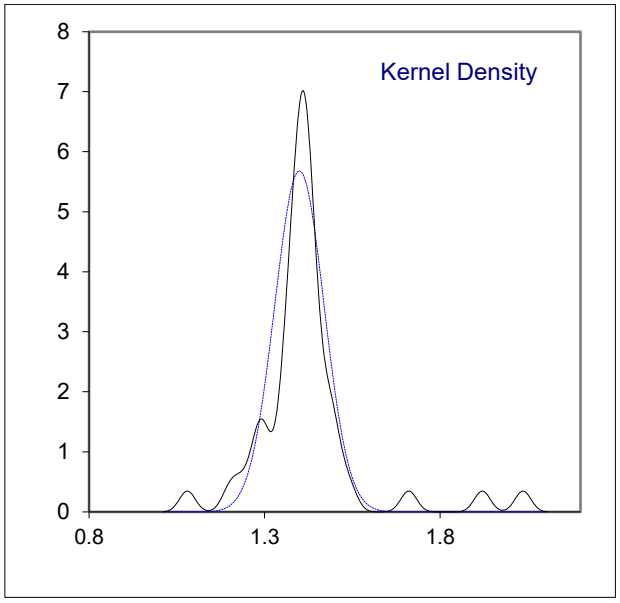

Kernel Density
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
1.5
2
2.5
3

Determination of n-Butane on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.23		-2.96	
171	D2163	1.44		0.71	
315	D2163	1.40		0.01	
317	D2163	1.36		-0.69	
323	D2163	1.42		0.36	
328	D2163	1.30		-1.74	
333	D2163	1.44		0.71	
334	D2163	1.39		-0.16	
335	D2163	1.36		-0.69	
347	D2163	1.379		-0.35	
352	EN27941	1.4927	C	1.64	first reported 1.4969
360	EN27941	1.45		0.89	
381	EN27941	1.377		-0.39	
444	D2163	1.487		1.54	
445	D2163	1.442		0.75	
467	D2163	1.08	R(0.01)	-5.58	
495	D2163	1.391		-0.14	
496	D2163	1.422		0.40	
508	D2163	1.51436	C	2.01	first reported 2.14364
529		-----		-----	
562		-----		-----	
754	D2163	1.378		-0.37	
861	D2163	1.405		0.10	
868	D2163	1.417		0.31	
970		-----		-----	
994	D2163	1.4901		1.59	
1011	ISO7941	1.20		-3.49	
1016	ISO7941	1.398		-0.02	
1026	ISO7941	1.4370	C	0.66	first reported 1.4577
1040	DIN51619	1.29	ex	-1.91	see paragraph 4.1
1109	IP405	1.41		0.19	
1191	IP473	1.36767		-0.55	
1213	D2163	1.92	C,R(0.01)	9.11	first reported 43.73
1259	EN27941	1.3		-1.74	
1320	D2163	1.38		-0.34	
1345	D2163	2.036	C,R(0.01)	11.14	first reported 1.706
1557	EN27941	1.407		0.14	
1603	In house	1.3555	ex,C	-0.77	first reported 1.6555. See paragraph 4.1
1634	ISO7941	1.41		0.19	
1709	D2163	1.434948		0.62	
1746		-----		-----	
1776	EN27941	1.478		1.38	
1845	D2163	1.543		2.51	
1882	EN27941	1.4217		0.39	
1941	EN27941	1.409		0.17	
1978	D2163	1.2802		-2.08	
1990	IP473	1.407		0.14	
2124	D2163	1.3374		-1.08	
6016	GOST10679	1.4022		0.05	
6018	EN27941	1.2641		-2.36	
6193		-----		-----	
6203	EN27941	1.46		1.06	
6262	D2163	1.7107	R(0.01)	5.45	
6285	EN27941/ISO7941/DIN51619	1.42		0.36	
6410	D2163	1.4141		0.26	
6411		-----		-----	

normality	suspect
n	44
outliers	4 + 2ex
mean (n)	1.3992
st.dev. (n)	0.07023
R(calc.)	0.1966
st.dev.(D2163:14)	0.05716
R(D2163:14)	0.1601
compare	
R(EN27941:93(liq))	0.3849

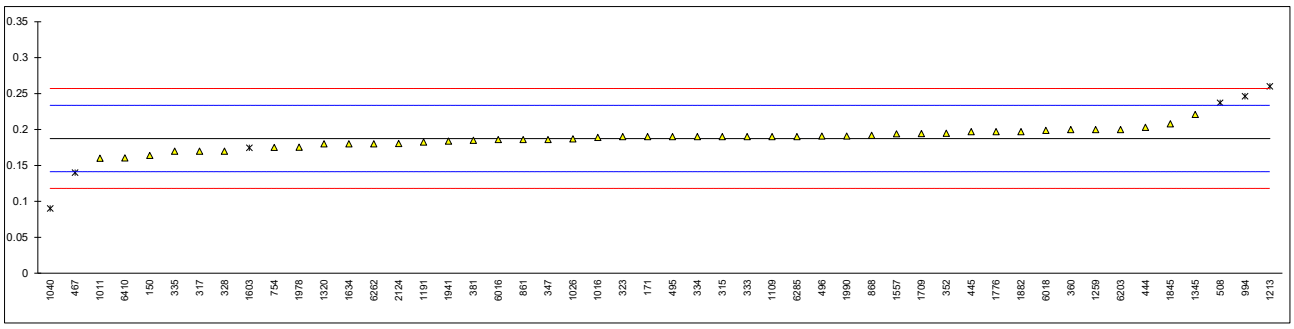

1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
467 1011 150 6018 1978 1040 328 1259 2124 1603 317 335 1191 381 754 347 1320 334 495 1016 315 6016 861 1557 1990 1941 1109 1634 6410 868 323 6285 1882 496 1709 1026 171 333 445 360 6203 1776 444 994 352 508 1845 6262 1213 1345


Kernel Density
8
7
6
5
4
3
2
1
0
0.8
1.3
1.8

Determination of 1-Butene on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.164	C	-1.02	first reported <0.01
171	D2163	0.19		0.11	
315	D2163	0.19		0.11	
317	D2163	0.17		-0.76	
323	D2163	0.19		0.11	
328	D2163	0.17		-0.76	
333	D2163	0.19		0.11	
334	D2163	0.19		0.11	
335	D2163	0.17		-0.76	
347	D2163	0.186		-0.07	
352	EN27941	0.1949	C	0.32	first reported 0.2965
360	EN27941	0.20		0.54	
381	EN27941	0.185		-0.11	
444	D2163	0.203		0.67	
445	D2163	0.197		0.41	
467	D2163	0.14	R(0.05)	-2.05	
495	D2163	0.190		0.11	
496	D2163	0.191		0.15	
508	D2163	0.23722	R(0.05)	2.15	
529		-----		-----	
562		-----		-----	
754	D2163	0.175		-0.54	
861	D2163	0.186		-0.07	
868	D2163	0.192		0.19	
970		-----		-----	
994	D2163	0.2463	R(0.05)	2.54	
1011	ISO7941	0.16		-1.19	
1016	ISO7941	0.189		0.06	
1026	ISO7941	0.1871	C	-0.02	first reported 0.1893
1040	DIN51619	0.09	ex	-4.21	see paragraph 4.1
1109	IP405	0.19		0.11	
1191	IP473	0.18238		-0.22	
1213	D2163	0.26	C,R(0.05)	3.13	first reported Not Detected
1259	EN27941	0.2		0.54	
1320	D2163	0.18		-0.32	
1345	D2163	0.221		1.45	
1557	EN27941	0.194		0.28	
1603	In house	0.1744	ex	-0.57	see paragraph 4.1
1634	ISO7941	0.18		-0.32	
1709	D2163	0.194482		0.30	
1746		-----		-----	
1776	EN27941	0.197	C	0.41	first reported 0.393
1845	D2163	0.208		0.89	
1882	EN27941	0.1971		0.41	
1941	EN27941	0.184		-0.15	
1978	D2163	0.1755		-0.52	
1990	IP473	0.191		0.15	
2124	D2163	0.1807		-0.29	
6016	GOST10679	0.1859		-0.07	
6018	EN27941	0.1988		0.49	
6193		-----		-----	
6203	EN27941	0.20		0.54	
6262	D2163	0.1801		-0.32	
6285	EN27941/ISO7941/DIN51619	0.19		0.11	
6410	D2163	0.1605		-1.17	
6411		-----		-----	

normality	OK
n	44
outliers	4 + 2ex
mean (n)	0.1875
st.dev. (n)	0.01222
R(calc.)	0.0342
st.dev.(D2163:14)	0.02314
R(D2163:14)	0.0648
compare	
R(EN27941:93(liq))	0.1595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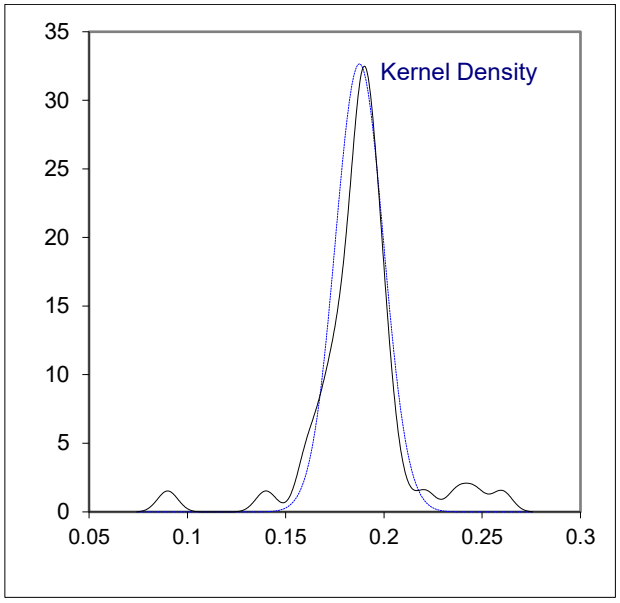
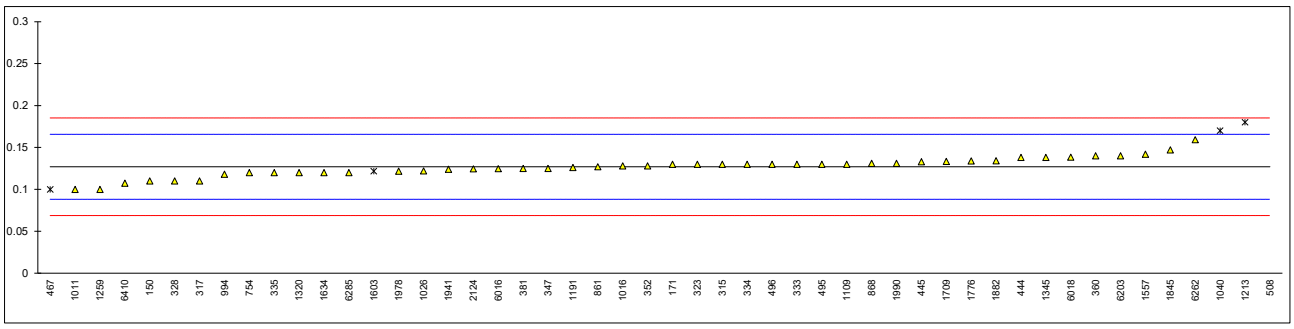
0.25
0.2
0.15
0.1
0.05
0
1040 467 1011 6410 150 335 317 328 1603 754 1978 1320 1634 6262 2124 1191 1941 381 6016 861 347 1026 1016 323 171 495 334 315 333 1109 6285 496 1990 868 1557 1709 352 445 1776 1882 6018 360 1259 6203 444 1845 1345 508 994 1213


