Results of Proficiency Test
Liquefied Butane
July 2020

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 test for Liquefied Butane every year. For this round robin a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up because iis has limited gas-handling facilities in place to prepare gas samples. 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 52 laboratories in 28 different countries registered for participation. See appendix 2 for the number of participants per country. In this report the results of this 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 optimize the costs for the participating laboratories, it was decided to prepare one Liquefied Butane mixture. The mixture was divided over a batch of 64 cylinders. Each cylinder was uniquely numbered. The cylinder size is a cost-effective one-liter cylinder with dip tube device. The limited cylinder size is chosen to optimize sample stability, cylinder costs, transport and handling costs. It was decided to send one cylinder of 1L, labelled #20090 and 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

One batch of 64 cylinders of one liter 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 20/0492, starting in May 2020). Each cylinder was uniquely numbered. Every cylinder in the batch was analyzed 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.

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 (D2163:14(2019)) in %mol/mol
Propane	0.004	0.057
Propene	0.004	0.092
iso-Butane	0.032	0.282
n-Butane	0.011	0.068
1-Butene	0.011	0.085
iso-Butene	0.008	0.077
trans-2-Butene	0.008	0.052
cis-2-Butene	0.010	0.085
1,3-Butadiene	0.004	0.039
iso-Pentane	0.004	0.015

Table 1: evaluation of homogeneity test results of subsamples #20090

The calculated repeatabilities were in agreement with 0.3 times the corresponding reproducibility of the reference test method ASTM D2163:14(2019). Therefore, homogeneity of the subsamples was assumed.

To each of the participating laboratories one 1L cylinder labelled #20090 was sent on June 24, 2020. An SDS was added to the sample package. The planned shipment date was May 27, 2020 but the PT had to be postponed for a month because of storage problems for gas samples as a consequence of lockdowns worldwide due to Covid-19.

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 ANALYZES

The participants were requested to determine on sample #20090: 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 were encountered with the dispatch of the samples due to the COVID-19 pandemic. Nearly all of the reporting participants reported their test results within the deadline. Five participants did not report any test results at all. Not all participants were able to report test results for all requested tests.

In total 47 participants reported 665 test results. Observed were 41 outlying test results, which is 6.2% 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 explained 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 D2163:14(2019) is used to evaluate the performance of the test results for the composition of Liquefied 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.

Four laboratories (404, 1776, 6019 and 6262) reported deviating test results for many of the gas composition test results. At least four 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. This means that 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.

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 five other laboratories (323, 1026, 1062, 1065 and 6018) with one, two or three outliers in the composition. Furthermore, three other laboratories (1556, 6193 and 6315) were excluded from the calculated results because the sum of the composition results was not 100%.

Propane: The determination of this component may be problematic depending on the requirements of the test method used. Four statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the requirements of ASTM D2163:14(2019) but it is in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

Propene: The determination of this component was problematic for a number of laboratories. Four statistical outliers were observed. However, the calculated reproducibility after rejection of the statistical outliers is in agreement with the requirements of ASTM D2163:14(2019) and in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

iso-Butane: The determination of this component may be problematic depending on the requirements of the test method used. Two statistical outliers were observed and three other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility of ASTM D2163:14(2019) but it is a good agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

n-Butane: The determination of this component was not problematic. Five statistical outliers were observed. However, the calculated reproducibility after rejection of the statistical outliers is in good agreement with the reproducibility of ASTM D2163:14(2019) and in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

1-Butene: The determination of this component may be problematic depending on the requirements of the test method used. One statistical outlier was observed and four other test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the requirements of ASTM D2163:14(2019) but it is in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

Iso-Butene: The determination of this component may be problematic depending on the requirements of the test method used. One statistical outlier was 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 D2163:14(2019) but it is in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

trans-2-Butene: The determination of this component was not problematic. Three statistical outliers were observed and two other test results were excluded. The calculated reproducibility after rejection of the suspect data is in good agreement with the reproducibility of ASTM D2163:14(2019) and in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

cis-2-Butene: The determination of this component may be problematic depending on the requirements of the test method used. Two 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 D2163:14(2019) but it is in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

1,3-Butadiene 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 agreement with the reproducibility of ASTM D2163:14(2019) and in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

n-Pentane: The determination of this component may not be problematic. 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 one other test result was excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility of ASTM D2163:14(2019) but it is in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

Total of the composition results: The sum of the test results of the composition per laboratory was calculated by iis. Since the composition results are requested as normalized, every laboratory should have an outcome of 100%. Four calculated results were found to be significantly lower than 100%. From one laboratory it was observed that component cis-2-Butene was not reported. From the other three laboratories may be the test results were not normalized before reporting. However, it was decided to exclude these test results in the evaluations of the Physical Properties.

Molar Mass: This calculated parameter may not be problematic. One statistical outlier was observed, but seven other test results were excluded. 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 (0.037 *vs* 0.069). See also the discussion in paragraph 5.

Relative Density at 60/60°F: This calculated parameter may not be problematic. No statistical outliers were observed but seven test results were excluded. The calculated reproducibility after rejection of the suspect data is 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* 0.0006). See also the discussion in paragraph 5.

Abs. Vapor Pres. at 100°F: This calculated parameter may be problematic dependent on test method used. No statistical outliers were observed in the ISO8973 test results but three test results were excluded. In the ASTM D2598 test results one statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is in agreement with the calculated

reproducibility using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (0.55 *vs* 0.58 psi). But the calculated reproducibility is not in agreement with the calculated reproducibility using the published vapor pressure factors obtained from ASTM D2598:16 over all reported component concentrations (1.49 *vs* 0.50 psi). See also the discussion in paragraph 5.

Rel. Vapor Pres. at 100°F: This calculated parameter may be problematic dependent on test method used. No statistical outliers were observed in the ISO8973/IP432 test results but one test result excluded. In the ASTM D2598 test results two statistical outliers were observed and one test result was excluded. 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 ISO8973:97 over all reported component concentrations (0.69 *vs* 0.58 psi). The calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published vapor pressure factors obtained from ASTM D2598:16 over all reported component concentrations (0.54 *vs* 0.50 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 but six other test results were excluded. 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 (2.42 *vs* 3.30 kPa). See also the discussion in paragraph 5.

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 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 (3.13 *vs* 3.30 kPa). See also the discussion in paragraph 5.

MON: This calculated parameter may be problematic. No statistical outliers were observed in the EN589 test results but six test results were excluded. Two statistical outliers were observed in the ASTM D2598 test results and one other test result was excluded. 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 EN598:08_A1:12 over all reported component concentrations (1.15 *vs* 0.27). The calculated reproducibility after rejection of the suspect data is also not in agreement with the calculated reproducibility using the published vapor pressure factors obtained from D2598:16 over all reported component concentrations (0.83 *vs* 0.11).

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. Two statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers 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 (13 *vs* 4 kJ/mol). However, the calculated reproducibility is smaller than in iis19S02B (46 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 problematic. Two statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not 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 (6 *vs* 3 kJ/mol). However, the calculated reproducibility is smaller than in iis19S02B (37 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, 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)	R(EN27941) liq.-inj.
Propane	%mol/mol	43	1.099	0.219	0.186	1.306
Propene	%mol/mol	43	1.073	0.230	0.299	1.368
iso-Butane	%mol/mol	42	77.441	1.583	0.940	1.486
n-Butane	%mol/mol	42	3.056	0.247	0.228	0.991

Component	unit	n	average	2.8 * sd	R(D2163)	R(EN27941) liq.-inj.
1-Butene	%mol/mol	42	4.994	0.451	0.284	1.026
iso-Butene	%mol/mol	42	3.942	0.333	0.255	1.026
trans-2-Butene	%mol/mol	42	1.677	0.190	0.174	1.026
cis-2-Butene	%mol/mol	40	5.002	0.471	0.284	1.026
1,3-Butadiene	%mol/mol	41	0.895	0.115	0.131	1.065
n-Pentane	%mol/mol	36	<0.1	n.a.	n.a.	n.a.
iso-Pentane	%mol/mol	43	0.819	0.120	0.050	0.798

Table 2: reproducibilities of the composition of sample #20090

Without further statistical calculations, it could be concluded that for many components there is not 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 **iis19S02B**
Molar Mass	g/mol	16	57.56	0.04	0.07	0.04
Rel. Density at 60/60°F		21	0.5705	0.0007	0.0006	0.0005
Abs. VP at 100°F ISO/IP	psi	8	72.24	0.55	0.58	0.35
Abs. VP at 100°F D2598	psi	6	71.76	1.49	0.50	0.40
Rel. VP at 100°F ISO/IP	psi	9	57.61	0.69	0.58	0.30
Rel. VP at 100°F D2598	psi	6	57.02	0.54	0.50	0.40
Abs. VP at 40°C	kPa	16	524.7	2.4	3.3	3.3
Rel. VP at 40°C	kPa	17	423.1	3.1	3.3	3.3
MON EN589		9	92.87	1.15	0.27	0.22
MON D2598		5	94.71	0.83	0.19	0.11
IGHV D3588	kJ/mol	6	2837	13	4	2
INHV D3588	kJ/mol	6	2621	6	3	2

Table 3: reproducibilities of calculated physical properties of sample #20090 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 the previous PT. See also the discussion in paragraph 5.

4.3 COMPARISON OF THE PROFICIENCY TEST OF JULY 2020 WITH PREVIOUS PTS

	July 2020	June 2019	June 2018	June 2017	June 2016
Number of reporting laboratories	47	41	51	49	49
Number of test results	665	549	660	623	627
Number of statistical outliers	41	53	45	30	63
Percentage of statistical outliers	6.2%	9.7%	6.8%	4.8%	10.0%

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 D2163:14(2019). The conclusions are given the following table.

Component	July 2020	June 2019	June 2018	June 2017	June 2016
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.

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 3). 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).

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.

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	1.121	1.099	0.022	0.32
Propene	1.124	1.073	0.051	0.48
iso-Butane	77.398	77.441	-0.043	-0.13
n-Butane	3.004	3.056	-0.051	-0.63
1-Butene	4.986	4.994	-0.009	-0.09
iso-Butene	3.986	3.942	0.044	0.48
trans-2-Butene	1.698	1.677	0.021	0.34
cis-2-Butene	4.984	5.002	-0.019	-0.18
1,3-Butadiene	0.900	0.895	0.005	0.11
iso-Pentane	0.800	0.819	-0.018	-1.02

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

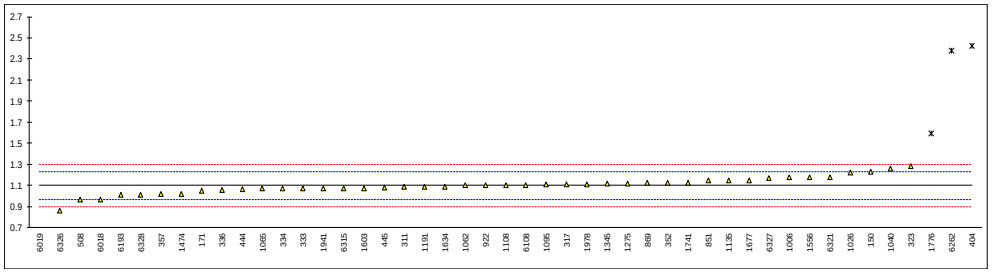
APPENDIX 1

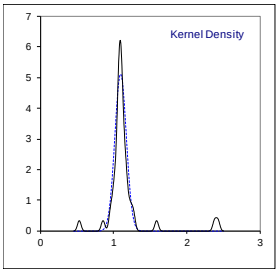
Determination of Propane on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.228		1.94	
171	D2163	1.0512		-0.72	
311	D2163	1.09		-0.14	
317	D2163	1.11		0.16	
323	D2163	1.28		2.72	
333	D2163	1.07		-0.44	
334	D2163	1.07		-0.44	
336	D2163	1.06		-0.59	
352	EN27941	1.1244		0.38	
357	D2163	1.019		-1.21	
404	D2163	2.427	R(0.01)	19.98	
444	ISO7941	1.0641		-0.53	
445	D2163	1.08		-0.29	
508	D2163	0.9626		-2.06	
754		-----		-----	
851	D2163	1.146678		0.71	
869	D2163	1.121		0.33	
875		-----		-----	
922	D2163	1.10		0.01	
1006	D2163	1.175		1.14	
1011		-----		-----	
1026	ISO7941	1.22		1.82	
1040	DIN51619	1.261		2.43	
1062	D2163	1.0993		0.00	
1065	D2163	1.0696215		-0.45	
1095	ISO7941	1.109		0.15	
1108	D2163	1.10		0.01	
1135		1.15		0.76	
1191	IP473	1.09		-0.14	
1275	EN27941	1.116		0.25	
1345	D2163	1.115		0.24	
1474	D2163	1.02	C	-1.19	first reported: 0.91
1556	EN27941	1.18		1.22	
1603		1.0720		-0.41	
1634	ISO7941	1.09		-0.14	
1677	D2163	1.150		0.76	
1741	EN27941	1.126		0.40	
1776	EN27941	1.59	R(0.01)	7.38	
1941	EN27941	1.07		-0.44	
1978	D2163	1.1104		0.17	
6018	EN27941	0.968		-1.97	
6019	EN27941	0.536	R(0.01)	-8.48	
6108	D2163	1.1025		0.05	
6142		-----		-----	
6193	D2163	1.01		-1.34	
6203		-----		-----	
6262	D2163	2.38	C,R(0.01)	19.27	first reported: 2.77
6315	DIN51619	1.070		-0.44	
6321	D2163	1.180		1.22	
6326	D2163	0.86		-3.60	
6327	EN27941	1.1665		1.01	
6328	D2163	1.01		-1.34	

normality	suspect
n	43
outliers	4
mean (n)	1.0992
st.dev. (n)	0.07806
R(calc.)	0.2186
st.dev.(D2163:14)	0.06646
R(D2163:14)	0.1861

