Institute for
Interlaboratory Studies

Results of Proficiency Test Liquefied Propane and Total Sulfur in LPG October 2022

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 Total Sulfur in LPG is also organized every year. During the annual proficiency testing program 2022/2023 it was decided to continue the round robin for both the analysis of Liquefied Propane and the analysis of Total Sulfur 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 (iis22S04P) and a co-operation with Nippon Gases (Belgium) was set up for the Total Sulfur in LPG PT (iis22S04S). Both EffecTech and Nippon Gases are fully equipped and have experience in the preparation of gas mixtures.

In the interlaboratory studies for Liquefied Propane 61 laboratories in 31 countries and for Total Sulfur in LPG 41 laboratories in 24 countries registered for participation, see appendix 2 for the number of participants per country. In this report the results of the Liquefied Propane and Total Sulfur in LPG proficiency tests 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.

Sample ID	PT ID	Quantity	Purpose
#22200	iis22S04P	1 L	Composition and Physical properties
#22201	iis22S04S	5 L	Total Sulfur

Table 1: Gas samples used in PTs Liquefied Propane and Total Sulfur in LPG

The limited cylinder sizes are chosen to optimize transport and handling costs. Each cylinder was uniquely numbered.
Sample analyzes for fit-for-use and homogeneity testing were subcontracted to an ISO/IEC17025 accredited laboratory.
The 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 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 64 uniquely coded one-liter 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 ISO/IEC17025 (job 22/0880). Each cylinder (with dip tube device) was filled with approximately 200 grams of Liquefied Propane mixture and labelled #22200. 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 (D2163:14R19) in %mol/mol
Ethane	0.0037	0.0683
Propane	0.0643	1.2457
Propene	0.0070	0.0714
iso-Butane	0.0181	0.0612
n-Butane	0.0250	0.0642
1-Butene	0.0025	0.0234
iso-Butene	0.0030	0.0221
n-Pentane	0.0105	0.0270

Table 2: homogeneity test results of subsamples #22200

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 Total Sulfur in LPG a batch of 43 uniquely coded five-liter cylinders (with dip tube device) was prepared and tested for homogeneity by Nippon Gases (Belgium) (order/ref. nr. 441,717,001). Each cylinder was filled with approximately 1500 grams of LPG, spiked with Dimethyl Sulfide (DMS) and labelled #22201.

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)	1.2
reference test method	ASTM D6667:21 LP gases
0.3 x R (reference test method)	9.0

Table 3: evaluation of the repeatability of subsamples #22201

The calculated repeatability is 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 28, 2022. 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 #22200: 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.
On sample #22201 it was requested to determine Total Sulfur.

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 two weeks.
For the Liquefied Propane PT (iis22S04P) three participants reported after the extended reporting date and twelve other participants did not report any test results. Not all participants were able to report all tests requested. In total 49 participants reported 599 numerical test results. Observed were 41 outlying test results, which is 6.8%.
For the Total Sulfur in LPG PT (iis22S04S) five participants reported after the extended reporting date and eleven other participants did not report any test results. In total 30 participants reported 30 numerical test results. No outlying test results were observed.

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 in appendix 1. The abbreviations, used in these tables, are explained in appendix 3.

In the iis PT reports ASTM test methods are referred to with a number (e.g. D2163) and an added designation for the year that the test method was adopted or revised (e.g. D2163:14). When a method has been reapproved an “R” will be added and the year of approval (e.g. D2163:14R19).

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 comparison 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.

Four laboratories had at least four statistical outliers in the measured gas composition (of the eight test results, not counting iso-Pentane which was not present in this sample). As the test results of each component of the composition are not independent, it was decided to exclude the remaining test results from these laboratories from the statistical evaluation in the gas composition. Also, the reported test results for the parameters calculated from the gas composition were excluded from the statistical evaluation for these four laboratories.

For comparison to the reported test results for the Physical Properties iis calculated these Physical Properties for all laboratories that reported composition results. In the statistical evaluation of the calculated properties (both in the reported test values as well in the iis calculated values) the calculated results of above-mentioned laboratories were excluded as well as the calculated results of six other laboratories with one, two or three outliers in the composition. Furthermore, one laboratory did not report n-Pentane but appeared to have reported the Physical Properties calculated with n-Pentane. Therefore, this laboratory is excluded in the Physical Properties calculations of iis.

sample #22200

Total of the composition results: The total of the test results of the composition per laboratory was calculated by iis. Since the composition is requested as normalized the total should be 100%. Five calculated results were found to be significantly different than 100%. It was decided to exclude the test results of these laboratories for all further statistical evaluations.

Ethane: The determination of this component was not problematic. Four statistical outliers were observed and six other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14R19 and in agreement with EN27941:93(liq).

Propane: The determination of this component was not problematic. Four statistical outliers were observed and six other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14R19 and EN27941:93(liq).

Propene: The determination of this component was not problematic. No statistical outliers were observed but nine test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14R19 and EN27941:93(liq).

iso-Butane: The determination of this component may be problematic depending on the test method used. Four statistical outliers were observed and five other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the requirements of ASTM D2163:14R19 but is in agreement with EN27941:93(liq).

n-Butane: The determination of this component may be problematic depending on the test method used. Seven statistical outliers were observed and five other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the requirements of ASTM D2163:14R19 but is in agreement with EN27941:93(liq).

1-Butene: The determination of this component was not problematic. Three statistical outliers were observed and five other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14R19 and EN27941:93(liq).

iso-Butene: The determination of this component was not problematic. Two statistical outliers were observed and five other test results were excluded. The calculated reproducibility after rejection of the suspect data is in full agreement with the requirements of ASTM D2163:14R19 and in agreement with EN27941:93(liq).

n-Pentane: The determination of this component may be problematic depending on the test method used. Seven statistical outliers were observed and four 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 D2163:14R19 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 are calculated.

Molar Mass: This calculated parameter may not be problematic. One statistical outlier was observed and six 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 (0.14 vs. 0.13 g/mol).

Relative Density at 60/60 °F: This calculated parameter may be problematic. No statistical outliers were observed but nine 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 (0.0025 vs. 0.0008).

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.
No statistical outliers were observed in the ISO8973 test results but two test results were 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 (1.13 vs. 1.30 psi).
In the ASTM D2598 test results one statistical outlier was observed and four other test results were 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 ASTM D2598:21 over all reported component concentrations (1.94 vs. 1.36 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.
One statistical outlier was observed in the ISO8973 test results and three 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 vapor pressure factors obtained from ISO8973:97(amd.1-20) over all reported component concentrations (1.39 vs. 1.30 psi).
In the ASTM D2598 test results two statistical outliers were observed and three other test results were 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 ASTM D2598:21 over all reported component concentrations (1.58 vs. 1.36 psi).

Abs. Vapor Pres. at 40 °C: This calculated parameter may not be problematic. One statistical outlier was observed but six test results were 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 (8.27 vs. 9.25 kPa).

Rel. Vapor Pres. at 40 °C: This calculated parameter may not be problematic. No statistical outliers were observed but six 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 vapor pressure factors obtained from ISO8973:97(amd.1-20) over all reported component concentrations (9.68 vs. 9.25 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.

One statistical outlier was observed in the EN589 test results and four other test results were 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+A1:22(E) over all reported component concentrations (0.10 vs. 0.05).
In the ASTM D2598 test results one statistical outlier was observed and four other test results were 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 D2589:21 over all reported component concentrations (0.33 vs. 0.12).

Ideal Gross Heating Value at 14.696 psia / 60 °F: 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 Ideal Gross Heating Values obtained from ASTM D3588:98R17 over all reported component concentrations (5.71 vs. 6.23 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 three 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 Ideal Gross Heating Values obtained from ASTM D3588:98R17 over all reported component concentrations (5.63 vs. 5.83 kJ/mol).

sample #22201

Total Sulfur: The determination of this component was not problematic. No statistical outliers were observed. The calculated reproducibility is in agreement with the requirements of ASTM D6667:21 LP Gas.

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 reproducibility derived from the reference method are presented in the next table.

Component	unit	n	average	2.8 * sd	R(lit)
Ethane	%mol/mol	39	0.527	0.178	0.212
Propane	%mol/mol	39	92.788	1.038	4.151
Propene	%mol/mol	40	0.749	0.129	0.236
iso-Butane	%mol/mol	40	1.745	0.259	0.206
n-Butane	%mol/mol	37	2.753	0.368	0.217
1-Butene	%mol/mol	40	0.286	0.051	0.078
iso-Butene	%mol/mol	40	0.250	0.072	0.074

Component	unit	n	average	2.8 * sd	R(lit)
n-Pentane	%mol/mol	36	0.948	0.250	0.091
iso-Pentane	%mol/mol	33	<0.01	n.e.	n.e.

Table 4: reproducibilities of the composition of sample #22200

Parameter	unit	n	average	2.8 * sd	R(calc all)*
Molar Mass	g/mol	18	44.96	0.14	0.13
Rel. Density at 60/60 °F		22	0.5119	0.0025	0.0008
Abs. VP at 100 °F ISO/IP	psi	9	186.20	1.13	1.30
Abs. VP at 100 °F D2598	psi	3	182.35	1.94	1.36
Rel. VP at 100 °F ISO/IP	psi	9	171.44	1.39	1.30
Rel. VP at 100 °F D2598	psi	10	167.16	1.58	1.36
Abs. VP at 40 °C	kPa	16	1320	8	9
Rel. VP at 40 °C	kPa	17	1218	10	9
MON EN589		8	95.01	0.10	0.05
MON D2598		7	96.12	0.33	0.12
IGHV D3588	kJ/mol	8	2260	6	6
INHV D3588	kJ/mol	8	2081	6	6

Table 5: reproducibilities of calculated parameters on sample #22200 using one set of factors.

*) Reproducibility calculated over all values calculated by iis by using reported component concentrations of all participants

Component	unit	n	average	2.8 * sd	R(lit)
Total Sulfur	mg/kg	30	37.1	24.4	29.1

Table 6: reproducibility of Sulfur on sample #22201

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 reference test method. The problematic components have been discussed in paragraph 4.1.

4.3 COMPARISON OF THE PROFICIENCY TEST OF OCTOBER 2022 WITH PREVIOUS PTS

	October 2022	October 2021	October 2020	October 2019	October 2018
Number of reporting laboratories	49	50	43	46	44
Number of test results	599	617	550	574	495
Number of statistical outliers	41	45	35	48	20
Percentage of statistical outliers	6.8%	7.3%	6.4%	8.4%	4.0%

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

	October 2022	October 2021	October 2020	October 2019	October 2018
Number of reporting laboratories	30	32	28	13	15
Number of test results	30	32	28	13	15
Number of statistical outliers	0	2	4	0	1
Percentage of statistical outliers	0%	6.3%	14.3%	0%	6.7%

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 to the requirements of the reference test methods. The conclusions are given in the following tables.

Component	October 2022	October 2021	October 2020	October 2019	October 2018
Ethane	+	+/-	+	+	++
Propane	++	++	++	++	++
Propene	++	++	++	++	++
iso-Butane	-	-	-	+	-
n-Butane	-	-	-	+/-	--
1-Butene	+	+	--	++	+
iso-Butene	+/-	+	-	+	+
n-Pentane	--	--	(--)	+/-	-
iso-Pentane	n.e.	n.e.	n.e.	n.a.	n.a.

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

**) results in brackets no z-scores are calculated

Component	October 2022	October 2021	October 2020	October 2019	October 2018
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.

Parameter	EffecTech in %mol/mol	Average PT in %mol/mol	Difference in %mol/mol	z-score
Ethane	0.587	0.527	0.060	0.79
Propane	92.830	92.788	0.042	0.03
Propene	0.762	0.749	0.012	0.27
iso-Butane	1.698	1.745	-0.047	-0.63
n-Butane	2.667	2.753	-0.086	-1.12
1-Butene	0.284	0.286	-0.002	-0.07
iso-Butene	0.249	0.250	-0.001	-0.03
n-Pentane	0.923	0.948	-0.025	-0.77

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

The consensus values as determined in this PT are compared with the average values from the homogeneity testing by Nippon Gases (Belgium) in the following table.

Parameter	Nippon Gases in mg/kg	Average PT in mg/kg	Difference in mg/kg	z-score
Sulfur	38.723	37.141	1.559	0.15

Table 12: comparison of consensus values with values determined by Nippon Gases

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.