Kernel Density
35
30
25
20
15
10
5
0
0.05
0.1
0.15
0.2
0.25
0.3

Determination of iso-Butene on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.11	C	-0.87	first reported <0.01
171	D2163	0.13		0.16	
315	D2163	0.13		0.16	
317	D2163	0.11		-0.87	
323	D2163	0.13		0.16	
328	D2163	0.11		-0.87	
333	D2163	0.13		0.16	
334	D2163	0.13		0.16	
335	D2163	0.12		-0.36	
347	D2163	0.125		-0.10	
352	EN27941	0.1281	C	0.06	first reported 0.2466
360	EN27941	0.14		0.67	
381	EN27941	0.125		-0.10	
444	D2163	0.138		0.57	
445	D2163	0.133		0.31	
467	D2163	0.10	ex	-1.39	see paragraph 4.1
495	D2163	0.130		0.16	
496	D2163	0.130		0.16	
508	D2163	0.30043	C,R(0.01)	8.94	first reported 0.17043
529		-----		-----	
562		-----		-----	
754	D2163	0.120		-0.36	
861	D2163	0.127		0.00	
868	D2163	0.131		0.21	
970		-----		-----	
994	D2163	0.1182		-0.45	
1011	ISO7941	0.10		-1.39	
1016	ISO7941	0.128		0.06	
1026	ISO7941	0.1220	C	-0.25	first reported 0.1233
1040	DIN51619	0.17	ex	2.22	see paragraph 4.1
1109	IP405	0.13		0.16	
1191	IP473	0.12600		-0.05	
1213	D2163	0.18	C,R(0.01)	2.74	first reported Not Detected
1259	EN27941	0.1		-1.39	
1320	D2163	0.12		-0.36	
1345	D2163	0.138		0.57	
1557	EN27941	0.142		0.78	
1603	In house	0.1216	ex	-0.27	see paragraph 4.1
1634	ISO7941	0.12		-0.36	
1709	D2163	0.133364		0.33	
1746		-----		-----	
1776	EN27941	0.134		0.37	
1845	D2163	0.147		1.04	
1882	EN27941	0.1342		0.38	
1941	EN27941	0.124		-0.15	
1978	D2163	0.1217		-0.27	
1990	IP473	0.131		0.21	
2124	D2163	0.1245		-0.12	
6016	GOST10679	0.1247		-0.11	
6018	EN27941	0.1384		0.59	
6193		-----		-----	
6203	EN27941	0.14		0.67	
6262	D2163	0.1592		1.66	
6285	EN27941/ISO7941/DIN51619	0.12		-0.36	
6410	D2163	0.1074		-1.00	
6411		-----		-----	

normality	suspect
n	45
outliers	2 + 3ex
mean (n)	0.1269
st.dev. (n)	0.01145
R(calc.)	0.0321
st.dev.(D2163:14)	0.01941
R(D2163:14)	0.0543
compare	
R(EN27941:93(liq))	0.1595


0.3
0.25
0.2
0.15
0.1
0.05
0
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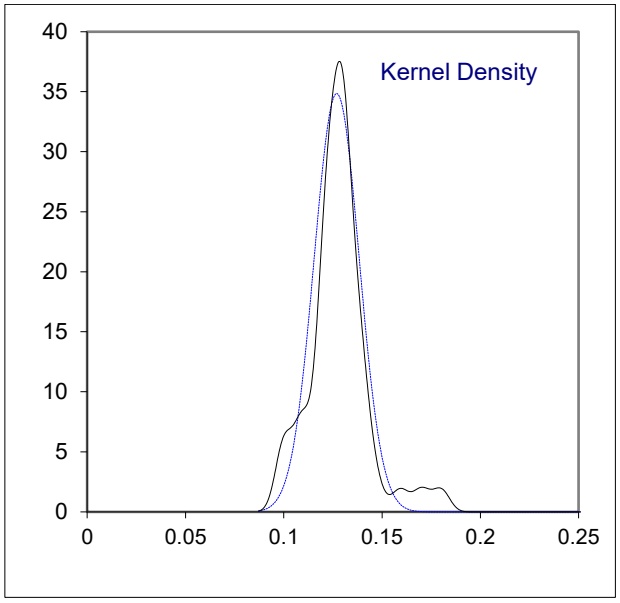
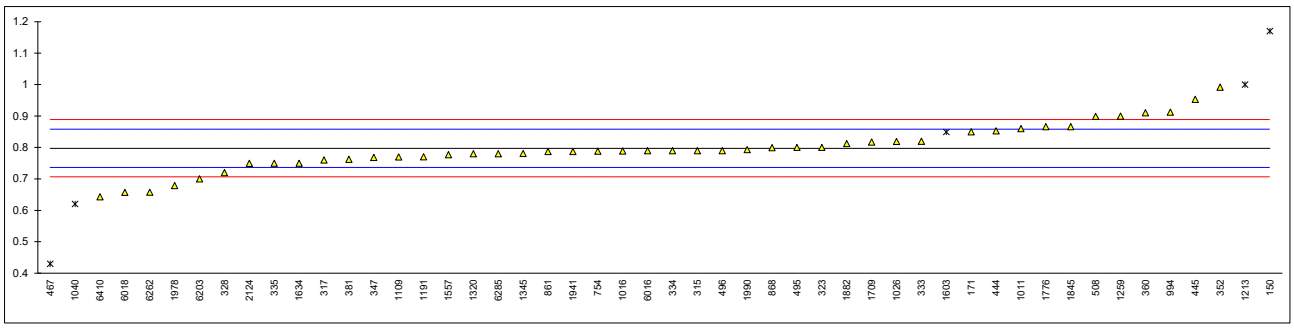

Kernel Density
40
35
30
25
20
15
10
5
0
0 0.05 0.1 0.15 0.2 0.25

Determination of n-Pentane on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.17	C,R(0.01)	12.28	first reported 1.15
171	D2163	0.85		1.73	
315	D2163	0.79		-0.25	
317	D2163	0.76		-1.24	
323	D2163	0.80		0.08	
328	D2163	0.72		-2.55	
333	D2163	0.82		0.74	
334	D2163	0.79		-0.25	
335	D2163	0.75		-1.57	
347	D2163	0.768		-0.97	
352	EN27941	0.9922		6.42	
360	EN27941	0.91		3.71	
381	EN27941	0.762		-1.17	
444	D2163	0.853		1.83	
445	D2163	0.953		5.12	
467	D2163	0.43	R(0.01)	-12.11	
495	D2163	0.800		0.08	
496	D2163	0.790		-0.25	
508	D2163	0.89874		3.34	
529		-----		-----	
562		-----		-----	
754	D2163	0.788		-0.31	
861	D2163	0.787		-0.35	
868	D2163	0.799		0.05	
970		-----		-----	
994	D2163	0.9125		3.79	
1011	ISO7941	0.86		2.06	
1016	ISO7941	0.789		-0.28	
1026	ISO7941	0.8191	C	0.71	first reported 0.7023
1040	DIN51619	0.62	ex	-5.85	see paragraph 4.1
1109	IP405	0.77		-0.91	
1191	IP473	0.77045		-0.89	
1213	D2163	1.0	ex,C	6.67	first reported 0.05. See paragraph 4.1
1259	EN27941	0.9		3.38	
1320	D2163	0.78		-0.58	
1345	D2163	0.781	C	-0.54	first reported 1.112
1557	EN27941	0.777		-0.68	
1603	In house	0.8491	ex	1.70	see paragraph 4.1
1634	ISO7941	0.75		-1.57	
1709	D2163	0.817214		0.65	
1746		-----		-----	
1776	EN27941	0.866		2.26	
1845	D2163	0.866		2.26	
1882	EN27941	0.8122		0.48	
1941	EN27941	0.787		-0.35	
1978	D2163	0.6786		-3.92	
1990	IP473	0.793		-0.15	
2124	D2163	0.7494		-1.59	
6016	GOST10679	0.7899		-0.25	
6018	EN27941	0.6573		-4.62	
6193		-----		-----	
6203	EN27941	0.70		-3.21	
6262	D2163	0.6579		-4.60	
6285	EN27941/ISO7941/DIN51619	0.78		-0.58	
6410	D2163	0.6433		-5.08	
6411		-----		-----	

normality	OK
n	45
outliers	2 + 3ex
mean (n)	0.7975
st.dev. (n)	0.07321
R(calc.)	0.2050
st.dev.(D2163:14)	0.03034
R(D2163:14)	0.0850
compare	
R(EN27941:93(liq))	0.3100