Compare R(EN27941:93(liq)) = 1.3058

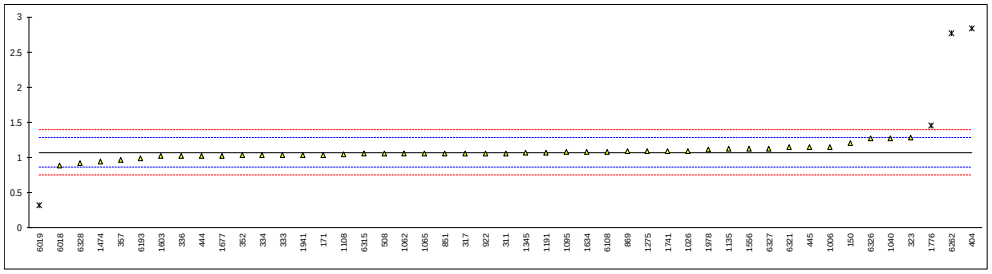


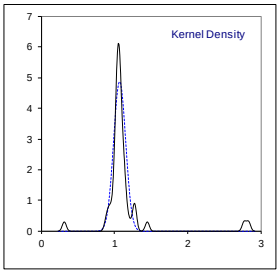


Determination of Propene on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.203		1.22	
171	D2163	1.0331		-0.37	
311	D2163	1.06		-0.12	
317	D2163	1.06		-0.12	
323	D2163	1.28		1.94	
333	D2163	1.03		-0.40	
334	D2163	1.03		-0.40	
336	D2163	1.02		-0.50	
352	EN27941	1.0289		-0.41	
357	D2163	0.967		-0.99	
404	D2163	2.831	R(0.01)	16.49	
444	ISO7941	1.0203		-0.49	
445	D2163	1.15		0.72	
508	D2163	1.0568		-0.15	
754		-----		-----	
851	D2163	1.058097		-0.14	
869	D2163	1.088		0.14	
875		-----		-----	
922	D2163	1.06		-0.12	
1006	D2163	1.150		0.72	
1011		-----		-----	
1026	ISO7941	1.09		0.16	
1040	DIN51619	1.277		1.91	
1062	D2163	1.057		-0.15	
1065	D2163	1.058009		-0.14	
1095	ISO7941	1.078		0.05	
1108	D2163	1.05		-0.22	
1135		1.12		0.44	
1191	IP473	1.07		-0.03	
1275	EN27941	1.088		0.14	
1345	D2163	1.063		-0.09	
1474	D2163	0.94	C	-1.25	first reported: 0.82
1556	EN27941	1.12		0.44	
1603		1.0169		-0.53	
1634	ISO7941	1.08		0.07	
1677	D2163	1.021		-0.49	
1741	EN27941	1.089		0.15	
1776	EN27941	1.45	R(0.01)	3.54	
1941	EN27941	1.03		-0.40	
1978	D2163	1.1158		0.40	
6018	EN27941	0.890		-1.72	
6019	EN27941	0.318	R(0.01)	-7.08	
6108	D2163	1.0840		0.10	
6142		-----		-----	
6193	D2163	0.99		-0.78	
6203		-----		-----	
6262	D2163	2.77	C,R(0.01)	15.91	first reported: 3.28
6315	DIN51619	1.056		-0.16	
6321	D2163	1.145		0.68	
6326	D2163	1.27		1.85	
6327	EN27941	1.1260		0.50	
6328	D2163	0.92		-1.44	

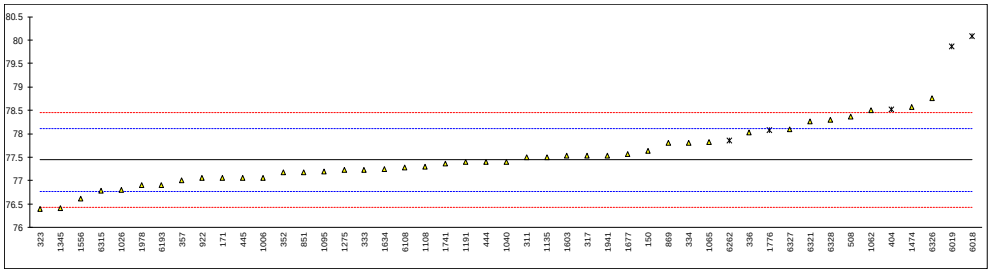
normality	suspect	
n	43	
outliers	4	
mean (n)	1.0730	
st.dev. (n)	0.08210	
R(calc.)	0.2299	
st.dev.(D2163:14)	0.10663	
R(D2163:14)	0.2986	Compare R(EN27941:93(liq)) = 1.3684

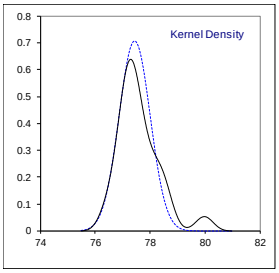




Determination of iso-Butane on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	77.640		0.59	
171	D2163	77.0530		-1.16	
311	D2163	77.50		0.18	
317	D2163	77.54		0.29	
323	D2163	76.39		-3.13	
333	D2163	77.23		-0.63	
334	D2163	77.81		1.10	
336	D2163	78.02		1.72	
352	EN27941	77.1743		-0.79	
357	D2163	77.000		-1.31	
404	D2163	78.513	ex	3.19	test result excluded, see §4.1
444	ISO7941	77.3950		-0.14	
445	D2163	77.06		-1.14	
508	D2163	78.3730		2.78	
754		-----		-----	
851	D2163	77.177474		-0.79	
869	D2163	77.798		1.06	
875		-----		-----	
922	D2163	77.05		-1.17	
1006	D2163	77.065		-1.12	
1011		-----		-----	
1026	ISO7941	76.81		-1.88	
1040	DIN51619	77.397		-0.13	
1062	D2163	78.498		3.15	
1065	D2163	77.821039		1.13	
1095	ISO7941	77.188		-0.75	
1108	D2163	77.29		-0.45	
1135		77.50		0.18	
1191	IP473	77.39		-0.15	
1275	EN27941	77.224		-0.65	
1345	D2163	76.408		-3.08	
1474	D2163	78.57		3.36	
1556	EN27941	76.62	C	-2.45	first reported: 80.87
1603		77.53		0.26	
1634	ISO7941	77.245		-0.58	
1677	D2163	77.568		0.38	
1741	EN27941	77.362		-0.24	
1776	EN27941	78.07	ex	1.87	test result excluded, see §4.1
1941	EN27941	77.54		0.29	
1978	D2163	76.9033		-1.60	
6018	EN27941	80.077	R(0.01)	7.85	
6019	EN27941	79.867	R(0.01)	7.23	
6108	D2163	77.2792		-0.48	
6142		-----		-----	
6193	D2163	76.91		-1.58	
6203		-----		-----	
6262	D2163	77.86	ex	1.25	test result excluded, see §4.1
6315	DIN51619	76.779		-1.97	
6321	D2163	78.269		2.47	
6326	D2163	78.75		3.90	
6327	EN27941	78.0985		1.96	
6328	D2163	78.30	C	2.56	first reported: 77.96
	normality	OK			
	n	42			
	outliers	2 (+3ex)			
	mean (n)	77.4411			
	st.dev. (n)	0.56520			
	R(calc.)	1.5826			
	st.dev.(D2163:14)	0.33567			
	R(D2163:14)	0.9399			Compare R(EN27941:93(liq)) = 1.4861



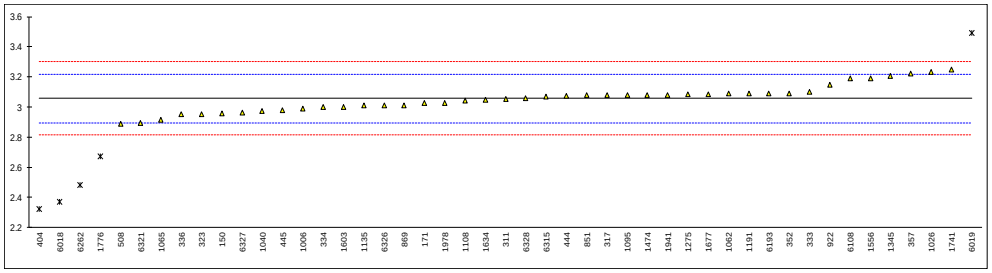


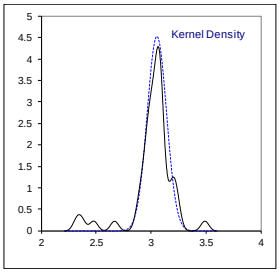
Determination of n-Butane on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	2.958		-1.20	
171	D2163	3.0254		-0.37	
311	D2163	3.05		-0.07	
317	D2163	3.08		0.30	
323	D2163	2.95		-1.30	
333	D2163	3.10		0.55	
334	D2163	3.00		-0.69	
336	D2163	2.95		-1.30	
352	EN27941	3.0919		0.45	
357	D2163	3.223		2.06	
404	D2163	2.325	R(0.01)	-8.99	
444	ISO7941	3.0756		0.25	
445	D2163	2.98		-0.93	
508	D2163	2.8883		-2.06	
754		-----		-----	
851	D2163	3.076695		0.26	
869	D2163	3.011		-0.55	
875		-----		-----	
922	D2163	3.15		1.16	
1006	D2163	2.990		-0.81	
1011		-----		-----	
1026	ISO7941	3.23		2.15	
1040	DIN51619	2.971		-1.04	
1062	D2163	3.089		0.41	
1065	D2163	2.912687		-1.76	
1095	ISO7941	3.080		0.30	
1108	D2163	3.04		-0.19	
1135		3.01		-0.56	
1191	IP473	3.09		0.42	
1275	EN27941	3.082		0.32	
1345	D2163	3.204		1.83	
1474	D2163	3.08	C	0.30	first reported: 3.41
1556	EN27941	3.19	C	1.65	first reported: 3.37
1603		3.0000		-0.69	
1634	ISO7941	3.045		-0.13	
1677	D2163	3.086		0.37	
1741	EN27941	3.246		2.34	
1776	EN27941	2.67	R(0.01)	-4.75	
1941	EN27941	3.08		0.30	
1978	D2163	3.0261		-0.36	
6018	EN27941	2.370	R(0.01)	-8.44	
6019	EN27941	3.493	R(0.01)	5.38	
6108	D2163	3.1892		1.64	
6142		-----		-----	
6193	D2163	3.09		0.42	
6203		-----		-----	
6262	D2163	2.48	C,R(0.01)	-7.09	first reported: 2.31
6315	DIN51619	3.069		0.16	
6321	D2163	2.896		-1.97	
6326	D2163	3.01		-0.56	
6327	EN27941	2.9615		-1.16	
6328	D2163	3.06	C	0.05	first reported: 3.58

normality	OK
n	42
outliers	5
mean (n)	3.0557
st.dev. (n)	0.08829
R(calc.)	0.2472
st.dev.(D2163:14)	0.08124
R(D2163:14)	0.2275