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

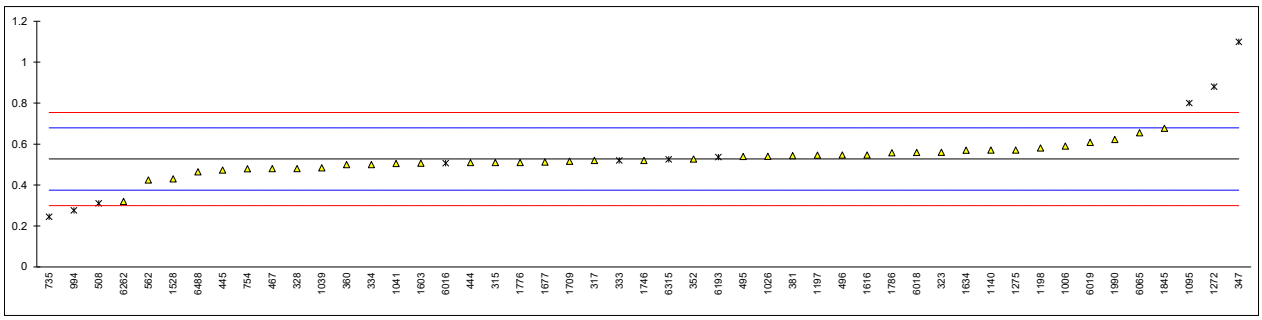
Total of reported (normalized) hydrocarbon composition test results; results in %mol/mol

lab	method	iis calculated	remarks
150		-----	
171		-----	
315	D2163	99.99	
317	D2163	100.00	
323	D2163	100.00	
328	D2712	100.00	
333	D2163	**99.70**	not 100% and excluded from evaluations
334	EN27941	100.00	
335		-----	
347	D2163	100.00	
352	EN27941	100.00	
360	EN27941	100.00	
381	EN27941	100.00	
444	D2163	100.00	
445	D2163	100.00	
467	D2163	100.00	
495	D2163	100.00	
496	D2163	100.00	
508	D2163	100.00	
562	D2163	100.00	
735	D2163	100.00	
754	D2163	100.10	
861		-----	
868		-----	
970		-----	
994	D2163	**97.75**	not 100% and excluded from evaluations
1006	D2163	100.00	
1012		-----	
1026	ISO7941	100.00	
1039	EN27941	100.00	
1041		100.00	
1095	ISO7941	100.00	
1109		-----	
1140	IP405	100.00	
1197	D2163	100.00	
1198	D2163	100.00	
1272	EN27941	100.01	
1275	D2163	100.00	
1528	EN27941	100.00	
1603	In house	100.00	
1616	D2163	100.00	
1634	ISO7941	99.98	
1677	D2163	100.00	
1709	D2163	100.00	
1746	D2163	100.00	
1776	EN27941	100.01	
1786	D2163	100.00	
1845	D2163	100.00	
1990	IP473	**99.10**	did not report n-Pentane
6016	GOST10679	**99.73**	not 100% and excluded from evaluations
6018	ISO7941	100.00	
6019	ISO7941	100.00	
6065	D2163	100.00	
6193	EN15984	**99.75**	not 100% and excluded from evaluations
6262	D2163	100.00	
6315	DIN51619	**99.53**	not 100% and excluded from evaluations
6448	D2163	-----	
6474		-----	
6486		-----	
6488	EN27941	100.00	
7014		-----	

Determination of Ethane on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	0.51		-0.22	
317	D2163	0.52		-0.09	
323	D2163	0.56		0.44	
328	D2712	0.48		-0.62	
333	D2163	0.52	ex	-0.09	see §4.1
334	EN27941	0.5		-0.35	
335		-----		-----	
347	D2163	1.099	C,R(0.01)	7.55	first reported 1.433
352	EN27941	0.5262		-0.01	
360	EN27941	0.50		-0.35	
381	EN27941	0.543		0.21	
444	D2163	0.5093		-0.23	
445	D2163	0.473		-0.71	
467	D2163	0.48		-0.62	
495	D2163	0.539		0.16	
496	D2163	0.546		0.25	
508	D2163	0.31	ex	-2.86	see §4.1
562	D2163	0.424		-1.36	
735	D2163	0.244	R(0.05)	-3.73	
754	D2163	0.479		-0.63	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2163	0.2752	ex	-3.32	see §4.1
1006	D2163	0.590		0.83	
1012		-----		-----	
1026	ISO7941	0.540		0.17	
1039	EN27941	0.484		-0.57	
1041		0.505		-0.29	
1095	ISO7941	0.8	R(0.05)	3.60	
1109		-----		-----	
1140	IP405	0.571		0.58	
1197	D2163	0.54554		0.25	
1198	D2163	0.581		0.71	
1272	EN27941	0.8799	R(0.05)	4.66	
1275	D2163	0.571		0.58	
1528	EN27941	0.43	C	-1.28	first reported 0.35
1603	In house	0.5059		-0.28	
1616	D2163	0.546	C	0.25	first reported 0.499
1634	ISO7941	0.57		0.57	
1677	D2163	0.512		-0.20	
1709	D2163	0.515884		-0.14	
1746	D2163	0.52		-0.09	
1776	EN27941	0.51		-0.22	
1786	D2163	0.557287		0.40	
1845	D2163	0.677		1.98	
1990	IP473	0.6220		1.25	
6016	GOST10679	0.5064	ex	-0.27	see §4.1
6018	ISO7941	0.5582		0.41	
6019	ISO7941	0.60769	C	1.07	first reported 0.44693
6065	D2163	0.6546		1.68	
6193	EN15984	0.536	ex	0.12	see §4.1
6262	D2163	0.32		-2.73	
6315	DIN51619	0.525	ex	-0.02	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	0.4643		-0.83	
7014		-----		-----	

	normality	not OK
	n	39
	outliers	4 +6ex
	mean (n)	0.5269
	st.dev. (n)	0.06357
	R(calc.)	0.1780
	st.dev.(D2163:14R19)	0.07582
	R(D2163:14R19)	0.2123
compare:		
	R(EN27941:93(liq))	0.2992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1
0.8
0.6
0.4
0.2
0
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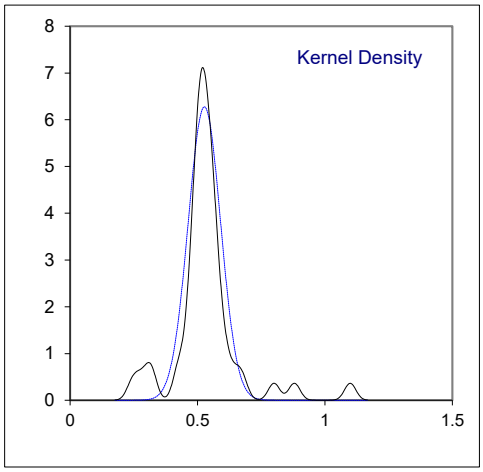
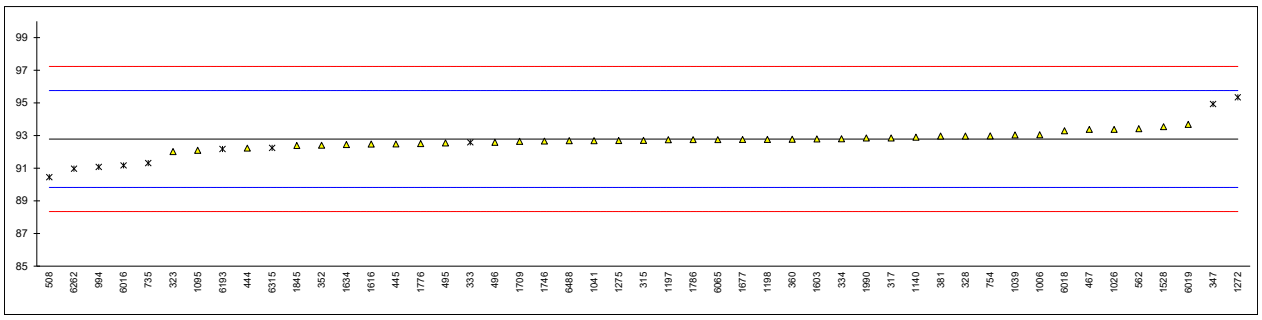

Kernel Density
8
7
6
5
4
3
2
1
0
0
0.5
1
1.5

Determination of Propane on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	92.71		-0.05	
317	D2163	92.86		0.05	
323	D2163	92.02		-0.52	
328	D2712	92.97		0.12	
333	D2163	92.58	ex	-0.14	see §4.1
334	EN27941	92.8		0.01	
335		-----		-----	
347	D2163	94.926	C,R(0.01)	1.44	first reported 95.211
352	EN27941	92.4046		-0.26	
360	EN27941	92.78		-0.01	
381	EN27941	92.97		0.12	
444	D2163	92.2264		-0.38	
445	D2163	92.482		-0.21	
467	D2163	93.38		0.40	
495	D2163	92.551		-0.16	
496	D2163	92.594		-0.13	
508	D2163	90.45	R(0.01)	-1.58	
562	D2163	93.421		0.43	
735	D2163	91.317	ex	-0.99	see §4.1
754	D2163	92.977		0.13	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2163	91.0703	ex	-1.16	see §4.1
1006	D2163	93.046		0.17	
1012		-----		-----	
1026	ISO7941	93.380		0.40	
1039	EN27941	93.040		0.17	
1041		92.691		-0.07	
1095	ISO7941	92.1		-0.46	
1109		-----		-----	
1140	IP405	92.901		0.08	
1197	D2163	92.738228		-0.03	
1198	D2163	92.769		-0.01	
1272	EN27941	95.342	R(0.01)	1.72	
1275	D2163	92.699		-0.06	
1528	EN27941	93.54	C	0.51	first reported 93.85
1603	In house	92.7914		0.00	
1616	D2163	92.480	C	-0.21	first reported 91.964
1634	ISO7941	92.45		-0.23	
1677	D2163	92.760		-0.02	
1709	D2163	92.642309		-0.10	
1746	D2163	92.66		-0.09	
1776	EN27941	92.51		-0.19	
1786	D2163	92.746148		-0.03	
1845	D2163	92.386		-0.27	
1990	IP473	92.8540		0.04	
6016	GOST10679	91.1755	ex	-1.09	see §4.1
6018	ISO7941	93.2946		0.34	
6019	ISO7941	93.68287	C	0.60	first reported 94.28127
6065	D2163	92.7463	C	-0.03	first reported 92.8019
6193	EN15984	92.174	ex	-0.41	see §4.1
6262	D2163	90.97	R(0.01)	-1.23	
6315	DIN51619	92.25	ex	-0.36	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	92.689		-0.07	
7014		-----		-----	

	normality	OK
	n	39
	outliers	4 +6ex
	mean (n)	92.7883
	st.dev. (n)	0.37056
	R(calc.)	1.0376
	st.dev.(D2163:14R19)	1.48255
	R(D2163:14R19)	4.1512
compare:		
	R(EN27941:93(liq))	1.0203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97
95
93
91
89
87
85
508
6262
994
6016
735
323
1095
6193
444
6315
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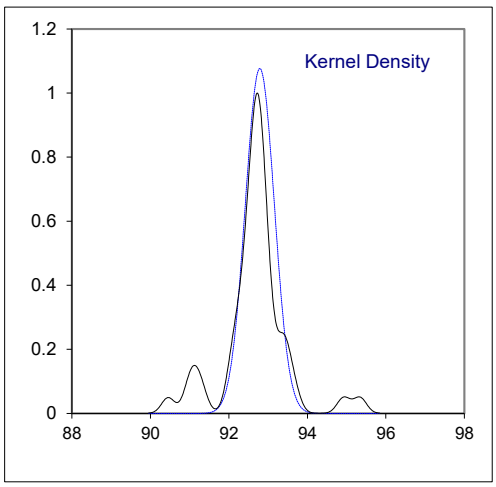
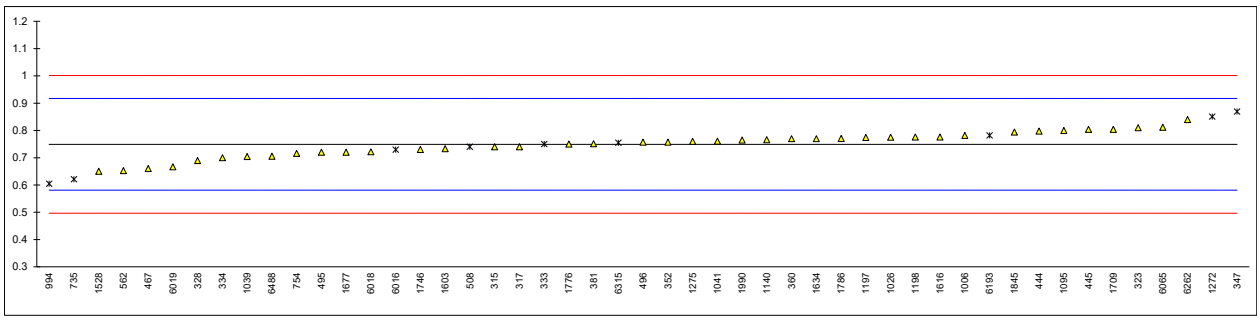
352
1634
1616
445
1776
495
333
496
1709
1746
6488
1041
1275
315
1197
1786
6065
1677
1198
360
1603
334
1990
317
1140
381
328
754
1039
1006
6018
467
1026
562
1528
6019
347
1272

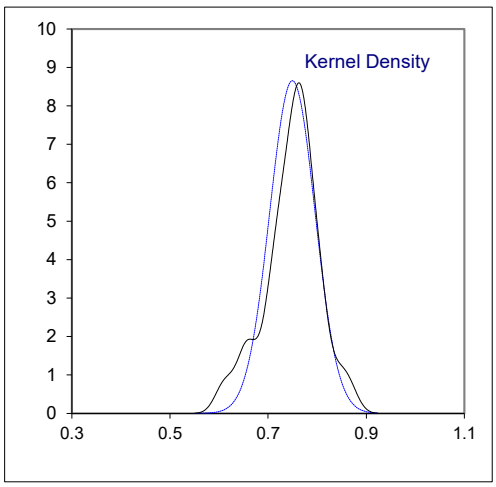

Kernel Density
1.2
1
0.8
0.6
0.4
0.2
0
88
90
92
94
96
98

Determination of Propene on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	0.74		-0.11	
317	D2163	0.74		-0.11	
323	D2163	0.81		0.72	
328	D2712	0.69		-0.71	
333	D2163	0.75	ex	0.01	see §4.1
334	EN27941	0.7		-0.59	
335		-----		-----	
347	D2163	0.869	ex,C	1.42	see §4.1 / first reported 0.952
352	EN27941	0.7571		0.09	
360	EN27941	0.77		0.25	
381	EN27941	0.751		0.02	
444	D2163	0.7976		0.57	
445	D2163	0.804		0.65	
467	D2163	0.66		-1.06	
495	D2163	0.720		-0.35	
496	D2163	0.757		0.09	
508	D2163	0.74	ex	-0.11	see §4.1
562	D2163	0.653		-1.14	
735	D2163	0.621	ex	-1.53	see §4.1
754	D2163	0.716		-0.40	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2163	0.6049	ex	-1.72	see §4.1
1006	D2163	0.782		0.39	
1012		-----		-----	
1026	ISO7941	0.775		0.31	
1039	EN27941	0.704		-0.54	
1041		0.761		0.14	
1095	ISO7941	0.8		0.60	
1109		-----		-----	
1140	IP405	0.766		0.20	
1197	D2163	0.773947		0.29	
1198	D2163	0.776		0.32	
1272	EN27941	0.8509	ex	1.21	see §4.1
1275	D2163	0.760		0.13	
1528	EN27941	0.65		-1.18	
1603	In house	0.7334		-0.19	
1616	D2163	0.776	C	0.32	first reported 0.704
1634	ISO7941	0.77		0.25	
1677	D2163	0.720		-0.35	
1709	D2163	0.804406		0.65	
1746	D2163	0.73		-0.23	
1776	EN27941	0.75		0.01	
1786	D2163	0.770887		0.26	
1845	D2163	0.794		0.53	
1990	IP473	0.7650		0.19	
6016	GOST10679	0.7297	ex	-0.23	see §4.1
6018	ISO7941	0.7216		-0.33	
6019	ISO7941	0.66639	C	-0.99	first reported 0.59132
6065	D2163	0.8117		0.74	
6193	EN15984	0.782	ex	0.39	see §4.1
6262	D2163	0.84		1.08	
6315	DIN51619	0.755	ex	0.07	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	0.706		-0.51	
7014		-----		-----	

	normality	OK
	n	40
	outliers	0+ 9ex
	mean (n)	0.7493
	st.dev. (n)	0.04612
	R(calc.)	0.1291
	st.dev.(D2163:14R19)	0.08413
	R(D2163:14R19)	0.2356
compare:		
	R(EN27941:93(liq))	0.2138

