Results of Proficiency Test
Liquefied Butane Analysis
June 2019

Organised by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

Author: ing. C.M. Nijssen - Wester
Corrector: ing. A.S. Noordman – de Neef & ing. R. van den Berg

Report: iis19S02B

September 2019

CONTENTS

1 INTRODUCTION

Since 2009, the Institute for Interlaboratory Studies (iis) organizes a proficiency test for Liquefied Butane every year. Because iis has limited gas-handling facilities in place to prepare gas samples, a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up. This company is fully equipped and has experience in the preparation of synthetic gas samples for PT purposes. EffecTech maintains an ISO/IEC17043 accreditation for the preparation of PT samples in homogeneous and stable batches and an ISO/IEC17025 accreditation for the calibration and assignment of reference values for these samples.

In this interlaboratory study 49 laboratories in 27 different countries registered for participation. See appendix 2 for the number of participants per country. In this report, the results of the 2019 Liquefied Butane proficiency test 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.
To optimise the costs for the participating laboratories, it was decided to prepare one Liquefied Butane mixture. The mixture was divided over a batch of 53 cylinders. Each cylinder was uniquely numbered. The cylinder size is a cost-effective one-litre cylinder with dip tube device. The limited cylinder size is chosen to optimise sample stability, cylinder costs, transport and handling costs. It was decided to send one cylinder of 1L (labelled #19100) filled with approximately 200 grams Liquefied Butane.
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 an accredited provider of proficiency testing schemes under the requirements of ISO/IEC17043:2010 by UKAS (no. 4719).

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

In this proficiency test one sample was used. One batch of 53 cylinders of one litre with an artificial Liquefied Butane mixture was prepared and tested for homogeneity by EffecTech (Uttoxeter, United Kingdom) in conformance with ISO6142, ISO Guide 35 and ISO17025 (job 19/0543, starting in May 2019). Each cylinder was uniquely numbered. Every cylinder in the batch was analysed using replicate measurements. The within bottle and between bottle variations were then assessed in accordance with ISO Guide 35. This evaluation showed that the between bottle variations were all small compared to the uncertainties on the reference values on each component. Hence, a single reference value could be safely assigned to the entire batch of samples.
The repeatability values (r) were calculated per component by multiplication of the respective standard deviation by 2.8. Subsequently, the calculated repeatabilities were 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:

	r (observed) in %mol/mol	0.3 * R (ASTM D2163:14e1) in %mol/mol
Propane	0.003	0.052
Propene	0.004	0.102
iso-Butane	0.049	0.276
n-Butane	0.031	0.085
1-Butene	0.031	0.077
iso-Butene	0.008	0.085
trans-2-Butene	0.026	0.064
cis-2-Butene	0.014	0.092
1,3-Butadiene	0.004	0.037
iso-Pentane	0.003	0.014

Table 1: evaluation of homogeneity test results of samples #19100

The calculated calculated repeatabilities were in agreement with 0.3 times the corresponding reproducibility of the reference test method ASTM D2163:14e1. Therefore, homogeneity of the subsamples #19100 was assumed.

To each of the participating laboratories one 1L cylinder labelled #19100 was sent on May 29, 2019. An SDS was added to the sample package.

2.5 STABILITY OF THE SAMPLES

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

2.6 ANALYSES

The participants were requested to determine on sample #19100: Propane, Propene, iso-Butane, n-Butane, 1-Butene, iso-Butene, trans-2-Butene, cis-2-Butene, 1,3-Butadiene, n-Pentane, iso-Pentane, Molar Mass, Relative Density at 60/60°F, Absolute and Relative Vapor pressure at 100°F (in psi) and at 40°C (in kPa), Motor Octane Number (MON), Ideal Gross Heating Value and Ideal Net Heating Value both at 14.696 psia and 60°F.

It was explicitly requested to treat the sample as if it was a routine sample and to report the test results using the indicated units on the report form and not to round the results, but report as much significant figures as possible. It was also requested not to report ‘less than’ 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 appropriate reference test method 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 original test results are placed under 'Remarks' in the test 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.

According to ISO5725 the original test results per determination were submitted to Dixon's, Grubbs' and/or Rosner's outlier tests. 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 requirements 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 these 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 analysis 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 was projected over the Kernel Density Graph for reference.

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, e.g. ASTM, ISO or EN reproducibilities, the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation of 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. In some cases a reproducibility based on former iis proficiency tests could be used.

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 result tables of appendix 1.

Absolute values for z<2 are very common and absolute values for z>3 are very rare.
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

In this interlaboratory study, some problems with sample dispatch were encountered. Eight laboratories did not report any test results. Four laboratories reported test results after the final reporting date. Not all laboratories were able to report all analyses requested. In total 41 participants reported 549 test results. Observed were 53 outlying test results, which is 9.7% of the numerical test results. In proficiency studies, outlier percentages of 3% - 7.5% are quite normal.

Not all original 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 COMPONENT OR PER PARAMETER

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

In the iis PT reports, ASTM methods are referred to with a number (e.g. D3588) and an added designation for the year that the method was adopted or revised (e.g. D3588:98).
If applicable, a designation in parentheses is added to designate the year of reapproval (e.g. D3588:98(2017)). In the results tables of appendix 1 only the method number and year of adoption or revision e.g. D3588:98 will be used.

Method ASTM D2163:14e1 is used to evaluate the performance of the test results for the composition of Liquified Butane. Although the reproducibility is given in %V/V, following the Ideal Gas Law (or General Gas Equation) for the same Temperature and Pressure, the reproducibility in %mol/mol will follow the same equation. In this test method no reproducibilities are mentioned for the following components: 1-Butene, iso-Butene, trans-2-Butene, cis-2-Butene and 1,3-Butadiene. For these components the mentioned reproducibility for n-Butane has been used in this report.

Six laboratories (508, 1546, 1603, 1753, 6018 and 6019) reported deviating test results for many of the gas composition test results. At least three of the ten test results were statistical outliers (not counting n-Pentane, which was not present in this sample). As the ten test results are not independent, it was decided not to use any of the reported results of these laboratories for the statistical evaluation, therefore, the remaining reported test results were excluded. Also, the reported test results for the parameters calculated from the measured Gas Composition were excluded for these laboratories, when not marked as a statistical outlier.

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 these calculated properties, the calculated results of above-mentioned laboratories were excluded as well as the calculated results of seven other laboratories (323, 445, 1026, 1040, 1062, 1634, 6201) with one or two outliers in the composition.

Propane: The determination of this component was not problematic. Four statistical outliers were observed and two other test results were excluded. However, the calculated reproducibility after rejection of the suspect data is in good agreement with the requirements of ASTM D2163:14e1 and in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

Propene: The determination of this component was not problematic. Three statistical outliers were observed and three other test results were excluded. However, the calculated reproducibility after rejection of the suspect data is in good agreement with the requirements of ASTM D2163:14e1 and in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

iso-Butane: The determination of this component may be problematic depending on the requirements of the test method used. Four statistical outliers were observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is almost in agreement with the reproducibility of ASTM D2163:14e1, and in good agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

n-Butane: The determination of this component may be problematic depending on the requirements of the test method used. Five statistical outliers were observed and three other test result were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility of ASTM D2163:14e1, but it is in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

1-Butene: The determination of this component was not problematic. Four statistical outliers were observed and two other test results were excluded. However, the calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14e1 and in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

Iso-Butene: The determination of this component was not problematic. Six statistical outliers were observed and two other test results were excluded. However, the calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility of ASTM D2163:14e1 and in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

trans-2-Butene: The determination of this component was not problematic. Six statistical outliers were observed. However, the calculated reproducibility after rejection of the statistical outliers is in agreement with the reproducibility of ASTM D2163:14e1 and in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

cis-2-Butene: The determination of this component may be problematic depending on the requirements of the test method used. Seven statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the reproducibility of ASTM D2163:14e1, but it is in

agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

1,3-Butadiene The determination of this component was not problematic. Three statistical outliers were observed and five other test results were excluded. However, the calculated reproducibility after rejection of the suspect data is in good agreement with the reproducibility of ASTM D2163:14e1 and in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

n-Pentane: Most of the laboratories agreed that the amount of n-Pentane was lower than 0.1%mol/mol, therefore no z-scores were calculated.

iso-Pentane: The determination of this component may be problematic depending on the requirements of the test method used. Three statistical outliers were observed and four other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility of ASTM D2163:14e1, but it is in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).
The overall mean of the test results is slightly beside the application range of the reproducibility of iso-Pentane. It is observed that the majority of the test results of the group lies between the 3s-lines. Therefore it is decided to use the reproducibility as mentioned in ASTM D2163:14e1 to calculate the z-scores.

Molar Mass: This calculated parameter may not be problematic. One statistical outlier was observed and three other test results were excluded. The reported test results after rejection of the suspect data vary over a small range from 57.46 - 57.49 g/mol. The calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published relative molecular masses obtained from one test method (ISO8973:97/ IP432:00) over all reported component concentrations (0.024 *vs* 0.040). See also the discussion in paragraph 5.

Relative Density at 60/60°F: This calculated parameter may be problematic. One statistical outlier was observed and four other test results were excluded. The reported test results after rejection of the statistical outliers vary over a range from 0.5713 - 0.5721. The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published relative density at 60/60°F obtained from one test method (ASTM D2598:16) over all reported component concentrations (0.0007 *vs* 0.0005). See also the discussion in paragraph 5.

Abs. Vapor Pres. at 100°F: This calculated parameter may not be problematic.
Two statistical outliers were observed in the ISO8973:97 test results. In the ASTM D2598:16 test results no statistical outliers were observed. The reported ISO8973 test results vary after rejection of the statistical outliers over a range from 71.5 – 71.6 psi. The reported D2598 test results vary over a range from 71.0 – 71.3 psi.

The calculated reproducibility after rejection of the statistical outliers is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (ISO8973:97) over all reported component concentrations (0.12 *vs* 0.47 psi). Also, the calculated reproducibility is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (ASTM D2598:16) over all reported component concentrations (0.35 *vs* 0.40 psi). See also the discussion in paragraph 5.

Rel. Vapor Pres. at 100°F: This calculated parameter may not be problematic.
One statistical outlier was observed in the ISO8973:97/IP432:00 test results. In the ASTM D2598 test results one test result was excluded. The reported ISO8973/IP432 test results vary after rejection of statistical outlier over a range from 56.8 – 57.0 psi. The reported D2598 test results vary after rejection of the suspect data over a range from 56.34 – 56.6 psi.
The calculated reproducibility after rejection of the statistical outlier is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (ISO8973:97) over all reported component concentrations (0.25 *vs* 0.47 psi). Also, the calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (ASTM D2598:16) over all reported component concentrations (0.28 *vs* 0.40 psi). See also the discussion in paragraph 5.

Abs. Vapor Pres. at 40°C: This calculated parameter may not be problematic. One statistical outlier was observed and three other test results were excluded. The reported test results after rejection of the suspect data vary from 518.325 – 520.7 kPa. The calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (ISO8973:97) over all reported component concentrations (1.85 *vs* 3.32 kPa). See also the discussion in paragraph 5.

Rel. Vapor Pres. at 40°C: This calculated parameter may not be problematic. One statistical outlier was observed and three other test results were excluded. The reported test results after rejection of the suspect data vary from 416 – 420.5 kPa. The calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (ISO8973:97/IP432:00) over all reported component concentrations (3.07 *vs* 3.32 kPa). See also the discussion in paragraph 5.

MON: This calculated parameter may be problematic. One statistical outlier was observed in the EN589 test results and one other test result was excluded. Only two test results were reported for ASTM D2598. The reported EN589 test results vary after rejection of the suspect data over a range from 91.656 – 92.7. The reported D2598 test results were 94.5 and 94.54.

The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapor pressure factors obtained from one test method (e.g. EN598:08_A1:12) over all reported component concentrations (1.24 *vs* 0.22). It was also observed that the test methods (EN vs ASTM) give different mean values (92.24 *vs* 94.52). See also the discussion in paragraph 5.
Unfortunately, method EN589:08_A1:12 does not mention a MON factor for 1,3-Butadiene. Therefore, iis did use an estimated value of 70 (in analogy of the MON factors of the other components). Method ASTM D2598:16 does not mention MON factors for iso-Butene, trans-2-Butene or 1,3-Butadiene. Therefore, iis has used for iso-Butene, trans-2-Butene the same value of cis-2-Butene (83.5) and 70 for 1,3-Butadiene. The use of different factors than mentioned above for the calculation of MON may cause a higher variation in test results.

Ideal Gross Heating Value at 14.696 psia / 60°F: In this PT none of the participants reported to have used ISO6976, therefore the results for all laboratories were only calculated according to ASTM D3588.
This calculated parameter may be very problematic. No statistical outliers were observed. The calculated reproducibility is not at all in agreement with the calculated reproducibility using the published Ideal Gross Heating Value factors obtained from one test method (ASTM D3588:98(2017)) over all reported component concentrations (46 *vs* 2 kJ/mol). The calculated reproducibility is smaller than in iis18S02B (66 kJ/mol) See also the discussion in paragraph 5.

Ideal Net Heating Value at 14.696 psia / 60°F: In this PT none of the participants reported to have used ISO6976, therefore the results for all laboratories were only calculated according to ASTM D3588.
This calculated parameter may be very problematic. No statistical outliers were observed. The calculated reproducibility is not at all in agreement with the calculated reproducibility using the published Ideal Net Heating Value factors obtained from one test method (e.g. ASTM D3588:98(2017)) over all reported component concentrations (37 *vs* 2 kJ/mol). The calculated reproducibility is smaller than in iis18S02B (50 kJ/mol). See also the discussion in paragraph 5.

4.2 PERFORMANCE EVALUATION FOR THE GROUP OF LABORATORIES

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

Component	unit	n	average	2.8 * sd	R(D2163) in **%mol**	R(EN27941) liq.-inj. in **%mol**	R(EN27941) liq.-inj. in **%M/M**
Propane	%mol/mol	35	1.008	0.087	0.175	1.302	1
Propene	%mol/mol	35	1.277	0.149	0.335	1.365	1
iso-Butane	%mol/mol	35	73.467	1.025	0.920	1.482	1.5
n-Butane	%mol/mol	33	5.086	0.346	0.286	0.988	1
1-Butene	%mol/mol	35	4.010	0.193	0.257	1.024	1
iso-Butene	%mol/mol	33	4.930	0.244	0.282	1.024	1
trans-2-Butene	%mol/mol	35	2.652	0.159	0.213	1.024	1
cis-2-Butene	%mol/mol	34	6.040	0.385	0.309	1.024	1
1,3-Butadiene	%mol/mol	33	0.808	0.085	0.125	1.062	1
n-Pentane	%mol/mol	30	<0.01	n.a.	n.a.	n.a.	n.a.
iso-Pentane	%mol/mol	34	0.605	0.072	0.047	0.796	1

Table 2: reproducibilities of the composition of sample #19100

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

Parameter	unit	n	average	2.8 * sd over reported test results	2.8 * sd calc. overall results using one set of factors	2.8 * sd calc. overall results using one set of factors **iis18S02B**
Molar Mass	g/mol	14	57.48	0.02	0.04	0.08
Rel. Density at 60/60°F		17	0.5718	0.0007	0.0005	0.0005
Abs. VP at 100°F ISO/IP	psi	6	71.56	0.12	0.47	0.56
Abs. VP at 100°F D2598	psi	4	71.16	0.35	0.40	0.49
Rel. VP at 100°F ISO/IP	psi	9	56.91	0.25	0.47	0.56
Rel. VP at 100°F D2598	psi	5	56.45	0.28	0.40	0.49
Abs. VP at 40°C	kPa	12	519.6	1.9	3.3	4.0
Rel. VP at 40°C	kPa	13	418.4	3.1	3.3	4.0
MON EN589		6	92.24	1.24	0.22	0.21
MON D2598		2	94.52	n.a.	0.11	0.14
IGHV D3588	kJ/mol	4	2822	46	2	3
INHV D3588	kJ/mol	4	2609	37	2	3

Table 3: reproducibilities of calculated physical properties of sample #19100 using one set of factors.