1.2
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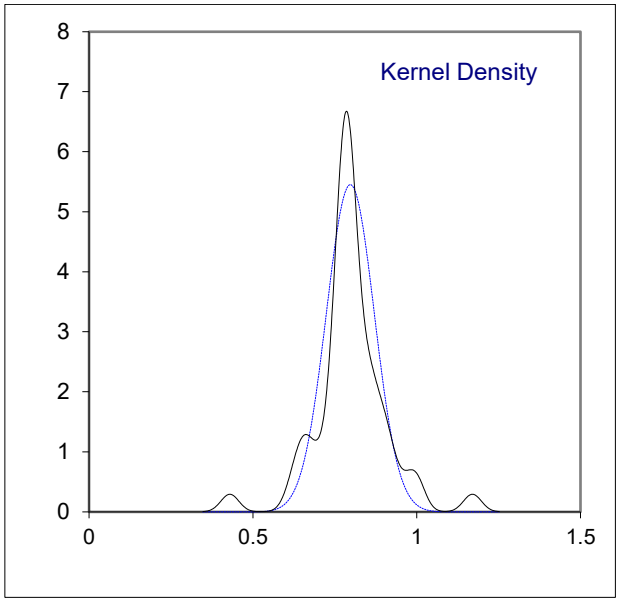
0.8
0.7
0.6
0.5
0.4
467 1040 6410 6018 6262 1978 6203 328 2124 335 1634 317 381 347 1109 1191 1557 1320 6285 1345 861 1941 754 1016 6016 334 315 496 1990 868 495 323 1882 1709 1026 333 1603 171 444 1011 1778 1845 508 1259 360 994 445 352 1213 150


Kernel Density
8
7
6
5
4
3
2
1
0
0
0.5
1
1.5

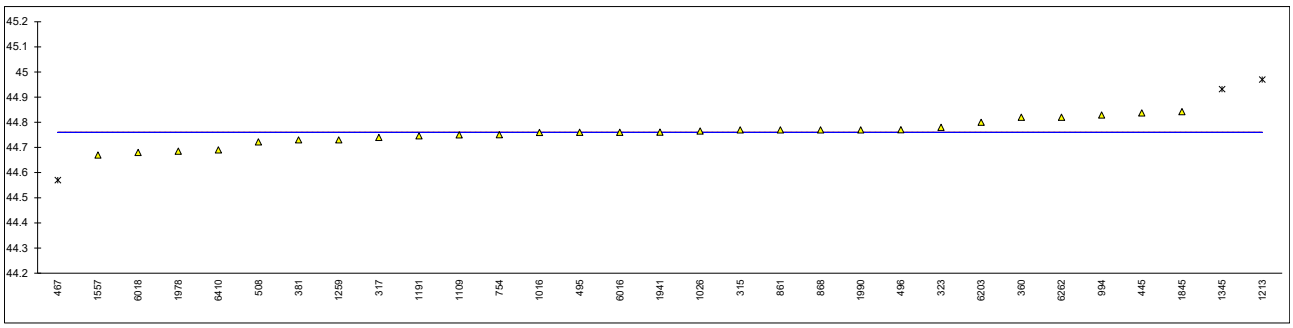
Determination of iso-Pentane on sample #21200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	<0.01		-----	
171	D2163	<0.01		-----	
315		-----		-----	
317	D2163	<0.01		-----	
323	D2163	<0.01		-----	
328	D2163	< 0.01		-----	
333	D2163	< 0.01		-----	
334	D2163	<0.01		-----	
335	D2163	< 0.01		-----	
347		-----		-----	
352		-----		-----	
360	EN27941	<0.01		-----	
381	EN27941	<0,1		-----	
444	D2163	0.002		-----	
445	D2163	0.003		-----	
467	D2163	<0,01		-----	
495	D2163	<0.01		-----	
496	D2163	0.002		-----	
508	D2163	0.000000		-----	
529		-----		-----	
562		-----		-----	
754	D2163	< 0.01		-----	
861	D2163	<0.01		-----	
868	D2163	<0.01		-----	
970		-----		-----	
994		-----		-----	
1011	ISO7941	<0.1		-----	
1016	ISO7941	0.000		-----	
1026	ISO7941	0.00133	C	-----	first reported <0.02
1040	DIN51619	0		-----	
1109	IP405	0.00		-----	
1191	IP473	0.005		-----	
1213	D2163	ND (<0.01)		-----	
1259		-----		-----	
1320	D2163	<0.01		-----	
1345	D2163	0.003		-----	
1557	EN27941	<0,01		-----	
1603	In house	<Quant. Limit		-----	
1634	ISO7941	0		-----	
1709	D2163	ND		-----	
1746		-----		-----	
1776	EN27941	<0,1		-----	
1845	D2163	0		-----	
1882	EN27941	0.0016		-----	
1941		-----		-----	
1978		-----		-----	
1990		-----		-----	
2124	D2163	0.0000		-----	
6016		-----		-----	
6018	EN27941	<0,01		-----	
6193		-----		-----	
6203	EN27941	<0.01		-----	
6262	D2163	<0.01		-----	
6285		-----		-----	
6410	D2163	0.0000		-----	
6411		-----		-----	
	n	38			
	mean (n)	<0.01			

Determination of Molar Mass on sample #21200; results in g/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	44.77		-----	
317	INH-001	44.74		-----	
323	D2598	44.78		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347		-----		-----	
352		-----		-----	
360	ISO8973	44.82		-----	
381	D2598	44.73		-----	
444		-----		-----	
445	D2163	44.837		-----	
467	ISO8973	44.57	ex	-----	see paragraph 4.1
495	D2163	44.76		-----	
496	D2163	44.771		-----	
508	D2598	44.72223	C	-----	first reported 44.79698
529		-----		-----	
562		-----		-----	
754	D2421	44.7507		-----	
861	D2598	44.77		-----	
868	D2598	44.77		-----	
970		-----		-----	
994	D2163	44.829		-----	
1011		-----		-----	
1016	EN27941	44.7596		-----	
1026	ISO8973	44.7655	C	-----	first reported 44.6727
1040		-----		-----	
1109	ISO8973	44.75		-----	
1191	ISO8973	44.7458		-----	
1213	D2598	44.97	ex,C	-----	first reported 50.26. See paragraph 4.1
1259	ISO8973	44.73		-----	
1320		-----		-----	
1345	D2421	44.932	R(0.05)	-----	
1557	ISO8973	44.67		-----	
1603		-----		-----	
1634		-----		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1845	D2163	44.8422		-----	
1882		-----		-----	
1941	D2421	44.7607		-----	
1978	D2598	44.6853		-----	
1990	D2598	44.77		-----	
2124		-----		-----	
6016		44.76		-----	
6018	ISO8973	44.68		-----	
6193		-----		-----	
6203	ISO8973	44.80		-----	
6262	D2163	44.82		-----	
6285		-----		-----	
6410	D2421	44.69		-----	
6411		-----		-----	
					iis calc. based on ALL reported composition results: *)
	normality	OK			OK
	n	28			46
	outliers	1 + 2ex			0 + 4ex
	mean (n)	44.760			44.768
	st.dev. (n)	0.0456			0.0489
	R(calc.)	0.128			0.137

*) Calculated by iis based on molecular masses as given in table 2 of ASTM D2421:21e1.
NB. Effect of different factors of ASTM D2421:21e1 and ISO8973:97(amd.1-20)/IP432:00(2017) on the calculation is very small.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44.9
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44.7
44.6
44.5
44.4
44.3
44.2
467
1557
6018
1978
6410
508
381
1259
317
1191
1109
754
1016
495
6016
1941
1026
315
861
868
1990
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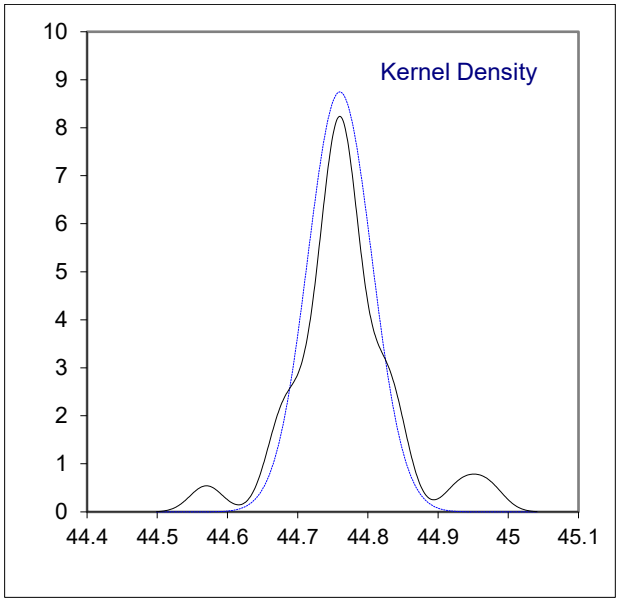
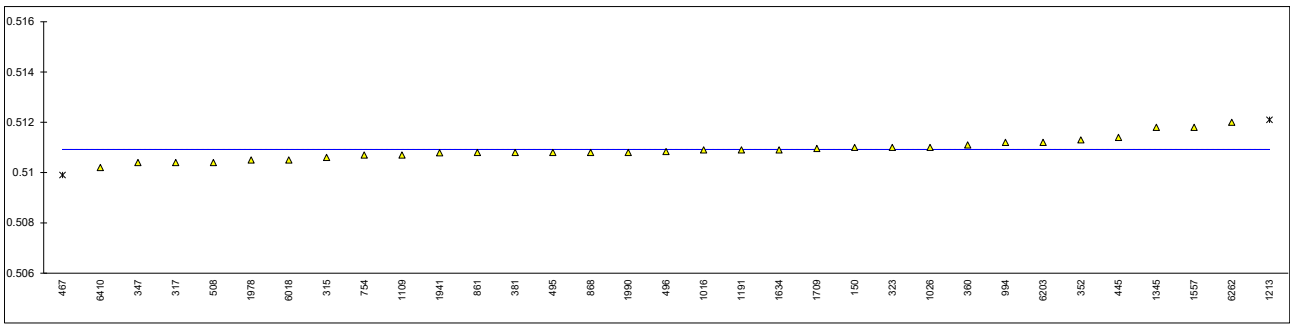
1845
1345
1213