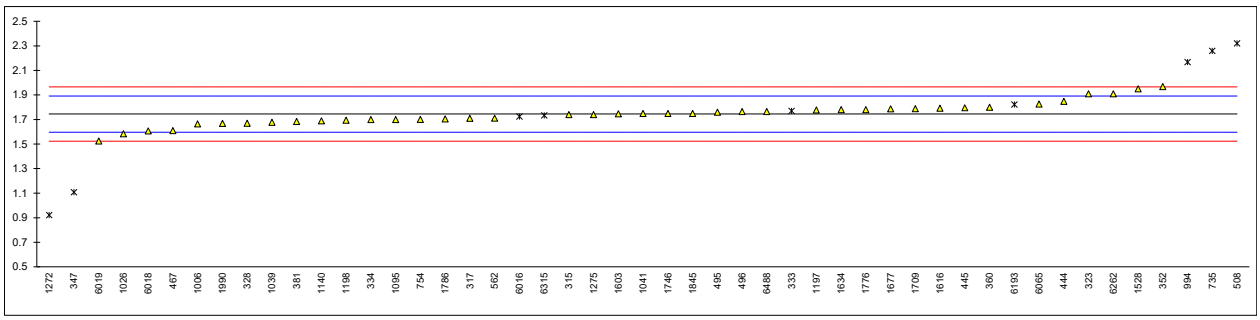

1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
994 735 1528 562 467 6019 328 334 1039 6488 754 495 1677 6018 6016 1746 1603 508 315 317 333 1776 381 6315 496 352 1275 1041 1990 1140 360 1634 1786 1197 1026 1198 1616 1006 6193 1845 444 1095 445 1709 323 6065 6262 1272 347


Kernel Density
10
9
8
7
6
5
4
3
2
1
0
0.3
0.5
0.7
0.9
1.1

Determination of iso-Butane on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	1.74		-0.06	
317	D2163	1.71		-0.47	
323	D2163	1.91		2.25	
328	D2712	1.67		-1.01	
333	D2163	1.77	ex	0.34	see §4.1
334	EN27941	1.7		-0.61	
335		-----		-----	
347	D2163	1.108	C,R(0.01)	-8.65	first reported 0.868
352	EN27941	1.9684		3.04	
360	EN27941	1.80		0.75	
381	EN27941	1.684		-0.82	
444	D2163	1.8485		1.41	
445	D2163	1.796		0.70	
467	D2163	1.61		-1.83	
495	D2163	1.760		0.21	
496	D2163	1.765		0.28	
508	D2163	2.32	R(0.01)	7.82	
562	D2163	1.711		-0.46	
735	D2163	2.259	R(0.01)	6.99	
754	D2163	1.702		-0.58	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2163	2.1686	ex	5.76	see §4.1
1006	D2163	1.665		-1.08	
1012		-----		-----	
1026	ISO7941	1.584		-2.18	
1039	EN27941	1.678		-0.90	
1041		1.750		0.07	
1095	ISO7941	1.7		-0.61	
1109		-----		-----	
1140	IP405	1.690		-0.74	
1197	D2163	1.777856		0.45	
1198	D2163	1.694		-0.69	
1272	EN27941	0.9211	R(0.01)	-11.19	
1275	D2163	1.740		-0.06	
1528	EN27941	1.95		2.79	
1603	In house	1.7456		0.01	
1616	D2163	1.792	C	0.64	first reported 2.018
1634	ISO7941	1.78		0.48	
1677	D2163	1.787		0.58	
1709	D2163	1.788912		0.60	
1746	D2163	1.75		0.07	
1776	EN27941	1.78		0.48	
1786	D2163	1.705083		-0.54	
1845	D2163	1.750		0.07	
1990	IP473	1.6690		-1.03	
6016	GOST10679	1.7247	ex	-0.27	see §4.1
6018	ISO7941	1.6075		-1.86	
6019	ISO7941	1.52516	C	-2.98	first reported 1.18326
6065	D2163	1.8259		1.10	
6193	EN15984	1.822	ex	1.05	see §4.1
6262	D2163	1.91		2.25	
6315	DIN51619	1.733	ex	-0.16	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	1.765		0.28	
7014		-----		-----	

	normality	OK
	n	40
	outliers	4 +5ex
	mean (n)	1.7446
	st.dev. (n)	0.09237
	R(calc.)	0.2586
	st.dev.(D2163:14R19)	0.07362
	R(D2163:14R19)	0.2061
compare:		
	R(EN27941:93(liq))	0.3870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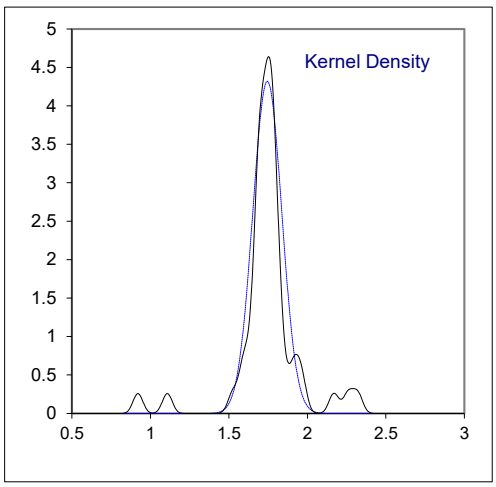
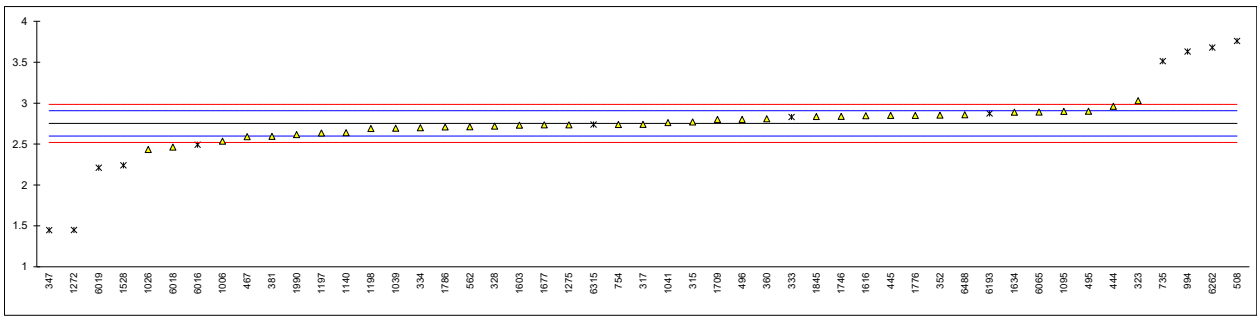
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
1272 347 6019 1026 6018 467 1006 1990 328 1039 381 1140 1198 334 1095 754 1786 317 562 6016 6315 315 1275 1603 1041 1746 1845 495 496 6488 333 1197 1634 1776 1677 1709 1616 445 360 6193 6065 444 323 6262 1528 352 994 735 508

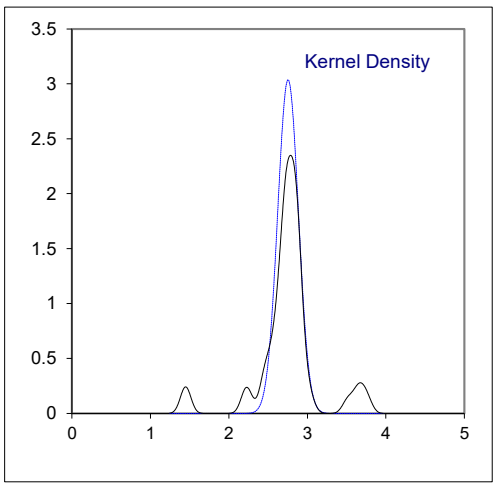

Kernel Density
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.5 1 1.5 2 2.5 3

Determination of n-Butane on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	2.77		0.22	
317	D2163	2.74		-0.17	
323	D2163	3.03		3.57	
328	D2712	2.72		-0.43	
333	D2163	2.83	ex	0.99	see §4.1
334	EN27941	2.7		-0.69	
335		-----		-----	
347	D2163	1.448	C,R(0.01)	-16.84	first reported 1.092
352	EN27941	2.8525		1.28	
360	EN27941	2.81		0.73	
381	EN27941	2.594		-2.05	
444	D2163	2.9628		2.70	
445	D2163	2.849		1.24	
467	D2163	2.59		-2.11	
495	D2163	2.901		1.91	
496	D2163	2.803		0.64	
508	D2163	3.76	R(0.01)	12.99	
562	D2163	2.712		-0.53	
735	D2163	3.513	R(0.01)	9.80	
754	D2163	2.739		-0.18	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2163	3.6310	ex	11.32	see §4.1
1006	D2163	2.536		-2.80	
1012		-----		-----	
1026	ISO7941	2.433		-4.13	
1039	EN27941	2.694		-0.76	
1041		2.762		0.11	
1095	ISO7941	2.9		1.89	
1109		-----		-----	
1140	IP405	2.640		-1.46	
1197	D2163	2.635493		-1.52	
1198	D2163	2.690		-0.82	
1272	EN27941	1.4499	R(0.01)	-16.81	
1275	D2163	2.736		-0.22	
1528	EN27941	2.24	C,R(0.05)	-6.62	first reported 2.06
1603	In house	2.7312		-0.28	
1616	D2163	2.847	C	1.21	first reported 3.066
1634	ISO7941	2.89		1.76	
1677	D2163	2.735		-0.24	
1709	D2163	2.801465		0.62	
1746	D2163	2.84		1.12	
1776	EN27941	2.85		1.25	
1786	D2163	2.709129		-0.57	
1845	D2163	2.837		1.08	
1990	IP473	2.6150		-1.78	
6016	GOST10679	2.4911	ex	-3.38	see §4.1
6018	ISO7941	2.4640		-3.73	
6019	ISO7941	2.21213	C,R(0.05)	-6.98	first reported 2.19383
6065	D2163	2.8913		1.78	
6193	EN15984	2.874	ex	1.56	see §4.1
6262	D2163	3.68	R(0.01)	11.96	
6315	DIN51619	2.738	ex	-0.20	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	2.859		1.36	
7014		-----		-----	

	normality	OK
	n	37
	outliers	7 +5ex
	mean (n)	2.7532
	st.dev. (n)	0.13131
	R(calc.)	0.3677
	st.dev.(D2163:14R19)	0.07752
	R(D2163:14R19)	0.2170
compare:		
	R(EN27941:93(liq))	0.3870

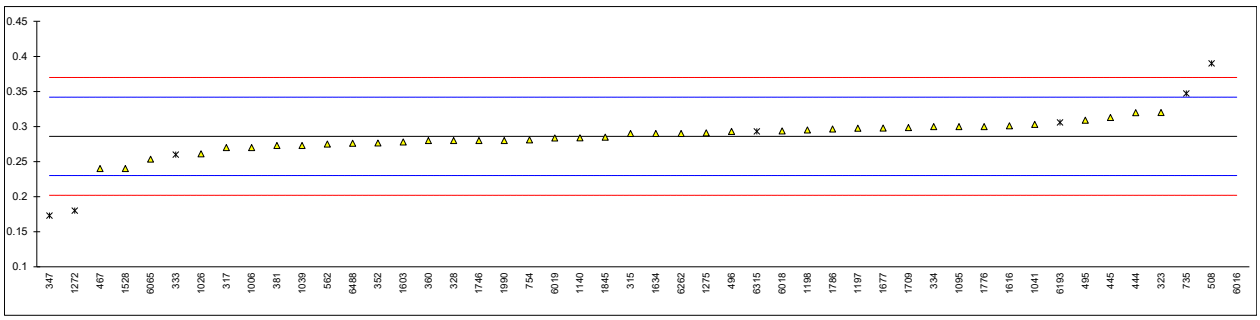

4
3.5
3
2.5
2
1.5
1
347 1272 6019 1528 1026 6018 6016 1006 467 381 1990 1197 1140 1198 1039 334 1786 562 328 1603 1677 1275 6315 754 317 1041 315 1709 496 360 333 1845 1746 1616 445 1776 352 6488 6193 1634 6065 1095 495 444 323 735 994 6262 508