Without further statistical calculations, it could be concluded that for many tests there is a good compliance of the group of participating laboratories with the reproducibilities calculated over all reported test results of this PT compared to 2018 PT. See also the discussion in paragraph 5.

4.3 COMPARISON OF THE PROFICIENCY TEST OF JUNE 2019 WITH PREVIOUS PTS

	June 2019	June 2018	June 2017	June 2016	June 2015
Number of reporting labs	41	51	49	49	46
Number of test results reported	549	660	623	627	538
Number of statistical outliers	53	45	30	63	45
Percentage outliers	9.7%	6.8%	4.8%	10.0%	8.4%

Table 4: comparison with previous proficiency tests

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

The performance of the determinations of the proficiency tests was compared against the requirements of ASTM D2163:14e1. The conclusions are given the following table.

Component	June 2019	June 2018	June 2017	June 2016	June 2015
Propane	++	+	++	+	+
Propene	++	+	++	++	++
iso-Butane	-	-	-	+/-	-
n-Butane	-	-	+/-	-	-
1-Butene	+	+	+	+/-	+
iso-Butene	+	+/-	+	+/-	+/-
trans-2-Butene	+	+	+	+	+
cis-2-Butene	-	-	-	+/-	+/-
1,3-Butadiene	+	+	+	+	+
n-Pentane	n.e.	n.e.	n.e.	n.e.	n.e.
iso-Pentane	-	-	-	-	-

Table 5: comparison determinations against the requirements of ASTM D2163

The following performance categories were used in the above table:

++ : 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

5 DISCUSSION

Because the majority of the reproducibility requirements of ASTM D2163 differ significantly from the reproducibility requirements of EN27941 (for liquid injection), the outcome of the evaluations will be strongly dependent on the reference test method selected for the evaluation.

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

Component	Average values by EffecTech in %mol/mol	Consensus values from participants test results in %mol/mol	Absolute differences in %mol/mol	z-score
Propane	1.001	1.008	-0.007	-0.11
Propene	1.299	1.277	0.022	0.19
iso-Butane	73.667	73.467	0.200	0.61
n-Butane	5.005	5.086	-0.081	-0.79
1-Butene	3.980	4.010	-0.030	-0.33
iso-Butene	4.991	4.930	0.061	0.61
trans-2-Butene	2.662	2.652	0.010	0.13
cis-2-Butene	5.994	6.040	-0.046	-0.41
1,3-Butadiene	0.801	0.808	-0.007	-0.17
iso-Pentane	0.600	0.605	-0.005	-0.34

Table 6: comparison of consensus values with values determined by EffecTech (Uttoxeter, United Kingdom)

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.
Some test methods do not mention a factor of each component of the Butane mixture for calculation of some physical properties. In these cases iis used for example a factor from a comparable test method or an average value (see paragraph 4.1 and appendix 1).

For the calculation of the Molar Mass, Relative Density and Vapor Pressure, Motor Octane Number, Ideal Gross Heating Value and Ideal Net Heating Value several standardized test methods are available, e.g. ASTM D2421 for the interconversion of the units to gas-volume, liquid-volume or mass basis.

The calculation of Relative Density, on a liquid volume basis, is described in ASTM D2598. Furthermore, 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 (given for all components). In ASTM D2598 the Vapor Pressure is calculated from the liquid volume percentage per component and a Vapor Pressure factor of that component (given for only several components).

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.
The calculation of Gross and Net Heating Values is described in ASTM D3588 and ISO6976 (on a molar basis.

Also, the selection of the tables for the component factors to be used for the calculations may cause additional uncertainty. This has been at least observed for Motor Octane Number.

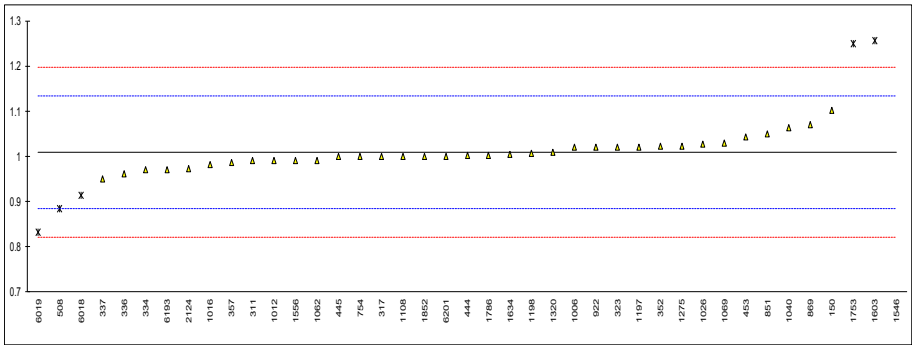
APPENDIX 1

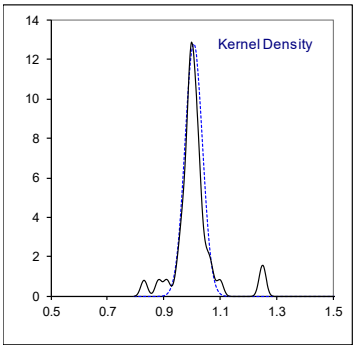
Determination of Propane on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.101		1.48	
171		-----		-----	
311	D2163	0.99		-0.29	
317	D2163	1.00		-0.13	
323	D2163	1.02		0.19	
333		-----		-----	
334	D2163	0.97		-0.61	
336	D2163	0.96		-0.77	
337	D2163	0.95		-0.93	
352	EN27941	1.0223		0.23	
357	D2163	0.986		-0.35	
444	D2163	1.0017		-0.10	
445	D2163	1.00		-0.13	
453		1.042		0.54	
508	D2163	0.883315	ex	-2.00	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	1.00		-0.13	
851	D2163	1.048996		0.65	
869	D2163	1.070		0.99	
875		-----		-----	
922	D2163	1.02		0.19	
1006	D2163	1.02		0.19	
1012	D2163	0.99		-0.29	
1016	ISO7941	0.982		-0.42	
1026	ISO7941	1.0272		0.30	
1040	DIN51619	1.063		0.88	
1062	D2163	0.9915		-0.27	
1065		-----		-----	
1069		1.03		0.35	
1108	D2163	1.00		-0.13	
1197	D2163	1.021		0.21	
1198	D2163	1.007		-0.02	
1275	EN27941	1.023		0.24	
1320	DIN51619	1.008		0.00	
1546	EN27941	2.057	R(0.01)	16.77	
1556	EN27941	0.99		-0.29	
1603	in house	1.2550	R(0.01)	3.95	
1634	ISO7941	1.005		-0.05	
1753	D2163	1.249	C,R(0.01)	3.85	first reported: 0.874
1786	D2163	1.003		-0.08	
1852	DIN51619	1.00		-0.13	
2124	D2163	0.9718		-0.58	
6018	ISO7941	0.913	ex	-1.52	test result excluded, see paragraph 4.1
6019	ISO7941	0.832	R(0.01)	-2.82	
6054		-----		-----	
6193	D2163	0.97		-0.61	
6201	D2163	1.00		-0.13	
6238		-----		-----	

normality	suspect
n	35
outliers	4 (+2ex)
mean (n)	1.0081
st.dev. (n)	0.03114
R(calc.)	0.0872
st.dev.(D2163:14e1)	0.06255
R(D2163:14e1)	0.1751

compare R(EN27941:93(liq)) = 1.3024



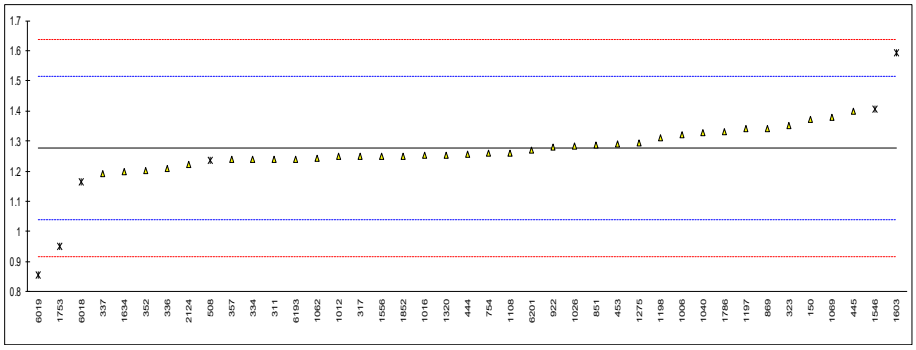


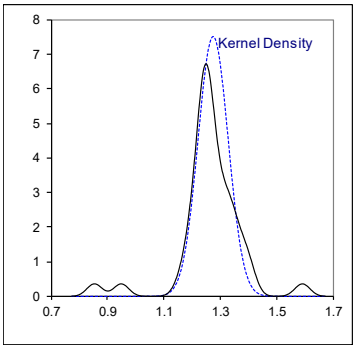
Determination of Propene on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.372		0.80	
171		-----		-----	
311	D2163	1.24		-0.31	
317	D2163	1.25		-0.22	
323	D2163	1.35		0.61	
333		-----		-----	
334	D2163	1.24		-0.31	
336	D2163	1.21		-0.56	
337	D2163	1.19		-0.72	
352	EN27941	1.2011		-0.63	
357	D2163	1.239		-0.31	
444	D2163	1.2557		-0.18	
445	D2163	1.40		1.03	
453		1.291		0.12	
508	D2163	1.234500	ex	-0.35	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	1.26		-0.14	
851	D2163	1.285233		0.07	
869	D2163	1.342		0.55	
875		-----		-----	
922	D2163	1.28		0.03	
1006	D2163	1.32		0.36	
1012	D2163	1.248		-0.24	
1016	ISO7941	1.253		-0.20	
1026	ISO7941	1.2828		0.05	
1040	DIN51619	1.328		0.43	
1062	D2163	1.2430		-0.28	
1065		-----		-----	
1069		1.38		0.86	
1108	D2163	1.26		-0.14	
1197	D2163	1.340		0.53	
1198	D2163	1.309		0.27	
1275	EN27941	1.295		0.15	
1320	DIN51619	1.254		-0.19	
1546	EN27941	1.407	ex	1.09	test result excluded, see paragraph 4.1
1556	EN27941	1.25		-0.22	
1603	in house	1.5929	R(0.01)	2.64	
1634	ISO7941	1.20		-0.64	
1753	D2163	0.951	C,R(0.01)	-2.72	first reported: 0.966
1786	D2163	1.332		0.46	
1852	DIN51619	1.25		-0.22	
2124	D2163	1.2215		-0.46	
6018	ISO7941	1.163	ex	-0.95	test result excluded, see paragraph 4.1
6019	ISO7941	0.856	R(0.01)	-3.52	
6054		-----		-----	
6193	D2163	1.24		-0.31	
6201	D2163	1.27		-0.06	
6238		-----		-----	

	normality	OK
	n	35
	outliers	3 (+3ex)
	mean (n)	1.2766
	st.dev. (n)	0.05318
	R(calc.)	0.1489
	st.dev.(D2163:14e1)	0.11959
	R(D2163:14e1)	0.3348

compare R(EN27941:93(liq)) = 1.3648



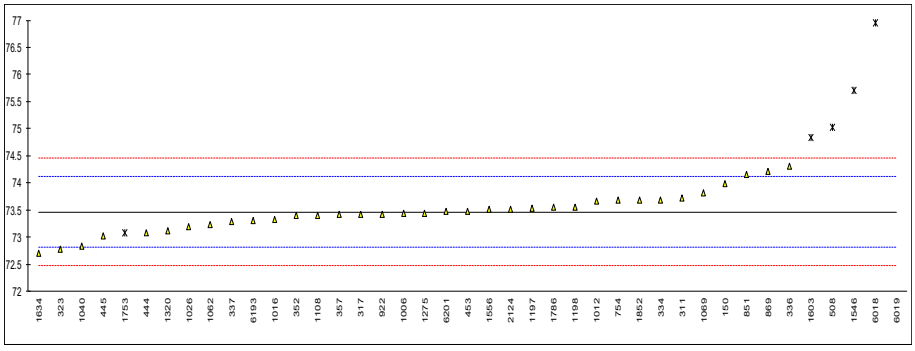


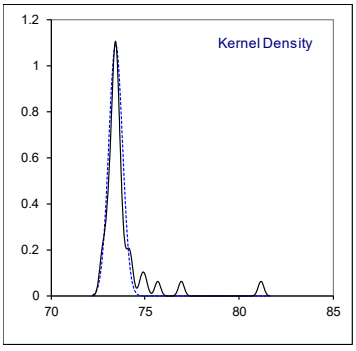
Determination of iso-Butane on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	73.995		1.61	
171		-----		-----	
311	D2163	73.73		0.80	
317	D2163	73.42		-0.14	
323	D2163	72.78		-2.09	
333		-----		-----	
334	D2163	73.69		0.68	
336	D2163	74.31		2.56	
337	D2163	73.29		-0.54	
352	EN27941	73.3923		-0.23	
357	D2163	73.413		-0.17	
444	D2163	73.0888		-1.15	
445	D2163	73.02		-1.36	
453		73.474		0.02	
508	D2163	75.031113	R(0.05)	4.76	
704		-----		-----	
707		-----		-----	
754	D2163	73.68		0.65	
851	D2163	74.160996		2.11	
869	D2163	74.205		2.24	
875		-----		-----	
922	D2163	73.42		-0.14	
1006	D2163	73.44		-0.08	
1012	D2163	73.672		0.62	
1016	ISO7941	73.325		-0.43	
1026	ISO7941	73.1858		-0.86	
1040	DIN51619	72.831		-1.94	
1062	D2163	73.2287		-0.73	
1065		-----		-----	
1069		73.82		1.07	
1108	D2163	73.40		-0.20	
1197	D2163	73.527		0.18	
1198	D2163	73.554		0.26	
1275	EN27941	73.446		-0.06	
1320	DIN51619	73.124		-1.04	
1546	EN27941	75.702	R(0.01)	6.80	
1556	EN27941	73.51		0.13	
1603	in house	74.8373	ex	4.17	test result excluded, see paragraph 4.1
1634	ISO7941	72.71		-2.30	
1753	D2163	73.071	ex,C	-1.21	test result excluded, see paragraph 4.1, first reported: 72.324
1786	D2163	73.547		0.24	
1852	DIN51619	73.68		0.65	
2124	D2163	73.5169		0.15	
6018	ISO7941	76.957	R(0.01)	10.62	
6019	ISO7941	81.189	R(0.01)	23.49	
6054		-----		-----	
6193	D2163	73.30		-0.51	
6201	D2163	73.47		0.01	
6238		-----		-----	