Compare R(EN27941:93(liq)) = 0.9907

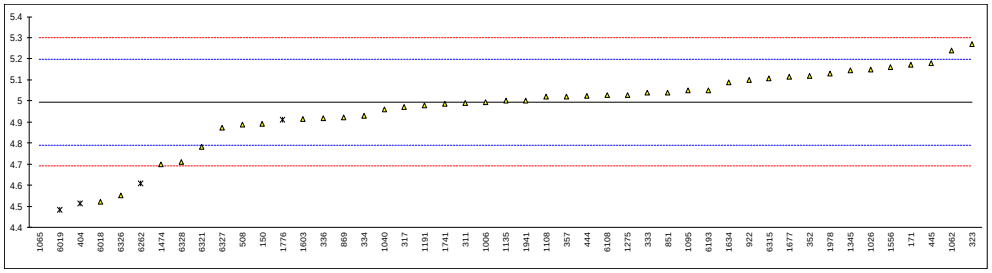


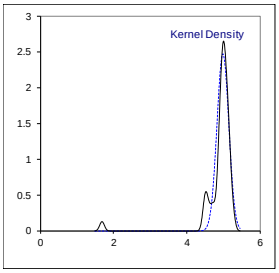


Determination of 1-Butene on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	4.891		-1.02	
171	D2163	5.1712		1.75	
311	D2163	4.99		-0.04	
317	D2163	4.97		-0.24	
323	D2163	5.27		2.72	
333	D2163	5.04		0.45	
334	D2163	4.93		-0.63	
336	D2163	4.92		-0.73	
352	EN27941	5.1182		1.22	
357	D2163	5.022		0.27	
404	D2163	4.513	ex	-4.75	test result excluded, see §4.1
444	ISO7941	5.0238		0.29	
445	D2163	5.18		1.83	
508	D2163	4.8873		-1.06	
754		-----		-----	
851	D2163	5.040712		0.46	
869	D2163	4.922		-0.71	
875		-----		-----	
922	D2163	5.10		1.04	
1006	D2163	4.995		0.01	
1011		-----		-----	
1026	ISO7941	5.15		1.54	
1040	DIN51619	4.960		-0.34	
1062	D2163	5.239		2.41	
1065	D2163	1.6823155	R(0.01)	-32.68	
1095	ISO7941	5.050		0.55	
1108	D2163	5.02		0.25	
1135		5.00		0.06	
1191	IP473	4.98		-0.14	
1275	EN27941	5.029		0.34	
1345	D2163	5.145		1.49	
1474	D2163	4.70	C	-2.90	first reported: 4.58
1556	EN27941	5.16	C	1.63	first reported: 5.45
1603		4.9163		-0.77	
1634	ISO7941	5.09		0.94	
1677	D2163	5.113		1.17	
1741	EN27941	4.985		-0.09	
1776	EN27941	4.91	ex	-0.83	test result excluded, see §4.1
1941	EN27941	5.00		0.06	
1978	D2163	5.1316		1.35	
6018	EN27941	4.522		-4.66	
6019	EN27941	4.483	ex	-5.05	test result excluded, see §4.1
6108	D2163	5.0266		0.32	
6142		-----		-----	
6193	D2163	5.05		0.55	
6203		-----		-----	
6262	D2163	4.61	ex,C	-3.79	test result excluded, see §4.1, first reported: 4.63
6315	DIN51619	5.106		1.10	
6321	D2163	4.783		-2.09	
6326	D2163	4.55		-4.38	
6327	EN27941	4.8735		-1.19	
6328	D2163	4.71		-2.81	

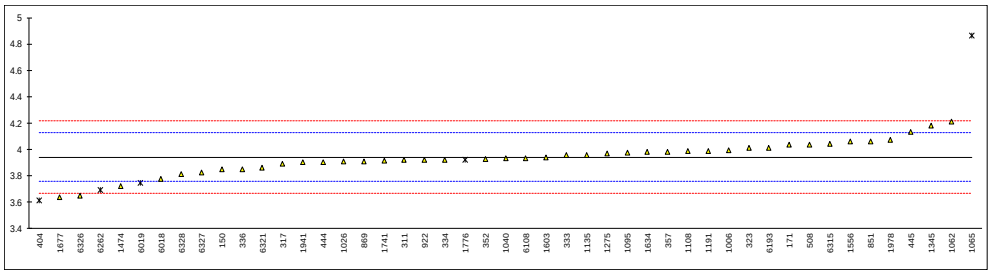
normality	suspect	
n	42	
outliers	1 (+4ex)	
mean (n)	4.9943	
st.dev. (n)	0.16114	
R(calc.)	0.4512	
st.dev.(D2163:14)	0.10134	
R(D2163:14)	0.2837	Compare R(EN27941:93(liq)) = 1.0263

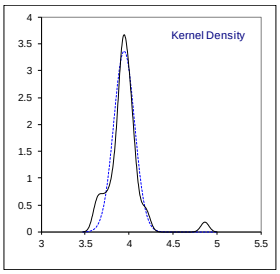




Determination of iso-Butene on sample #20090; results in %mol/mol

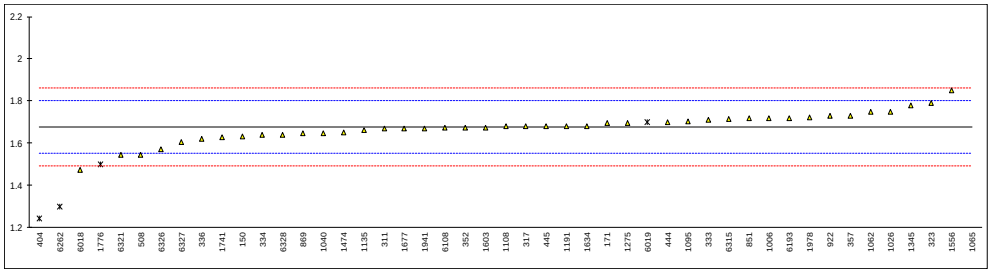
lab	method	value	mark	z(targ)	remarks
150	D2163	3.848		-1.03	
171	D2163	4.0332		1.01	
311	D2163	3.92		-0.24	
317	D2163	3.89		-0.57	
323	D2163	4.01		0.75	
333	D2163	3.96		0.20	
334	D2163	3.92		-0.24	
336	D2163	3.85		-1.00	
352	EN27941	3.9280		-0.15	
357	D2163	3.982		0.44	
404	D2163	3.610	ex	-3.64	test result excluded, see §4.1
444	ISO7941	3.9038		-0.41	
445	D2163	4.13		2.07	
508	D2163	4.0369		1.05	
754		-----		-----	
851	D2163	4.060821		1.31	
869	D2163	3.910		-0.35	
875		-----		-----	
922	D2163	3.92		-0.24	
1006	D2163	3.995		0.59	
1011		-----		-----	
1026	ISO7941	3.91		-0.35	
1040	DIN51619	3.933		-0.09	
1062	D2163	4.209		2.94	
1065	D2163	4.8630305	R(0.01)	10.12	
1095	ISO7941	3.977		0.39	
1108	D2163	3.99		0.53	
1135		3.96		0.20	
1191	IP473	3.99		0.53	
1275	EN27941	3.971		0.32	
1345	D2163	4.180		2.62	
1474	D2163	3.72		-2.43	
1556	EN27941	4.06	C	1.30	first reported: 4.29
1603		3.9376		-0.04	
1634	ISO7941	3.98		0.42	
1677	D2163	3.635		-3.36	
1741	EN27941	3.914		-0.30	
1776	EN27941	3.92	ex	-0.24	test result excluded, see §4.1
1941	EN27941	3.90		-0.46	
1978	D2163	4.0714		1.43	
6018	EN27941	3.778		-1.79	
6019	EN27941	3.748	ex	-2.12	test result excluded, see §4.1
6108	D2163	3.9360		-0.06	
6142		-----		-----	
6193	D2163	4.01		0.75	
6203		-----		-----	
6262	D2163	3.69	ex,C	-2.76	test result excluded, see §4.1, first reported: 3.56
6315	DIN51619	4.039		1.07	
6321	D2163	3.861		-0.88	
6326	D2163	3.65		-3.20	
6327	EN27941	3.8235		-1.30	
6328	D2163	3.81		-1.44	
	normality	suspect			
	n	42			
	outliers	1 (+4ex)			
	mean (n)	3.9415			
	st.dev. (n)	0.11881			
	R(calc.)	0.3327			
	st.dev.(D2163:14)	0.09111			
	R(D2163:14)	0.2551			Compare R(EN27941:93(liq)) = 1.0263

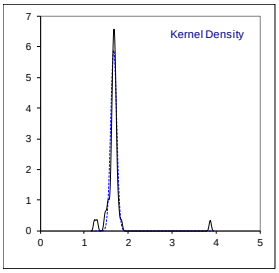




Determination of trans-2-Butene on sample #20090; results in %mol/mol

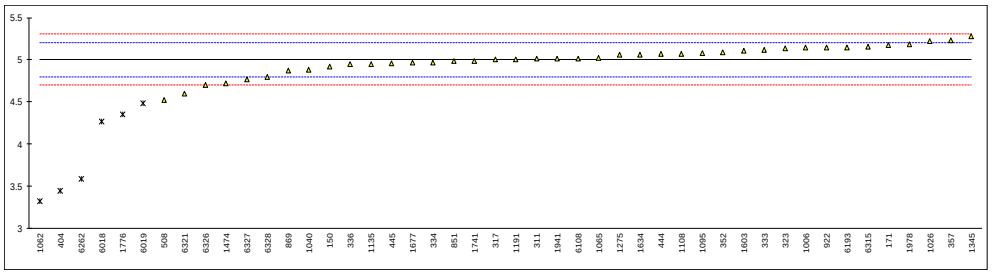
lab	method	value	mark	z(targ)	remarks
150	D2163	1.630		-0.75	
171	D2163	1.6967		0.33	
311	D2163	1.67		-0.10	
317	D2163	1.68		0.06	
323	D2163	1.79		1.83	
333	D2163	1.71		0.54	
334	D2163	1.64		-0.59	
336	D2163	1.62		-0.91	
352	EN27941	1.6728		-0.06	
357	D2163	1.731		0.88	
404	D2163	1.242	R(0.01)	-7.01	
444	ISO7941	1.7009		0.39	
445	D2163	1.68		0.06	
508	D2163	1.5464		-2.10	
754		-----		-----	
851	D2163	1.719332		0.69	
869	D2163	1.645		-0.51	
875		-----		-----	
922	D2163	1.73		0.86	
1006	D2163	1.720		0.70	
1011		-----		-----	
1026	ISO7941	1.75		1.19	
1040	DIN51619	1.645		-0.51	
1062	D2163	1.749		1.17	
1065	D2163	3.8609155	R(0.01)	35.23	
1095	ISO7941	1.705		0.46	
1108	D2163	1.68		0.06	
1135		1.66		-0.27	
1191	IP473	1.68		0.06	
1275	EN27941	1.697		0.33	
1345	D2163	1.779		1.65	
1474	D2163	1.65		-0.43	
1556	EN27941	1.85		2.80	
1603		1.6734		-0.05	
1634	ISO7941	1.68		0.06	
1677	D2163	1.670		-0.10	
1741	EN27941	1.627		-0.80	
1776	EN27941	1.50	ex	-2.85	test result excluded, see §4.1
1941	EN27941	1.67		-0.10	
1978	D2163	1.7222		0.74	
6018	EN27941	1.473		-3.28	
6019	EN27941	1.700	ex	0.38	test result excluded, see §4.1
6108	D2163	1.6726		-0.06	
6142		-----		-----	
6193	D2163	1.72		0.70	
6203		-----		-----	
6262	D2163	1.30	C, R(0.01)	-6.07	first reported: 1.22
6315	DIN51619	1.715		0.62	
6321	D2163	1.546		-2.10	
6326	D2163	1.57		-1.72	
6327	EN27941	1.6050		-1.15	
6328	D2163	1.64		-0.59	
	normality	suspect			
	n	42			
	outliers	3 (+2ex)			
	mean (n)	1.6765			
	st.dev. (n)	0.06772			
	R(calc.)	0.1896			
	st.dev.(D2163:14)	0.06201			
	R(D2163:14)	0.1736			Compare R(EN27941:93(liq)) = 1.0263