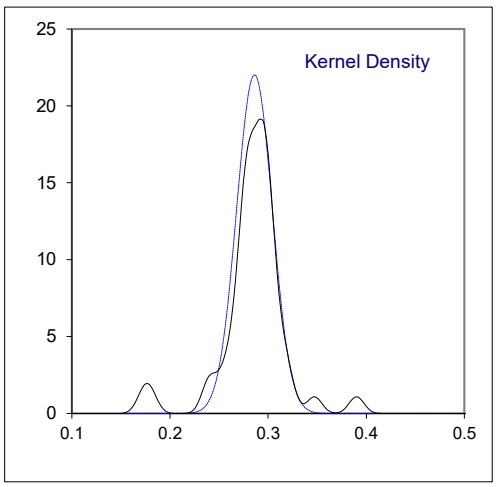

Kernel Density
3.5
3
2.5
2
1.5
1
0.5
0
0 1 2 3 4 5

Determination of 1-Butene on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	0.29		0.14	
317	D2163	0.27		-0.57	
323	D2163	0.32		1.22	
328	D2712	0.28		-0.21	
333	D2163	0.26	ex	-0.93	see §4.1
334	EN27941	0.3		0.50	
335		-----		-----	
347	D2163	0.173	C,R(0.01)	-4.04	first reported 0.145
352	EN27941	0.2766		-0.34	
360	EN27941	0.28		-0.21	
381	EN27941	0.273		-0.46	
444	D2163	0.3197		1.21	
445	D2163	0.313		0.97	
467	D2163	0.24		-1.64	
495	D2163	0.309		0.82	
496	D2163	0.293		0.25	
508	D2163	0.39	R(0.01)	3.72	
562	D2163	0.275		-0.39	
735	D2163	0.347	ex	2.18	see §4.1
754	D2163	0.281		-0.18	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1006	D2163	0.270		-0.57	
1012		-----		-----	
1026	ISO7941	0.261		-0.89	
1039	EN27941	0.273		-0.46	
1041		0.303		0.61	
1095	ISO7941	0.3		0.50	
1109		-----		-----	
1140	IP405	0.284		-0.07	
1197	D2163	0.297731		0.42	
1198	D2163	0.295		0.32	
1272	EN27941	0.1800	R(0.01)	-3.79	
1275	D2163	0.291		0.18	
1528	EN27941	0.24	C	-1.64	first reported 0.19
1603	In house	0.2780		-0.28	
1616	D2163	0.301	C	0.54	first reported 0.297
1634	ISO7941	0.29		0.14	
1677	D2163	0.298		0.43	
1709	D2163	0.298469		0.45	
1746	D2163	0.28		-0.21	
1776	EN27941	0.30		0.50	
1786	D2163	0.296513		0.38	
1845	D2163	0.285		-0.03	
1990	IP473	0.2800		-0.21	
6016	GOST10679	1.1535	ex	31.01	see §4.1
6018	ISO7941	0.2937		0.28	
6019	ISO7941	0.28381	C	-0.08	first reported 0.21470
6065	D2163	0.2534		-1.16	
6193	EN15984	0.306	ex	0.72	see §4.1
6262	D2163	0.29		0.14	
6315	DIN51619	0.293	ex	0.25	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	0.276		-0.36	
7014		-----		-----	

	normality	OK
	n	40
	outliers	3 +5ex
	mean (n)	0.2860
	st.dev. (n)	0.01810
	R(calc.)	0.0507
	st.dev.(D2163:14R19)	0.02798
	R(D2163:14R19)	0.0783
compare:		
	R(EN27941:93(liq))	0.1604

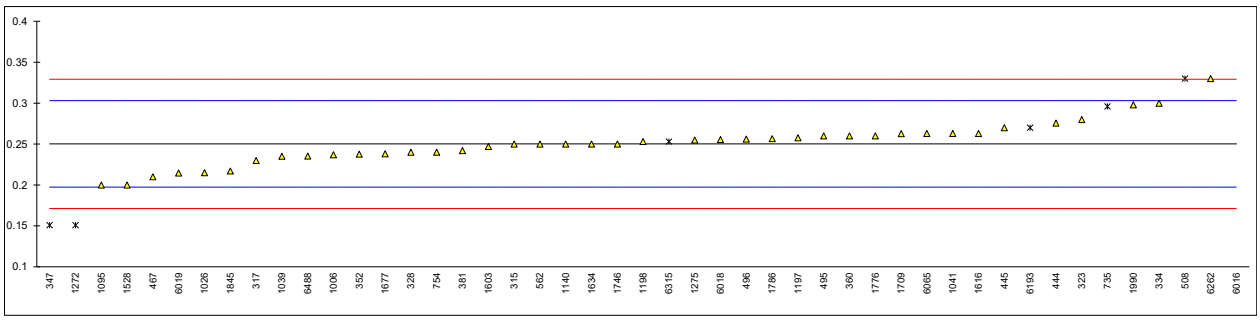

0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
347 1272 467 1528 6065 333 1026 317 1006 381 1039 562 6488 352 1603 360 328 1746 1990 754 6019 1140 1845 315 1634 6262 1275 496 6315 6018 1198 1786 1197 1677 1709 334 1095 1776 1616 1041 6193 495 445 444 323 735 508 6016

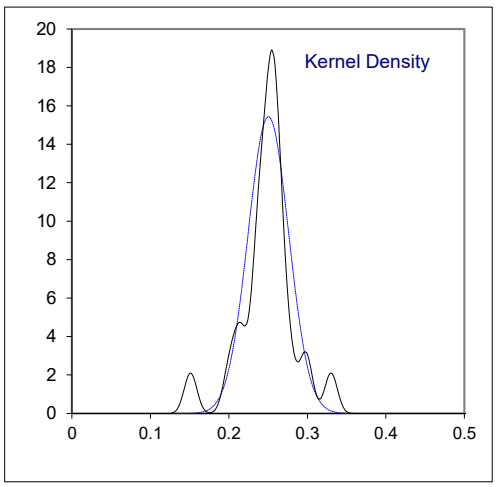

Kernel Density
25
20
15
10
5
0
0.1
0.2
0.3
0.4
0.5

Determination of iso-Butene on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	0.25		-0.01	
317	D2163	0.23		-0.77	
323	D2163	0.28		1.13	
328	D2712	0.24		-0.39	
333	D2163	<0.01	f-?	<-9.12	possibly a false negative test result?
334	EN27941	0.3		1.89	
335		-----		-----	
347	D2163	0.151	C,R(0.05)	-3.77	first reported 0.127
352	EN27941	0.2378		-0.47	
360	EN27941	0.26		0.37	
381	EN27941	0.242		-0.31	
444	D2163	0.2757		0.97	
445	D2163	0.270		0.75	
467	D2163	0.21		-1.53	
495	D2163	0.260		0.37	
496	D2163	0.256		0.22	
508	D2163	0.33	ex	3.03	see §4.1
562	D2163	0.250		-0.01	
735	D2163	0.296	ex	1.74	see §4.1
754	D2163	0.240		-0.39	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1006	D2163	0.237		-0.50	
1012		-----		-----	
1026	ISO7941	0.215		-1.34	
1039	EN27941	0.235		-0.58	
1041		0.263		0.49	
1095	ISO7941	0.2		-1.91	
1109		-----		-----	
1140	IP405	0.250		-0.01	
1197	D2163	0.257573		0.28	
1198	D2163	0.253		0.11	
1272	EN27941	0.1510	R(0.05)	-3.77	
1275	D2163	0.255		0.18	
1528	EN27941	0.20		-1.91	
1603	In house	0.2471		-0.12	
1616	D2163	0.263	C	0.49	first reported 0.268
1634	ISO7941	0.25		-0.01	
1677	D2163	0.238		-0.46	
1709	D2163	0.262743		0.48	
1746	D2163	0.25		-0.01	
1776	EN27941	0.26		0.37	
1786	D2163	0.256523		0.24	
1845	D2163	0.217		-1.26	
1990	IP473	0.298		1.81	
6016	GOST10679	0.9812	ex	27.75	see §4.1
6018	ISO7941	0.2556		0.20	
6019	ISO7941	0.21457	C	-1.35	first reported 0.19275
6065	D2163	0.2629		0.48	
6193	EN15984	0.270	ex	0.75	see §4.1
6262	D2163	0.33		3.03	
6315	DIN51619	0.253	ex	0.11	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	0.2355		-0.56	
7014		-----		-----	

	normality	suspect
	n	40
	outliers	2 +5ex
	mean (n)	0.2502
	st.dev. (n)	0.02585
	R(calc.)	0.0724
	st.dev.(D2163:14R19)	0.02634
	R(D2163:14R19)	0.0738
compare:		
	R(EN27941:93(liq))	0.1604

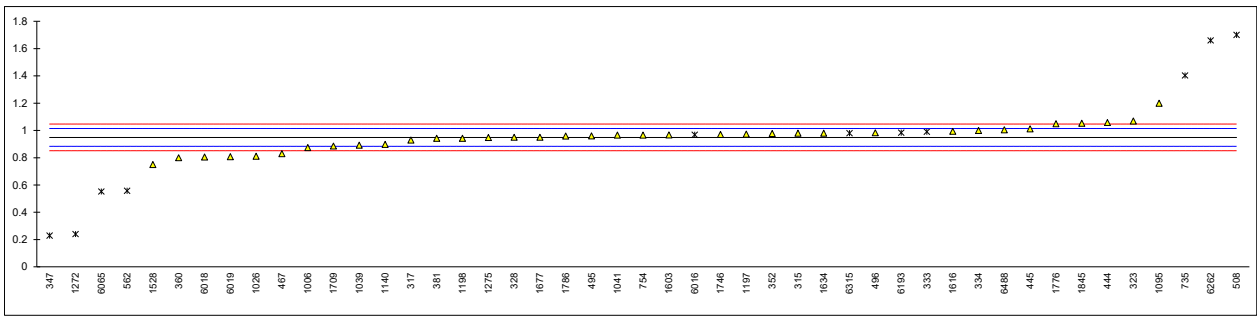

0.4
0.35
0.3
0.25
0.2
0.15
0.1
347 1272 1095 1528 467 6019 1026 1845 317 1039 6488 1006 352 1677 328 754 381 1603 315 562 1140 1634 1746 1198 6315 1275 6018 496 1786 1197 495 360 1776 1709 6065 1041 1616 445 6193 444 323 735 1990 334 508 6262 6016


Kernel Density
20
18
16
14
12
10
8
6
4
2
0
0 0.1 0.2 0.3 0.4 0.5

Determination of n-Pentane on sample #22200; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	0.98	C	0.97	first reported <0.01
317	D2163	0.93		-0.56	
323	D2163	1.07		3.74	
328	D2712	0.95		0.05	
333	D2163	0.99	ex	1.28	see §4.1
334	EN27941	1		1.59	
335		-----		-----	
347	D2163	0.228	C,R(0.01)	-22.15	first reported 0.172
352	EN27941	0.9772	C	0.89	first reported as iso-Pentane
360	EN27941	0.80		-4.56	
381	EN27941	0.943		-0.16	
444	D2163	1.0578		3.37	
445	D2163	1.011		1.93	
467	D2163	0.83		-3.64	
495	D2163	0.960		0.36	
496	D2163	0.983		1.07	
508	D2163	1.70	R(0.01)	23.12	
562	D2163	0.557	R(0.01)	-12.03	
735	D2163	1.403	R(0.01)	13.98	
754	D2163	0.966		0.54	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1006	D2163	0.874		-2.29	
1012		-----		-----	
1026	ISO7941	0.812		-4.19	
1039	EN27941	0.892		-1.73	
1041		0.966		0.54	
1095	ISO7941	1.2		7.74	
1109		-----		-----	
1140	IP405	0.898		-1.55	
1197	D2163	0.973631		0.78	
1198	D2163	0.943		-0.16	
1272	EN27941	0.2398	R(0.01)	-21.79	
1275	D2163	0.948		-0.01	
1528	EN27941	0.75		-6.10	
1603	In house	0.9673		0.58	
1616	D2163	0.994	C	1.40	first reported 1.180
1634	ISO7941	0.98	C	0.97	first reported 0
1677	D2163	0.950		0.05	
1709	D2163	0.885812		-1.92	
1746	D2163	0.97		0.67	
1776	EN27941	1.05		3.13	
1786	D2163	0.95843		0.31	
1845	D2163	1.053		3.22	
1990		-----		-----	
6016	GOST10679	0.9683	ex	0.61	see §4.1
6018	ISO7941	0.8048		-4.41	
6019	ISO7941	0.80675	C	-4.35	first reported 0.89543
6065	D2163	0.5521	C,R(0.01)	-12.19	first reported 0.4983
6193	EN15984	0.984	ex	1.10	see §4.1
6262	D2163	1.66	R(0.01)	21.89	
6315	DIN51619	0.980	ex	0.97	see §4.1
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	1.005		1.74	
7014		-----		-----	

	normality	suspect
	n	36
	outliers	7 +4ex
	mean (n)	0.9483
	st.dev. (n)	0.08941
	R(calc.)	0.2503
	st.dev.(D2163:14R19)	0.03252
	R(D2163:14R19)	0.0910
compare:		
	R(EN27941:93(liq))	0.3118


1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
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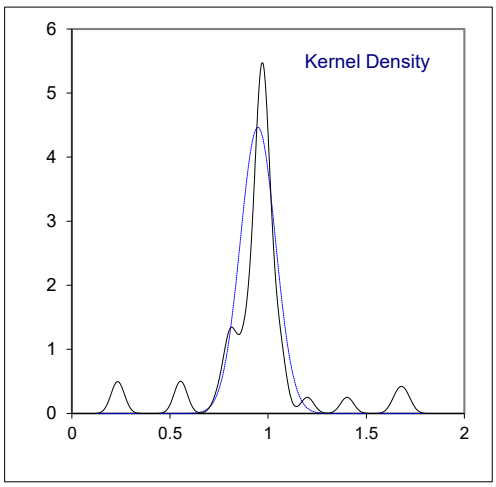