	normality	OK
	n	35
	outliers	4 (+2ex)
	mean (n)	73.4673
	st.dev. (n)	0.36613
	R(calc.)	1.0252
	st.dev.(D2163:14e1)	0.32867
	R(D2163:14e1)	0.9203

compare R(EN27941:93(liq)) = 1.4821



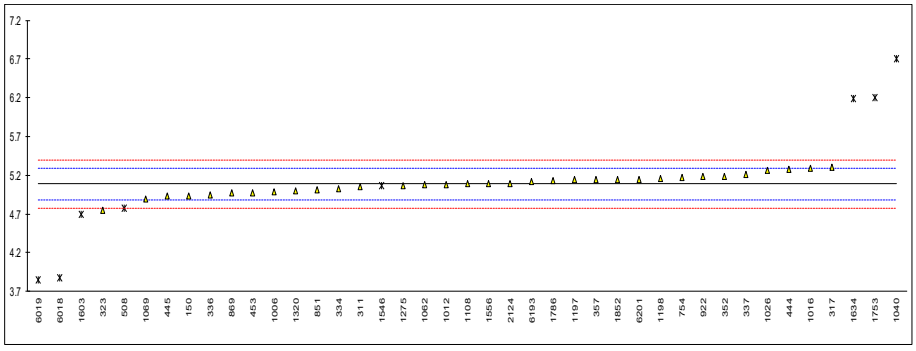


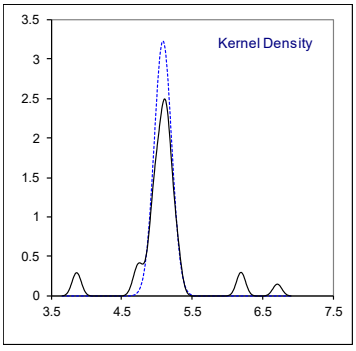
Determination of n-Butane on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	4.934		-1.49	
171		-----		-----	
311	D2163	5.05		-0.35	
317	D2163	5.30		2.09	
323	D2163	4.75		-3.29	
333		-----		-----	
334	D2163	5.03		-0.55	
336	D2163	4.95		-1.33	
337	D2163	5.21		1.21	
352	EN27941	5.1872		0.99	
357	D2163	5.147		0.59	
444	D2163	5.2726		1.82	
445	D2163	4.93		-1.53	
453		4.975		-1.09	
508	D2163	4.770207	ex	-3.09	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	5.17		0.82	
851	D2163	5.007253		-0.77	
869	D2163	4.970		-1.14	
875		-----		-----	
922	D2163	5.18		0.92	
1006	D2163	4.98		-1.04	
1012	D2163	5.083		-0.03	
1016	ISO7941	5.285		1.95	
1026	ISO7941	5.2575		1.68	
1040	DIN51619	6.710	R(0.01)	15.89	
1062	D2163	5.0815		-0.05	
1065		-----		-----	
1069		4.89		-1.92	
1108	D2163	5.09		0.04	
1197	D2163	5.144		0.57	
1198	D2163	5.158		0.70	
1275	EN27941	5.071		-0.15	
1320	DIN51619	5.003		-0.81	
1546	EN27941	5.067	ex	-0.19	test result excluded, see paragraph 4.1
1556	EN27941	5.09		0.04	
1603	in house	4.6946	ex	-3.83	test result excluded, see paragraph 4.1
1634	ISO7941	6.19	C,R(0.01)	10.80	first reported: 5.955
1753	D2163	6.199	C,R(0.01)	10.89	first reported: 5.504
1786	D2163	5.137		0.50	
1852	DIN51619	5.15		0.62	
2124	D2163	5.0934		0.07	
6018	ISO7941	3.873	R(0.01)	-11.87	
6019	ISO7941	3.850	R(0.01)	-12.10	
6054		-----		-----	
6193	D2163	5.12		0.33	
6201	D2163	5.15		0.62	
6238		-----		-----	

	normality	OK
	n	33
	outliers	5 (+3ex)
	mean (n)	5.0863
	st.dev. (n)	0.12342
	R(calc.)	0.3456
	st.dev.(D2163:14e1)	0.10217
	R(D2163:14e1)	0.2861

compare R(EN27941:93(liq)) = 0.9881



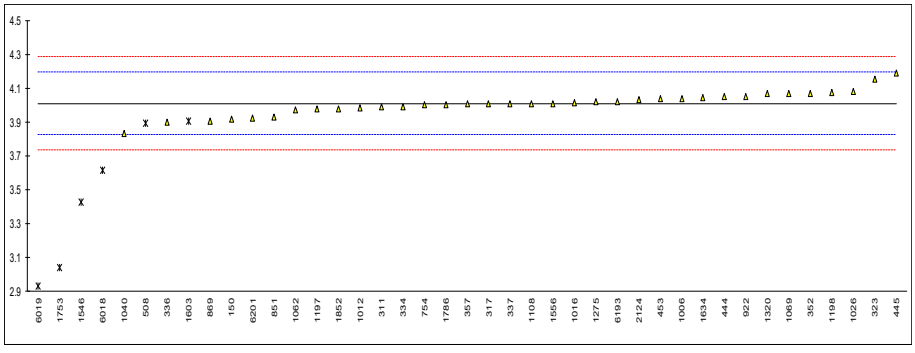


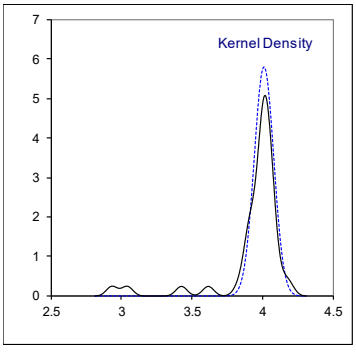
Determination of 1-Butene on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	3.915		-1.04	
171		-----		-----	
311	D2163	3.99		-0.22	
317	D2163	4.01		0.00	
323	D2163	4.15		1.52	
333		-----		-----	
334	D2163	3.99		-0.22	
336	D2163	3.90		-1.20	
337	D2163	4.01		0.00	
352	EN27941	4.0703		0.65	
357	D2163	4.009		-0.01	
444	D2163	4.0485		0.42	
445	D2163	4.19		1.96	
453		4.039		0.31	
508	D2163	3.891649	ex	-1.29	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	4.00		-0.11	
851	D2163	3.926850		-0.91	
869	D2163	3.907		-1.13	
875		-----		-----	
922	D2163	4.05		0.43	
1006	D2163	4.04		0.32	
1012	D2163	3.985		-0.28	
1016	ISO7941	4.016		0.06	
1026	ISO7941	4.0829		0.79	
1040	DIN51619	3.834		-1.92	
1062	D2163	3.9693		-0.45	
1065		-----		-----	
1069		4.07		0.65	
1108	D2163	4.01		0.00	
1197	D2163	3.980		-0.33	
1198	D2163	4.073		0.68	
1275	EN27941	4.018		0.08	
1320	DIN51619	4.068		0.63	
1546	EN27941	3.425	R(0.01)	-6.38	
1556	EN27941	4.01		0.00	
1603	in house	3.9038	ex	-1.16	test result excluded, see paragraph 4.1
1634	ISO7941	4.045		0.38	
1753	D2163	3.040	C,R(0.01)	-10.57	first reported: 4.099
1786	D2163	4.002		-0.09	
1852	DIN51619	3.98		-0.33	
2124	D2163	4.0324		0.24	
6018	ISO7941	3.615	R(0.01)	-4.31	
6019	ISO7941	2.932	R(0.01)	-11.75	
6054		-----		-----	
6193	D2163	4.02		0.11	
6201	D2163	3.92		-0.98	
6238		-----		-----	

normality	suspect
n	35
outliers	4 (+2ex)
mean (n)	4.0103
st.dev. (n)	0.06890
R(calc.)	0.1929
st.dev.(D2163:14e1)	0.09181
R(D2163:14e1)	0.2571

compare R(EN27941:93(liq)) = 1.0236



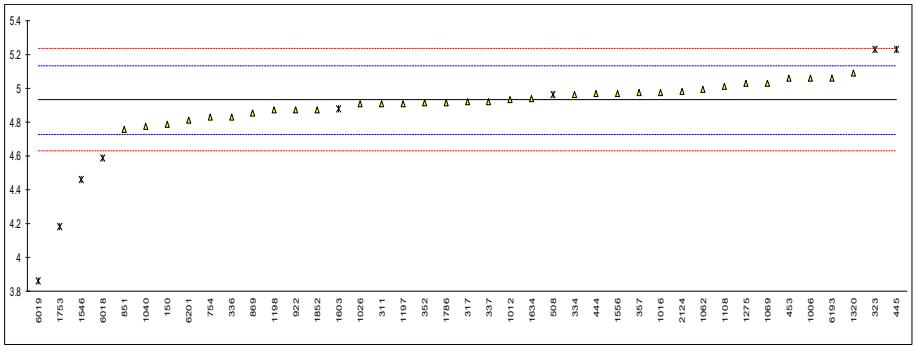


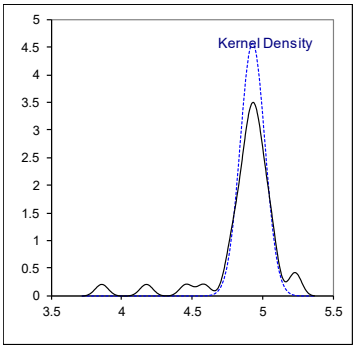
Determination of iso-Butene on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	4.787		-1.41	
171		-----		-----	
311	D2163	4.91		-0.19	
317	D2163	4.92		-0.09	
323	D2163	5.23	R(0.05)	2.98	
333		-----		-----	
334	D2163	4.96		0.30	
336	D2163	4.83		-0.99	
337	D2163	4.92		-0.09	
352	EN27941	4.9144		-0.15	
357	D2163	4.975		0.45	
444	D2163	4.9688		0.39	
445	D2163	5.23	R(0.05)	2.98	
453		5.059		1.29	
508	D2163	4.959459	ex	0.30	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	4.83		-0.99	
851	D2163	4.757328		-1.71	
869	D2163	4.854		-0.75	
875		-----		-----	
922	D2163	4.87		-0.59	
1006	D2163	5.06		1.30	
1012	D2163	4.931		0.01	
1016	ISO7941	4.975		0.45	
1026	ISO7941	4.9079		-0.21	
1040	DIN51619	4.772		-1.56	
1062	D2163	4.9916		0.62	
1065		-----		-----	
1069		5.03		1.00	
1108	D2163	5.01		0.80	
1197	D2163	4.910		-0.19	
1198	D2163	4.869		-0.60	
1275	EN27941	5.029		0.99	
1320	DIN51619	5.086		1.55	
1546	EN27941	4.460	R(0.05)	-4.66	
1556	EN27941	4.97		0.40	
1603	in house	4.8788	ex	-0.50	test result excluded, see paragraph 4.1
1634	ISO7941	4.94		0.10	
1753	D2163	4.179	C,R(0.01)	-7.45	first reported: 5.110
1786	D2163	4.916		-0.13	
1852	DIN51619	4.87		-0.59	
2124	D2163	4.9809		0.51	
6018	ISO7941	4.585	R(0.05)	-3.42	
6019	ISO7941	3.863	R(0.01)	-10.59	
6054		-----		-----	
6193	D2163	5.06		1.30	
6201	D2163	4.81		-1.19	
6238		-----		-----	

normality	OK
n	33
outliers	6 (+2ex)
mean (n)	4.9300
st.dev. (n)	0.08728
R(calc.)	0.2444
st.dev.(D2163:14e1)	0.10074
R(D2163:14e1)	0.2821

compare R(EN27941:93(liq)) = 1.0236



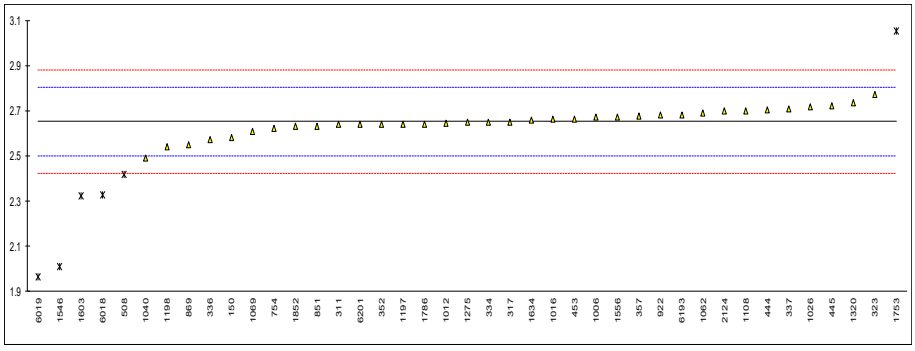


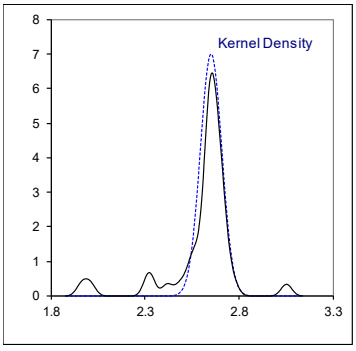
Determination of trans-2-Butene on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	2.579		-0.96	
171		-----		-----	
311	D2163	2.64		-0.16	
317	D2163	2.65		-0.03	
323	D2163	2.77		1.55	
333		-----		-----	
334	D2163	2.65		-0.03	
336	D2163	2.57		-1.08	
337	D2163	2.71		0.76	
352	EN27941	2.6406		-0.15	
357	D2163	2.677		0.33	
444	D2163	2.7035		0.67	
445	D2163	2.72		0.89	
453		2.664		0.16	
508	D2163	2.419696	R(0.05)	-3.05	
704		-----		-----	
707		-----		-----	
754	D2163	2.62		-0.42	
851	D2163	2.631815		-0.27	
869	D2163	2.549		-1.35	
875		-----		-----	
922	D2163	2.68		0.37	
1006	D2163	2.67		0.24	
1012	D2163	2.645		-0.09	
1016	ISO7941	2.662		0.13	
1026	ISO7941	2.7155		0.83	
1040	DIN51619	2.490		-2.13	
1062	D2163	2.6886		0.48	
1065		-----		-----	
1069		2.61		-0.55	
1108	D2163	2.70		0.63	
1197	D2163	2.642		-0.13	
1198	D2163	2.541		-1.46	
1275	EN27941	2.648		-0.05	
1320	DIN51619	2.734		1.07	
1546	EN27941	2.011	R(0.01)	-8.41	
1556	EN27941	2.67		0.24	
1603	in house	2.3215	R(0.01)	-4.34	
1634	ISO7941	2.66		0.10	
1753	D2163	3.052	C,R(0.01)	5.25	first reported: 2.870
1786	D2163	2.642		-0.13	
1852	DIN51619	2.63		-0.29	
2124	D2163	2.6998		0.63	
6018	ISO7941	2.326	R(0.01)	-4.28	
6019	ISO7941	1.966	R(0.01)	-9.00	
6054		-----		-----	
6193	D2163	2.68		0.37	
6201	D2163	2.64		-0.16	
6238		-----		-----	