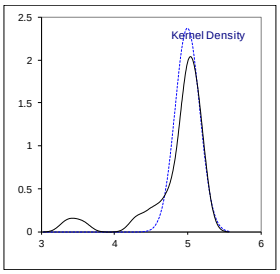




Determination of cis-2-Butene on sample #20090; results in %mol/mol

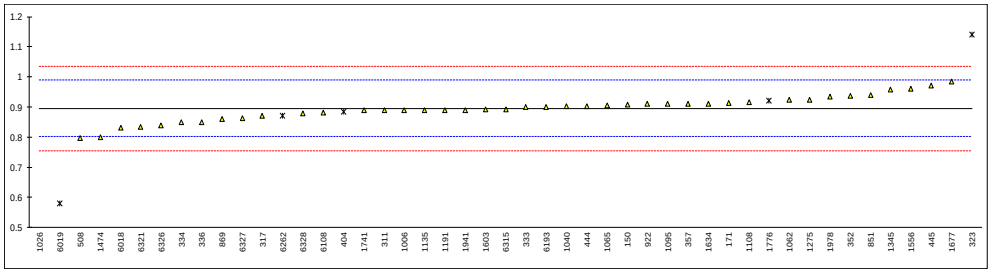
lab	method	value	mark	z(targ)	remarks
150	D2163	4.921		-0.80	
171	D2163	5.1710		1.66	
311	D2163	5.01		0.08	
317	D2163	5.00		-0.02	
323	D2163	5.14		1.36	
333	D2163	5.12		1.16	
334	D2163	4.97		-0.32	
336	D2163	4.95		-0.52	
352	EN27941	5.0885		0.85	
357	D2163	5.229		2.24	
404	D2163	3.446	R(0.01)	-15.35	
444	ISO7941	5.0697		0.66	
445	D2163	4.96		-0.42	
508	D2163	4.5239		-4.72	
754		-----		-----	
851	D2163	4.985154		-0.17	
869	D2163	4.875		-1.26	
875		-----		-----	
922	D2163	5.15		1.46	
1006	D2163	5.145		1.41	
1011		-----		-----	
1026	ISO7941	5.22		2.15	
1040	DIN51619	4.880		-1.21	
1062	D2163	3.325	R(0.01)	-16.54	
1065	D2163	5.0220915		0.20	
1095	ISO7941	5.081		0.78	
1108	D2163	5.07		0.67	
1135		4.95		-0.52	
1191	IP473	5.00		-0.02	
1275	EN27941	5.057		0.54	
1345	D2163	5.277		2.71	
1474	D2163	4.72	C	-2.78	first reported: 4.54
1556		-----		-----	
1603		5.1039		1.00	
1634	ISO7941	5.065		0.62	
1677	D2163	4.966		-0.36	
1741	EN27941	4.986		-0.16	
1776	EN27941	4.35	ex	-6.43	test result excluded, see §4.1
1941	EN27941	5.01		0.08	
1978	D2163	5.1868		1.82	
6018	EN27941	4.272	R(0.05)	-7.20	
6019	EN27941	4.487	ex	-5.08	test result excluded, see §4.1
6108	D2163	5.0101		0.08	
6142		-----		-----	
6193	D2163	5.15		1.46	
6203		-----		-----	
6262	D2163	3.59	C,R(0.01)	-13.93	first reported: 3.44
6315	DIN51619	5.159		1.55	
6321	D2163	4.600		-3.97	
6326	D2163	4.7		-2.98	
6327	EN27941	4.7695		-2.30	
6328	D2163	4.80	C	-1.99	first reported: 4.62
	normality	suspect			
	n	40			
	outliers	2 (+4ex)			
	mean (n)	5.0023			
	st.dev. (n)	0.16821			
	R(calc.)	0.4710			
	st.dev.(D2163:14)	0.10141			
	R(D2163:14)	0.2840			Compare R(EN27941:93(liq)) = 1.0263

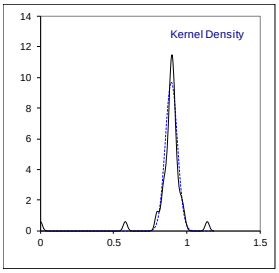




Determination of 1,3-Butadiene on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.907		0.26	
171	D2163	0.9120		0.36	
311	D2163	0.89		-0.11	
317	D2163	0.87		-0.53	
323		1.14	R(0.01)	5.24	
333	D2163	0.90		0.11	
334	D2163	0.85		-0.96	
336	D2163	0.85		-0.96	
352	EN27941	0.9362		0.88	
357	D2163	0.910		0.32	
404	D2163	0.883	ex	-0.26	test result excluded, see §4.1
444	ISO7941	0.9038		0.19	
445	D2163	0.97		1.60	
508	D2163	0.7954		-2.13	
754		-----		-----	
851	D2163	0.9389934		0.94	
869		0.861		-0.73	
875		-----		-----	
922	D2163	0.91		0.32	
1006	D2163	0.890		-0.11	
1011		-----		-----	
1026	ISO7941	0.0021	C,R(0.01)	-19.10	first reported: 0.04
1040	DIN51619	0.903		0.17	
1062	D2163	0.924		0.62	
1065	D2163	0.90398295		0.19	
1095	ISO7941	0.910		0.32	
1108	D2163	0.915		0.43	
1135		0.89		-0.11	
1191	IP473	0.89		-0.11	
1275	EN27941	0.924		0.62	
1345	D2163	0.959	C	1.37	first reported: 0.870
1474	D2163	0.80		-2.03	
1556	EN27941	0.96		1.39	
1603		0.8908		-0.09	
1634	ISO7941	0.91		0.32	
1677	D2163	0.984		1.90	
1741	DIN51619	0.889		-0.13	
1776	EN27941	0.92	ex	0.53	test result excluded, see §4.1
1941	DIN51619	0.89		-0.11	
1978	D2163	0.9344		0.84	
6018	EN27941	0.830		-1.39	
6019	EN27941	0.581	R(0.01)	-6.72	
6108	D2163	0.8826		-0.27	
6142		-----		-----	
6193	D2163	0.90		0.11	
6203		-----		-----	
6262	D2163	0.87	ex,C	-0.53	test result excluded, see §4.1, first reported: 0.00
6315	DIN51619	0.893		-0.04	
6321	D2163	0.835		-1.28	
6326	D2163	0.84		-1.18	
6327	EN27941	0.8625		-0.70	
6328	D2163	0.88		-0.32	
	normality	OK			
	n	41			
	outliers	3 (+3ex)			
	mean (n)	0.8950			
	st.dev. (n)	0.04123			
	R(calc.)	0.1154			
	st.dev.(D2163:14)	0.04675			
	R(D2163:14)	0.1309			Compare R(EN27941:93(liq)) = 1.0646





Determination of n-Pentane on sample #20090; results in %mol/mol

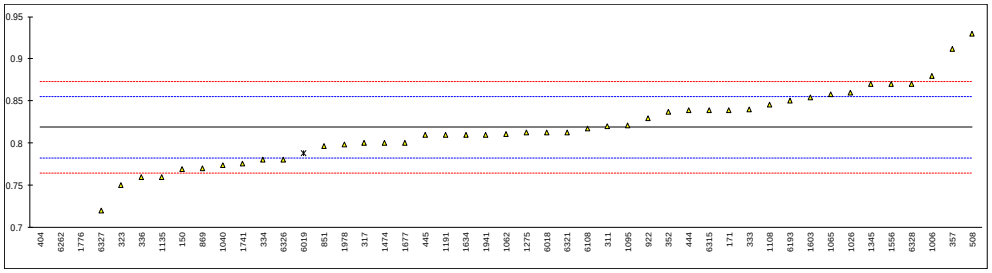
lab	method	value	mark	z(targ)	remarks
150	D2163	0		-----	
171	D2163	0		-----	
311	D2163	<0.01		-----	
317	D2163	<0.01		-----	
323	D2163	<0.01		-----	
333	D2163	<0.01		-----	
334	D2163	<0.01		-----	
336	D2163	<0.01		-----	
352		-----		-----	
357	D2163	0.001		-----	
404		-----		-----	
444	ISO7941	0.0003		-----	
445	D2163	<0.1		-----	
508	D2163	0.0000		-----	
754		-----		-----	
851		-----		-----	
869	D2163	0		-----	
875		-----		-----	
922	D2163	<0.01		-----	
1006	D2163	0		-----	
1011		-----		-----	
1026	ISO7941	0.73		-----	possible false positive test result?
1040	DIN51619	0.000		-----	
1062	D2163	0.0003		-----	
1065		-----		-----	
1095	ISO7941	0		-----	
1108		-----		-----	
1135		0.00		-----	
1191	IP473	0		-----	
1275	EN27941	0.000		-----	
1345	D2163	<0.01		-----	
1474	D2163	0.00		-----	
1556		-----		-----	
1603		<0,0005		-----	
1634	ISO7941	0		-----	
1677	D2163	<0.001		-----	
1741		-----		-----	
1776	EN27941	<0,1		-----	
1941		-----		-----	
1978	D2163	0		-----	
6018	EN27941	<0,1		-----	
6019	EN27941	<0,1		-----	
6108	D2163	Not detected		-----	
6142		-----		-----	
6193	D2163	0		-----	
6203		-----		-----	
6262	D2163	0.02	C	-----	first reported: 0.68
6315	DIN51619	0		-----	
6321	D2163	<0.1		-----	
6326	D2163	ND		-----	
6327	EN27941	0.0000		-----	
6328	D2163	0.00		-----	
	n	36			
	mean (n)	<0.1			

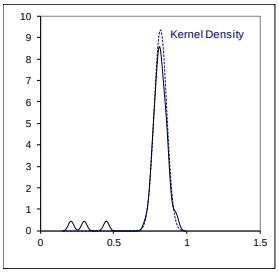
Determination of iso-Pentane on sample #20090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.769		-2.76	
171	D2163	0.8391		1.13	
311	D2163	0.82		0.07	
317	D2163	0.80		-1.04	
323	D2163	0.75		-3.82	
333	D2163	0.84		1.18	
334	D2163	0.78		-2.15	
336	D2163	0.76		-3.26	
352	EN27941	0.8371		1.02	
357	D2163	0.912		5.18	
404	D2163	0.210	R(0.01)	-33.81	
444	ISO7941	0.8389		1.12	
445	D2163	0.81		-0.49	
508	D2163	0.9294		6.15	
754		-----		-----	
851	D2163	0.796106		-1.26	
869	D2163	0.770		-2.71	
875		-----		-----	
922	D2163	0.83		0.63	
1006	D2163	0.880		3.40	
1011		-----		-----	
1026	ISO7941	0.86		2.29	
1040	DIN51619	0.774		-2.48	
1062	D2163	0.811		-0.43	
1065	D2163	0.858211		2.19	
1095	ISO7941	0.821		0.13	
1108	D2163	0.846		1.51	
1135		0.76		-3.26	
1191	IP473	0.81		-0.49	
1275	EN27941	0.813		-0.32	
1345	D2163	0.870	C	2.85	first reported: 0.959
1474	D2163	0.80	C	-1.04	first reported: 1.00
1556	EN27941	0.87	C	2.85	first reported: 0.92
1603		0.8542		1.97	
1634	ISO7941	0.81		-0.49	
1677	D2163	0.800		-1.04	
1741	EN27941	0.776		-2.37	
1776	EN27941	0.45	R(0.01)	-20.48	
1941	EN27941	0.81		-0.49	
1978	D2163	0.7981		-1.15	
6018	EN27941	0.813		-0.32	
6019	EN27941	0.788	ex	-1.71	test result excluded, see §4.1
6108	D2163	0.8175		-0.07	
6142		-----		-----	
6193	D2163	0.85		1.74	
6203		-----		-----	
6262	D2163	0.30	C,R(0.01)	-28.81	first reported: 0.24
6315	DIN51619	0.839		1.13	
6321	D2163	0.813		-0.32	
6326	D2163	0.78		-2.15	
6327	EN27941	0.720	C	-5.48	first reported: 0.7135
6328	D2163	0.87		2.85	

	normality	OK
	n	43
	outliers	3 (+1ex)
	mean (n)	0.8187
	st.dev. (n)	0.04267
	R(calc.)	0.1195
	st.dev.(D2163:14)	0.01801
	R(D2163:14)	0.0504