Kernel Density
6
5
4
3
2
1
0
0
0.5
1
1.5
2

Determination of iso-Pentane on sample #22200; results in %mol/mol

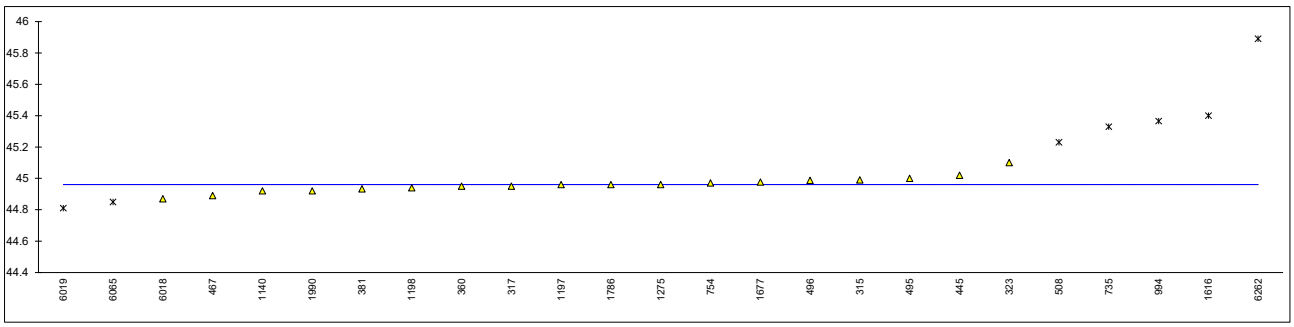
lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2163	<0.01	C	-----	first reported 0.98
317	D2163	<0.01		-----	
323	D2163	<0.01		-----	
328	D2712	<0.01		-----	
333	D2163	<0.01		-----	
334	EN27941	<0.1		-----	
335		-----		-----	
347		-----		-----	
352		-----		-----	
360	EN27941	< 0.1		-----	
381	EN27941	<0,1		-----	
444	D2163	0.0003		-----	
445	D2163	<0.001		-----	
467	D2163	<0,01		-----	
495	D2163	0		-----	
496	D2163	<0,01		-----	
508	D2163	0.00		-----	
562		-----		-----	
735	D2163	<0.01		-----	
754	D2163	<0,01		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2163	<0.01		-----	
1006	D2163	0		-----	
1012		-----		-----	
1026	ISO7941	0		-----	
1039		-----		-----	
1041		<0,10		-----	
1095	ISO7941	<0.1		-----	
1109		-----		-----	
1140	IP405	0.0		-----	
1197	D2163	0.000		-----	
1198	D2163	0.000		-----	
1272	EN27941	0.000		-----	
1275	D2163	<0.1		-----	
1528	EN27941	<0.01		-----	
1603	In house	N.N.		-----	N.N. = below quantitation level (< 0,001)
1616	D2163	<0.01		-----	
1634	ISO7941	0.00	C	-----	first reported 1.01
1677	D2163	< 0.001		-----	
1709	D2163	<0.01		-----	
1746		-----		-----	
1776		-----		-----	
1786	D2163	0.00		-----	
1845	D2163	0		-----	
1990		-----		-----	
6016		-----		-----	
6018	ISO7941	<0,01		-----	
6019	ISO7941	0.00028	C	-----	first reported 0.00024
6065	D2163	0.00		-----	
6193	EN15984	0		-----	
6262		-----	W	-----	test result withdrawn, reported 1.66
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488	EN27941	not detected		-----	
7014		-----		-----	
	n	33			
	mean (n)	<0.01			

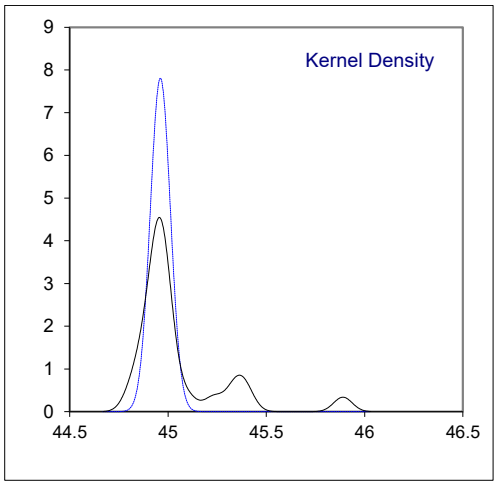
Determination of Molar Mass on sample #22200; results in g/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	44.99		-----	
317	INH-001	44.95		-----	
323	D2598	45.1		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347		-----		-----	
352		-----		-----	
360	ISO8973	44.95		-----	
381	ISO8973	44.9323		-----	
444		-----		-----	
445	D2163	45.020		-----	
467	ISO8973	44.89		-----	
495	D2163	45.00		-----	
496	D2163	44.987		-----	
508	D2598	45.23	ex	-----	see §4.1
562		-----		-----	
735	D2421	45.329	ex	-----	see §4.1
754	D2421	44.970		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2421	45.365	ex,E	-----	see §4.1 / calc. difference, iis calc. 43.866
1006		-----		-----	
1012		-----		-----	
1026		-----		-----	
1039		-----		-----	
1041		-----		-----	
1095		-----		-----	
1109		-----		-----	
1140	Calculated	44.92		-----	
1197	D2421	44.96	C	-----	reported: 4496 g/mol
1198	D2421	44.94		-----	
1272		-----		-----	
1275	EN589	44.961		-----	
1528		-----		-----	
1603		-----		-----	
1616	D2163	45.40	C,G(0.01),E	-----	first reported 45.12 / calc. difference, iis calc. 45.00
1634		-----		-----	
1677	ISO8973	44.976		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1786	D2421	44.96		-----	
1845		-----		-----	
1990	D2598	44.9200	E	-----	calc. difference, iis calc. 44.2677
6016		-----		-----	
6018	ISO8973	44.87		-----	
6019	ISO8973	44.81	ex,C	-----	see §4.1 / first reported 44.796
6065	D2598	44.85	ex	-----	see §4.1
6193		-----		-----	
6262	D2163	45.89	ex,E	-----	see §4.1 / calc. difference, iis calc. 45.36
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488		-----		-----	
7014		-----		-----	

			iis calc. based on ALL reported composition results: *)
	normality	not OK	OK
	n	18	33
	outliers	1 +6ex	0 +16ex
	mean (n)	44.961	44.970
	st.dev. (n)	0.0511	0.0479
	R(calc.)	0.143	0.134

*) Calculated by iis based on molecular masses given in table 2 of ASTM D2421:21e1.
NB. Effect of different factors of ASTM D2421:21e1 and ISO8973:97(amd.1-20)/IP432:00R17 on the calculation is very small.


46
45.8
45.6
45.4
45.2
45
44.8
44.6
44.4
6019
6065
6018
467
1140
1990
381
1198
360
317
1197
1786
1275
754
1677
496
315
495
445
323
508
735
984
1616
6262

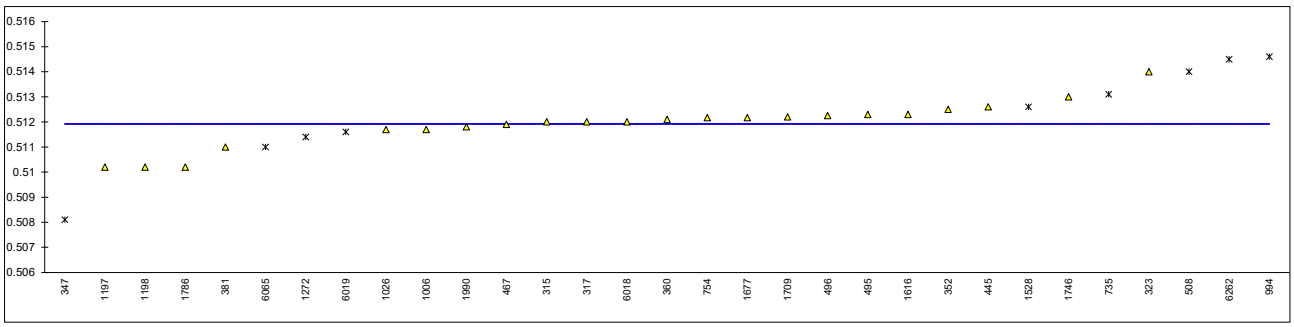

Kernel Density
9
8
7
6
5
4
3
2
1
0
44.5
45
45.5
46
46.5

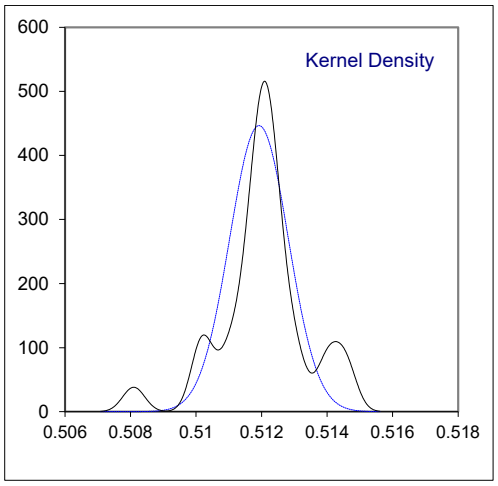
Determination of Relative Density at 60/60 °F on sample #22200; unitless results

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D2598	0.512		-----	
317	D2598	0.512		-----	
323	D2598	0.514		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347	D2598	0.5081	ex,C	-----	see §4.1 / first reported 0.5072
352	ISO8973	0.5125		-----	
360	D2598	0.5121		-----	
381	ISO8973	0.511		-----	
444		-----		-----	
445	ISO8973	0.5126		-----	
467	ISO8973	0.5119		-----	
495	D2598	0.5123		-----	
496	D2598	0.51225		-----	
508	D2598	0.514	ex	-----	see §4.1
562		-----		-----	
735	D2598	0.5131	ex	-----	see §4.1
754	D2598	0.51217		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	D2598	0.5146	ex,E	-----	see §4.1 / calc. difference, iis calc. 0.5116
1006	D2598	0.5117		-----	
1012		-----		-----	
1026	ISO8973	0.511695	C	-----	first reported 511.695
1039		-----		-----	
1041		-----		-----	
1095		-----		-----	
1109		-----		-----	
1140		-----		-----	
1197	D2598	0.5102		-----	
1198	D2598	0.5102		-----	
1272	ISO8973	0.51140	ex,E	-----	see §4.1 / calc. difference, iis calc. 0.50875
1275		-----		-----	
1528	ISO8973	0.5126	ex	-----	see §4.1
1603		-----		-----	
1616	D2598	0.5123	C	-----	first reported 0.5130
1634		-----		-----	
1677	D2598	0.51217		-----	
1709	D2598	0.5122		-----	
1746	D2598	0.513		-----	
1776		-----		-----	
1786	D2598	0.5102		-----	
1845		-----		-----	
1990	D2598	0.5118		-----	
6016		-----		-----	
6018	ISO8973	0.512		-----	
6019	ISO8973	0.5116	ex,C	-----	see §4.1 / first reported 0.512
6065	D2598	0.511	ex	-----	see §4.1
6193		-----		-----	
6262	D2598	0.5145	ex	-----	see §4.1
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488		-----		-----	
7014		-----		-----	

			iis calc. based on ALL reported composition results: *)
	normality	suspect	OK
	n	22	33
	outliers	0 +9ex	0 + 16ex
	mean (n)	0.51192	0.51213
	st.dev. (n)	0.000894	0.000281
	R(calc.)	0.00250	0.00079

*) Calculated by iis based on relative densities at 60/60 °F (15.6/15.6 °C) given in table 1 of ASTM D2598:21.
N.B. Effect of different factors from ASTM D2598:21 and ISO8973:97(amd.1-20)/IP432:00R17 on the calculation is very small.


0.516
0.515
0.514
0.513
0.512
0.511
0.51
0.509
0.508
0.507
0.506
347
1197
1198
1786
381
6065
1272
6019
1026
1006
1990
467
315
317
6018
360
754
1677
1709
496
495
1616
352
445
1528
1746
735
323
508
6262
994


Kernel Density
600
500
400
300
200
100
0
0.506
0.508
0.51
0.512
0.514
0.516
0.518

Determination of Absolute Vapor Pressure at 100 °F on sample #22200; results in psi

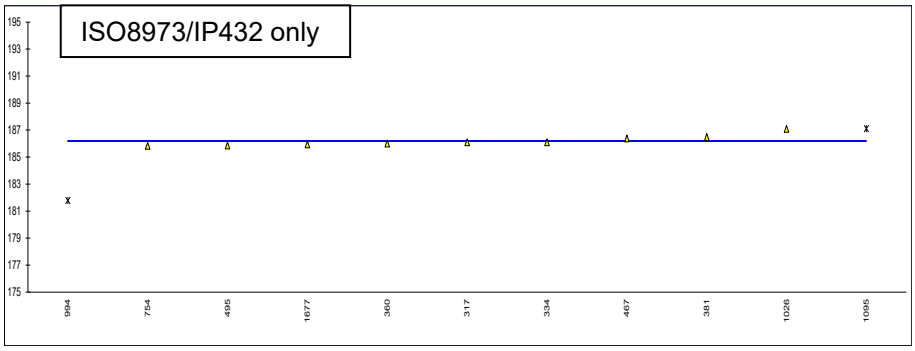
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315		-----		-----	-----		-----	
317	ISO8973	186.1		-----	-----		-----	
323		-----		-----	-----		-----	
328		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	ISO8973	186.1		-----	-----		-----	
335		-----		-----	-----		-----	
347	D2598	-----		-----	191	ex,E	-----	see §4.1 / calc. difference, iis calc. 189
352		-----		-----	-----		-----	
360	ISO8973	186.0		-----	-----		-----	
381	ISO8973	186.48		-----	-----		-----	
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
467	ISO8973	186.37		-----	-----		-----	
495	ISO8973	185.851		-----	-----		-----	
496	D2598	-----		-----	181.55		-----	
508		-----		-----	-----		-----	
562		-----		-----	-----		-----	
735	D2598	-----		-----	179.5	ex,E	-----	see §4.1 / calc. difference, iis calc. 177.4
754	ISO8973	185.827		-----	-----		-----	
861		-----		-----	-----		-----	
868		-----		-----	-----		-----	
970		-----		-----	-----		-----	
994	ISO8973	181.775	ex	-----	-----		-----	see §4.1
1006	D2598	-----		-----	182.8		-----	
1012		-----		-----	-----		-----	
1026	ISO8973	187.093		-----	-----		-----	
1039		-----		-----	-----		-----	
1041		-----		-----	-----		-----	
1095	ISO8973	187.1	ex	-----	-----		-----	see §4.1
1109		-----		-----	-----		-----	
1140		-----		-----	-----		-----	
1197		-----		-----	-----		-----	
1198		-----		-----	-----		-----	
1272		-----		-----	-----		-----	
1275		-----		-----	-----		-----	
1528		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1616		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	ISO8973	185.938	C	-----	-----		-----	first reported 1282.0
1709		-----		-----	-----		-----	
1746		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
1786		-----		-----	-----		-----	
1845		-----		-----	-----		-----	
1990	D2598	-----		-----	182.7	E	-----	calc. difference, iis calc. 184.4
6016		-----		-----	-----		-----	
6018	D2598	-----		-----	1289	D(0.01),E	-----	calc. difference, iis calc. 183
6019	D2598	-----		-----	187.82	ex,C,E	-----	see §4.1 / fr. 170.39 / see remarks below
6065	D2598	-----		-----	183	ex	-----	see §4.1
6193		-----		-----	-----		-----	
6262		-----		-----	-----		-----	
6315		-----		-----	-----		-----	
6448		-----		-----	-----		-----	
6474		-----		-----	-----		-----	
6486		-----		-----	-----		-----	
6488		-----		-----	-----		-----	
7014		-----		-----	-----		-----	