normality	suspect
n	35
outliers	6
mean (n)	2.6521
st.dev. (n)	0.05688
R(calc.)	0.1593
st.dev.(D2163:14e1)	0.07622
R(D2163:14e1)	0.2134

compare R(EN27941:93(liq)) = 1.0236



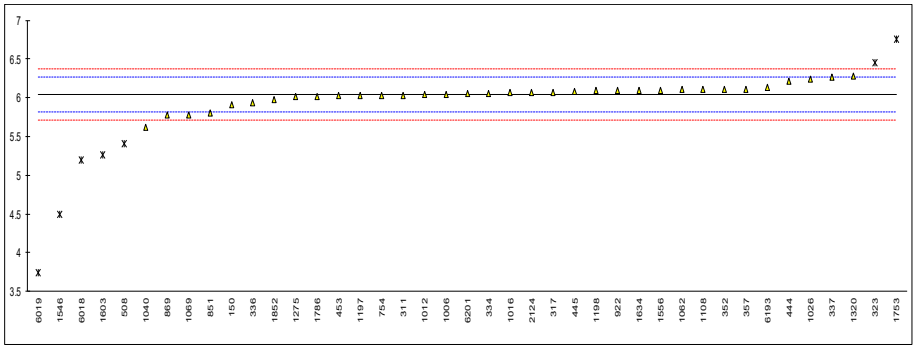


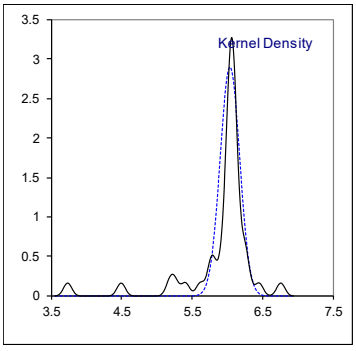
Determination of cis-2-Butene on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	5.907		-1.20	
171		-----		-----	
311	D2163	6.03		-0.09	
317	D2163	6.07		0.28	
323	D2163	6.45	R(0.01)	3.72	
333		-----		-----	
334	D2163	6.06		0.19	
336	D2163	5.94		-0.90	
337	D2163	6.26		2.00	
352	EN27941	6.1102		0.64	
357	D2163	6.112		0.66	
444	D2163	6.2080		1.53	
445	D2163	6.08		0.37	
453		6.023		-0.15	
508	D2163	5.409121	R(0.01)	-5.71	
704		-----		-----	
707		-----		-----	
754	D2163	6.03		-0.09	
851	D2163	5.797087		-2.20	
869	D2163	5.776		-2.39	
875		-----		-----	
922	D2163	6.09		0.46	
1006	D2163	6.04		0.00	
1012	D2163	6.039		0.00	
1016	ISO7941	6.063		0.21	
1026	ISO7941	6.2451		1.86	
1040	DIN51619	5.621		-3.79	
1062	D2163	6.1082		0.62	
1065		-----		-----	
1069		5.78		-2.35	
1108	D2163	6.11		0.64	
1197	D2163	6.023		-0.15	
1198	D2163	6.088		0.44	
1275	EN27941	6.013		-0.24	
1320	DIN51619	6.274		2.12	
1546	EN27941	4.500	R(0.01)	-13.95	
1556	EN27941	6.10		0.55	
1603	in house	5.2599	R(0.01)	-7.06	
1634	ISO7941	6.095		0.50	
1753	D2163	6.759	C, R(0.01)	6.52	first reported: 6.367
1786	D2163	6.017		-0.20	
1852	DIN51619	5.98		-0.54	
2124	D2163	6.0638		0.22	
6018	ISO7941	5.189	R(0.01)	-7.70	
6019	ISO7941	3.743	R(0.01)	-20.80	
6054		-----		-----	
6193	D2163	6.14		0.91	
6201	D2163	6.05		0.10	
6238		-----		-----	

	normality	not OK
	n	34
	outliers	7
	mean (n)	6.0395
	st.dev. (n)	0.13749
	R(calc.)	0.3850
	st.dev.(D2163:14e1)	0.11039
	R(D2163:14e1)	0.3091

compare R(EN27941:93(liq)) = 1.0236



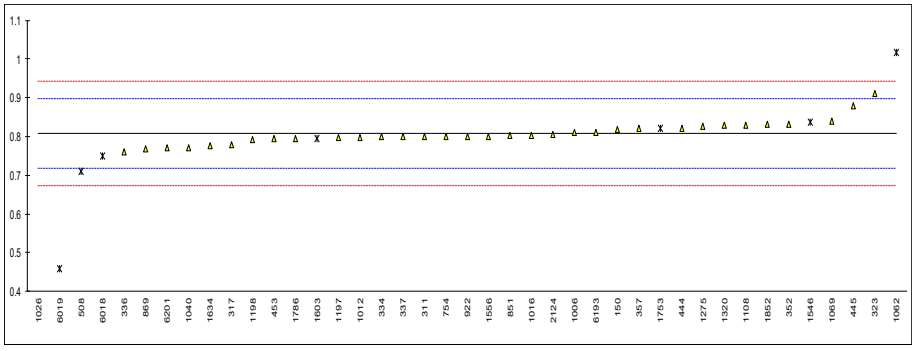


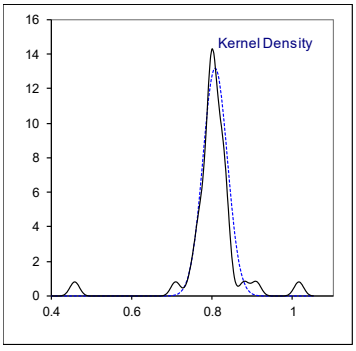
Determination of 1,3-Butadiene on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.819		0.24	
171		-----		-----	
311	D2163	0.80		-0.18	
317	D2163	0.78		-0.63	
323	D2163	0.91		2.28	
333		-----		-----	
334	D2163	0.80		-0.18	
336	D2163	0.76		-1.08	
337	D2163	0.80		-0.18	
352	EN27941	0.8328		0.55	
357	D2163	0.820		0.26	
444	D2163	0.8217		0.30	
445	D2163	0.88		1.61	
453		0.794		-0.32	
508	D2163	0.710211	ex	-2.19	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	0.80		-0.18	
851	D2163	0.801572		-0.15	
869	D2163	0.769		-0.88	
875		-----		-----	
922	D2163	0.80		-0.18	
1006	D2163	0.81		0.04	
1012	D2163	0.797		-0.25	
1016	ISO7941	0.802		-0.14	
1026	ISO7941	0.0022	R(0.01)	-18.05	
1040	DIN51619	0.772		-0.81	
1062	D2163	1.0158	R(0.01)	4.65	
1065		-----		-----	
1069		0.84		0.71	
1108	D2163	0.83		0.49	
1197	D2163	0.796		-0.27	
1198	D2163	0.793		-0.34	
1275	EN27941	0.826		0.40	
1320	DIN51619	0.829		0.47	
1546	EN27941	0.836	ex	0.62	test result excluded, see paragraph 4.1
1556	EN27941	0.801		-0.16	
1603	in house	0.7951	ex	-0.29	test result excluded, see paragraph 4.1
1634	ISO7941	0.775		-0.74	
1753	D2163	0.820	ex,C	0.26	test result excluded, see paragraph 4.1, first reported: 1.007
1786	D2163	0.795		-0.30	
1852	DIN51619	0.831		0.51	
2124	D2163	0.8050		-0.07	
6018	ISO7941	0.749	ex	-1.33	test result excluded, see paragraph 4.1
6019	ISO7941	0.460	R(0.01)	-7.80	
6054		-----		-----	
6193	D2163	0.81		0.04	
6201	D2163	0.77		-0.86	
6238		-----		-----	

normality	not OK
n	33
outliers	3 (+5ex)
mean (n)	0.8082
st.dev. (n)	0.03021
R(calc.)	0.0846
st.dev.(D2163:14e1)	0.04465
R(D2163:14e1)	0.1250

compare R(EN27941:93(liq)) = 1.0617





Determination of n-Pentane on sample #19100; results in %mol/mol

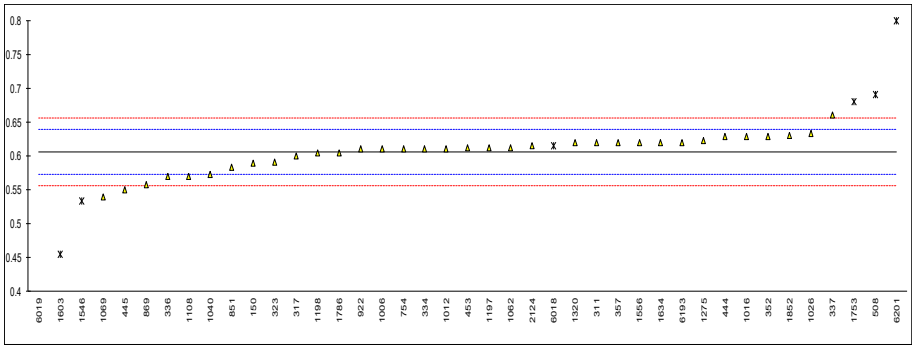
lab	method	value	mark	z(targ)	remarks
150	D2163	0.002		-----	
171		-----		-----	
311	D2163	<0.01		-----	
317	D2163	<0.01		-----	
323	D2163	<0.01		-----	
333		-----		-----	
334	D2163	0		-----	
336	D2163	<0.01		-----	
337		-----		-----	
352		-----		-----	
357	D2163	0.003		-----	
444	D2163	0.0016		-----	
445	D2163	< 0.01		-----	
453		-----		-----	
508	D2163	0.000000		-----	
704		-----		-----	
707		-----		-----	
754	D2163	0		-----	
851		-----		-----	
869	D2163	0		-----	
875		-----		-----	
922	D2163	<0.01		-----	
1006	D2163	0		-----	
1012	D2163	<0.01		-----	
1016	ISO7941	0.003		-----	
1026	ISO7941	0.6609		-----	possible false positive test result?
1040	DIN51619	0.004		-----	
1062	D2163	0		-----	
1065		-----		-----	
1069		0.01		-----	
1108	D2163	0.00		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320	DIN51619	0.002		-----	
1546	EN27941	0		-----	
1556		-----		-----	
1603	in house	< 0,01		-----	
1634	ISO7941	0		-----	
1753		-----		-----	
1786		-----		-----	
1852	DIN51619	0.00		-----	
2124	D2163	0.0000		-----	
6018	ISO7941	<0.1		-----	
6019	ISO7941	<0.1		-----	
6054		-----		-----	
6193	D2163	0		-----	
6201	D2163	<0.01		-----	
6238		-----		-----	
	n	30			
	mean (n)	<0.1			

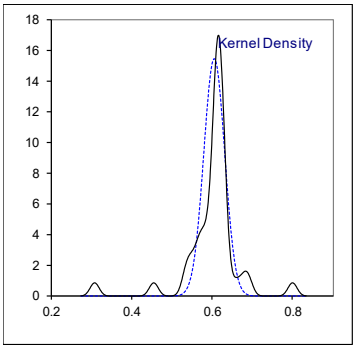
Determination of iso-Pentane on sample #19100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.589		-0.98	
171		-----		-----	
311	D2163	0.62		0.87	
317	D2163	0.60	C	-0.32	first reported: 0.78
323	D2163	0.59		-0.92	
333		-----		-----	
334	D2163	0.61		0.27	
336	D2163	0.57		-2.12	
337	D2163	0.66		3.27	
352	EN27941	0.6292		1.42	
357	D2163	0.620		0.87	
444	D2163	0.6285		1.38	
445	D2163	0.55		-3.32	
453		0.612		0.39	
508	D2163	0.690730	ex	5.11	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2163	0.61		0.27	
851	D2163	0.582869		-1.35	
869	D2163	0.558		-2.84	
875		-----		-----	
922	D2163	0.61		0.27	
1006	D2163	0.61		0.27	
1012	D2163	0.611		0.33	
1016	ISO7941	0.629		1.41	
1026	ISO7941	0.6323		1.61	
1040	DIN51619	0.573		-1.94	
1062	D2163	0.6121		0.40	
1065		-----		-----	
1069		0.54		-3.92	
1108	D2163	0.57		-2.12	
1197	D2163	0.612		0.39	
1198	D2163	0.604		-0.09	
1275	EN27941	0.623		1.05	
1320	DIN51619	0.619		0.81	
1546	EN27941	0.534	ex	-4.28	test result excluded, see paragraph 4.1
1556	EN27941	0.62		0.87	
1603	in house	0.4550	R(0.01)	-9.01	
1634	ISO7941	0.62		0.87	
1753	D2163	0.680	ex,C	4.47	test result excluded, see paragraph 4.1, first reported: 0.879
1786	D2163	0.605		-0.03	
1852	DIN51619	0.63		1.47	
2124	D2163	0.6145		0.54	
6018	ISO7941	0.615	ex	0.57	test result excluded, see paragraph 4.1
6019	ISO7941	0.308	R(0.01)	-17.81	
6054		-----		-----	
6193	D2163	0.62		0.87	
6201	D2163	0.80	R(0.01)	11.65	
6238		-----		-----	

normality	OK
n	34
outliers	3 (+4ex)
mean (n)	0.6054
st.dev. (n)	0.02585
R(calc.)	0.0724
st.dev.(D2163:14e1)	0.01670
R(D2163:14e1)	0.0468