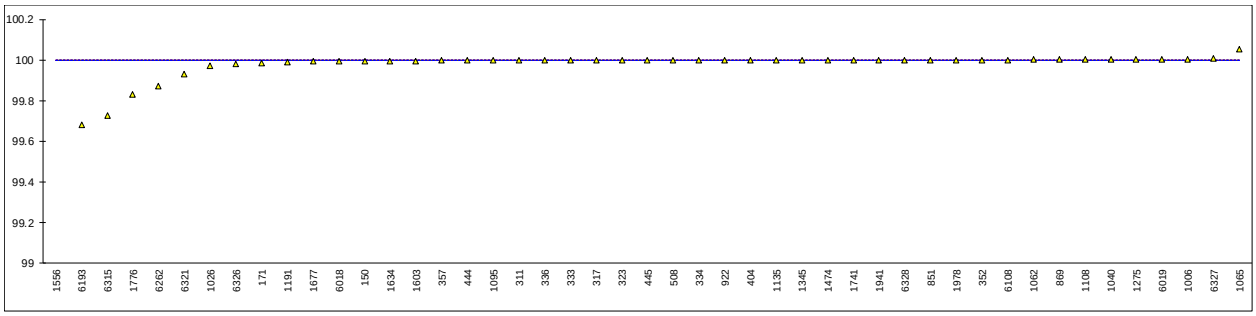
Compare R(EN27941:93(liq)) = 0.7981





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

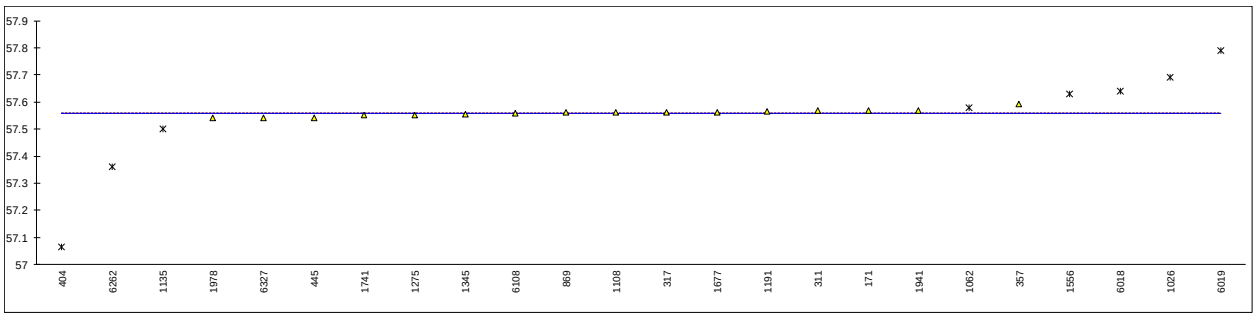
lab	method	value	remarks
150	D2163	100.00	
171	D2163	99.99	
311	D2163	100.00	
317	D2163	100.00	
323	D2163	100.00	
333	D2163	100.00	
334	D2163	100.00	
336	D2163	100.00	
352	EN27941	100.00	
357	D2163	100.00	
404	D2163	100.00	
444	ISO7941	100.00	
445	D2163	100.00	
508	D2163	100.00	
754		-----	
851	D2163	100.00	
869	D2163	100.00	
875		-----	
922	D2163	100.00	
1006	D2163	100.01	
1011		-----	
1026	ISO7941	99.97	
1040	DIN51619	100.00	
1062	D2163	100.00	
1065	D2163	100.05	
1095	ISO7941	100.00	
1108	D2163	100.00	
1135		100.00	
1191	IP473	99.99	
1275	EN27941	100.00	
1345	D2163	100.00	
1474	D2163	100.00	
1556	EN27941	**95.01**	Not 100%; did not report test result for component of cis-2-Butene
1603		100.00	
1634	ISO7941	100.00	
1677	D2163	99.99	
1741	EN27941	100.00	
1776	EN27941	**99.83**	Not 100%
1941	EN27941	100.00	
1978	D2163	100.00	
6018	EN27941	99.99	
6019	EN27941	100.00	
6108	D2163	100.00	
6142		-----	
6193	D2163	**99.68**	Not 100%
6203		-----	
6262	D2163	**99.87**	Not 100%
6315	DIN51619	**99.73**	Not 100%
6321	D2163	99.93	
6326	D2163	99.98	
6327	EN27941	100.01	
6328	D2163	100.00	

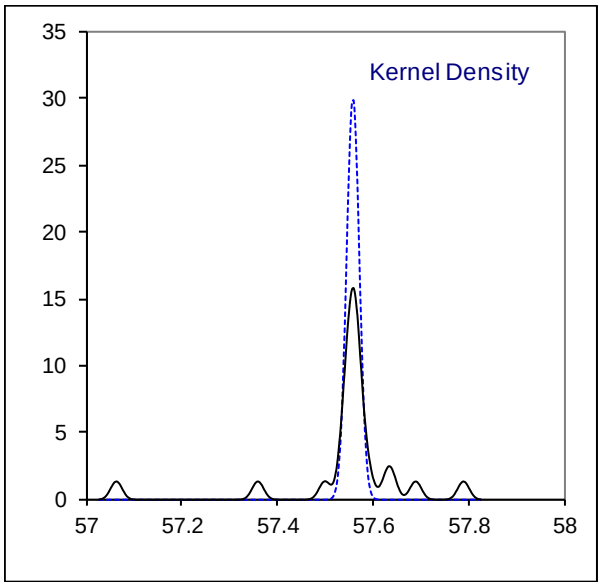


Determination of Molar Mass on sample #20090; results in g/mol

Lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171	D2421	57.57		-----	
311	INH-407	57.57		-----	
317	INH-001	57.56		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
352		-----		-----	
357	ISO8973	57.592		-----	
404	ISO8973	57.064	ex,C	-----	test result excluded, see §4.1, reported 57064 g/mol (unit error?)
444		-----		-----	
445	ISO8973	57.541		-----	
508		-----		-----	
754		-----		-----	
851		-----		-----	
869	D2598	57.56		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026	ISO8973	57.69	ex	-----	test result excluded, see §4.1
1040		-----		-----	
1062	D2163	57.58	ex	-----	test result excluded, see §4.1
1065		-----		-----	
1095		-----		-----	
1108	ISO8973	57.56		-----	
1135	D2421	57.5	C,G(0.01)	-----	first reported: 56.3
1191	ISO8973	57.5634		-----	
1275	EN589	57.552		-----	
1345	D2421	57.554		-----	
1474		-----		-----	
1556	ISO8973	57.63	ex, E	-----	test result excluded, see §4.1, calculation error, iis calc. 54.738
1603		-----		-----	
1634		-----		-----	
1677	ISO8973	57.560		-----	
1741	ISO8973	57.55		-----	
1776		-----		-----	
1941	D2421	57.570		-----	
1978	D2598	57.54	C	-----	first reported: 57.1317
6018	ISO8973	57.64	ex	-----	test result excluded, see §4.1
6019	ISO8973	57.79	ex	-----	test result excluded, see §4.1
6108	D2163	57.5586		-----	
6142		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262	D2598	57.36	ex, E	-----	test result excluded, see §4.1, calculation error, iis calc. 57.013
6315		-----		-----	
6321		-----		-----	
6326		-----		-----	
6327	ISO8973	57.5403		-----	
6328		-----		-----	
					iis calculated from all reported composition results: *)
	normality	suspect			suspect
	n	16			35
	outliers	1 (+7ex)			0 (+12ex)
	mean (n)	57.559			57.560
	st.dev. (n)	0.0133	RSD = 0.02%		0.0246 RSD = 0.04%
	R(calc.)	0.037			0.069
comp	R(iis19S02B)	0.024			0.040

*) 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

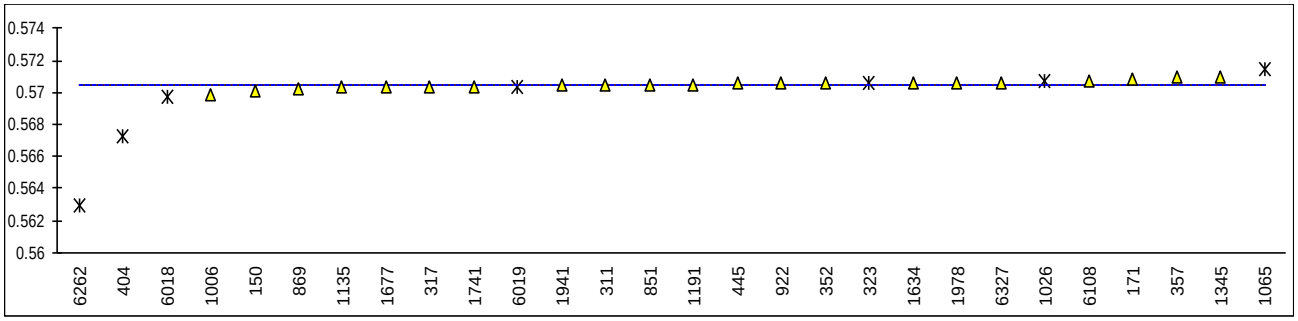

57.9
57.8
57.7
57.6
57.5
57.4
57.3
57.2
57.1
57
404
6262
1135
1978
6327
445
1741
1275
1345
6108
869
1108
317
1677
1191
311
171
1941
1062
357
1556
6018
1026
6019

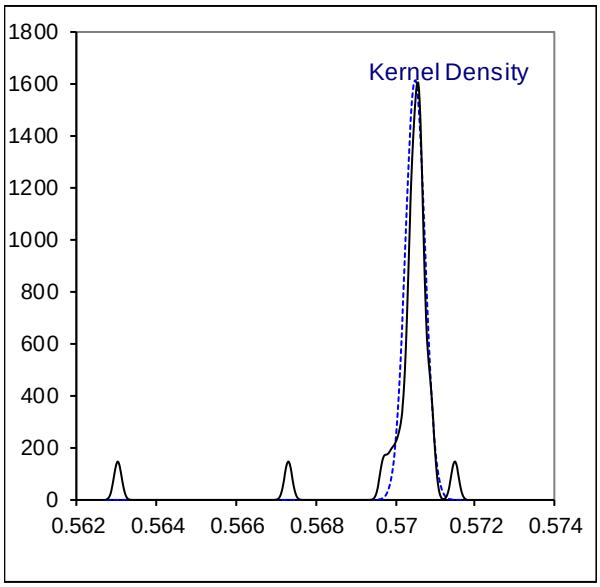

Kernel Density
35
30
25
20
15
10
5
0
57
57.2
57.4
57.6
57.8
58

Determination of Relative Density at 60/60°F on sample #20090; unitless results

lab	method	value	mark	z(targ)	remarks
150	D2598	0.57007		-----	
171	D2598	0.5708		-----	
311	INH-407	0.5705		-----	
317	INH-001	0.5704		-----	
323	D2598	0.5706	ex	-----	test result excluded, see §4.1
333		-----		-----	
334		-----		-----	
336		-----		-----	
352	ISO8973	0.5706		-----	
357	D2598	0.5709		-----	
404	ISO8973	0.5673	ex	-----	test result excluded, see §4.1
444		-----		-----	
445	ISO8973	0.5706		-----	
508		-----		-----	
754		-----		-----	
851	D2598	0.5705		-----	
869	D2598	0.5702		-----	
875		-----		-----	
922	D2598	0.5706		-----	
1006	D2598	0.5699		-----	
1011		-----		-----	
1026	ISO8973	0.5707	ex	-----	test result excluded, see §4.1
1040		-----		-----	
1062		-----		-----	
1065	Calculated	0.5715	ex	-----	test result excluded, see §4.1
1095		-----		-----	
1108		-----		-----	
1135	D2598	0.5703		-----	
1191	ISO8973	0.5705		-----	
1275		-----		-----	
1345	D2598	0.5709		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	ISO8973	0.5706		-----	
1677	D2598	0.57038		-----	
1741	ISO8973	0.5704		-----	
1776		-----		-----	
1941	D2598	0.57041		-----	
1978	D2598	0.5706		-----	
6018	ISO8973	0.5697	ex	-----	test result excluded, see §4.1
6019	ISO8973	0.5704	ex	-----	test result excluded, see §4.1
6108	D2598	0.5707	C	-----	first reported: 0.5659
6142		-----		-----	
6193		-----	W	-----	first reported: 573.6 kg/m^3
6203		-----		-----	
6262	ISO8973	0.563	ex,C,E	-----	test result ex., see §4.1, fr.: 0.5684, calc. error: iis calc. 0.5676
6315		-----		-----	
6321		-----		-----	
6326		-----		-----	
6327	ISO8973	0.5706	C	-----	first reported: 0.5720
6328		-----		-----	
					iis calculated from all reported composition results: *)
	normality	OK			OK
	n	21			35
	outliers	0 (+7ex)			0 (+12ex)
	mean (n)	0.5705			0.5704
	st.dev. (n)	0.00025	RSD = 0.04%		0.00023 RSD = 0.04%
	R(calc.)	0.0007			0.0006
comp	R(iis19S02B)	0.0007			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 D2163:14(2019)
N.B. Effect of different factors from ASTM D2598:16 and ISO8973:97/IP432:00 on the calculation is very small.