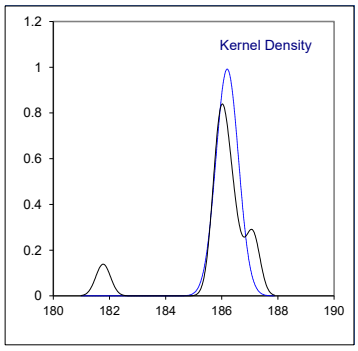
Lab 6019 calculation difference, iis calculated 183.48 (D2598) and 187.80 (ISO8973)

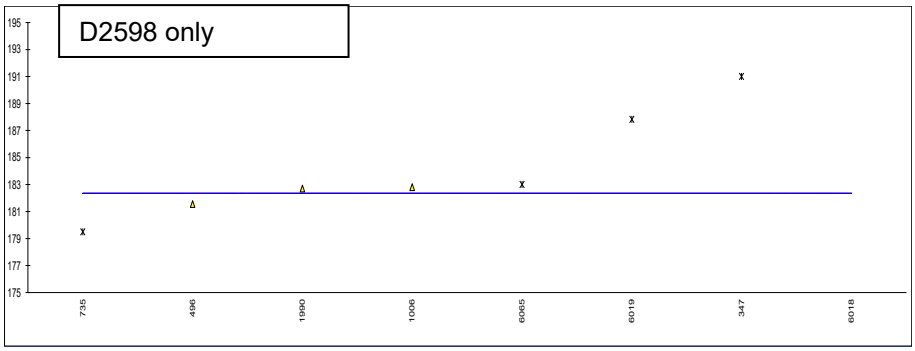
	ISO8973/IP432	D2598
normality	not OK	unknown
n	9	3
outliers	0 +2ex	1 +4ex
mean (n)	186.195	182.350
st.dev. (n)	0.4022	0.6946
R(calc.)	1.126	1.945

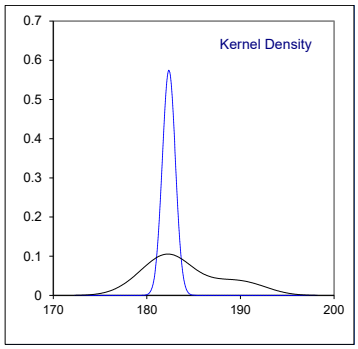
	iis calc. based on all reported composition results *)	iis calc. based on all reported composition results **)
normality	OK	OK
n	33	33
outliers	0 +16ex	0 +16ex
mean (n)	186.078	181.681
st.dev. (n)	0.4639	0.4870
R(calc.)	1.299	1.364

*) Calculated by iis based on Vapor Pressure factors at 100 °F (37.8 °C) given in table A.1 of ISO8973:97(amd.1-20)/IP432:00R17
**) Calculated by iis based on Vapor Pressure factors at 100 °F (37.8 °C) as given in table 1 of ASTM D2598:21.









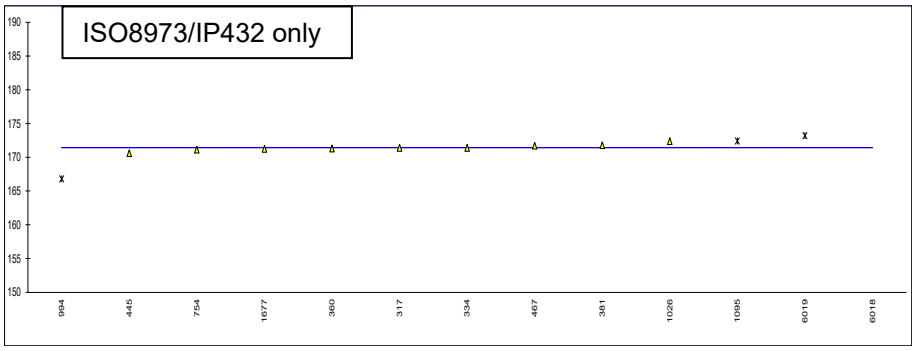
Determination of Relative Vapor Pressure at 100 °F on sample #22200; results in psi

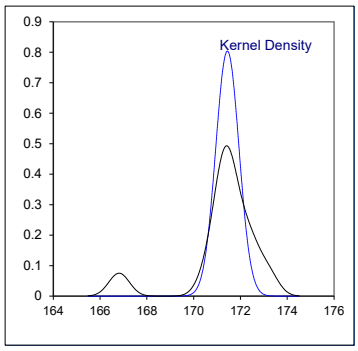
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315		-----		-----	-----		-----	
317	ISO8973	171.4		-----	-----		-----	
323	D2598	-----		-----	164.0	G(0.01),E	-----	calc. difference, iis calc. 166.1
328		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	ISO8973	171.4		-----	-----		-----	
335		-----		-----	-----		-----	
347		-----		-----	-----		-----	
352		-----		-----	-----		-----	
360	ISO8973	171.3		-----	-----		-----	
381	ISO8973	171.78		-----	-----		-----	
444	D2598	-----		-----	166.13		-----	
445	ISO8973	170.6		-----	-----		-----	
467	ISO8973	171.72		-----	-----		-----	
495	D2598	-----		-----	171.159	G(0.05),E	-----	calc diff iis calc 166.69 (171.13 with ISO8973)
496	D2598	-----		-----	166.85		-----	
508	D2598	-----		-----	164	ex, E	-----	see §4.1 / calc. difference, iis calc. 162
562		-----		-----	-----		-----	
735	D2598	-----		-----	164.9	ex, E	-----	see §4.1 / calc. difference, iis calc. 162.7
754	ISO8973	171.131		-----	-----		-----	
861		-----		-----	-----		-----	
868		-----		-----	-----		-----	
970		-----		-----	-----		-----	
994	ISO8973	166.810	ex	-----	-----		-----	see §4.1
1006	D2598	-----		-----	168.1		-----	
1012		-----		-----	-----		-----	
1026	ISO8973	172.397		-----	-----		-----	
1039		-----		-----	-----		-----	
1041		-----		-----	-----		-----	
1095	ISO8973	172.4	ex	-----	-----		-----	see §4.1
1109		-----		-----	-----		-----	
1140		-----		-----	-----		-----	
1197	D2598	-----		-----	167.16		-----	
1198	D2598	-----		-----	167.23		-----	
1272		-----		-----	-----		-----	
1275		-----		-----	-----		-----	
1528		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1616	D2598	-----		-----	167	C	-----	first reported 165
1634		-----		-----	-----		-----	
1677	ISO8973	171.246	C	-----	-----		-----	first reported 1180.7
1709	D2598	-----		-----	167		-----	
1746	D2598	-----		-----	166.9		-----	
1776		-----		-----	-----		-----	
1786	D2598	-----		-----	167.23		-----	
1845		-----		-----	-----		-----	
1990	D2598	-----		-----	168	E	-----	calc. difference, iis calc. 170
6016		-----		-----	-----		-----	
6018	ISO8973	1188	G(0.01),E	-----	-----		-----	calc. difference, iis calc. 172
6019	ISO8973	173.18	ex,C	-----	-----		-----	see §4.1 / reported 1194 kPa
6065	D2598	-----		-----	168	ex	-----	see §4.1
6193		-----		-----	-----		-----	
6262		-----		-----	-----		-----	
6315		-----		-----	-----		-----	
6448		-----		-----	-----		-----	
6474		-----		-----	-----		-----	
6486		-----		-----	-----		-----	
6488		-----		-----	-----		-----	
7014		-----		-----	-----		-----	

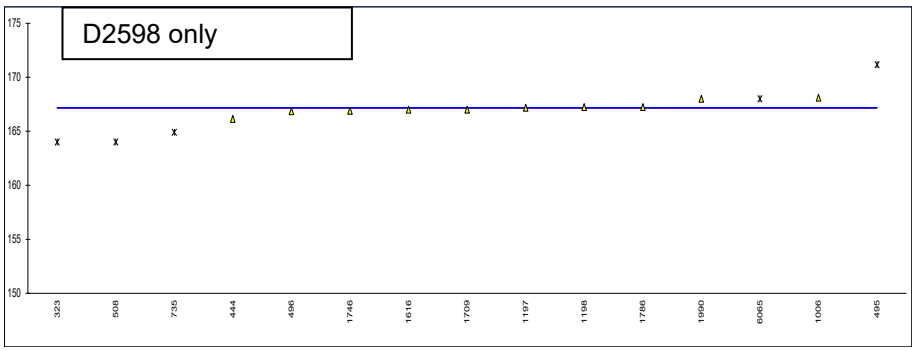
	ISO8973/IP432	D2598
normality	suspect	OK
n	9	10
outliers	1 +3ex	2 +3ex
mean (n)	171.442	167.160
st.dev. (n)	0.4964	0.5652
R(calc.)	1.390	1.582

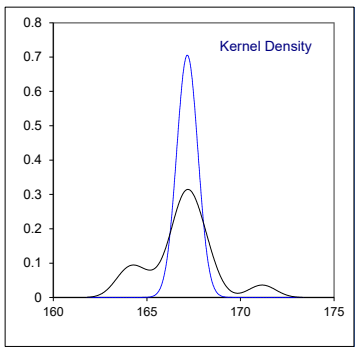
	iis calc. based on all reported composition results *)	iis calc. based on all reported composition results **)
normality	OK	OK
n	33	33
outliers	0 +16ex	0 +16ex
mean (n)	171.382	166.985
st.dev. (n)	0.4639	0.4870
R(calc.)	1.299	1.364

*) Calculated by iis based on Vapor Pressure factors at 100 °F (37.8 °C) given in table A.1 of ISO8973:97(amd.1-20)/IP432:00R17
**) Calculated by iis based on Vapor Pressure factors at 100 °F (37.8 °C) given in table 1 of ASTM D2598:21.







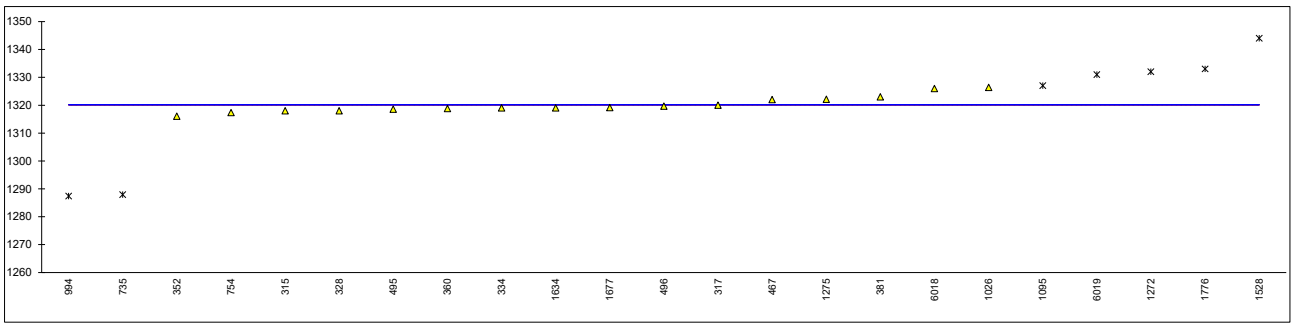


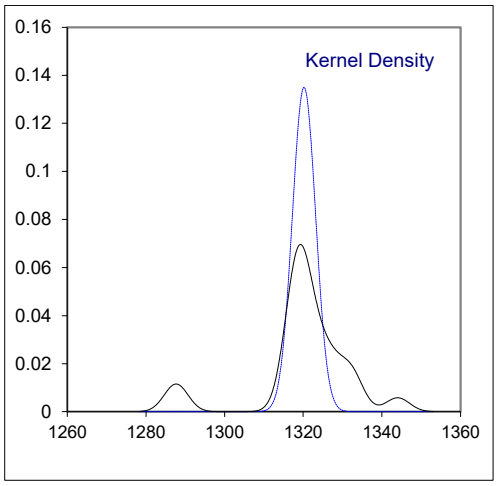
Determination of Absolute Vapor Pressure at 40 °C on sample #22200; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	1318		-----	
317	ISO8973	1320		-----	
323		-----		-----	
328	ISO8973	1318		-----	
333		-----		-----	
334	ISO8973	1319		-----	
335		-----		-----	
347		-----		-----	
352	ISO8973	1316		-----	
360	ISO8973	1318.8		-----	
381	ISO8973	1323		-----	
444		-----		-----	
445		-----		-----	
467	ISO8973	1322		-----	
495	ISO8973	1318.6		-----	
496	ISO8973	1319.66		-----	
508		-----		-----	
562		-----		-----	
735	ISO8973	1287.9	ex	-----	see §4.1
754	ISO8973	1317.346		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	ISO8973	1287.43	ex,E	-----	see §4.1 / calc. difference, iis calc. 1281.96
1006		-----		-----	
1012		-----		-----	
1026	ISO8973	1326.384		-----	
1039		-----		-----	
1041		-----		-----	
1095	ISO8973	1327	ex	-----	see §4.1
1109		-----		-----	
1140		-----		-----	
1197		-----		-----	
1198		-----		-----	
1272	ISO8973	1332.0	ex,E	-----	see §4.1 / calc. difference, iis calc. 1364.7
1275	EN589	1322.1		-----	
1528	ISO8973	1344	ex,C,E	-----	see §4.1 / first reported 1347 / calc. difference, iis calc. 1321
1603		-----		-----	
1616		-----		-----	
1634	ISO8973	1319		-----	
1677	ISO8973	1319.1		-----	
1709		-----		-----	
1746		-----		-----	
1776	ISO8973	1333	G(0.05),E	-----	calc. difference, iis calc. 1316
1786		-----		-----	
1845		-----		-----	
1990		-----		-----	
6016		-----		-----	
6018	ISO8973	1326		-----	
6019	ISO8973	1331	ex,C	-----	see §4.1 / first reported 1327
6065		-----		-----	
6193		-----		-----	
6262		-----		-----	
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488		-----		-----	
7014		-----		-----	

			iis calc. based on ALL reported composition results: *)
	normality	suspect	OK
	n	16	33
	outliers	1 +6ex	0 +16ex
	mean (n)	1320.187	1319.248
	st.dev. (n)	2.9550	3.3025
	R(calc.)	8.274	9.247