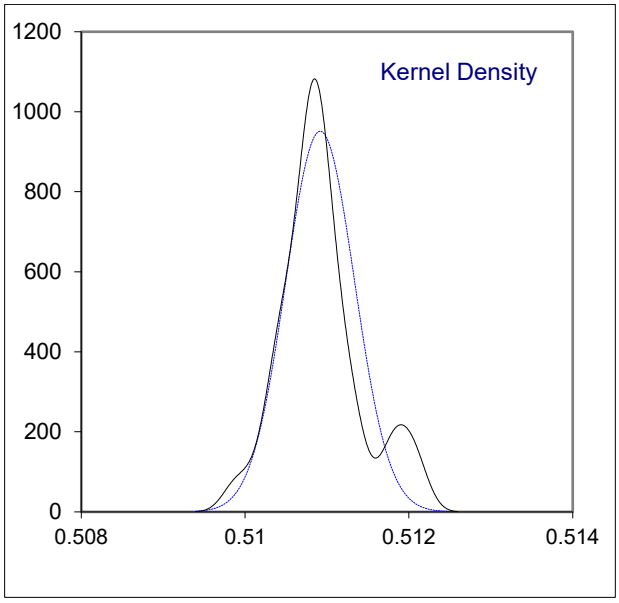

Kernel Density
10
9
8
7
6
5
4
3
2
1
0
44.4
44.5
44.6
44.7
44.8
44.9
45
45.1

Determination of Relative Density at 60/60°F on sample #21200;

lab	method	value	mark	z(targ)	remarks
150	D2598	0.5110		-----	
171		-----		-----	
315	D2598	0.5106		-----	
317	INH-001	0.5104		-----	
323	D2598	0.511		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347	D2598	0.5104		-----	
352	ISO8973	0.5113	C	-----	first reported 0.5109
360	D2598	0.5111		-----	
381	D2598	0.5108	C	-----	reported 510.8
444		-----		-----	
445	ISO8973	0.5114		-----	
467	ISO8973	0.5099	ex	-----	see paragraph 4.1. Calculated and reported at 15°C
495	D2598	0.5108		-----	
496	D2598	0.51084		-----	
508	D2598	0.5104	C	-----	first reported 0.5110
529		-----		-----	
562		-----		-----	
754	D2598	0.5107		-----	
861	D2598	0.5108		-----	
868	D2598	0.5108		-----	
970		-----		-----	
994	D2598	0.5112		-----	
1011		-----		-----	
1016	ISO8973	0.5109		-----	
1026	ISO8973	0.5110	C	-----	first reported 492.479. Reported at 15°C
1040		-----		-----	
1109	D2598	0.5107		-----	
1191	ISO8973	0.5109	C	-----	first reported 510.9
1213	D2598	0.5121	ex,C	-----	first reported 0.5436. See paragraph 4.1
1259		-----		-----	
1320		-----		-----	
1345	D2598	0.5118		-----	
1557	ISO8973	0.51180		-----	
1603		-----		-----	
1634	ISO8973	0.5109		-----	
1709	D2598	0.510958		-----	
1746		-----		-----	
1776		-----		-----	
1845		-----		-----	
1882		-----		-----	
1941	D2598	0.51079		-----	
1978	D2598	0.5105		-----	
1990	D2598	0.5108		-----	
2124		-----		-----	
6016		-----		-----	
6018	ISO8973	0.5105		-----	
6193		-----		-----	
6203	ISO8973	0.5112		-----	
6262	D2598	0.5120		-----	
6285		-----		-----	
6410	D2598	0.5102		-----	
6411		-----		-----	
					iis calc. based on all reported composition results: *)
	normality	OK			OK
	n	31			46
	outliers	0 + 2ex			0 + 4ex
	mean (n)	0.51092			0.51082
	st.dev. (n)	0.000419			0.000307
	R(calc.)	0.00117			0.00086

*) Calculated by iis based on relative densities at 60/60°F (15.6/15.6°C) as given in table 1 of ASTM D2598:21.
N.B. Effect of different factors from ASTM D2598:21 and ISO8973:97(amd.1-20)/IP432:00(2017) on the calculation is very small.


0.516
0.514
0.512
0.51
0.508
0.506
467
6410
347
317
508
1978
6018
315
754
1109
1941
861
381
495
868
1990
496
1016
1191
1634
1709
150
323
1026
360
994
6203
352
445
1345
1557
6262
1213


Kernel Density
1200
1000
800
600
400
200
0
0.508
0.51
0.512
0.514

Determination of Absolute Vapor Pressure at 100°F on sample #21200; results in psi

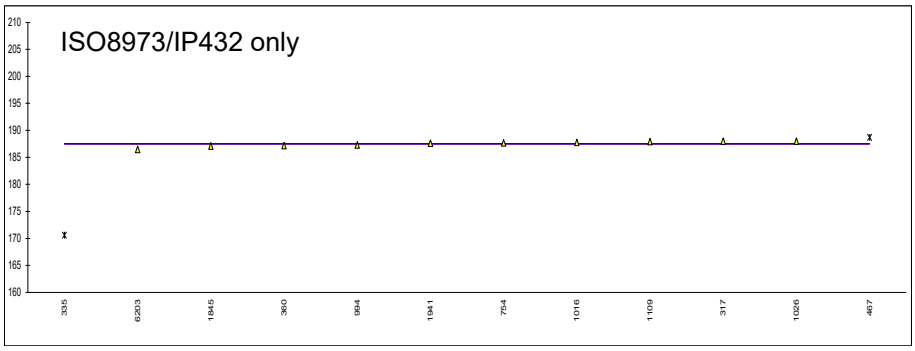
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315	D2598	-----		-----	186	E	-----	calc. difference, iis calc. 184
317	ISO8973	188.0		-----	-----		-----	
323		-----		-----	-----		-----	
328		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334		-----		-----	-----		-----	
335	ISO8973	170.6	E,D(0.01)	-----	-----		-----	calc. difference, iis calc. 188.1
347	D2598	-----		-----	183.5		-----	
352		-----		-----	-----		-----	
360	ISO8973	187.2		-----	-----		-----	
381		-----		-----	-----		-----	
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
467	ISO8973	188.7	ex	-----	-----		-----	see paragraph 4.1
495	D2598	-----		-----	183.6		-----	
496	D2598	-----		-----	183.54		-----	
508		-----		-----	-----		-----	
529		-----		-----	-----		-----	
562		-----		-----	-----		-----	
754	ISO8973	187.68		-----	-----		-----	
861	D2598	-----		-----	183.7		-----	
868	D2598	-----		-----	183.6		-----	
970		-----		-----	-----		-----	
994	ISO8973	187.29		-----	-----		-----	
1011		-----		-----	-----		-----	
1016	EN589	187.7645		-----	-----		-----	
1026	ISO8973	188.0	C	-----	-----		-----	first reported 191.128
1040		-----		-----	-----		-----	
1109	ISO8973	187.92		-----	-----		-----	
1191		-----		-----	-----		-----	
1213		-----		-----	-----		-----	
1259		-----		-----	-----		-----	
1320		-----		-----	-----		-----	
1345		-----		-----	-----		-----	
1557		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1709		-----		-----	-----		-----	
1746		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
1845	ISO8973	187.099		-----	-----		-----	
1882		-----		-----	-----		-----	
1941	ISO8973	187.64		-----	-----		-----	
1978	D2598	-----		-----	170.0245	E,D(0.01)	-----	see remark below this table
1990	D2598	-----		-----	183.7		-----	
2124		-----		-----	-----		-----	
6016		-----		-----	-----		-----	
6018		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6203	ISO8973	186.47		-----	-----		-----	
6262		-----		-----	-----		-----	
6285		-----		-----	-----		-----	
6410		-----		-----	-----	W	-----	first reported 170.2581
6411		-----		-----	-----		-----	

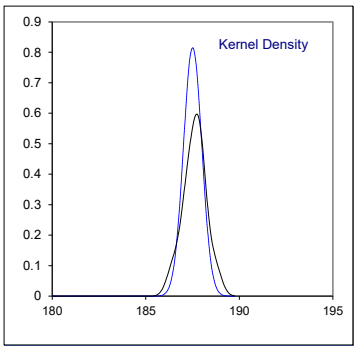
Lab 1978: calc. difference, iis calc. 184.5091, test result probably mixed up with Relative Vapor Pressure at 100°F

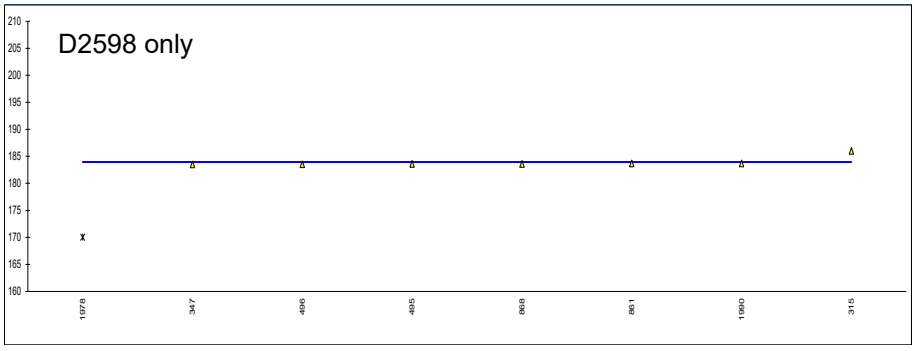
	ISO8973/IP432	D2598
normality	OK	unknown
n	10	7
outliers	1 + 1ex	1
mean (n)	187.506	183.949
st.dev. (n)	0.4892	0.9077
R(calc.)	1.370	2.541

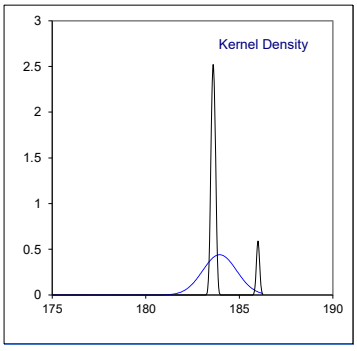
	iis calc. based on all reported composition results *)	iis calc. based on all reported composition results **)
normality	OK	OK
n	46	46
outliers	0 + 4ex	0 + 4ex
mean (n)	187.638	183.588
st.dev. (n)	0.6337	0.5910
R(calc.)	1.774	1.655

*) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table A.1 of ISO8973:97(amd.1-20)/IP432:00(2017)
**) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table 1 of ASTM D2598:21.