0.574
0.572
0.57
0.568
0.566
0.564
0.562
0.56
6262
404
6018
1006
150
869
1135
1677
317
1741
6019
1941
311
851
1191
445
922
352
323
1634
1978
6327
1026
6108
171
357
1345
1065


Kernel Density
1800
1600
1400
1200
1000
800
600
400
200
0
0.562
0.564
0.566
0.568
0.57
0.572
0.574

Determination of Abs. Vapor Pressure at 100°F on sample #20090; results in psi

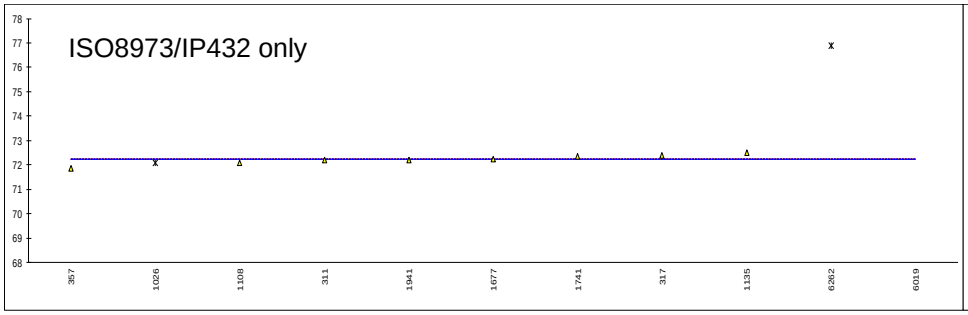
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171	D2598	-----		-----	71.17		-----	
311	ISO8973	72.2		-----	-----		-----	
317	ISO8973	72.4		-----	-----		-----	
323		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	D2598	-----		-----	56.7	G(0.01), E	-----	calculation error, iis calc. 71.54
336		-----		-----	-----		-----	
352		-----		-----	-----		-----	
357	ISO8973	71.87		-----	-----		-----	
404		-----		-----	-----		-----	
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
508		-----		-----	-----		-----	
754		-----		-----	-----		-----	
851	D2598	-----		-----	71.6		-----	
869	D2598	-----		-----	71.69		-----	
875		-----		-----	-----		-----	
922	D2598	-----		-----	71.65		-----	
1006	D2598	-----		-----	71.7		-----	
1011		-----		-----	-----		-----	
1026	ISO8973	72.1	ex	-----	-----		-----	test result excluded, see §4.1
1040		-----		-----	-----		-----	
1062		-----		-----	-----		-----	
1065		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1108	ISO8973	72.1		-----	-----		-----	
1135	ISO8973	72.5		-----	-----		-----	
1191		-----		-----	-----		-----	
1275		-----		-----	-----		-----	
1345		-----		-----	-----		-----	
1474		-----		-----	-----		-----	
1556		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	ISO8973	72.255		-----	-----		-----	
1741	ISO8973	72.36		-----	-----		-----	
1776		-----		-----	-----		-----	
1941	ISO8973	72.21		-----	-----		-----	
1978	D2598	-----		-----	72.77	C, E	-----	first reported: 58.88, calc. error, iis calc. 71.56
6018		-----		-----	-----		-----	
6019	ISO8973	487	ex,E	-----	-----		-----	see remark below this table
6108		-----		-----	-----		-----	
6142		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6203		-----		-----	-----		-----	
6262	ISO8973	76.9	ex,C	-----	-----		-----	test result excluded, see §4.1, first rep.: 61.55
6315		-----		-----	-----		-----	
6321		-----		-----	-----		-----	
6326		-----		-----	-----		-----	
6327		-----		-----	-----		-----	
6328		-----		-----	-----		-----	

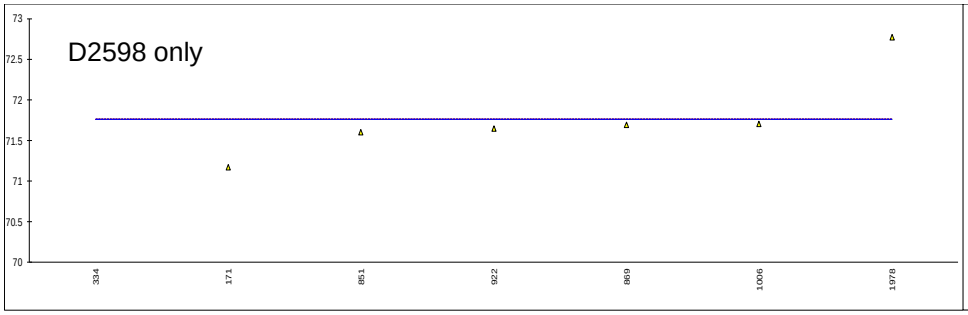
Lab 6019: test result excluded, see §4.1, calculation error iis calc. 70.68

	ISO8973/IP432		D2598	
normality	OK		unknown	
n	8		6	
outliers	0 (+3ex)		1	
mean (n)	72.2369		71.7633	
st.dev. (n)	0.19521	RSD = 0.3%	0.53185	RSD = 0.7%
R(calc.)	0.5466		1.4892	
compare				
R(iis19S02B)	0.1195		0.4695	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	suspect		suspect	
n	35		35	
outliers	0 (+12ex)		0 (+12ex)	
mean (n)	72.3140		71.5716	
st.dev. (n)	0.20722	RSD = 0.3%	0.17737	RSD = 0.3%
R(calc.)	0.5802		0.4966	
compare				
R(iis19S02B)	0.3530		0.4003	

*) 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.





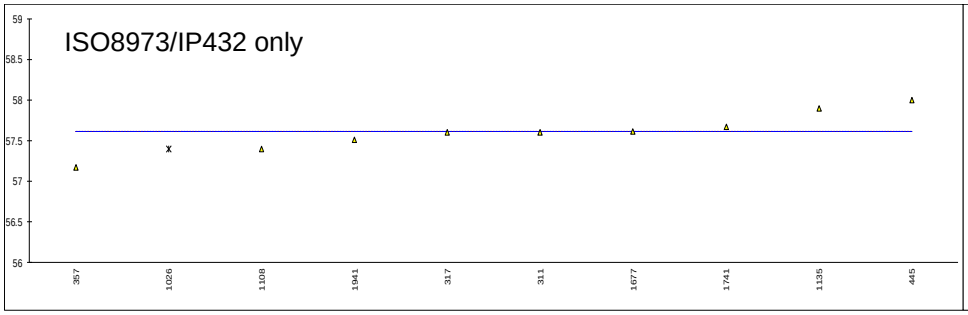
Determination of Rel. Vapor Pressure at 100°F on sample #20090; results in psi

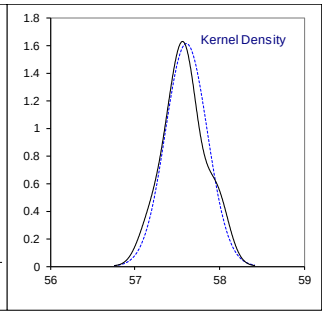
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150	D2598	-----		-----	57.4		-----	
171	D2598	-----		-----	56.87		-----	
311	ISO8973	57.6		-----	-----		-----	
317	ISO8973	57.6		-----	-----		-----	
323	D2598	-----		-----	57.49	ex	-----	test result excluded, see §4.1
333		-----		-----	-----		-----	
334	D2598	-----		-----	42.1	G(0.01), E	-----	calculation error, iis calc. 56.85
336		-----		-----	-----		-----	
352		-----		-----	-----		-----	
357	ISO8973	57.17		-----	-----		-----	
404		-----		-----	-----		-----	
444		-----		-----	-----		-----	
445	ISO8973	58		-----	-----		-----	
508		-----		-----	-----		-----	
754		-----		-----	-----		-----	
851	D2598	-----		-----	56.9		-----	
869	D2598	-----		-----	56.99		-----	
875		-----		-----	-----		-----	
922	D2598	-----		-----	56.95		-----	
1006	D2598	-----		-----	57.0		-----	
1011		-----		-----	-----		-----	
1026	ISO8973	57.4	ex	-----	-----		-----	test result excluded, see §4.1
1040		-----		-----	-----		-----	
1062		-----		-----	-----		-----	
1065		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1108	ISO8973	57.4		-----	-----		-----	
1135	ISO8973	57.9		-----	-----		-----	
1191		-----		-----	-----		-----	
1275		-----		-----	-----		-----	
1345		-----		-----	-----		-----	
1474		-----		-----	-----		-----	
1556		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	ISO8973	57.606		-----	-----		-----	
1741	ISO8973	57.67		-----	-----		-----	
1776		-----		-----	-----		-----	
1941	ISO8973	57.51		-----	-----		-----	
1978	D2598	-----		-----	58.88	C,G(0.01),E	-----	first reported: 72.77, calc. error, iis calc. 56.87
6018		-----		-----	-----		-----	
6019		-----		-----	-----		-----	
6108		-----		-----	-----		-----	
6142		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6203		-----		-----	-----		-----	
6262		-----		-----	-----		-----	
6315		-----		-----	-----		-----	
6321		-----		-----	-----		-----	
6326		-----		-----	-----		-----	
6327		-----		-----	-----		-----	
6328		-----		-----	-----		-----	

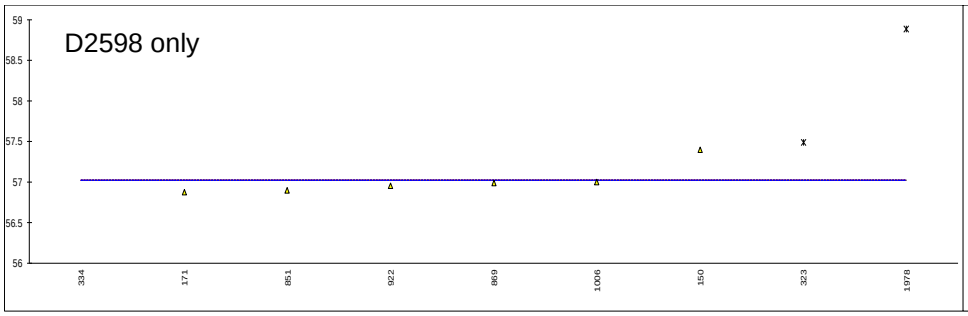
	ISO8973/IP432		D2598	
normality	OK		not OK	
n	9		6	
outliers	0 (+1ex)		2 (+1ex)	
mean (n)	57.6062		57.0183	
st.dev. (n)	0.24688	RSD = 0.4%	0.19364	RSD = 0.3%
R(calc.)	0.6913		0.5422	
compare				
R(iis19S02B)	0.2541		0.4695	

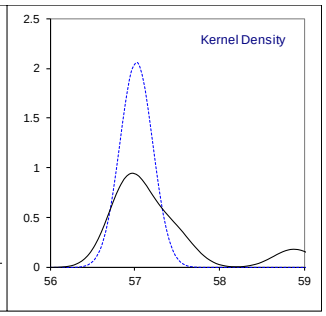
	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	suspect		suspect	
n	35		35	
outliers	0 (+12ex)		0 (+12ex)	
mean (n)	57.6181		56.8757	
st.dev. (n)	0.20722	RSD = 0.4%	0.17737	RSD = 0.3%
R(calc.)	0.5802		0.4966	
compare				
R(iis19S02B)	0.2797		0.4003	

*) 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.