compare R(EN27941:93(liq)) = 0.7960



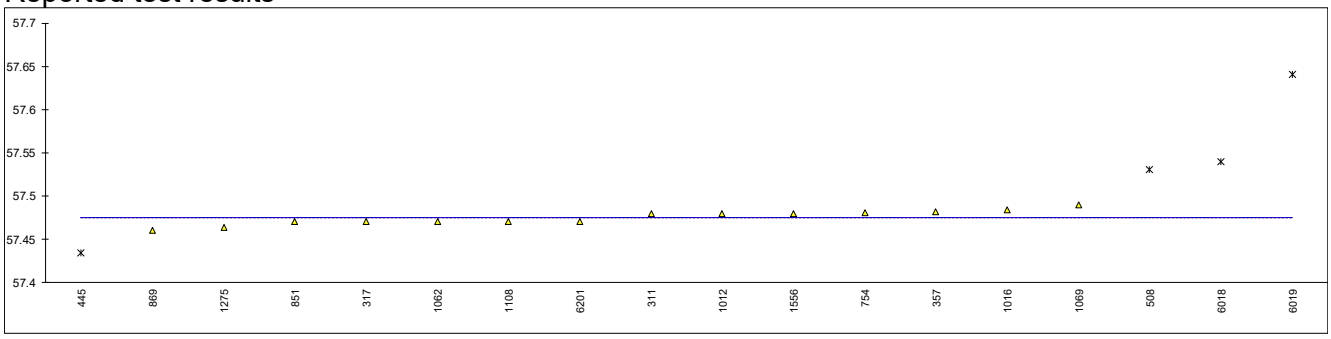


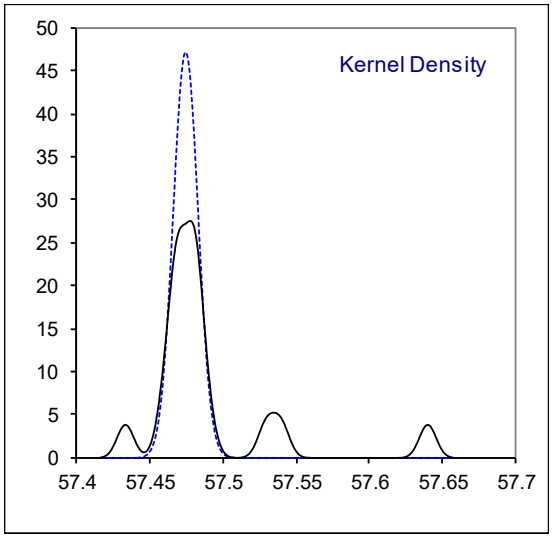
Determination of Molar Mass on sample #19100; results in g/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	INH-407	57.48		-----	
317	INH-001	57.47		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	57.482		-----	
444		-----		-----	
445	ISO8973	57.434	G(0.01)	-----	
453		-----		-----	
508	D2598	57.53	ex	-----	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2421	57.481		-----	
851	D2598	57.47		-----	
869	D2598	57.46		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1012	D2163	57.48		-----	
1016	EN27941	57.4837		-----	
1026		-----		-----	
1040		-----		-----	
1062	D2163	57.47		-----	
1065		-----		-----	
1069	ISO8973	57.49		-----	
1108	D2163	57.47		-----	
1197		-----		-----	
1198		-----		-----	
1275	EN589	57.464		-----	
1320		-----		-----	
1546		-----		-----	
1556		57.48		-----	
1603		-----		-----	
1634		-----		-----	
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018	ISO8973	57.54	ex	-----	test result excluded, see paragraph 4.1
6019	ISO8973	57.64	ex	-----	test result excluded, see paragraph 4.1
6054		-----		-----	
6193		-----		-----	
6201	ISO8973	57.47		-----	
6238		-----		-----	
					iis calculated from all reported composition results: *)
	normality	OK			OK
	n	14			28
	outliers	1 (+3ex)			0 (+13ex) see paragraph 4.1 for excluded test results
	mean (n)	57.475			57.473
	st.dev. (n)	0.0085	RSD = 0.01%		0.0141 RSD = 0.02%
	R(calc.)	0.024			0.040
comp.	R(iis18S02B)	0.058			0.076

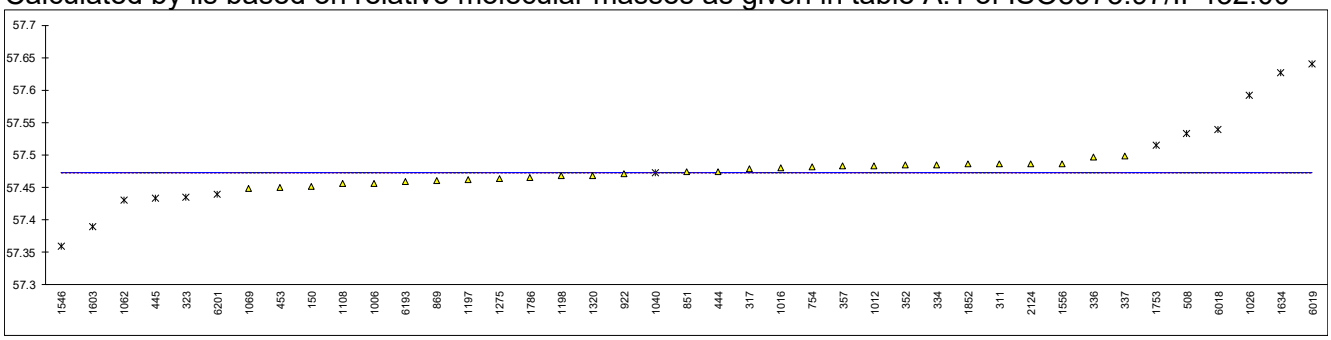
*) Calculated by iis based on relative molecular masses as given in table A.1 of ISO8973:97/IP432:00
NB. Effect of different factors of ISO8973:97/IP432:00 and ASTM D2421:18 on the calculation is very small

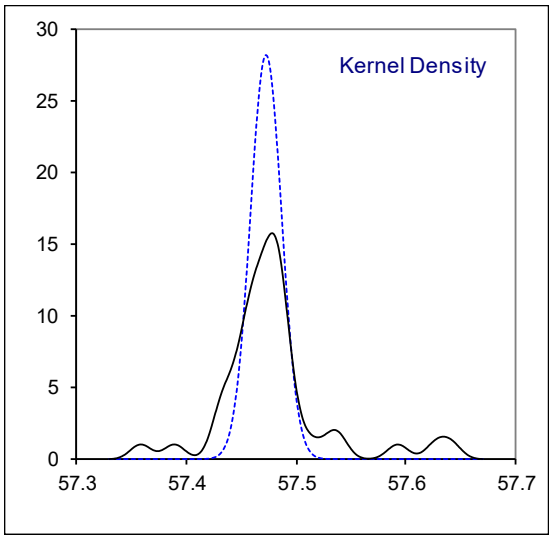
Reported test results





Calculated by iis based on relative molecular masses as given in table A.1 of ISO8973:97/IP432:00



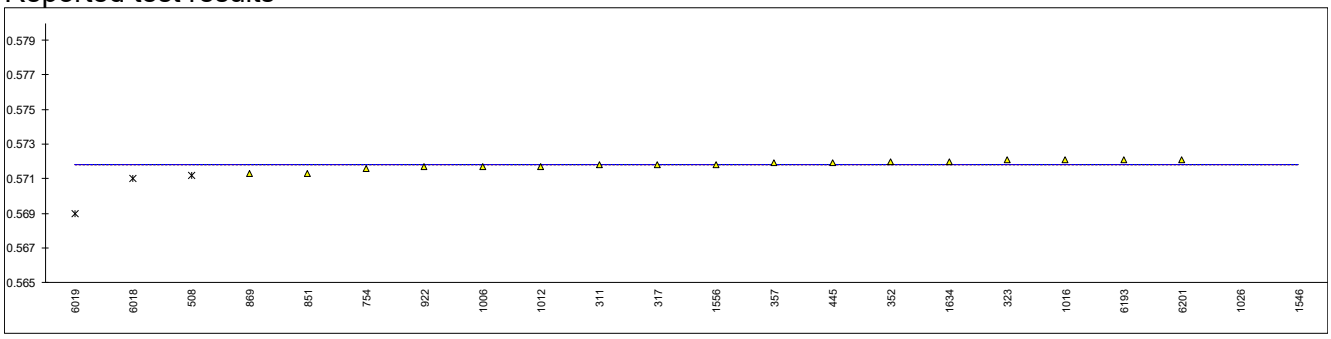


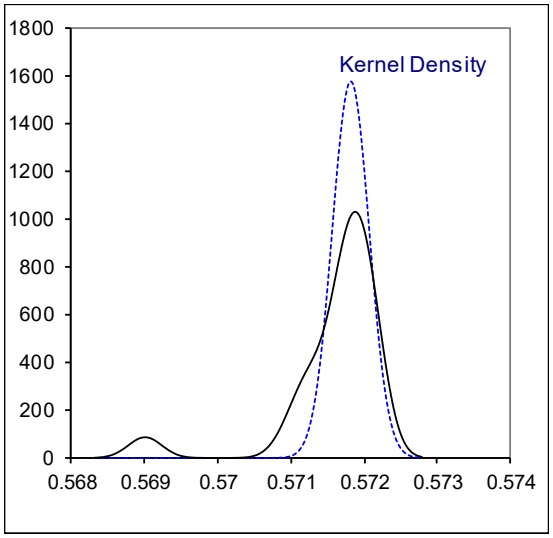
Determination of Relative Density at 60/60°F on sample #19100; unitless results

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	INH-407	0.5718		-----	
317	INH-001	0.5718		-----	
323	D2598	0.5721		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	ISO8973	0.572		-----	
357	D2598	0.5719		-----	
444		-----		-----	
445	ISO8973	0.5719		-----	
453		-----		-----	
508	D2598	0.5712	ex	-----	test result excluded, see paragraph 4.1
704		-----		-----	
707		-----		-----	
754	D2598	0.5716		-----	
851	D2598	0.5713		-----	
869	D2598	0.5713		-----	
875		-----		-----	
922	D2598	0.5717		-----	
1006	D2598	0.5717		-----	
1012	D2598	0.5717	C	-----	first reported: 0.5632
1016	ISO8973	0.5721		-----	
1026		560.8	G(0.01), E	-----	calculation error, iis calculated: 0.5719
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108		-----		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320		-----		-----	
1546	ISO8973	569.61	ex, E	-----	test result excluded, see p. 4.1, calc. error, iis calculated: 0.5696
1556	ISO8973	0.5718	C	-----	first reported: 571.8
1603		-----		-----	
1634	ISO8973	0.5720	C	-----	first reported: 572
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018	ISO8973	0.571	ex	-----	test result excluded, see paragraph 4.1
6019	ISO8973	0.569	ex	-----	test result excluded, see paragraph 4.1
6054		-----		-----	
6193	ISO8973	0.5721		-----	
6201	ISO8973	0.5721		-----	
6238		-----		-----	
					iis calculated from all reported composition results: *)
	normality	OK			OK
	n	17			28
	outliers	1 (+4ex)			0 (+13ex) see paragraph 4.1 for excluded test results
	mean (n)	0.5718			0.5717
	st.dev. (n)	0.00025	RSD = 0.04%		0.00016 RSD = 0.03%
	R(calc.)	0.0007			0.0005
comp.	R(iis18S02B)	0.0010			0.0005

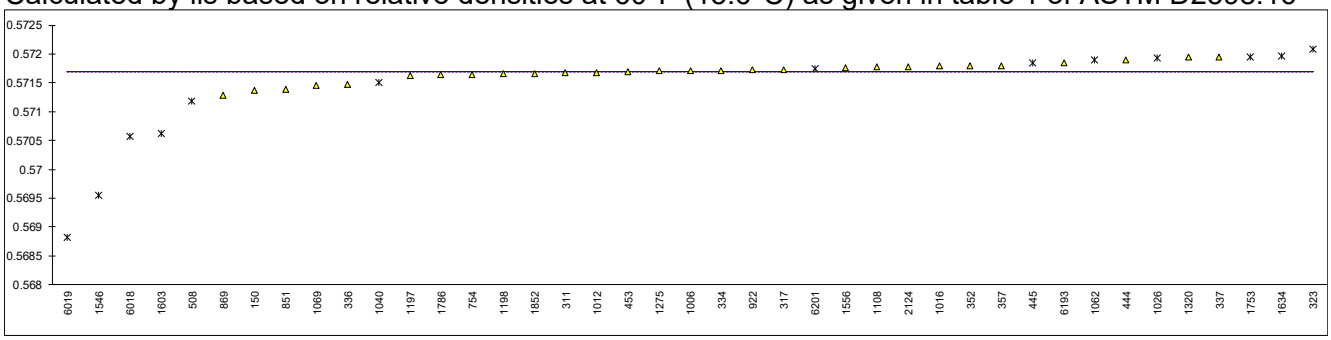
*) Calculated by iis based on relative densities at 60°F (15.6°C) as given in table 1 of ASTM D2598:16
N.B. ASTM D2598:16 does not mention a relative density factor at 60°F (15.6°C) for 1,3-Butadiene. For this component the value of 0.6272 is taken from ASTM D2163:14e1
N.B. Effect of different factors from ASTM D2598:16 and ISO8973:97/IP432:00 on the calculation is very small.

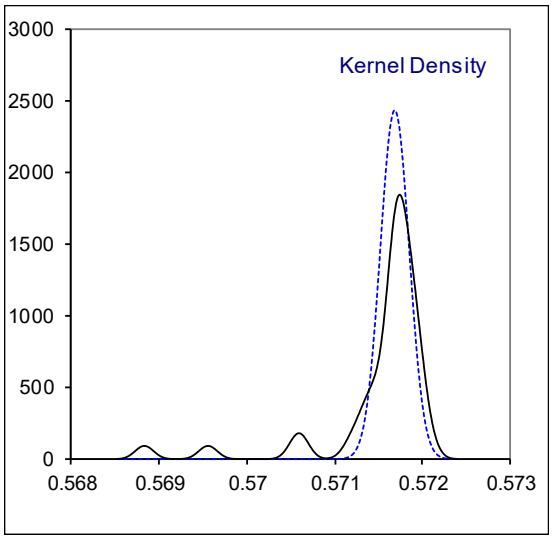
Reported test results





Calculated by iis based on relative densities at 60°F (15.6°C) as given in table 1 of ASTM D2598:16





Determination of Abs. Vapor Pressure at 100°F on sample #19100; results in psi

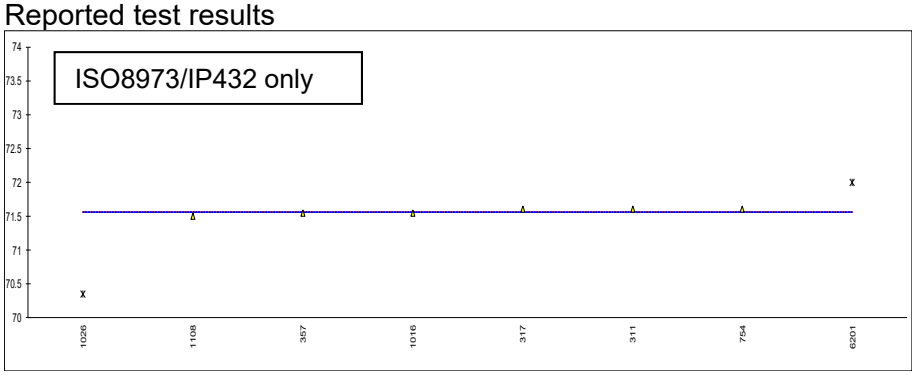
lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	ISO8973	71.6		-----	
317	ISO8973	71.6		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	71.54		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
508		-----		-----	
704		-----		-----	
707		-----		-----	
754	ISO8973	71.6		-----	
851	D2598	71.2		-----	
869	D2598	71.3		-----	
875		-----		-----	
922	D2598	71.13		-----	
1006	D2598	71.0		-----	
1012		-----		-----	
1016	EN589	71.5407		-----	
1026	ISO8973	70.343	G(0.01)	-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108	ISO8973	71.5		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320		-----		-----	
1546		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6054		-----		-----	
6193		-----		-----	
6201	ISO8973	72	G(0.01)	-----	
6238		-----		-----	