*) Calculated by iis based on Vapor Pressure factors at 40 °C given in table A.1 of ISO8973:97(amd.1-20)/IP432:00R17


1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
994
735
352
754
315
328
495
360
334
1634
1677
496
317
467
1275
381
6018
1026
1095
6019
1272
1776
1528

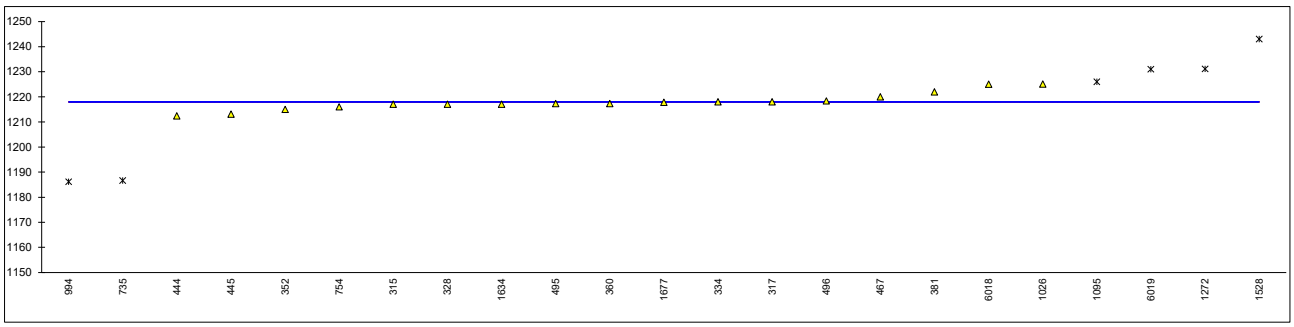

Kernel Density
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1260
1280
1300
1320
1340
1360

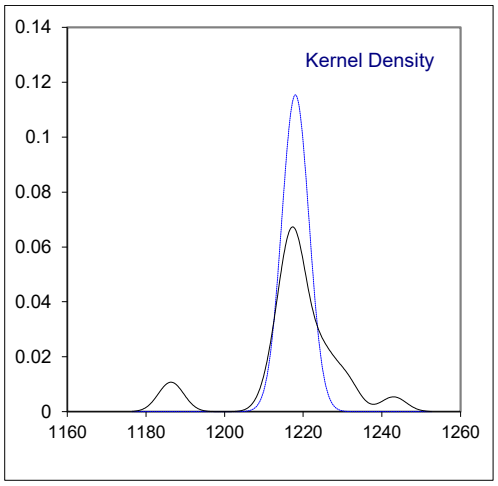
Determination of Relative Vapor Pressure at 40 °C on sample #22200; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	1217		-----	
317	ISO8973	1218		-----	
323		-----		-----	
328	ISO8973	1217		-----	
333		-----		-----	
334	ISO8973	1218		-----	
335		-----		-----	
347		-----		-----	
352	ISO8973	1215		-----	
360	ISO8973	1217.3		-----	
381	ISO8973	1222		-----	
444	IP432	1212.4		-----	
445	ISO8973	1213.1		-----	
467	ISO8973	1220		-----	
495	ISO8973	1217.3		-----	
496	ISO8973	1218.33		-----	
508		-----		-----	
562		-----		-----	
735	ISO8973	1186.6	ex	-----	see §4.1
754	ISO8973	1216.021		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994	ISO8973	1186.13	ex,E	-----	see §4.1 / calc. difference, iis calc. 1180.64
1006		-----		-----	
1012		-----		-----	
1026	ISO8973	1225.059		-----	
1039		-----		-----	
1041		-----		-----	
1095	ISO8973	1226	ex	-----	see §4.1
1109		-----		-----	
1140		-----		-----	
1197		-----		-----	
1198		-----		-----	
1272	ISO8973	1231.1	ex,E	-----	see §4.1 / calc. difference, iis calc. 1263.4
1275		-----		-----	
1528	ISO8973	1243	ex,C,E	-----	see §4.1 / first reported 1246 / calc. difference, iis calc. 1220
1603		-----		-----	
1616		-----		-----	
1634	ISO8973	1217		-----	
1677	ISO8973	1217.8		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1786		-----		-----	
1845		-----		-----	
1990		-----		-----	
6016		-----		-----	
6018	ISO8973	1225		-----	
6019	ISO8973	1231	ex,C	-----	see §4.1 / first reported 1226
6065		-----		-----	
6193		-----		-----	
6262		-----		-----	
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488		-----		-----	
7014		-----		-----	

			iis calc. based on ALL reported composition results: *)
	normality	OK	OK
	n	17	33
	outliers	0 +6ex	0 +16ex
	mean (n)	1218.018	1217.923
	st.dev. (n)	3.4572	3.3025
	R(calc.)	9.680	9.247

*) Calculated by iis based on Vapor Pressure factors at 40 °C given in table A.1 of ISO8973:97(amd.1-20)/IP432:00R17


1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
994
735
444
445
352
754
315
328
1634
495
360
1677
334
317
496
467
381
6018
1026
1095
6019
1272
1528


Kernel Density
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1160
1180
1200
1220
1240
1260

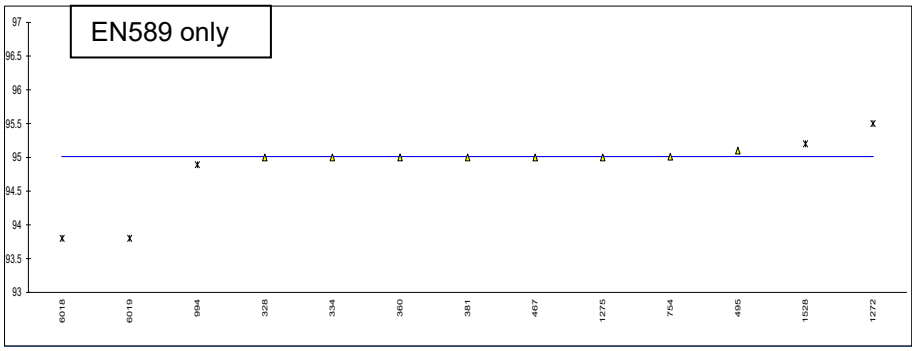
Determination of Motor Octane Number, MON on sample #22200;

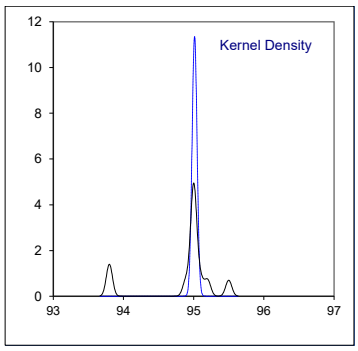
lab	method	EN589	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315		-----		-----	-----		-----	
317		-----		-----	-----		-----	
323		-----		-----	-----		-----	
328	EN589	95.0		-----	-----		-----	
333		-----		-----	-----		-----	
334	EN589	95.0		-----	-----		-----	
335		-----		-----	-----		-----	
347		-----		-----	-----		-----	
352		-----		-----	-----		-----	
360	EN589	95.0		-----	-----		-----	
381	EN589	95.0		-----	-----		-----	
444	D2598	-----		-----	96.0		-----	
445		-----		-----	-----		-----	
467	EN589	95.0		-----	-----		-----	
495	EN589	95.1		-----	-----		-----	
496	D2598	-----		-----	96.27		-----	
508	D2598	-----		-----	96.3	ex,E	-----	see §4.1 / calc. difference, iis calc. 95.8
562		-----		-----	-----		-----	
735	D2598	-----		-----	96.22	ex	-----	see §4.1
754	EN589	95.009		-----	-----		-----	
861		-----		-----	-----		-----	
868		-----		-----	-----		-----	
970		-----		-----	-----		-----	
994	EN589	94.89	ex, E	-----	-----		-----	see §4.1 / calc. difference, iis calc. 92.99
1006	D2598	-----		-----	95.0	D(0.01),E	-----	calc. diff., iis calc. 96.4 (95.0 with EN589)
1012		-----		-----	-----		-----	
1026		-----		-----	-----		-----	
1039		-----		-----	-----		-----	
1041		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1109		-----		-----	-----		-----	
1140		-----		-----	-----		-----	
1197	D2598	-----		-----	96.1		-----	
1198	D2598	-----		-----	96.1		-----	
1272	EN589	95.50	ex	-----	-----		-----	see §4.1
1275	EN589	95.0		-----	-----		-----	
1528	EN589	95.2	ex	-----	-----		-----	see §4.1
1603		-----		-----	-----		-----	
1616	D2598	-----		-----	96.3	C	-----	first reported 96.1
1634		-----		-----	-----		-----	
1677		-----		-----	-----		-----	
1709		-----		-----	-----		-----	
1746		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
1786	D2598	-----		-----	96.1		-----	
1845		-----		-----	-----		-----	
1990	D2598	-----		-----	96.0	E	-----	calc. difference, iis calc. 96.7
6016		-----		-----	-----		-----	
6018	EN589	93.8	D(0.01),E	-----	-----		-----	calc. difference, iis calc. 95.0
6019	EN589	93.8	ex,C,E	-----	-----		-----	see §4.1 / fr. 93.9 / calc.diff. iis calc. 95.1
6065	D2598	-----		-----	96.25	ex	-----	see §4.1
6193		-----		-----	-----		-----	
6262	D2598	-----		-----	96	ex	-----	see §4.1
6315		-----		-----	-----		-----	
6448		-----		-----	-----		-----	
6474		-----		-----	-----		-----	
6486		-----		-----	-----		-----	
6488		-----		-----	-----		-----	
7014		-----		-----	-----		-----	

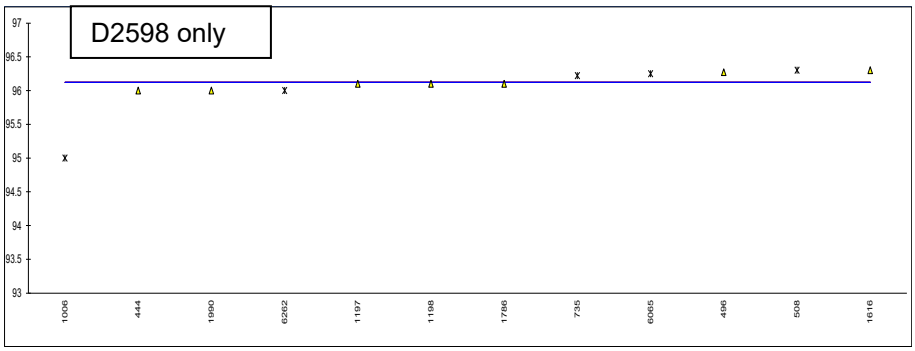
	EN589	D2598
normality	not OK	OK
n	8	7
outliers	1 +4ex	1 +4ex
mean (n)	95.014	96.124
st.dev. (n)	0.0350	0.1189
R(calc.)	0.098	0.333

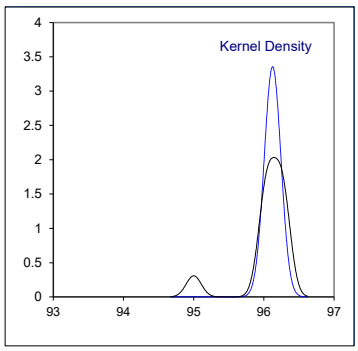
	iis calc. based on all reported composition results *)	iis calc. based on all reported composition results **)
normality	OK	OK
n	32	33
outliers	1 +16ex	0 +16ex
mean (n)	95.002	96.297
st.dev. (n)	0.0188	0.0443
R(calc.)	0.053	0.124

*) Calculated by iis based on MON factors given in table B.1 of EN589:18+A1:22(E).
**) 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.