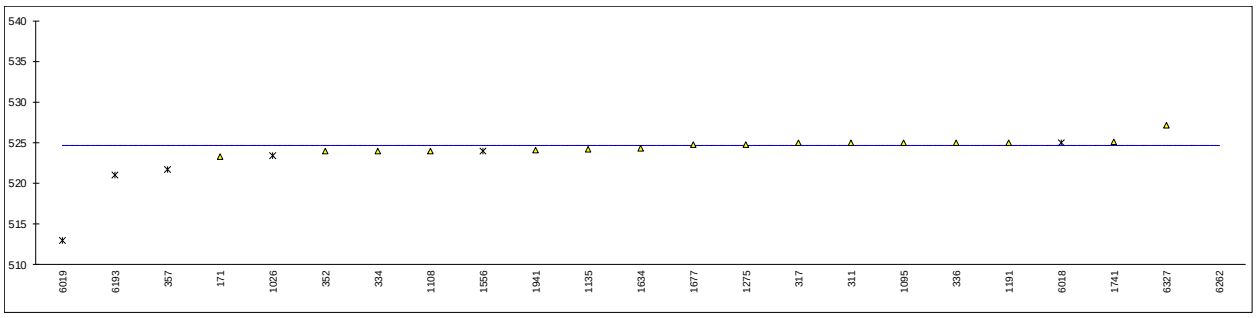


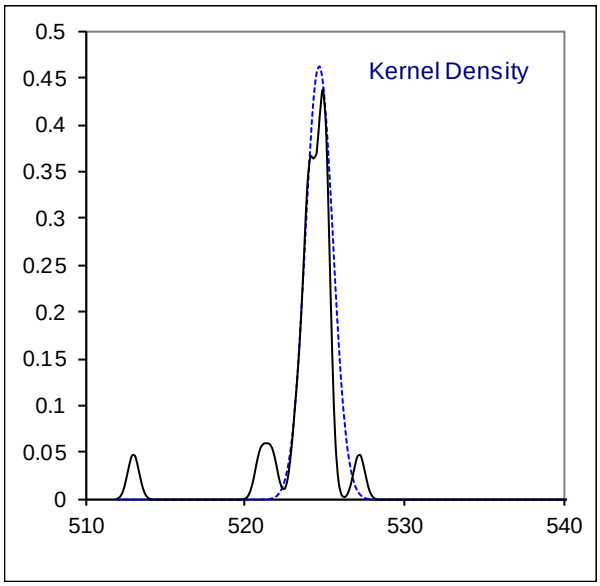


Determination of Abs. Vapor Pressure at 40°C on sample #20090; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171	ISO8973	523.26		-----	
311	ISO8973	525		-----	
317	ISO8973	525		-----	
323		-----		-----	
333		-----		-----	
334	ISO8973	524		-----	
336	ISO8973	525		-----	
352	ISO8973	524		-----	
357	ISO8973	521.7	D(0.01)	-----	
404		-----		-----	
444		-----		-----	
445		-----		-----	
508		-----		-----	
754		-----		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026	ISO8973	523.4	ex,E	-----	test result excluded, see §4.1, calculation error, iis calc. 522.56
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095	ISO8973	525		-----	
1108	ISO8973	524		-----	
1135	ISO8973	524.2	E	-----	calculation error, iis calc. 526.14
1191	ISO8973	525		-----	
1275	EN589	524.8		-----	
1345		-----		-----	
1474		-----		-----	
1556	ISO8973	524	ex,C, E	-----	test result excluded, see §4.1, fr.: 534, calc.error, iis calc. 508.34
1603		-----		-----	
1634	ISO8973	524.3		-----	
1677	ISO8973	524.7		-----	
1741	ISO8973	525.13		-----	
1776		-----		-----	
1941	ISO8973	524.07		-----	
1978		-----		-----	
6018	ISO8973	525	ex	-----	test result excluded, see §4.1
6019	ISO8973	513	ex	-----	test result excluded, see §4.1
6108		-----		-----	
6142		-----		-----	
6193	ISO8973	521	ex	-----	test result excluded, see §4.1
6203		-----		-----	
6262	ISO8973	561	ex,C, E	-----	test result excl., see §4.1, fr.: 453.95, calc.error, iis calc. 560.39
6315		-----		-----	
6321		-----		-----	
6326		-----		-----	
6327	ISO8973	527.19		-----	
6328		-----		-----	
					iis calculated from all reported test results *):
	normality	not OK			suspect
	n	16			33
	outliers	1 (+6ex)			2 (+12ex)
	mean (n)	524.6656			524.6146
	st.dev. (n)	0.86319	RSD = 0.2%		1.17724 RSD = 0.2%
	R(calc.)	2.4169			3.2963
comp	R(iis19S02B)	1.8535			3.3177

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

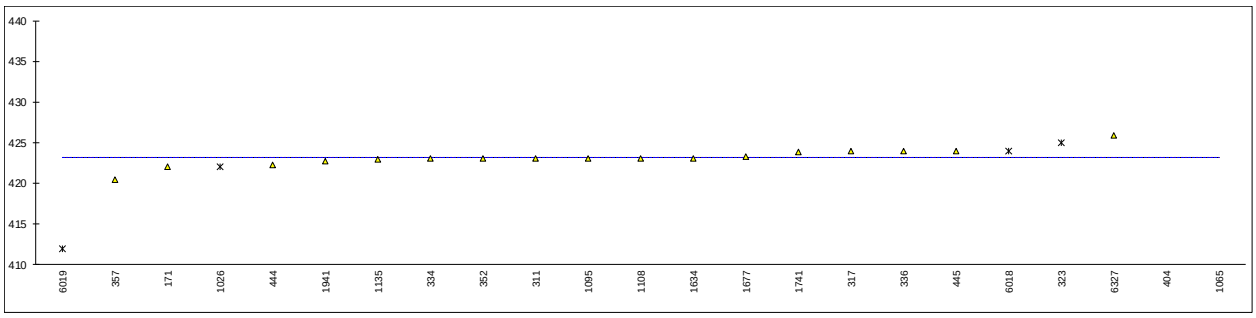

540
535
530
525
520
515
510
6019
6193
357
171
1026
352
334
1108
1556
1941
1135
1634
1677
1275
317
311
1095
336
1191
6018
1741
6327
6262

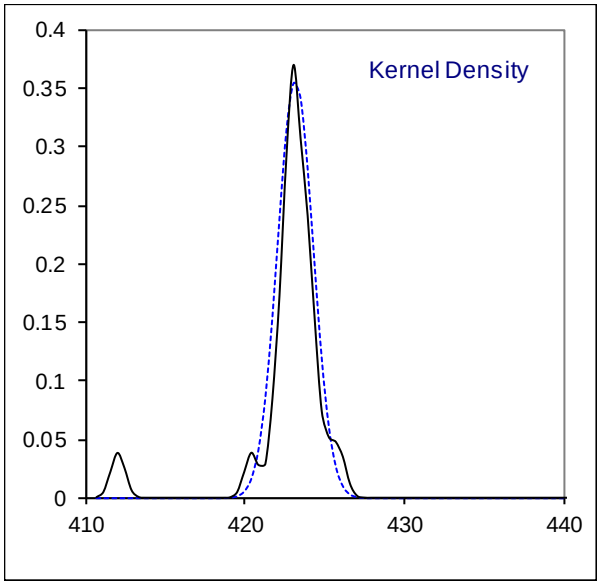

Kernel Density
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
510
520
530
540

Determination of Rel. Vapor Pressure at 40°C on sample #20090; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171	ISO8973	422.0		-----	
311	ISO8973	423		-----	
317	ISO8973	424		-----	
323	ISO8973	425	ex,E	-----	test result excluded, see §4.1, calc. error, iis calc. 426.76
333		-----		-----	
334	ISO8973	423		-----	
336	ISO8973	424	E	-----	calculation error, iis calc. 423.27
352	ISO8973	423		-----	
357	ISO8973	420.4		-----	
404	ISO8973	462	ex	-----	test result excluded, see §4.1
444	ISO8973	422.3		-----	
445	ISO8973	424.0		-----	
508		-----		-----	
754		-----		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026	ISO8973	422.0	ex,E	-----	test result excluded, see §4.1, calc. error, iis calc. 421.23
1040		-----		-----	
1062		-----		-----	
1065	Calculated	522.0	ex, E	-----	test result excluded, see §4.1, calc. error, iis calc. 421.57
1095	ISO8973	423		-----	
1108	ISO8973	423		-----	
1135	ISO8973	422.9	E	-----	calculation error, iis calc. 424.81
1191		-----		-----	
1275		-----		-----	
1345		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	ISO8973	423		-----	
1677	ISO8973	423.3		-----	
1741	ISO8973	423.81		-----	
1776		-----		-----	
1941	ISO8973	422.74		-----	
1978		-----		-----	
6018	ISO8973	424	ex	-----	test result excluded, see §4.1
6019	ISO8973	412	ex	-----	test result excluded, see §4.1
6108		-----		-----	
6142		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262		-----		-----	
6315		-----		-----	
6321		-----		-----	
6326		-----		-----	
6327	ISO8973	425.87		-----	
6328		-----		-----	
					iis calculated from all reported test results *):
	normality	not OK			suspect
	n	17			33
	outliers	0 (+6ex)			2 (+12ex)
	mean (n)	423.1365			423.2896
	st.dev. (n)	1.11787	RSD = 0.3%		1.17724 RSD = 0.3%
	R(calc.)	3.1300			3.2963
comp	R(iis19S02B)	3.0699			3.3177

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


440
435
430
425
420
415
410
6019
357
171
1026
444
1941
1135
334
352
311
1095
1108
1634
1677
1741
317
336
445
6018
323
6327
404
1065


Kernel Density
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
410
420
430
440

Determination of Motor Octane Number, MON on sample #20090;

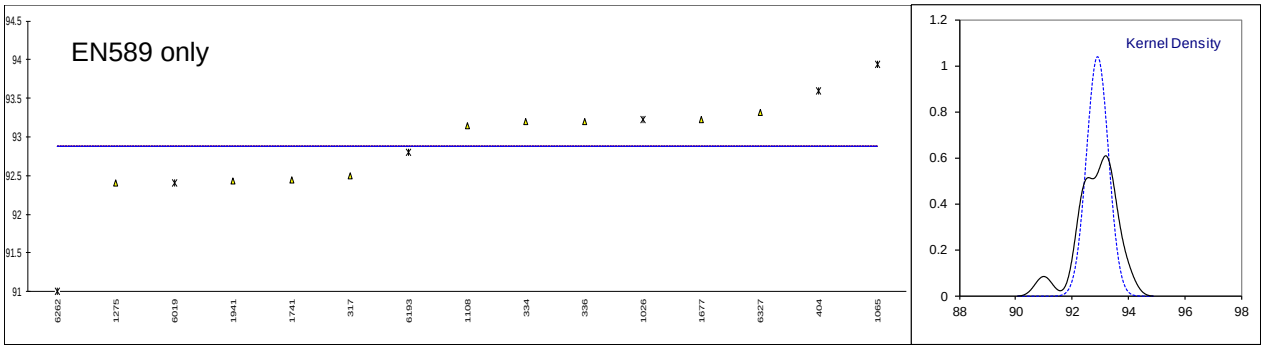
lab	method	EN589	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171	D2598	-----		-----	93.1	G(0.05), E	-----	calculation error, see below this table
311	D2598	-----		-----	94.5	C	-----	first reported: 90.0
317	EN589	92.5		-----	-----		-----	
323		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	EN589	93.2		-----	-----		-----	
336	EN589	93.2		-----	-----		-----	
352		-----		-----	-----		-----	
357		-----		-----	-----		-----	
404	EN589	93.6	ex	-----	-----		-----	test result excluded, see §4.1
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
508		-----		-----	-----		-----	
754		-----		-----	-----		-----	
851	D2598	-----		-----	95.0		-----	
869	D2598	-----		-----	94.9		-----	
875		-----		-----	-----		-----	
922		-----		-----	-----		-----	
1006		-----		-----	-----		-----	
1011		-----		-----	-----		-----	
1026		93.22	ex	-----	-----		-----	test result excluded, see §4.1
1040		-----		-----	-----		-----	
1062		-----		-----	-----		-----	
1065	Calculated	93.94	ex,E	-----	93.94	ex, E	-----	test result excluded, see §4.1, calc error *)
1095		-----		-----	-----		-----	
1108	EN589	93.15		-----	-----		-----	
1135	D2598	-----		-----	94.3		-----	
1191		-----		-----	-----		-----	
1275	EN589	92.4		-----	-----		-----	
1345		-----		-----	-----		-----	
1474		-----		-----	-----		-----	
1556		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1677	EN589	93.22		-----	-----		-----	
1741	EN589	92.45		-----	-----		-----	
1776		-----		-----	-----		-----	
1941	EN589	92.43		-----	-----		-----	
1978	D2598	-----		-----	92.36	G(0.05)	-----	
6018		-----		-----	-----		-----	
6019	EN589	92.4	ex, E	-----	-----		-----	test result excluded, see §4.1, calc. error *)
6108	D2598	-----		-----	94.8541	C	-----	first reported: 89.9968
6142		-----		-----	-----		-----	
6193	EN589	92.8	ex	-----	-----		-----	test result excluded, see §4.1
6203		-----		-----	-----		-----	
6262	EN589	91	ex,C,E	-----	-----		-----	test result excl. §4.1, fr.:90.18, calc. error *)
6315		-----		-----	-----		-----	
6321		-----		-----	-----		-----	
6326		-----		-----	-----		-----	
6327	EN589	93.32		-----	-----		-----	
6328		-----		-----	-----		-----	

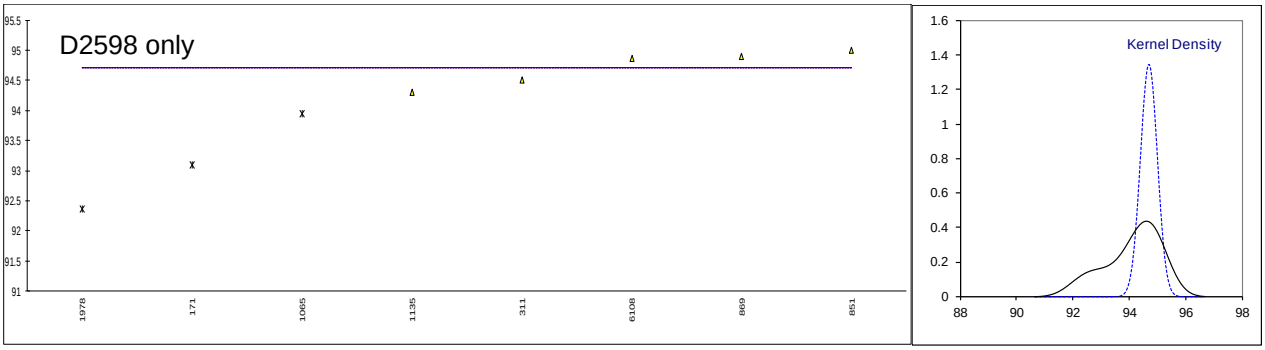
*) Calculation error:
Lab 171: iis calculated with EN589: 93.14 and with D2598: 94.77
Lab 1065: iis calculated with EN589: 93.23 and with D2598: 94.95
Lab 6019: iis calculated with EN589: 93.55
Lab 6262: iis calculated with EN589: 93.37

	EN589		D2598	
normality	OK		unknown	
n	9		5	
outliers	0 (+6ex)		2 (+1ex)	
mean (n)	92.874		94.711	
st.dev. (n)	0.4106	RSD = 0.4%	0.2971	RSD = 0.3%
R(calc.)	1.150		0.832	
compare				
R(iis19S02B)	1.243		n.e.	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	OK		OK	
n	35		35	
outliers	0 (+12ex)		0 (+12ex)	
mean (n)	93.144		94.842	
st.dev. (n)	0.0963	RSD = 0.1%	0.0681	RSD = 0.1%
R(calc.)	0.270		0.191	
compare				
R(iis19S02B)	0.215		0.110	

*) 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.