Determination of Relative Vapor Pressure at 100°F on sample #21200; results in psi

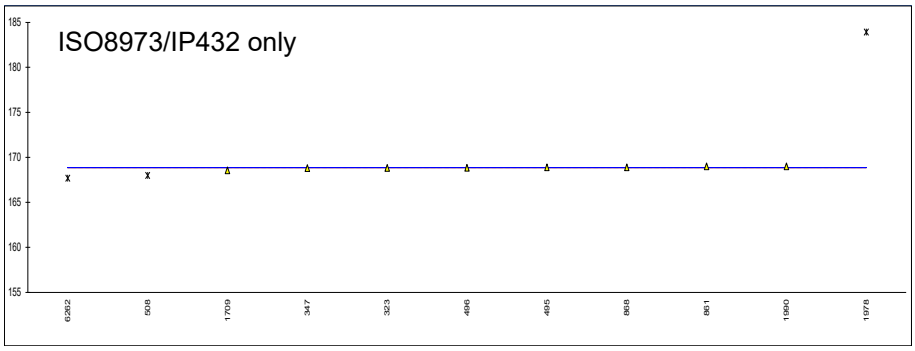
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315	ISO8973	171	E	-----	-----		-----	calc. difference, iis calc. 172.98
317	ISO8973	173.2		-----	-----		-----	
323	D2598	-----		-----	168.83		-----	
328		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334		-----		-----	-----		-----	
335		-----		-----	-----		-----	
347	D2598	-----		-----	168.8		-----	
352		-----		-----	-----		-----	
360	ISO8973	172.4		-----	-----		-----	
381		-----		-----	-----		-----	
444		-----		-----	-----		-----	
445	ISO8973	172.2		-----	-----		-----	
467	ISO8973	174.0	ex	-----	-----		-----	see paragraph 4.1
495	D2598	-----		-----	168.9		-----	
496	D2598	-----		-----	168.84		-----	
508	D2598	-----		-----	168	DG(0.01)	-----	
529		-----		-----	-----		-----	
562		-----		-----	-----		-----	
754	ISO8973	172.99		-----	-----		-----	
861	D2598	-----		-----	169.0		-----	
868	D2598	-----		-----	168.9		-----	
970		-----		-----	-----		-----	
994	ISO8973	172.34		-----	-----		-----	
1011		-----		-----	-----		-----	
1016	EN589	173.0686		-----	-----		-----	
1026	ISO8973	173.3	C	-----	-----		-----	first reported 176.432
1040		-----		-----	-----		-----	
1109	ISO8973	173.23		-----	-----		-----	
1191		-----		-----	-----		-----	
1213		-----		-----	-----		-----	
1259		-----		-----	-----		-----	
1320		-----		-----	-----		-----	
1345		-----		-----	-----		-----	
1557		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1709	D2598	-----		-----	168.5686		-----	
1746		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
1845		-----		-----	-----		-----	
1882		-----		-----	-----		-----	
1941	ISO8973	172.95		-----	-----		-----	
1978	D2598	-----		-----	183.9146	E,G(0.01)	-----	see remark below this table
1990	D2598	-----		-----	169		-----	
2124		-----		-----	-----		-----	
6016		-----		-----	-----		-----	
6018		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6203	ISO8973	171.72		-----	-----		-----	
6262	D2598	-----		-----	167.7	DG(0.01)	-----	
6285		-----		-----	-----		-----	
6410		-----		-----	-----		-----	
6411		-----		-----	-----		-----	

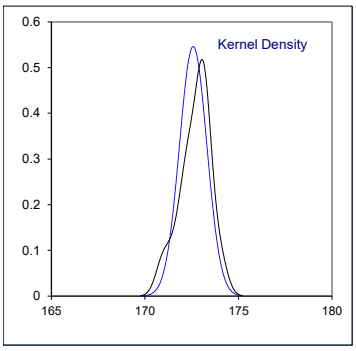
Lab 1978: calc. difference, iis calc. 169.81, test result probably mixed up with Absolute Vapor Pressure at 100°F

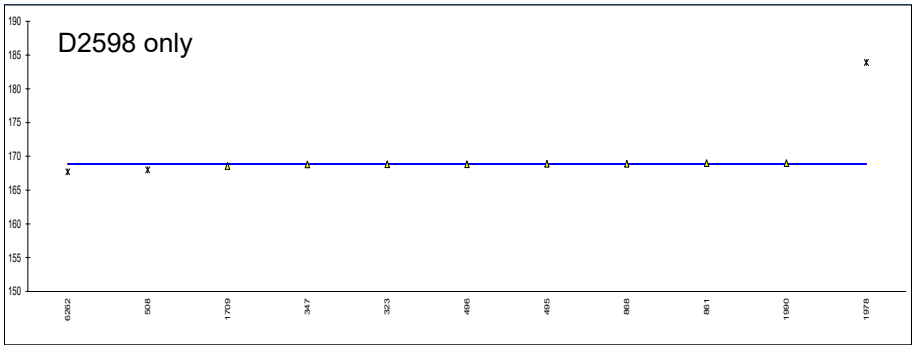
	ISO8973/IP432	D2598
normality	OK	not OK
n	11	8
outliers	0 + 1ex	3
mean (n)	172.582	168.855
st.dev. (n)	0.7307	0.1373
R(calc.)	2.046	0.384

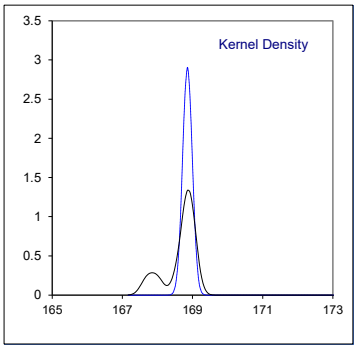
	iis calc. based on all reported composition results *)	iis calc. based on all reported composition results **)
normality	OK	OK
n	46	46
outliers	4	4
mean (n)	172.942	168.892
st.dev. (n)	0.6336	0.5910
R(calc.)	1.774	1.655

*) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table A.1 of ISO8973:97(amd.1-20)/IP432:00(2017)
**) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table 1 of ASTM D2598:21.







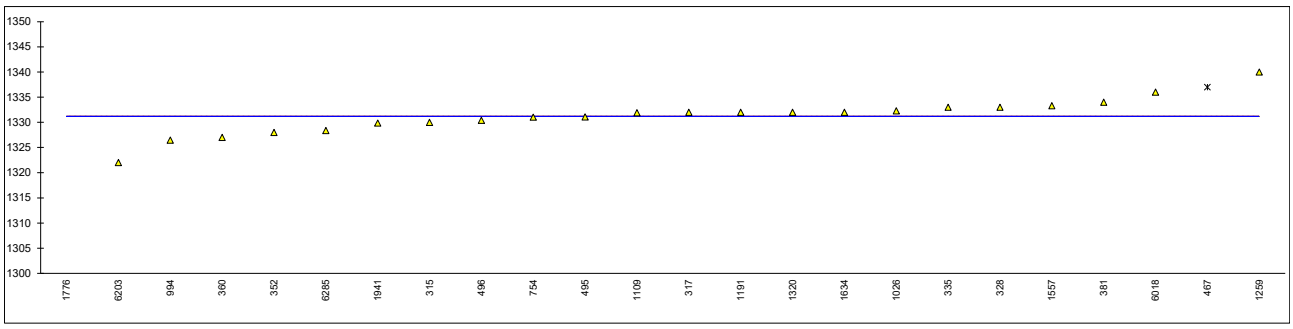


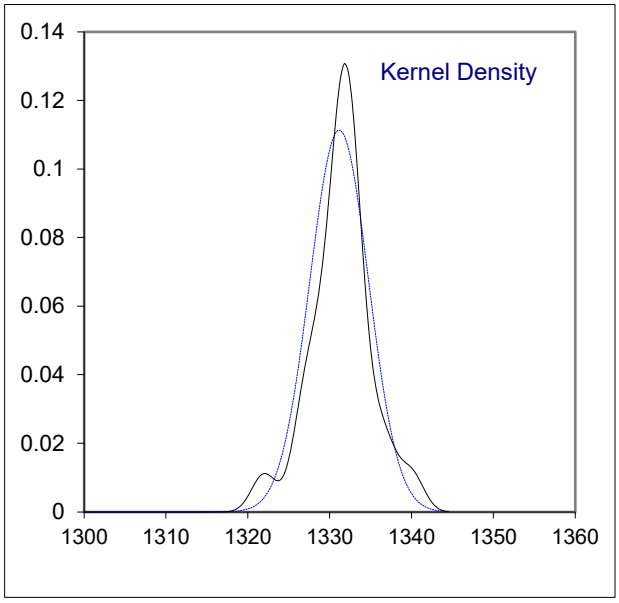
Determination of Absolute Vapor Pressure at 40°C on sample #21200; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	1330		-----	
317	ISO8973	1332		-----	
323		-----		-----	
328	ISO8973	1333		-----	
333		-----		-----	
334		-----		-----	
335	ISO8973	1333		-----	
347		-----		-----	
352	ISO8973	1328	C	-----	first reported 1346
360	ISO8973	1327		-----	
381	ISO8973	1334		-----	
444		-----		-----	
445		-----		-----	
467	ISO8973	1337	ex	-----	see paragraph 4.1
495	ISO8973	1331.1		-----	
496	ISO8973	1330.43		-----	
508		-----		-----	
529		-----		-----	
562		-----		-----	
754	ISO8973	1331.049		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	ISO8973	1326.49		-----	
1011		-----		-----	
1016		-----		-----	
1026	ISO8973	1332.31	C	-----	first reported 1355.79
1040		-----		-----	
1109	ISO8973	1331.92		-----	
1191	ISO8973	1332		-----	
1213		-----		-----	
1259	ISO8973	1340	C	-----	first reported 1341
1320	ISO8973	1332		-----	
1345		-----		-----	
1557	ISO8973	1333.3		-----	
1603		-----		-----	
1634	ISO8973	1332		-----	
1709		-----		-----	
1746		-----		-----	
1776	ISO8973	1224.5	E,G(0.01)	-----	see remark below this table
1845		-----		-----	
1882		-----		-----	
1941	ISO8973	1329.87		-----	
1978		-----		-----	
1990		-----		-----	
2124		-----		-----	
6016		-----		-----	
6018	ISO8973	1336	C	-----	first reported 1235
6193		-----		-----	
6203	ISO8973	1322		-----	
6262		-----		-----	
6285	ISO8973	1328.4		-----	
6410		-----	W	-----	first reported 1174.1708
6411		-----		-----	
					iis calc. based on all reported composition results:*)
	normality	not OK			OK
	n	22			46
	outliers	1 + 1ex			0 + 4ex
	mean (n)	1331.176			1329.874
	st.dev. (n)	3.5849			4.5715
	R(calc.)	10.038			12.800

Lab 1776: calc. difference, iis calc. 1325.73, test result possibly mixed up with Relative Vapor Pressure at 40°C?