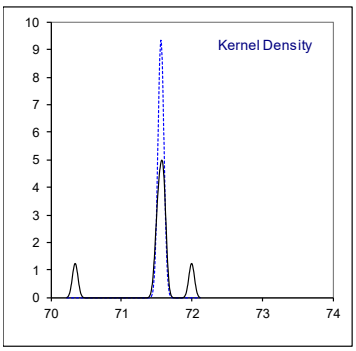
Evaluated over ISO8973/IP432 test results only				iis calculated from all test results *)	
	normality	OK		OK	
	n	6		28	
	outliers	2		0 (+13ex)	see paragraph 4.1 for excluded test results
	mean (n)	71.5635		71.6628	
	st.dev. (n)	0.04266	RSD = 0.06%	0.16767	RSD = 0.23%
	R(calc.)	0.1195		0.4695	
comp.	R(iis18S02B))	0.5214		0.5593	

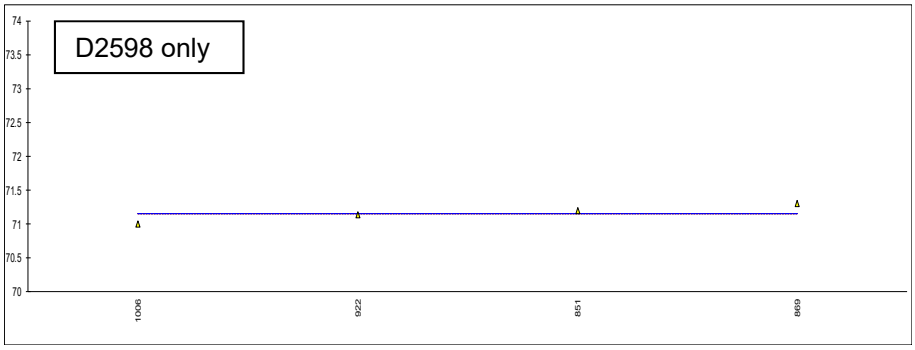
Evaluated over D2598 test results only				iis calculated from all test results **)	
	normality	unknown		OK	
	n	4		28	
	outliers	0		0 (+13ex)	see paragraph 4.1 for excluded test results
	mean (n)	71.1575		70.9775	
	st.dev. (n)	0.12606	RSD = 0.18%	0.14295	RSD = 0.20%
	R(calc.)	0.3530		0.4003	
comp.	R(iis18S02B))	1.5724		0.4861	

*) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table A.1 of ISO8973:97/IP432:00
**) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table 1 of ASTM D2598:16. For calculation of Vapor Pressure according to D2598, the factor for 1,3-Butadiene is taken from the GPSA data book (ed. 13) in psig (59.46 psia = 45 psig). The conversion from psia to psig was done as follows: 59.46 psia - (101.325 kPa * 0.145038) = 44.76 = 45 psig.

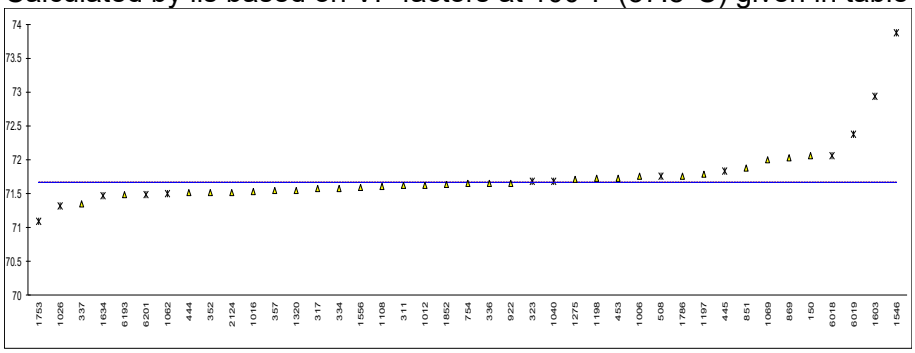
Reported test results

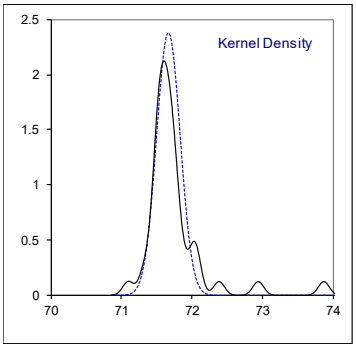




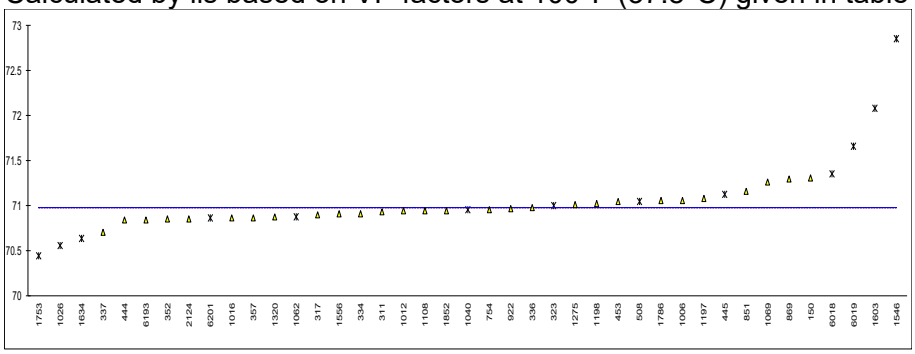


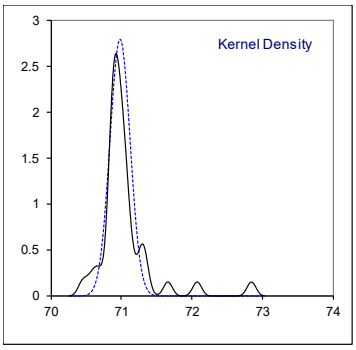
Calculated by iis based on VP factors at 100°F (37.8°C) given in table A.1 of ISO8973:97/IP432:00





Calculated by iis based on VP factors at 100°F (37.8°C) given in table 1 of ASTM D2598:16





Determination of Rel. Vapor Pressure at 100°F on sample #19100; results in psi

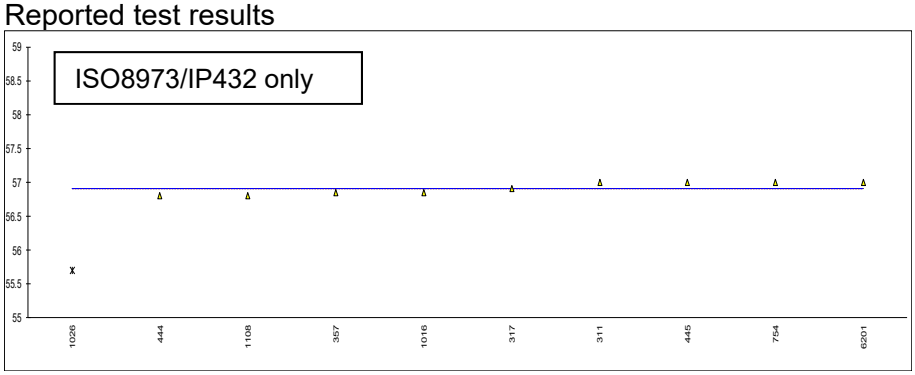
lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	ISO8973	57.0		-----	
317	ISO8973	56.9		-----	
323	D2598	56.34		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	56.84		-----	
444	ISO8973	56.8		-----	
445	ISO8973	57		-----	
453		-----		-----	
508	D2598	57	ex, E	-----	test res. excl., see p 4.1, iis calc. for D2598: 56.35 and for ISO8973: 57.06
704		-----		-----	
707		-----		-----	
754	ISO8973	57.0		-----	
851	D2598	56.5		-----	
869	D2598	56.6		-----	
875		-----		-----	
922	D2598	56.43		-----	
1006	D2598	56.4		-----	
1012		-----		-----	
1016	EN589	56.8447		-----	
1026	ISO8973	55.694	G(0.01)	-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108	ISO8973	56.8		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320		-----		-----	
1546		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6054		-----		-----	
6193		-----		-----	
6201	ISO8973	57		-----	
6238		-----		-----	

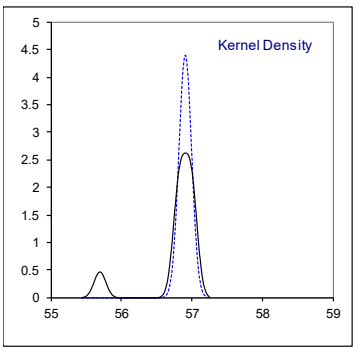
Evaluated over ISO8973/IP432 test results only				iis calculated from all test results *)	
	normality	OK		OK	
	n	9		28	
	outliers	1		0 (+13ex)	see paragraph 4.1 for excluded test results
	mean (n)	56.9094		56.9669	
	st.dev. (n)	0.09073	RSD = 0.16%	0.16767	RSD = 0.29%
	R(calc.)	0.2541		0.4695	
comp.	R(iis18S02B))	0.8193		0.5593	

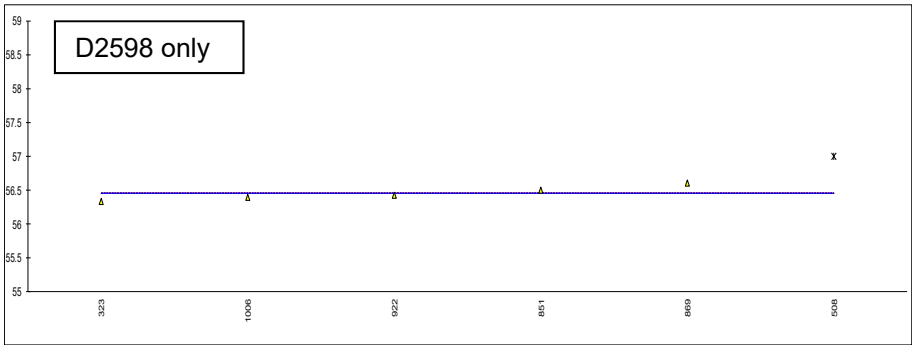
Evaluated over D2598 test results only				iis calculated from all test results **)	
	normality	OK		OK	
	n	5		28	
	outliers	0 (+1ex)		0 (+13ex)	see paragraph 4.1 for excluded test results
	mean (n)	56.4540		56.2815	
	st.dev. (n)	0.09990	RSD = 0.18%	0.14295	RSD = 0.25%
	R(calc.)	0.2797		0.4003	
comp.	R(iis18S02B))	1.0153		0.4861	

*) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table A.1 of ISO8973:97/IP432:00
**) Calculated by iis based on Vapor Pressure factors at 100°F (37.8°C) as given in table 1 of ASTM D2598:16. For calculation of Vapor Pressure according to D2598, the factor for 1,3-Butadiene is taken from the GPSA data book (ed. 13) in psig (59.46 psia = 45 psig). The conversion from psia to psig was done as follows: 59.46 psia - (101.325 kPa * 0.145038) = 44.76 = 45 psig.

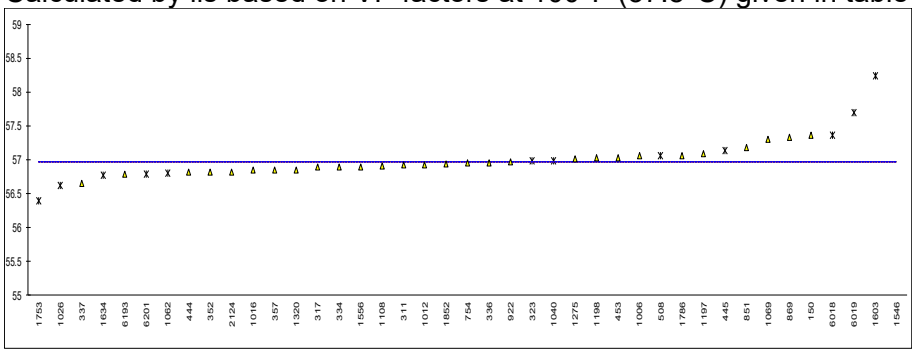
Reported test results

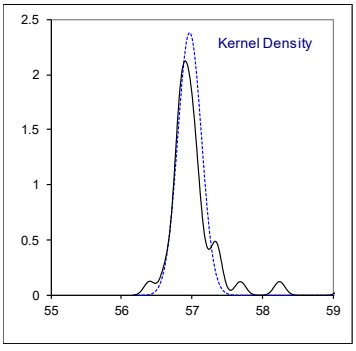




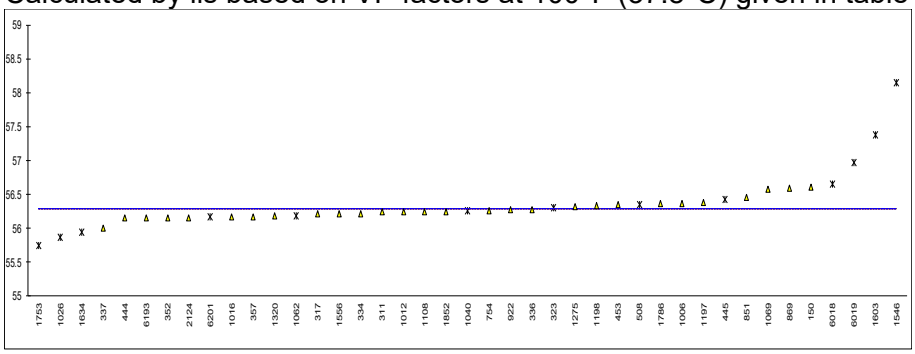


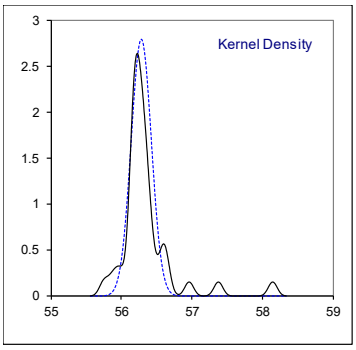
Calculated by iis based on VP factors at 100°F (37.8°C) given in table A.1 of ISO8973:97/IP432:00





Calculated by iis based on VP factors at 100°F (37.8°C) given in table 1 of ASTM D2598:16