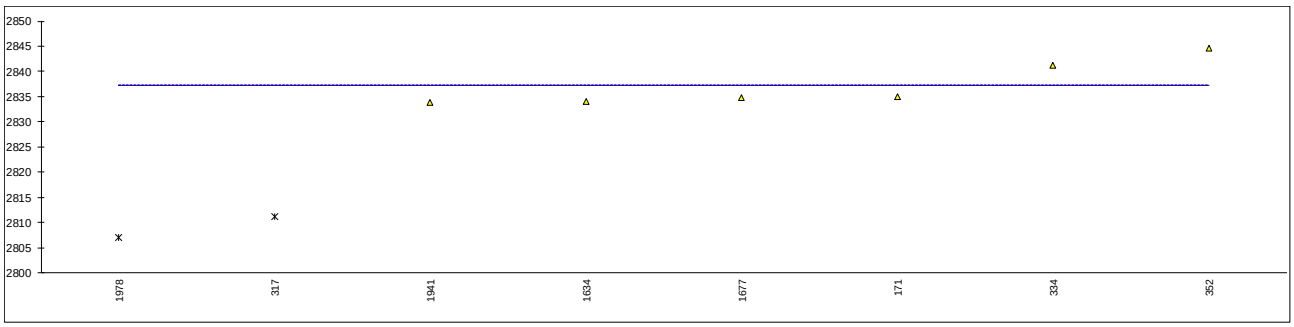


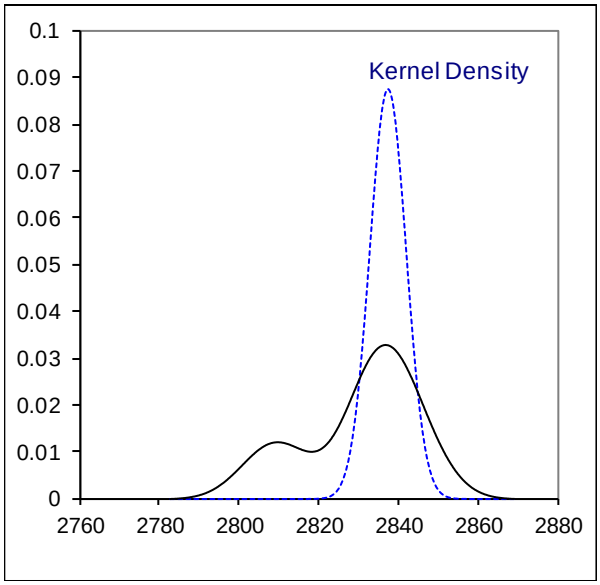
Determination of Ideal Gross Heating Value at 14.696 psia/60°F on sample #20090; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171	D3588	2835.0		-----	
311		-----		-----	
317	D3588	2811.24	C,DG(0.05),E	-----	first reported: 2811.37, calculation error, see below table *)
323		-----		-----	
333		-----		-----	
334	D3588	2841.3		-----	
336		-----		-----	
352	D3588	2844.70		-----	
357		-----		-----	
404		-----		-----	
444		-----		-----	
445		-----		-----	
508		-----		-----	
754		-----		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095		-----		-----	
1108		-----		-----	
1135		-----		-----	
1191		-----		-----	
1275		-----		-----	
1345		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	2834.13		-----	
1677	D3588	2834.85		-----	
1741		-----		-----	
1776		-----		-----	
1941	D3588	2833.80		-----	
1978		2806.9764	C,DG(0.05),E	-----	first reported: 2807.2300, calculation error, see below table *)
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6142		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262		-----		-----	
6315		-----		-----	
6321		-----		-----	
6326		-----		-----	
6327		-----		-----	
6328		-----		-----	
					iis calculated from all reported test results **):
	normality	unknown			suspect
	n	6			35
	outliers	2			0 (+12ex)
	mean (n)	2837.30			2833.22
	st.dev. (n)	4.568	RSD = 0.2%		1.297 RSD = 0.1%
	R(calc.)	12.79			3.63
comp	R(iis19S02B)	45.99			2.00

*) Calculation error:
Lab 317: iis calculated 2833.36 with 1,3-Butadiene (factor=2542.03) and 2811.24 without taking into account 1,3-Butadiene (factor=0)
Lab 1978: iis calculated 2831.79 with 1,3-Butadiene (factor=2542.03) and 2808.04 without taking into account 1,3-Butadiene (factor=0)

**) 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.


2850
2845
2840
2835
2830
2825
2820
2815
2810
2805
2800
1978
317
1941
1634
1677
171
334
352

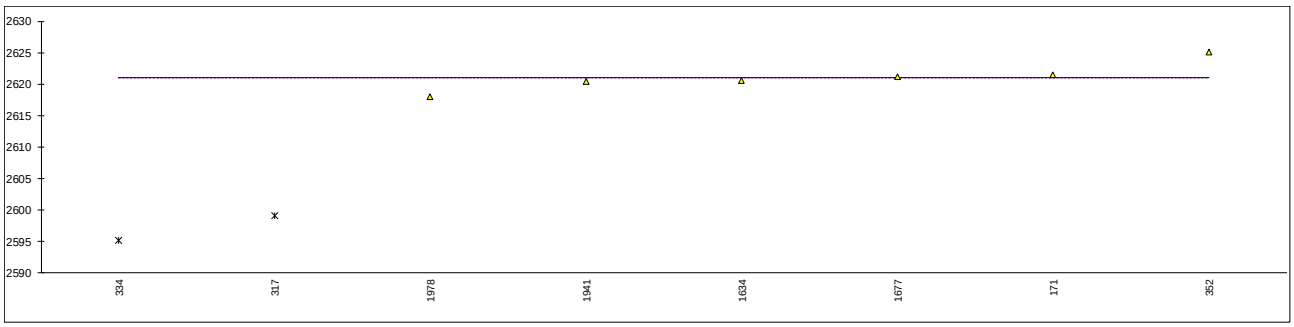

Kernel Density
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2760
2780
2800
2820
2840
2860
2880

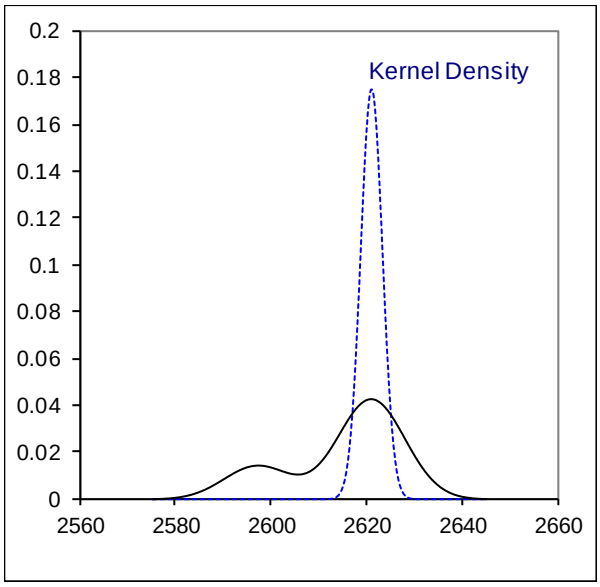
Determination of Ideal Net Heating Value at 14.696 psia/60°F on sample #20090; results in kJ/mol

lab	method	value	mark	z(targ)	Remarks
150		-----		-----	
171	D3588	2621.4		-----	
311		-----		-----	
317	D3588	2599.05	C,DG(0.01), E	-----	first reported: 2599.54, calculation error, see below table *)
323		-----		-----	
333		-----		-----	
334	D3588	2595.2	DG(0.01),E	-----	calculation error, see below table *)
336		-----		-----	
352	D3588	2625.02	E	-----	calculation error, see below table *)
357		-----		-----	
404		-----		-----	
444		-----		-----	
445		-----		-----	
508		-----		-----	
754		-----		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095		-----		-----	
1108		-----		-----	
1135		-----		-----	
1191		-----		-----	
1275		-----		-----	
1345		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	2620.55		-----	
1677	D3588	2621.09		-----	
1741		-----		-----	
1776		-----		-----	
1941	D3588	2620.43		-----	
1978		2617.9702		-----	
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6142		-----		-----	
6193		-----		-----	
6203		-----		-----	
6262		-----		-----	
6315		-----		-----	
6321		-----		-----	
6326		-----		-----	
6327		-----		-----	
6328		-----		-----	
					iis calculated from all reported test results **):
	normality	unknown			suspect
	n	6			35
	outliers	2			0 (+12ex)
	mean (n)	2621.08			2619.90
	st.dev. (n)	2.280	RSD = 0.09%		1.126 RSD = 0.04%
	R(calc.)	6.39			3.15
comp	R(iis19S02B)	37.01			1.79

*) Calculation error:
Lab 317: iis calculated 2620.00 with 1,3-Butadiene (factor=2542.03) and 2599.05 without taking into account 1,3-Butadiene (factor=0)
Lab 334: iis calculated 2620.47 with 1,3-Butadiene (factor=2542.03) and 2599.99 without taking into account 1,3-Butadiene (factor=0)
Lab 352: iis calculated 2619.92 with 1,3-Butadiene (factor=2542.03) and 2597.37 without taking into account 1,3-Butadiene (factor=0)

**) 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 Net Heating Value factor for 1,3-Butadiene. For the calculation, iis has used the factor 2408.8 from table 3 of ISO6976:16.


2630
2625
2620
2615
2610
2605
2600
2595
2590
334
317
1978
1941
1634
1677
171
352


Kernel Density
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2560
2580
2600
2620
2640
2660

APPENDIX 2

Number of participants per country

4 labs in BELGIUM
1 lab in CHILE
1 lab in CHINA, People's Republic
1 lab in DENMARK
1 lab in ESTONIA
2 labs in FINLAND
3 labs in FRANCE
1 lab in GEORGIA
3 labs in GERMANY
1 lab in GREECE
1 lab in HONG KONG
1 lab in IRELAND
1 lab in ISRAEL
1 lab in LITHUANIA
1 lab in MALAYSIA
2 labs in MEXICO
3 labs in NETHERLANDS
1 lab in PAKISTAN
1 lab in PANAMA
6 labs in PORTUGAL
2 labs in ROMANIA
2 labs in RUSSIAN FEDERATION
2 labs in SERBIA
2 labs in SWEDEN
1 lab in TAIWAN
4 labs in UNITED KINGDOM
2 labs in UNITED STATES OF AMERICA
1 lab in VIETNAM

APPENDIX 3

Abbreviations:

C	= final test result after checking of first reported suspect test result
D(0.01)	= outlier in Dixon's outlier test
D(0.05)	= straggler in Dixon's outlier test
G(0.01)	= outlier in Grubbs' outlier test
G(0.05)	= straggler in Grubbs' outlier test
DG(0.01)	= outlier in Double Grubbs' outlier test
DG(0.05)	= straggler in Double Grubbs' outlier test
R(0.01)	= outlier in Rosner's outlier test
R(0.05)	= straggler in Rosner's outlier test
E	= 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 ISO5725:86(1994)
6 ISO5725, parts 1-6:94
7 ISO13528:05
8 M. Thompson and R. Wood, J. AOAC Int, 76, 926, (1993)
9 W.J. Youden and E.H. Steiner, Statistical Manual of the AOAC, (1975)
10 IP367:84
11 DIN38402 T41/42
12 P.L. Davies, Fr. Z. Anal. Chem, 331, 513, (1988)
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16 Bernard Rosner, Percentage Points for a Generalized ESD Many-Outlier Procedure, Technometrics, 25(2), 165-172, (1983)
17 J.B. Maxwell, Data book on Hydrocarbons, 5th edition, 3 (1958)