*) Calculated by iis based on Vapor Pressure factors at 40°C as given in table A.1 of ISO8973:97(amd.1-20)/IP432:00(2017)

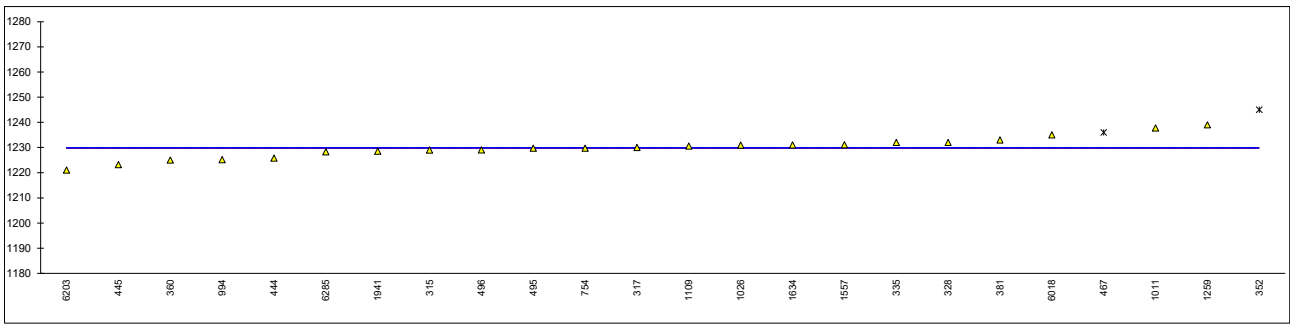

1350
1345
1340
1335
1330
1325
1320
1315
1310
1305
1300
1776
6203
994
360
352
6285
1941
315
496
754
495
1109
317
1191
1320
1634
1028
335
328
1557
381
6018
467
1259

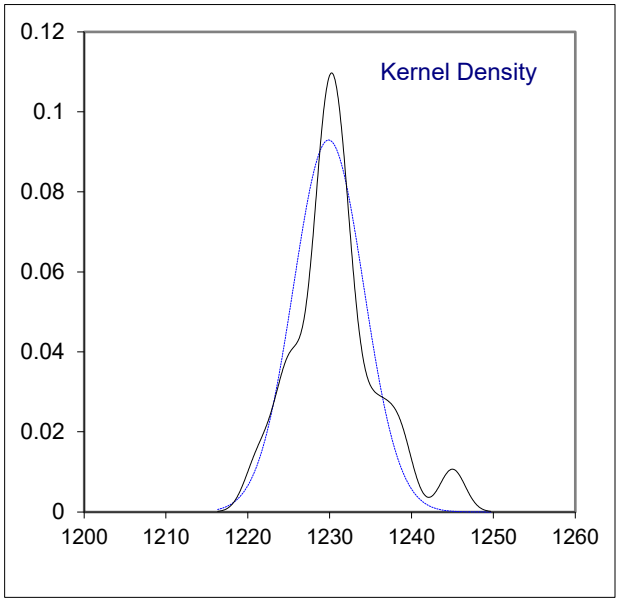

Kernel Density
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1300
1310
1320
1330
1340
1350
1360

Determination of Relative Vapor Pressure at 40°C on sample #21200; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	1229		-----	
317	ISO8973	1230		-----	
323		-----		-----	
328	ISO8973	1232		-----	
333		-----		-----	
334		-----		-----	
335	ISO8973	1232		-----	
347		-----		-----	
352	ISO8973	1245	E,D(0.05)	-----	calc. difference, iis calc. 1227
360	ISO8973	1225		-----	
381	ISO8973	1233		-----	
444	ISO8973	1225.8		-----	
445	ISO8973	1223.2		-----	
467	ISO8973	1236	ex	-----	see paragraph 4.1
495	ISO8973	1229.7		-----	
496	ISO8973	1229.10		-----	
508		-----		-----	
529		-----		-----	
562		-----		-----	
754	ISO8973	1229.72		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	ISO8973	1225.19		-----	
1011	ISO8973	1237.8		-----	
1016		-----		-----	
1026	ISO8973	1230.99	C	-----	first reported 1254.465
1040		-----		-----	
1109	ISO8973	1230.63		-----	
1191		-----		-----	
1213		-----		-----	
1259	ISO8973	1239		-----	
1320		-----		-----	
1345		-----		-----	
1557	ISO8973	1231.1		-----	
1603		-----		-----	
1634	ISO8973	1231		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1845		-----		-----	
1882		-----		-----	
1941	ISO8973	1228.55		-----	
1978		-----		-----	
1990		-----		-----	
2124		-----		-----	
6016		-----		-----	
6018	ISO8973	1235	C	-----	first reported 1336
6193		-----		-----	
6203	ISO8973	1221		-----	
6262		-----		-----	
6285	ISO8973	1228.3		-----	
6410		-----		-----	
6411		-----		-----	
					iis calc. based on all reported composition results:*)
	normality	OK			OK
	n	22			46
	outliers	1 + 1ex			4
	mean (n)	1229.867			1228.549
	st.dev. (n)	4.2930			4.5715
	R(calc.)	12.020			12.800

*) Calculated by iis based on Vapor Pressure factors at 40°C as given in table A.1 of ISO8973:97(amd.1-20)/IP432:00(2017)


1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
6203
445
360
994
444
6285
1941
315
496
495
754
317
1109
1026
1634
1557
335
328
381
6018
467
1011
1259
352


Kernel Density
0.12
0.1
0.08
0.06
0.04
0.02
0
1200
1210
1220
1230
1240
1250
1260

Determination of Motor Octane Number, MON on sample #21200;

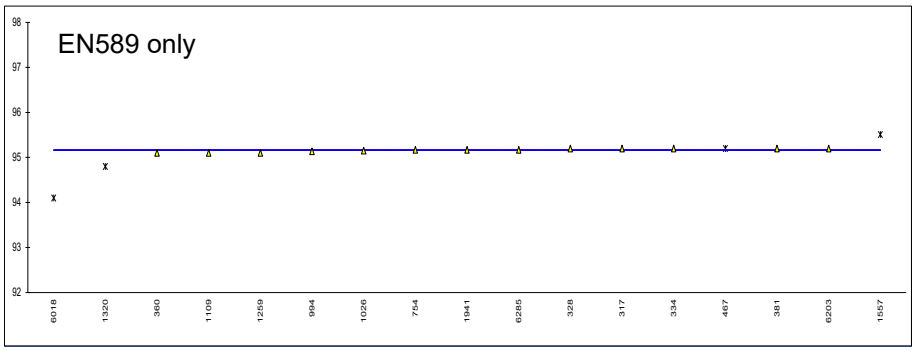
lab	method	EN589	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315		-----		-----	-----		-----	
317	EN589	95.2		-----	-----		-----	
323		-----		-----	-----		-----	
328	EN589	95.2		-----	-----		-----	
333		-----		-----	-----		-----	
334	EN589	95.2		-----	-----		-----	
335		-----		-----	-----		-----	
347		-----		-----	-----		-----	
352		-----		-----	-----		-----	
360	EN589	95.1		-----	-----		-----	
381	EN589	95.2		-----	-----		-----	
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
467	EN589	95.2	ex	-----	-----		-----	see paragraph 4.1
495	D2598	-----		-----	96.5		-----	
496	D2598	-----		-----	96.524		-----	
508	D2598	-----		-----	96.8	E,C	-----	fr. 96.9, calc. diff, iis calculated 96.4
529		-----		-----	-----		-----	
562		-----		-----	-----		-----	
754	EN589	95.17		-----	-----		-----	
861	D2598	-----		-----	96.6		-----	
868	D2598	-----		-----	96.6		-----	
970		-----		-----	-----		-----	
994	EN589	95.14		-----	-----		-----	
1011		-----		-----	-----		-----	
1016		-----		-----	-----		-----	
1026	EN589	95.153	C	-----	-----		-----	first reported 95.156
1040		-----		-----	-----		-----	
1109	EN589	95.1		-----	-----		-----	
1191		-----		-----	-----		-----	
1213		-----		-----	-----		-----	
1259	EN589	95.1		-----	-----		-----	
1320	EN589	94.8	E,G(0.05)	-----	-----		-----	calculation difference, iis calc. 95.2
1345		-----		-----	-----		-----	
1557	EN589	95.51	E,G(0.01)	-----	-----		-----	calculation difference, iis calc. 95.2
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1709		-----		-----	-----		-----	
1746		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
1845		-----		-----	-----		-----	
1882		-----		-----	-----		-----	
1941	EN589	95.17		-----	-----		-----	
1978	D2598	-----		-----	95.1795	E,G(0.05)	-----	see remark below this table
1990	D2598	-----		-----	96	E	-----	calculation difference, iis calc. 95.2
2124		-----		-----	-----		-----	
6016		-----		-----	-----		-----	
6018	EN589	94.1	E,G(0.01)	-----	-----		-----	calculation difference, iis calc. 95.2
6193		-----		-----	-----		-----	
6203	EN589	95.2		-----	-----		-----	
6262		-----		-----	-----		-----	
6285	EN589	95.17		-----	-----		-----	
6410	D2598	-----		-----	96.5292		-----	
6411		-----		-----	-----		-----	