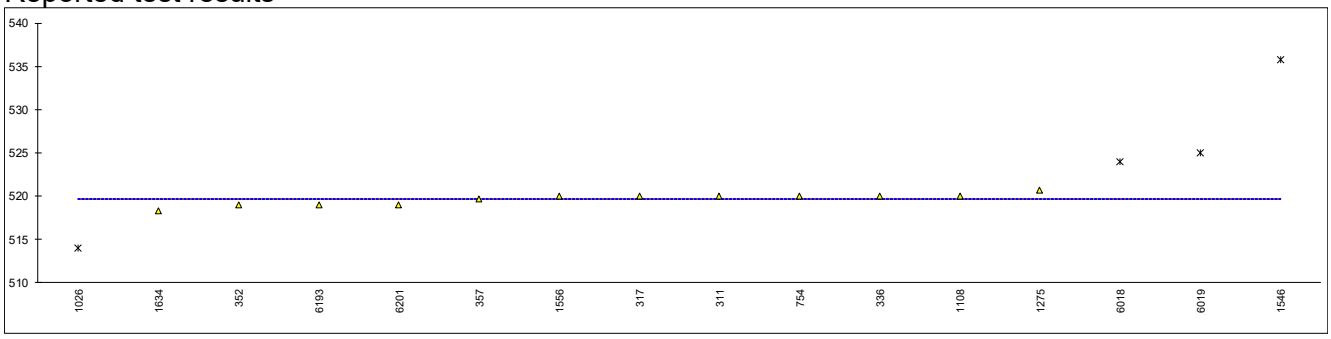


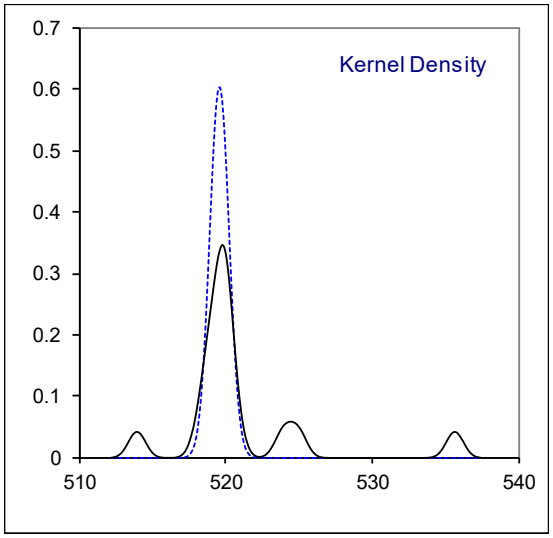
Determination of Abs. Vapor Pressure at 40°C on sample #19100; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	ISO8973	520		-----	
317	ISO8973	520		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336	ISO8973	520		-----	
337		-----		-----	
352	ISO8973	519		-----	
357	ISO8973	519.6		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
508		-----		-----	
704		-----		-----	
707		-----		-----	
754	ISO8973	520		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026	ISO8973	514	G(0.01), E	-----	calculation error, iis calculated: 517.9
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108	ISO8973	520		-----	
1197		-----		-----	
1198		-----		-----	
1275	EN589	520.7		-----	
1320		-----		-----	
1546	ISO8973	535.7	ex	-----	test result excluded, see paragraph 4.1
1556	ISO8973	519.94		-----	
1603		-----		-----	
1634	ISO8973	518.325	E	-----	calculation error, iis calculated: 519.1
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018	ISO8973	524	ex, E	-----	test result excluded, see paragraph 4.1, calc.error, iis calc.523.0
6019	ISO8973	525	ex	-----	test result excluded, see paragraph 4.1
6054		-----		-----	
6193	ISO8973	519		-----	
6201	ISO8973	519	C	-----	first reported: 75 psi
6238		-----		-----	
					iis calculated from al reported composition results *):
	normality	OK			OK
	n	12			28
	outliers	1 (+3ex)			0 (+13ex) see paragraph 4.1 for excluded test results
	mean (n)	519.6304			520.4489
	st.dev. (n)	0.66196	RSD = 0.13%		1.18488 RSD = 0.25%
	R(calc.)	1.8535			3.3177
comp.	R(iis18S02B)	9.9787			3.9849

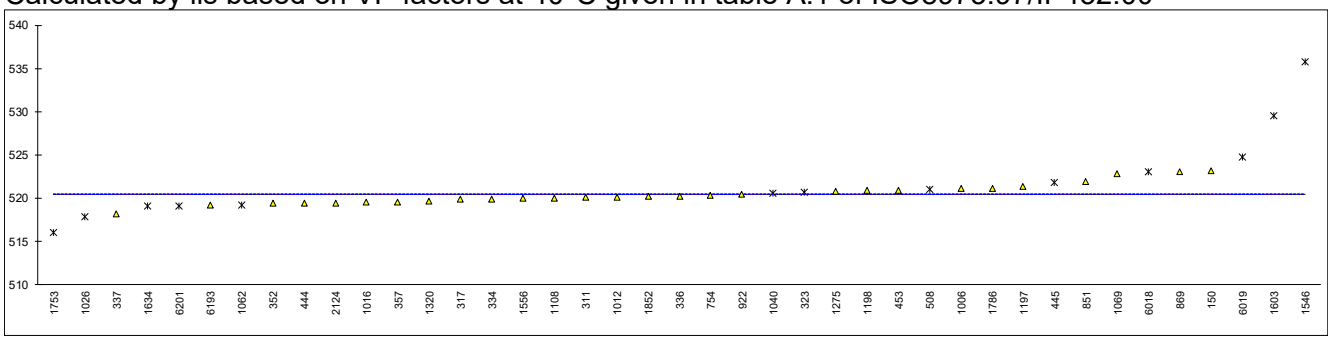
*) Calculated by iis based on the Vapor Pressure factors at 40°C as given in table A.1 of ISO8973:97/IP432:00

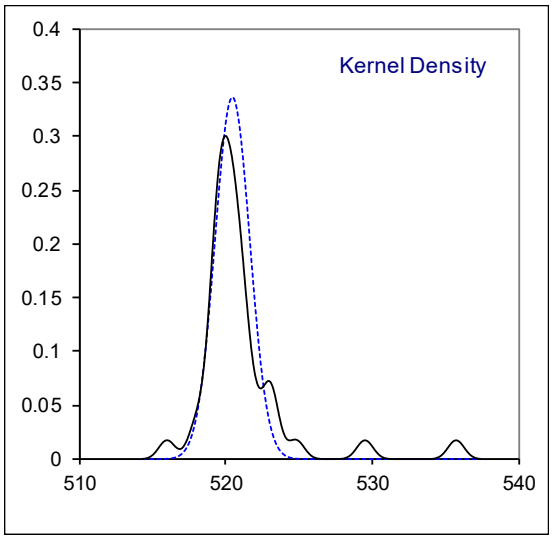
Reported test results





Calculated by iis based on VP factors at 40°C given in table A.1 of ISO8973:97/IP432:00



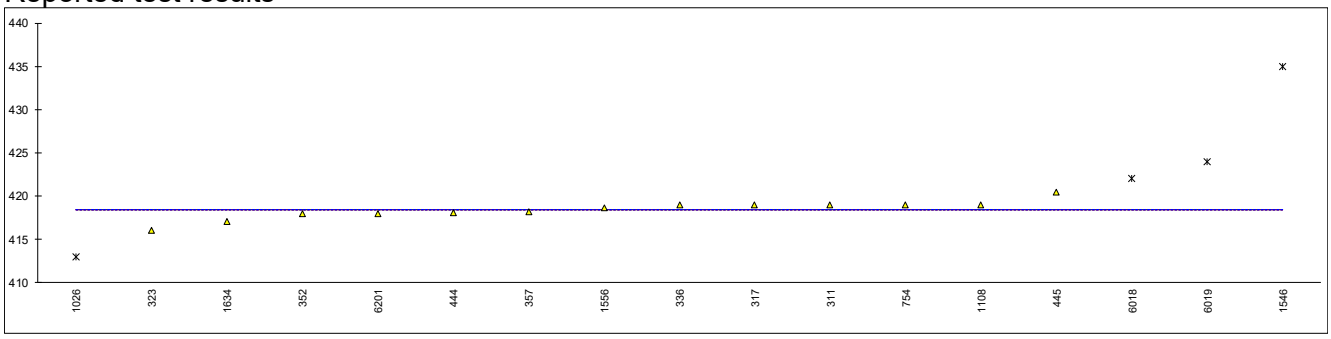


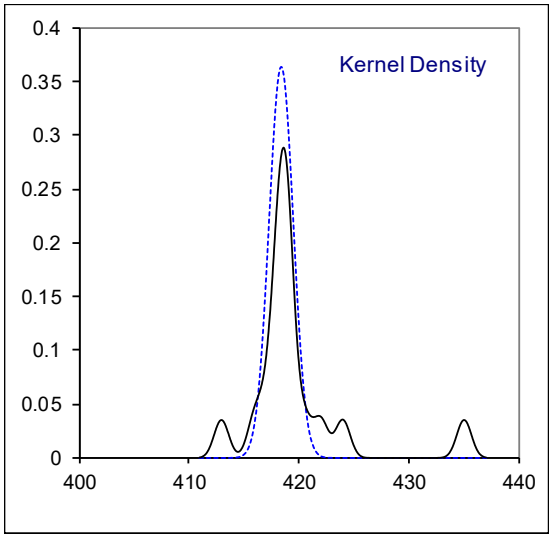
Determination of Rel. Vapor Pressure at 40°C on sample #19100; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311	ISO8973	419		-----	
317	ISO8973	419		-----	
323	ISO8973	416	E	-----	calculation error, iis calculated: 419.4
333		-----		-----	
334		-----		-----	
336	ISO8973	419		-----	
337		-----		-----	
352	ISO8973	418		-----	
357	ISO8973	418.2		-----	
444	ISO8973	418.1		-----	
445	ISO8973	420.5		-----	
453		-----		-----	
508		-----		-----	
704		-----		-----	
707		-----		-----	
754	ISO8973	419		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026	ISO8973	413	G(0.01), E	-----	calculation error, iis calculated: 416.6
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108	ISO8973	419		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320		-----		-----	
1546	ISO8973	435	ex	-----	test result excluded, see paragraph 4.1
1556	ISO8973	418.62		-----	
1603		-----		-----	
1634	ISO8973	417	E	-----	calculation error, iis calculated: 417.7
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018	ISO8973	422	ex	-----	test result excluded, see paragraph 4.1
6019	ISO8973	424	ex	-----	test result excluded, see paragraph 4.1
6054		-----		-----	
6193		-----		-----	
6201	ISO8973	418	C	-----	first reported: 61 psi
6238		-----		-----	
					iis calculated from al reported composition results *):
	normality	suspect			OK
	n	13			28
	outliers	1 (+3ex)			0 (+13ex) see paragraph 4.1 for excluded test results
	mean (n)	418.4169			419.1239
	st.dev. (n)	1.09638	RSD = 0.26%		1.18488 RSD = 0.28%
	R(calc.)	3.0699			3.3177
comp.	R(iis18S02B)	4.9520			3.9849

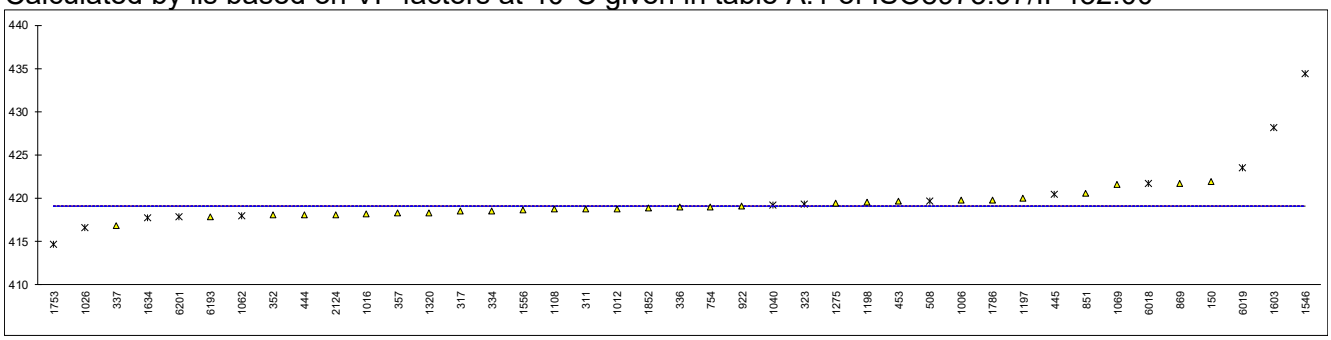
*) Calculated by iis based on the Vapor Pressure factors at 40°C as given in table A.1 of ISO8973:97/IP432:00

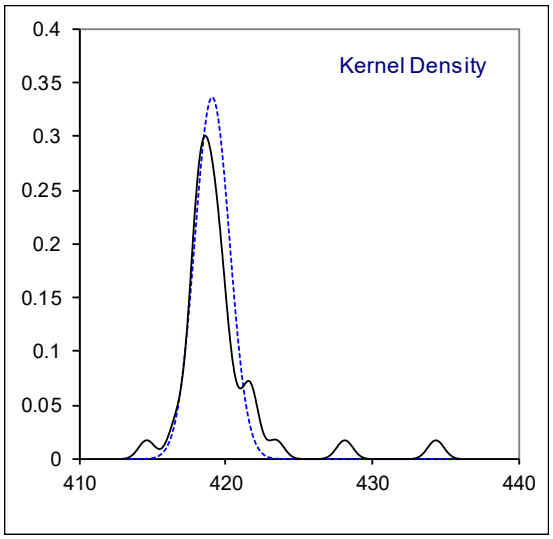
Reported test results





Calculated by iis based on VP factors at 40°C given in table A.1 of ISO8973:97/IP432:00





Determination of Motor Octane Number, MON on sample #19100;

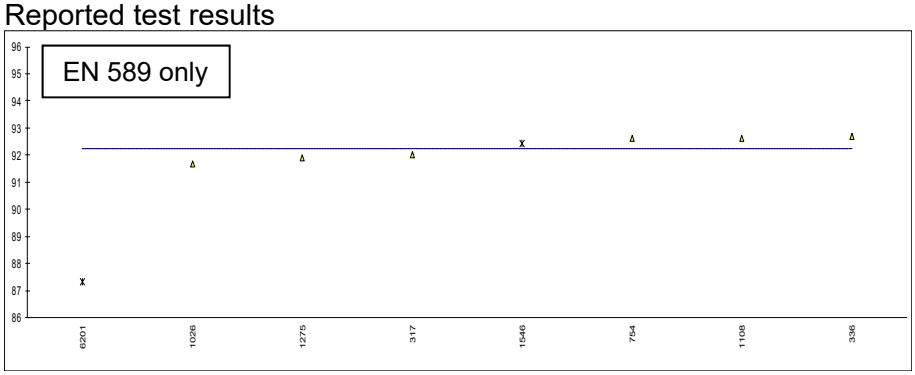
lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311		-----		-----	
317	EN589	92.0		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336	EN589	92.7	E	-----	calculation error, iis calculated: 92.2 (acc. to EN589)
337		-----		-----	
352		-----		-----	
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
508		-----		-----	
704		-----		-----	
707		-----		-----	
754	EN589	92.6	E	-----	calculation error, iis calculated: 92.0 (acc. to EN589)
851	D2598	94.5		-----	
869	D2598	94.54		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026	ISO8973	91.656		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108	EN589	92.6	E	-----	calculation error, iis calculated: 92.0 (acc. to EN589)
1197		-----		-----	
1198		-----		-----	
1275	EN589	91.9		-----	
1320		-----		-----	
1546	EN589	92.43	ex	-----	test result excluded, see paragraph 4.1
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6054		-----		-----	
6193		-----		-----	
6201	EN589	87.32	G(0.05), E	-----	calculation error, iis calculated: 91.8
6238		-----		-----	