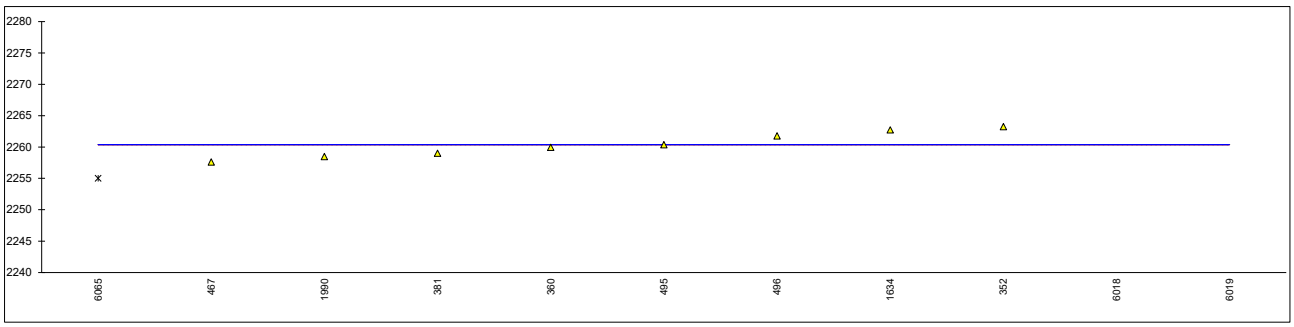


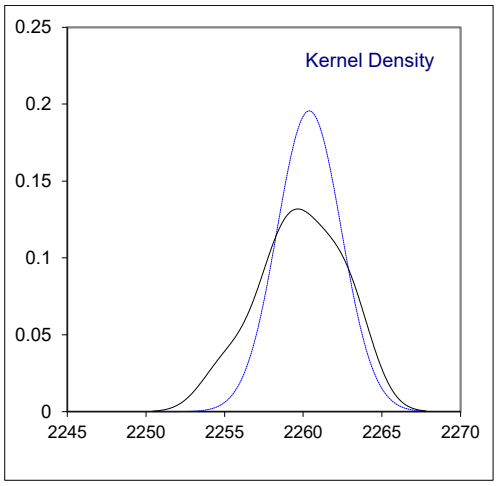
Determination of Ideal Gross Heating Value at 14.696 psia and 60 °F on sample #22200; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315		-----		-----	
317		-----		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347		-----		-----	
352	D3588	2263.2538		-----	
360	D3588	2259.94		-----	
381	D3588	2259		-----	
444		-----		-----	
445		-----		-----	
467	ISO6976 Calculated	2257.59		-----	
495	DIN51612	2260.35	C	-----	first reported 50.23 MJ/kg
496	D3588	2261.75		-----	
508		-----		-----	
562		-----		-----	
735		-----		-----	
754		-----		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1006		-----		-----	
1012		-----		-----	
1026		-----		-----	
1039		-----		-----	
1041		-----		-----	
1095		-----		-----	
1109		-----		-----	
1140		-----		-----	
1197		-----		-----	
1198		-----		-----	
1272		-----		-----	
1275		-----		-----	
1528		-----		-----	
1603		-----		-----	
1616		-----		-----	
1634	D3588	2262.72		-----	
1677		-----		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1786		-----		-----	
1845		-----		-----	
1990	D3588	2258.48	E	-----	calc. difference, iis calc. 2226.66
6016		-----		-----	
6018	D3588	12015	D(0.01),E	-----	calc. difference, iis calc. 2256
6019	D3588	12017	ex,E	-----	see §4.1 / calc. difference, iis calc. 2253
6065	D3588	2255	ex	-----	see §4.1
6193		-----		-----	
6262		-----		-----	
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488		-----		-----	
7014		-----		-----	

			iis calc. based on ALL reported composition results: *)
	normality	OK	OK
	n	8	33
	outliers	1 +2ex	0 +16ex
	mean (n)	2260.385	2260.930
	st.dev. (n)	2.0391	2.2248
	R(calc.)	5.709	6.229

*) Calculated by iis based on the Ideal Gross Heating Value at 14.696 psia/60 °F factors given in table 1 of ASTM D3588:98R17e1.


2280
2275
2270
2265
2260
2255
2250
2245
2240
6065
467
1990
381
360
495
496
1634
352
6018
6019

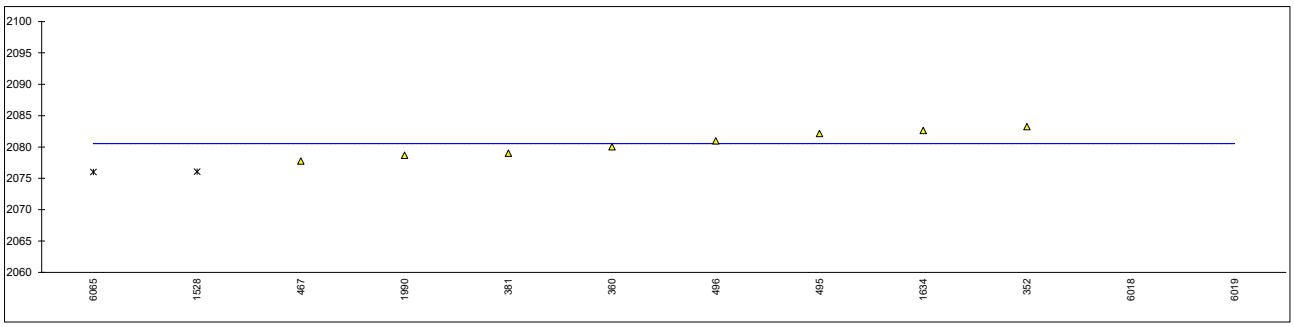

Kernel Density
0.25
0.2
0.15
0.1
0.05
0
2245
2250
2255
2260
2265
2270

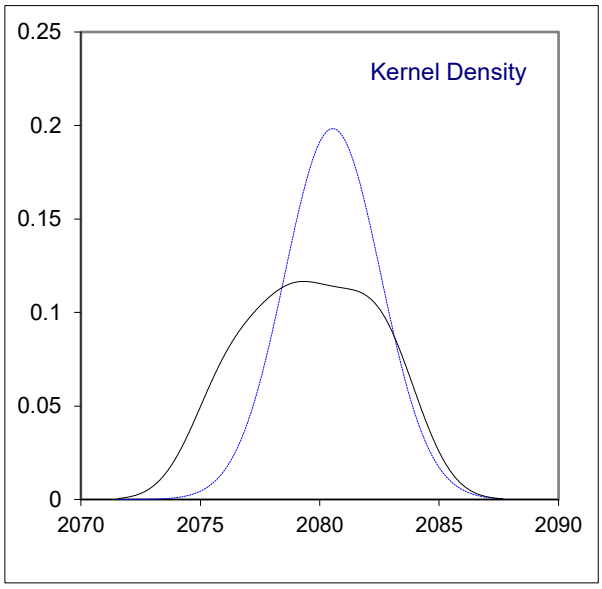
Determination of Ideal Net Heating Value at 14.696 psia and 60 °F on sample #22200; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315		-----		-----	
317		-----		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
347		-----		-----	
352	D3588	2083.2359		-----	
360	D3588	2080.02		-----	
381	D3588	2079		-----	
444		-----		-----	
445		-----		-----	
467	ISO6976 Calculated	2077.75		-----	
495	DIN51612	2082.15	C	-----	first reported 46.27 MJ/kg
496	D3588	2080.97		-----	
508		-----		-----	
562		-----		-----	
735		-----		-----	
754		-----		-----	
861		-----		-----	
868		-----		-----	
970		-----		-----	
994		-----		-----	
1006		-----		-----	
1012		-----		-----	
1026		-----		-----	
1039		-----		-----	
1041		-----		-----	
1095		-----		-----	
1109		-----		-----	
1140		-----		-----	
1197		-----		-----	
1198		-----		-----	
1272		-----		-----	
1275		-----		-----	
1528	In house	2076.04	ex	-----	see §4.1
1603		-----		-----	
1616		-----		-----	
1634	D3588	2082.63		-----	
1677		-----		-----	
1709		-----		-----	
1746		-----		-----	
1776		-----		-----	
1786		-----		-----	
1845		-----		-----	
1990	D3588	2078.67	E	-----	calc. difference, iis calc. 2049.28
6016		-----		-----	
6018	D3588	11058	D(0.01),E	-----	calc. difference, iis calc. 2077
6019	D3588	11059	ex, E	-----	see §4.1,calc. difference, iis calc. 2074
6065	D3588	2076	ex	-----	see §4.1
6193		-----		-----	
6262		-----		-----	
6315		-----		-----	
6448		-----		-----	
6474		-----		-----	
6486		-----		-----	
6488		-----		-----	
7014		-----		-----	

			iis calc. based on ALL reported composition results: *)
	normality	OK	OK
	n	8	33
	outliers	1 +3ex	16
	mean (n)	2080.553	2080.967
	st.dev. (n)	2.0119	2.0828
	R(calc.)	5.633	5.832

*) Calculated by iis based on the Ideal Net Heating Value at 14.696 psia/60 °F factors given in table 1 of ASTM D3588:98R17e1.

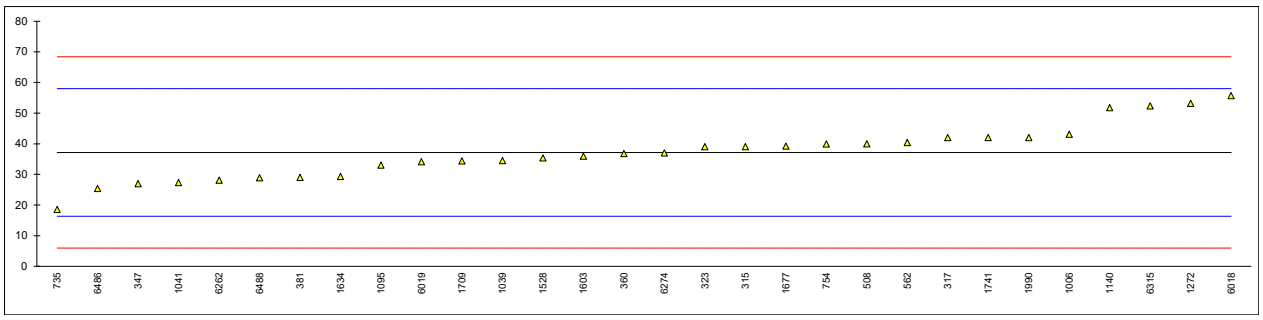

2100
2095
2090
2085
2080
2075
2070
2065
2060
6065
1528
467
1990
381
360
496
495
1634
352
6018
6019

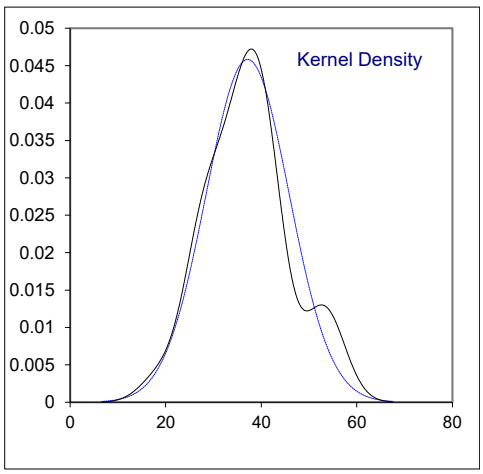

Kernel Density
0.25
0.2
0.15
0.1
0.05
0
2070
2075
2080
2085
2090

Determination of Total Sulfur on sample #22201; results in mg/kg

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	D6667	39		0.18	
317	D6667	42		0.47	
323	D6667	39		0.18	
337		-----		-----	
347	D6667	27		-0.97	
360	D6667	36.8		-0.03	
381	D6667	29		-0.78	
445		-----		-----	
495		-----		-----	
508	D6667	40		0.27	
562	D6667	40.38		0.31	
735	D6667	18.542		-1.79	
754	D6667	39.94		0.27	
1006	D6667	43.1		0.57	
1039	D6667	34.48		-0.26	
1041	D6667	27.3		-0.95	
1095	D6667	33		-0.40	
1109		-----		-----	
1140	D5504	51.80		1.41	
1272	D6667	53.17		1.54	
1357		-----		-----	
1528	D6667	35.35		-0.17	
1603	In house	35.920		-0.12	
1634	D6667	29.3		-0.75	
1677	D6667	39.2		0.20	
1709	D6667	34.377		-0.27	
1741		42		0.47	
1746		-----		-----	
1990	D6667	42.01		0.47	
6016		-----		-----	
6018	D6667	55.68		1.78	
6019	D6667	34.14		-0.29	
6262	D6667	28.1		-0.87	
6274	D6667	37		-0.01	
6315	ISO20846	52.35		1.46	
6474		-----		-----	
6486	D6667	25.4		-1.13	
6488	D6667	28.89		-0.79	
9008		-----		-----	

normality	OK
n	30
outliers	0
mean (n)	37.141
st.dev. (n)	8.7052
R(calc.)	24.375
st.dev.(D6667:21)	10.4069
R(D6667:21 LP gas)	29.139


80
70
60
50
40
30
20
10
0
735
6486
347
1041
6262
6488
381
1634
1095
6019
1709
1039
1528
1603
360
6274
323
315
1677
754
508
562
317
1741
1990
1006
1140
6315
1272
6018


Kernel Density
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
20
40
60
80

APPENDIX 2

Number of participants per country

Liquefied Propane iis22S04P

2 labs in AUSTRALIA
1 lab in AZERBAIJAN
2 labs in BELGIUM
1 lab in BULGARIA
1 lab in CHILE
2 labs in CHINA, People's Republic
1 lab in COLOMBIA
1 lab in DENMARK
1 lab in ESTONIA
4 labs in FRANCE
6 labs in GERMANY
1 lab in IRAN, Islamic Republic of
2 labs in KAZAKHSTAN
4 labs in MALAYSIA
4 labs in NETHERLANDS
1 lab in NIGER
1 lab in NIGERIA
1 lab in OMAN
1 lab in PANAMA
5 labs in PORTUGAL
1 lab in QATAR
1 lab in ROMANIA
1 lab in RUSSIAN FEDERATION
1 lab in SAUDI ARABIA
2 labs in SERBIA
1 lab in SPAIN
3 labs in SWEDEN
2 labs in TAIWAN
1 lab in UNITED ARAB EMIRATES
4 labs in UNITED KINGDOM
2 labs in UNITED STATES OF AMERICA

Sulfur (total) in LPG iis22S04S

2 labs in AUSTRALIA
2 labs in BELGIUM
1 lab in BULGARIA
1 lab in CHILE
1 lab in ESTONIA
1 lab in FRANCE
5 labs in GERMANY
2 labs in KAZAKHSTAN
1 lab in KUWAIT
1 lab in MALAYSIA
3 labs in NETHERLANDS
1 lab in NIGER
1 lab in OMAN
1 lab in PANAMA
4 labs in PORTUGAL
1 lab in ROMANIA
1 lab in RUSSIAN FEDERATION
1 lab in SAUDI ARABIA
3 labs in SERBIA
1 lab in SPAIN
2 labs in TAIWAN
1 lab in TURKEY
2 labs in UNITED KINGDOM
2 labs in UNITED STATES OF AMERICA

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

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