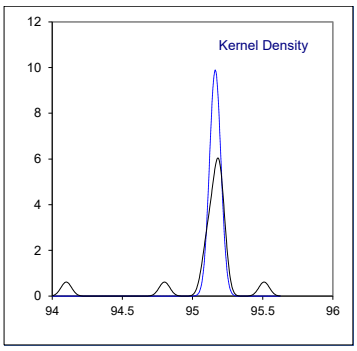
Lab 1978: calculation difference, iis calculated with D2598 96.5961 and with EN589 95.1796

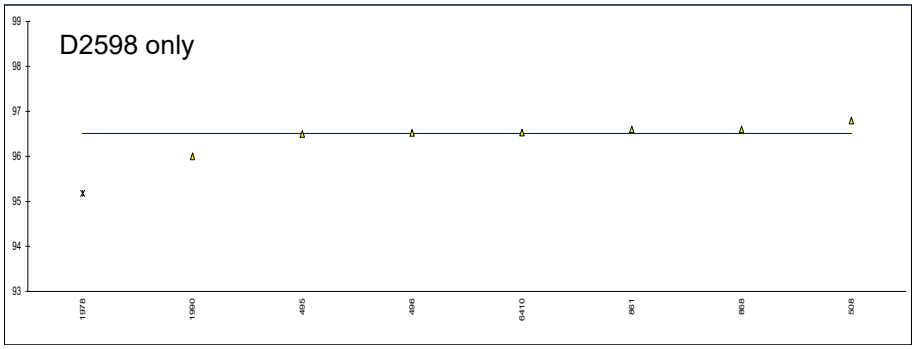
	EN589	D2598
normality	OK	unknown
n	13	7
outliers	3 + 1ex	1
mean (n)	95.162	96.508
st.dev. (n)	0.0403	0.2453
R(calc.)	0.113	0.687

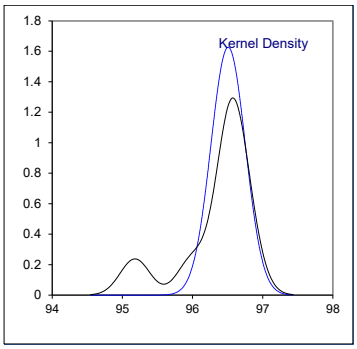
	iis calc. based on all reported composition results *)	iis calc. based on all reported composition results **)
normality	suspect	OK
n	42	44
outliers	4 + 4ex	2 + 4ex
mean (n)	95.161	96.527
st.dev. (n)	0.0125	0.0395
R(calc.)	0.035	0.111

*) Calculated by iis based on MON factors given in table B.1 of EN589:18.
**) Calculated by iis based on MON factors given in table 1 of ASTM D2598:21. This method does not mention MON factors for iso-Butene. For iso-Butene the value of 83.5 of cis-2-Butene is used in the calculations in analogy of the MON factors of the other components.





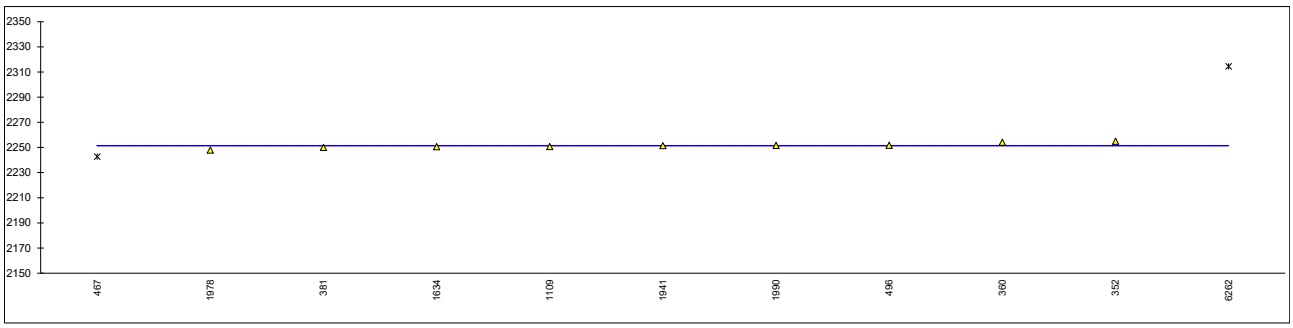


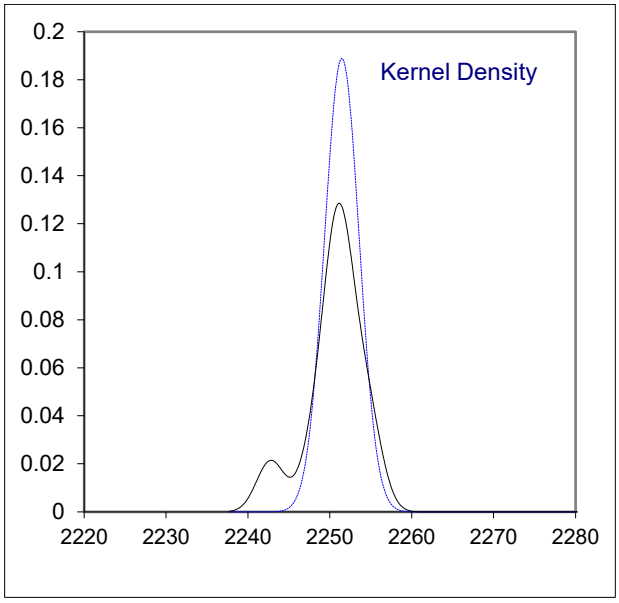


Determination of Ideal Gross Heating Value at 14.696 psia and 60°F on sample #21200; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315		-----		-----	
317		-----		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347		-----		-----	
352	D3588	2255.01	C	-----	first reported 2253.5066
360	D3588	2254.1		-----	
381	D3588	2250		-----	
444		-----		-----	
445		-----		-----	
467	ISO6976Calculated	2242.787	ex	-----	see paragraph 4.1. Calculated at 15°C
495		-----		-----	
496	D3588	2251.84		-----	
508		-----		-----	
529		-----		-----	
562		-----		-----	
754		-----		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1011		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1109	D3588	2250.73		-----	
1191		-----		-----	
1213		-----		-----	
1259		-----		-----	
1320		-----		-----	
1345		-----		-----	
1557		-----		-----	
1603		-----		-----	
1634	D3588	2250.63		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1845		-----		-----	
1882		-----		-----	
1941	D3588	2251.40		-----	
1978	D3588	2247.9208		-----	
1990	D3588	2251.73		-----	
2124		-----		-----	
6016		-----		-----	
6018		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262	D3588	2314.47	E,D(0.01)	-----	calculation difference, iis calculated 2254.14
6285		-----		-----	
6410		-----		-----	
6411		-----		-----	
					iis calc. based on all reported composition results:*)
	normality	OK			OK
	n	9			46
	outliers	1 + 1ex			0 + 4ex
	mean (n)	2251.485			2251.719
	st.dev. (n)	2.1115			2.2686
	R(calc.)	5.912			6.352

*) Calculated by iis based on the Ideal Gross Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017)e1.

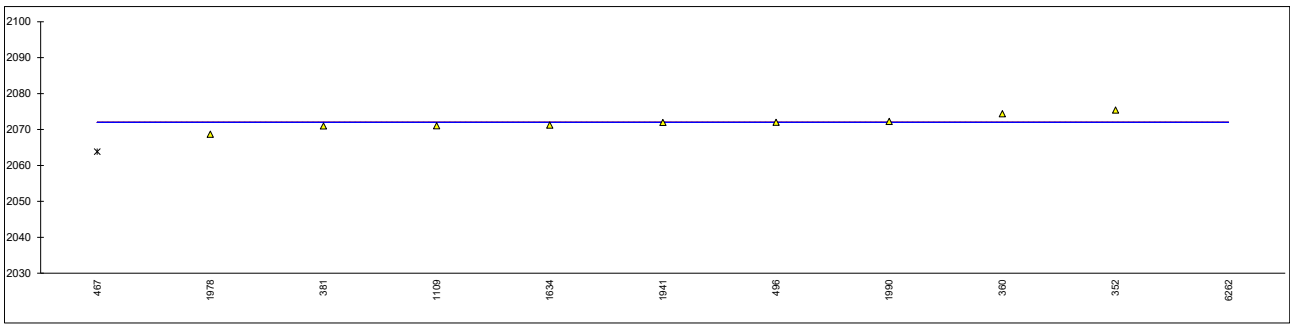

2350
2330
2310
2290
2270
2250
2230
2210
2190
2170
2150
467
1978
381
1634
1109
1941
1990
496
360
352
6262

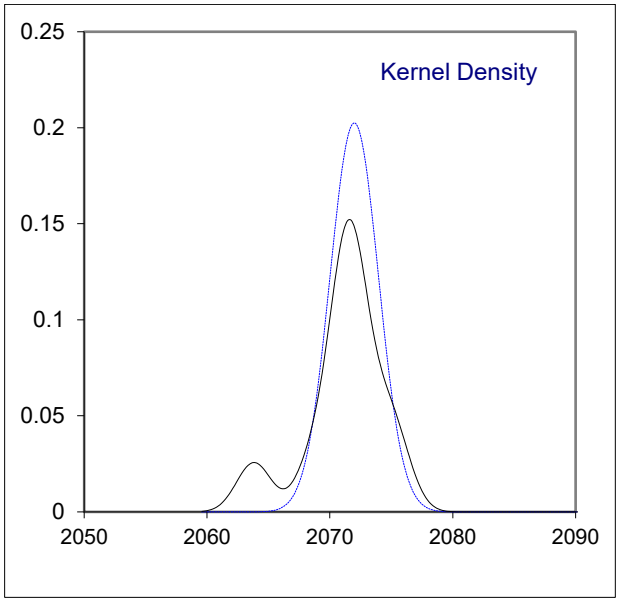

Kernel Density
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2220
2230
2240
2250
2260
2270
2280