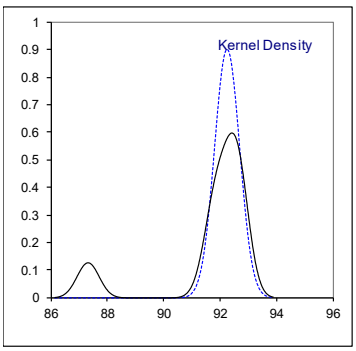
Evaluated over EN589 test results only				iis calculated from all test results *)	
	normality	OK		OK	
	n	6		28	
	outliers	1 (+1ex)		0 (+13ex)	see paragraph 4.1 for excluded test results
	mean (n)	92.243		92.008	
	st.dev. (n)	0.4438	RSD = 0.48%	0.0766	RSD = 0.08%
	R(calc.)	1.243		0.215	
comp.	R(iis18S02B))	0.8255		0.213	

Evaluated over D2598 test results only				iis calculated from all test results **)	
	normality	n.a.		OK	
	n	2		28	
	outliers	n.a.		0 (+13ex)	see paragraph 4.1 for excluded test results
	mean (n)	94.52		94.449	
	st.dev. (n)	n.a.	RSD = n.a.	0.0393	RSD = 0.04%
	R(calc.)	n.a.		0.110	
comp.	R(iis18S02B))	3.1224		0.141	

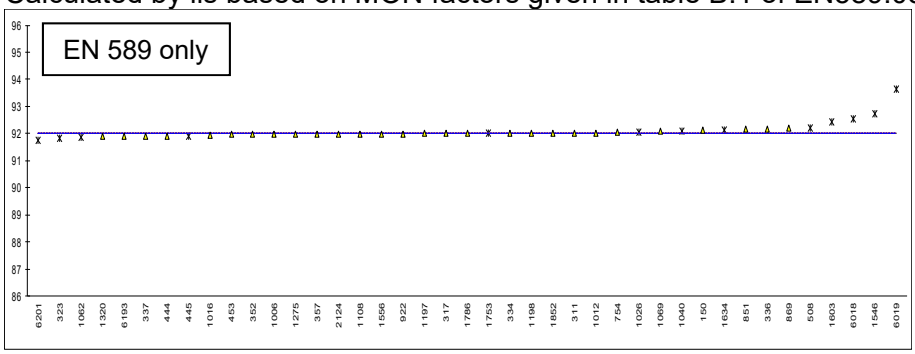
*) Calculated by iis based on MON factors given in table B.1 of EN589:08+A1:12. This method does not mention a MON factor for 1,3-Butadiene. For this component an estimated value of 70 is used in the calculations in analogy of the MON factors of the other components.
**) Calculated by iis based on MON factors given in table 1 of ASTM D2598:16. This method does not mention MON factors for iso-Butene, trans-2-Butene or 1,3-Butadiene. For iso-Butene and trans-2-Butene the value of 83.5 of cis-2-Butene is used in analogy of EN589 and for 1,3-Butadiene an estimated value of 70 is used in the calculations in analogy of the MON factors of the other components.

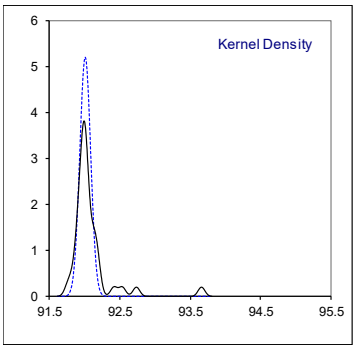
Reported test results

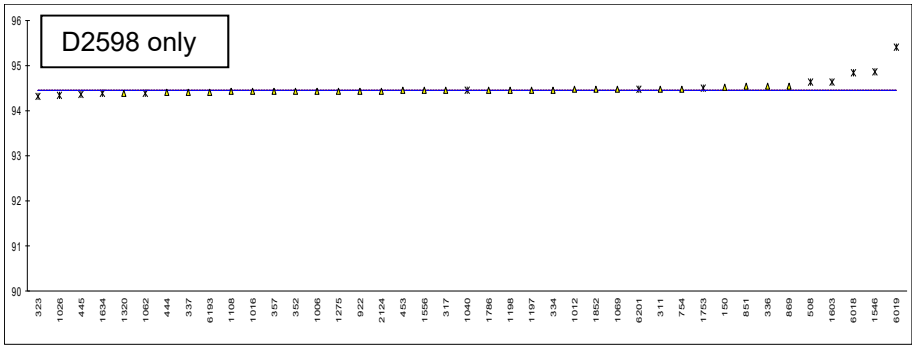


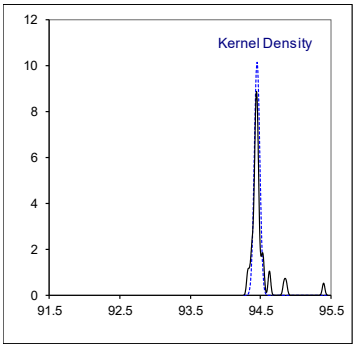


Calculated by iis based on MON factors given in table B.1 of EN589:05+A1:12







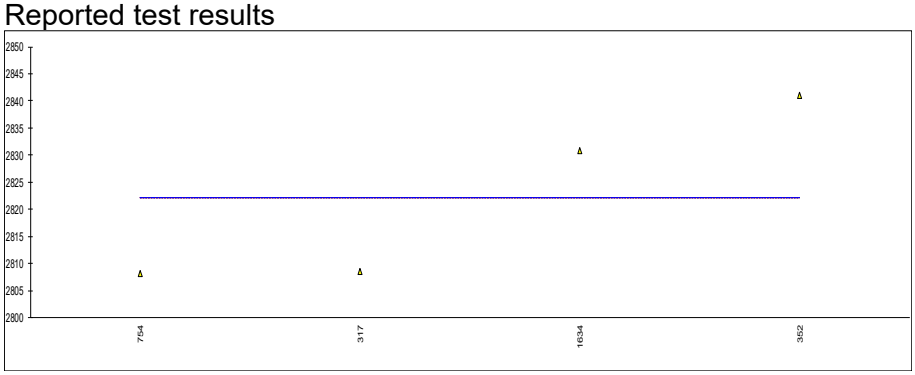


Determination of Ideal Gross Heating Value at 14.696 psia/60°F on sample #19100; results in kJ/mol

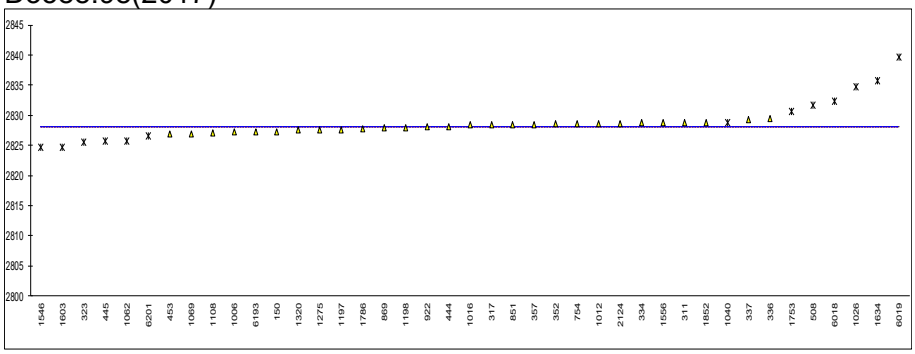
lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311		-----		-----	
317	D3588	2808.6		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	D3588	2841.05		-----	
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
508		-----		-----	
704		-----		-----	
707		-----		-----	
754	D3588	2808.2		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108		-----		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320		-----		-----	
1546		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	2830.75		-----	
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6054		-----		-----	
6193		-----		-----	
6201		-----		-----	
6238		-----		-----	
					iis calculated from all test results: *)
	normality	unknown			OK
	n	4			28
	outliers	0			0 (+13ex) see paragraph 4.1 for excluded test results
	mean (n)	2822.15			2828.10
	st.dev. (n)	16.425	RSD = 0.58%		0.714 RSD = 0.03%
	R(calc.)	45.99			2.00
comp.	R(iis18S02B)	65.731			2.84

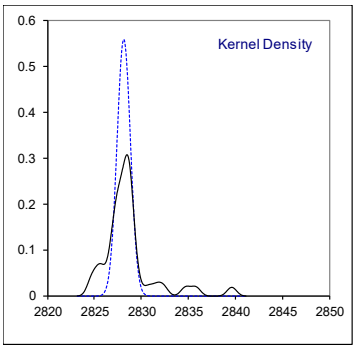
*) Calculated by iis based on the Ideal Gross Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017). Unfortunately, this method does not mention an Ideal Gross Heating Value factor for 1,3-Butadiene. For the calculation, iis has used the factor 2542.03 from table 3 of ISO6976:16.

Reported test results



Calculated by iis based on Ideal Gross Heating Value factors at 14696 psia/60°F given in table 1 of D3588:98(2017)



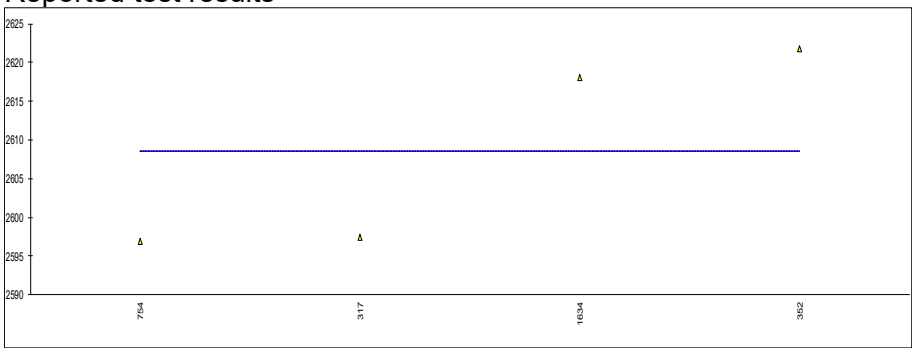


Determination of Ideal Net Heating Value at 14.696 psia/60°F on sample #19100; results in kJ/mol

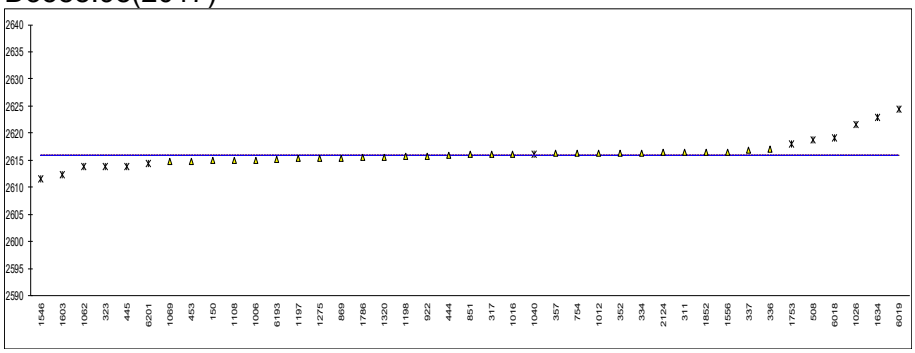
lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
311		-----		-----	
317	D3588	2597.4		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	D3588	2621.71		-----	
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
508		-----		-----	
704		-----		-----	
707		-----		-----	
754	D3588	2596.9		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1108		-----		-----	
1197		-----		-----	
1198		-----		-----	
1275		-----		-----	
1320		-----		-----	
1546		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	2618.08		-----	
1753		-----		-----	
1786		-----		-----	
1852		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6054		-----		-----	
6193		-----		-----	
6201		-----		-----	
6238		-----		-----	
					iis calculated from all test results: *)
	normality	unknown			OK
	n	4			28
	outliers	0			0 (+13ex) see paragraph 4.1 for excluded test results
	mean (n)	2608.52			2615.84
	st.dev. (n)	13.217	RSD = 0.58%		0.639 RSD = 0.02%
	R(calc.)	37.01			1.79
comp.	R(iis18S02B)	49.83			3.44

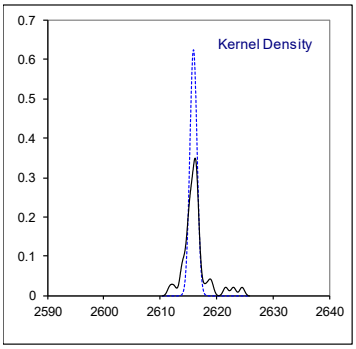
*) Calculated by iis based on the Ideal Net Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017). Unfortunately, this method does not mention an Ideal Gross Heating Value factor for 1,3-Butadiene. For the calculation, iis has used the factor 2408.8 from table 3 of ISO6976:16.

Reported test results



Calculated by iis based on Ideal Gross Heating Value factors at 14696 psia/60°F given in table 1 of D3588:98(2017)





APPENDIX 2

Number of participants per country

1 lab in AUSTRALIA
2 labs in BELGIUM
1 lab in BULGARIA
1 lab in CHINA, People's Republic
1 lab in CONGO Brazzaville
1 lab in COTE D'IVOIRE
1 lab in DENMARK
2 labs in FINLAND
4 labs in FRANCE
3 labs in GERMANY
1 lab in GREECE
1 lab in HONG KONG
1 lab in ISRAEL
3 labs in MALAYSIA
5 labs in NETHERLANDS
1 lab in NIGERIA
1 lab in PAKISTAN
1 lab in PANAMA
4 labs in PORTUGAL
1 lab in ROMANIA
2 labs in RUSSIAN FEDERATION
1 lab in SLOVAKIA
1 lab in SWEDEN
1 lab in TAIWAN
2 labs in UKRAINE
4 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	= possibly an error in calculations
W	= test result withdrawn on request of participant
ex	= test result excluded from the statistical evaluation
n.a.	= not applicable
n.d.	= not detected
n.e.	= not evaluated
fr.	= first reported
SDS	= Material Safety Data Sheet

Literature:

1 iis Interlaboratory Studies, Protocol for the Organization, Statistics and Evaluation, June 2018
2 prNEN 12766-2:00
3 ASTM E178:16
4 ASTM E130:95(2003)
5 ISO 5725:86(1994)
6 ISO 5725, parts 1-6:94
7 M. Thompson and R. Wood, J. AOAC Int, 76, 926, (1993)
8 W.J. Youden and E.H. Steiner, Statistical Manual of the AOAC, (1975)
9 IP 367:84
10 DIN 38402 T41/42
11 P.L. Davies, Fr. Z. Anal. Chem, 331, 513, (1988)
12 J.N. Miller, Analyst, 118, 455, (1993)
13 Analytical Methods Committee Technical Brief, No 4, January 2001
14 P.J. Lowthian and M. Thompson, The Royal Society of Chemistry, Analyst 2002, 127, 1359-1364 (2002)
15 ISO17043
16 EN27941
17 ASTM D2163
18 ASTM D2421
19 Bernard Rosner, Percentage Points for a Generalized ESD Many-Outlier Procedure, Technometrics, 25(2), 165-172, (1983)
20 J.B. Maxwell, Data book on Hydrocarbons, 5th edition, 3 (1958)