Determination of Ideal Net Heating Value at 14.696 psia and 60°F on sample #21200; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315		-----		-----	
317		-----		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347		-----		-----	
352	D3588	2075.43	C	-----	first reported 2074.1193
360	D3588	2074.4		-----	
381	D3588	2071		-----	
444		-----		-----	
445		-----		-----	
467	ISO6976Calculated	2063.832	ex	-----	see paragraph 4.1. Calculated at 15°C
495		-----		-----	
496	D3588	2071.99		-----	
508		-----		-----	
529		-----		-----	
562		-----		-----	
754		-----		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1011		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1109	D3588	2071.08		-----	
1191		-----		-----	
1213		-----		-----	
1259		-----		-----	
1320		-----		-----	
1345		-----		-----	
1557		-----		-----	
1603		-----		-----	
1634	D3588	2071.24		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1845		-----		-----	
1882		-----		-----	
1941	D3588	2071.95		-----	
1978	D3588	2068.6752		-----	
1990	D3588	2072.24		-----	
2124		-----		-----	
6016		-----		-----	
6018		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262	D3588	2130.94	E,D(0.01)	-----	calculation difference, iis calculated 2074.55
6285		-----		-----	
6410		-----		-----	
6411		-----		-----	
					iis calc. based on all reported composition results:*)
	normality	OK			OK
	n	9			46
	outliers	1 + 1ex			0 + 4ex
	mean (n)	2072.001			2072.269
	st.dev. (n)	1.9705			2.1274
	R(calc.)	5.517			5.957

*) Calculated by iis based on the Ideal Net Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017)e1.

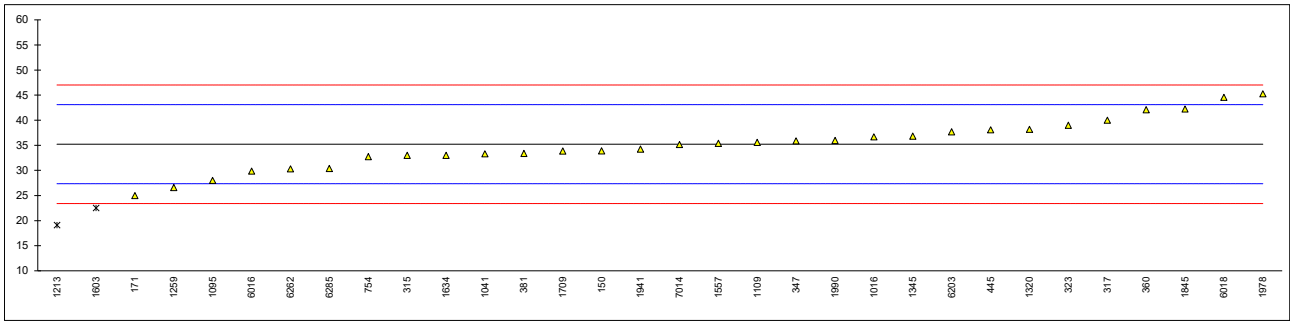

2100
2090
2080
2070
2060
2050
2040
2030
467
1978
381
1109
1634
1941
496
1990
360
352
6262


Kernel Density
0.25
0.2
0.15
0.1
0.05
0
2050
2060
2070
2080
2090

Determination of Total Sulfur on sample #21201; results in mg/kg

lab	method	value	mark	z(targ)	remarks
150	D6667	33.9		-0.33	
171	D6667	25		-2.59	
315	D6667	33		-0.56	
317	D6667	40		1.22	
323	D6667	39		0.96	
337		-----		-----	
347	D6667	35.9		0.17	
360	D6667	42.1		1.75	
381	D6667	33.4		-0.46	
445	D6667	38.1		0.73	
495		-----		-----	
562		-----		-----	
754	D6667	32.75		-0.63	
1011		-----		-----	
1012		-----		-----	
1016	D6667	36.7		0.38	
1041	D6667	33.3		-0.49	
1095	D6667	28		-1.83	
1109	D6667	35.6		0.10	
1213	D6228	19.1	C,G(0.05)	-4.09	first reported <1
1259	D6667	26.6		-2.19	
1320	D6667	38.18		0.75	
1345	D6667	36.84		0.41	
1557	D6667	35.4		0.05	
1603	In house	22.530	G(0.05)	-3.22	
1634	D6667	33		-0.56	
1709	D6667	33.855		-0.34	
1845	D5504	42.25		1.79	
1941	D6667	34.25		-0.24	
1978	D6667	45.281		2.56	
1990	D6667	35.98	C	0.20	first reported 21.117
6016	D6667	29.854		-1.36	
6018	D6667	44.56	C	2.37	first reported 18.01
6203	D6667	37.69		0.63	
6262	D6667	30.3		-1.25	
6285	D6667/EN17178	30.4		-1.22	
6364		-----		-----	
7014	D6667	35.17		-0.01	

normality	OK
n	30
outliers	2
mean (n)	35.212
st.dev. (n)	4.8642
R(calc.)	13.620
st.dev.(D6667:21)	3.9362
R(D6667:21)	11.021


60
55
50
45
40
35
30
25
20
15
10
1213
1603
171
1259
1095
6016
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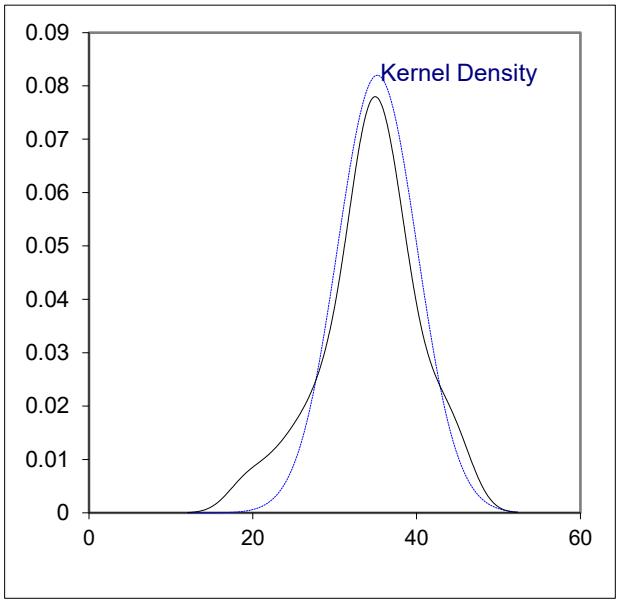
754
315
1634
1041
381
1709
150
1941
7014
1557
1109
347
1990
1016
1345
6203
445
1320
323
317
360
1845
6018
1978


Kernel Density
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
20
40
60

APPENDIX 2

Number of participants per country

Liquified Propane iis21S03P

1 lab in	ALGERIA
2 labs in	AUSTRALIA
1 lab in	AZERBAIJAN
2 labs in	BELGIUM
1 lab in	BULGARIA
2 labs in	CHILE
2 labs in	CHINA, People's Republic
1 lab in	CROATIA
1 lab in	DENMARK
1 lab in	FINLAND
4 labs in	FRANCE
1 lab in	GEORGIA
4 labs in	GERMANY
1 lab in	KAZAKHSTAN
1 lab in	MALAYSIA
1 lab in	MEXICO
4 labs in	NETHERLANDS
1 lab in	NIGER
1 lab in	OMAN
1 lab in	PANAMA
1 lab in	POLAND
4 labs in	PORTUGAL
1 lab in	ROMANIA
1 lab in	RUSSIAN FEDERATION
4 labs in	SERBIA
1 lab in	SLOVAKIA
2 labs in	SPAIN
3 labs in	SWEDEN
1 lab in	TAIWAN
2 labs in	UNITED KINGDOM
2 labs in	UNITED STATES OF AMERICA
1 lab in	VIETNAM

Sulfur (total) in LPG iis21S03S

1 lab in	AUSTRALIA
2 labs in	BELGIUM
1 lab in	BULGARIA
2 labs in	CHILE
1 lab in	CROATIA
1 lab in	FRANCE
1 lab in	GEORGIA
3 labs in	GERMANY
1 lab in	IRAN, Islamic Republic of
1 lab in	KAZAKHSTAN
1 lab in	KENYA
1 lab in	MALAYSIA
3 labs in	NETHERLANDS
1 lab in	NIGERIA
1 lab in	POLAND
4 labs in	PORTUGAL
1 lab in	ROMANIA
1 lab in	RUSSIAN FEDERATION
3 labs in	SERBIA
1 lab in	SLOVAKIA
1 lab in	SPAIN
1 lab in	SWEDEN
1 lab in	TAIWAN
1 lab in	UNITED KINGDOM
2 labs in	UNITED STATES OF AMERICA
1 lab in	VIETNAM

APPENDIX 3

Abbreviations

C	= final test result after checking of first reported suspect test result
D(0.01)	= outlier in Dixon's outlier test
D(0.05)	= straggler in Dixon's outlier test
G(0.01)	= outlier in Grubbs' outlier test
G(0.05)	= straggler in Grubbs' outlier test
DG(0.01)	= outlier in Double Grubbs' outlier test
DG(0.05)	= straggler in Double Grubbs' outlier test
R(0.01)	= outlier in Rosner's outlier test
R(0.05)	= straggler in Rosner's outlier test
E	= calculation difference between reported test result and result calculated by iis
W	= test result withdrawn on request of participant
ex	= test result excluded from statistical evaluation
n.a.	= not applicable
n.e.	= not evaluated
n.d.	= not detected
fr.	= first reported
f+?	= possibly a false positive test result?
f-?	= possibly a false negative test result?
SDS	= Safety Data Sheet

Literature

1 iis Interlaboratory Studies, Protocol for the Organisation, Statistics & Evaluation, June 2018
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