Results of Proficiency Test
Liquefied Butane
June 2021

Organized by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

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1 INTRODUCTION

Since 2009 the Institute for Interlaboratory Studies (iis) organizes a proficiency scheme for the analysis of Liquefied Butane every year. During the annual proficiency testing program 2020/2021 it was decided to continue the round robin for the analysis of Liquefied Butane. 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.

In this interlaboratory study 45 laboratories in 23 different countries registered for participation. See appendix 2 for the number of participants per country. In this report the results of the 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 (PT). To optimize costs for the participating laboratories it was decided to prepare one Liquefied Butane mixture. The mixture was divided over a batch of 50 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 #21090, filled with approximately 200 grams of 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 50 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 21/0552, starting in April/May 2021). 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	0.0064	0.0649
Propene	0.0058	0.0854
iso-Butane	0.0343	0.2782
n-Butane	0.0233	0.0874
1-Butene	0.0083	0.0819
iso-Butene	0.0035	0.0752
trans-2-Butene	0.0053	0.0598
cis-2-Butene	0.0069	0.0862
1,3-Butadiene	0.0032	0.0393
iso-Pentane	0.0047	0.0150

Table 1: evaluation of the repeatabilities of subsamples #21090

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

To each of the participating laboratories one 1L cylinder labelled #21090 was sent on May 26, 2021. 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 ANALYZES

The participants were requested to determine: 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 test results, but report as much significant figures as possible. It was also requested not to report ‘less than’ test results, which are above the detection limit, because such test results cannot be used for meaningful statistical evaluations.

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

3 RESULTS

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

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

3.1 STATISTICS

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

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

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

For each assigned value, the uncertainty was determined in accordance with ISO13528. Subsequently the calculated uncertainty was evaluated against the respective 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 test results are plotted. The corresponding laboratory numbers are on the X-axis. The straight horizontal line presents the consensus value (a trimmed mean). The four striped lines, parallel to the consensus value line, are the +3s, +2s, -2s and -3s target reproducibility limits of the selected reference test method. Outliers and other data, which were excluded from the calculations, are represented as a cross. Accepted data are represented as a triangle.

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

3.3 Z-SCORES

To evaluate the performance of the participating laboratories the z-scores were calculated. As it was decided to evaluate the performance of the participants in this proficiency test (PT) against the literature requirements, 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, like Horwitz or an estimated reproducibility based on former iis proficiency tests.

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

The z-scores were calculated according to:

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

The $z_{(target)}$ scores are listed in the 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 proficiency test some problems were encountered with the dispatch of the samples. Therefore, the reporting time on the data entry portal was extended with another week. Six participants reported test results after the extended final reporting date and five other participants did not report any test results. Not all participants were able to report all tests requested.

In total 40 participants reported 549 numerical test results. Observed were 28 outlying test results, which is 5.1%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.

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

4.1 EVALUATION PER 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. D2163) and an added designation for the year that the method was adopted or revised (e.g. D2163:14). If applicable, a designation in parentheses is added to designate the year of reapproval (e.g. D2163:14(2019)). In the results tables of appendix 1 only the method number and year of adoption or revision (e.g. D2163:14) 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.

Two laboratories 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 statistical calculations 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 seven other laboratories with one, two or three outliers in the composition. Furthermore, three laboratories did not report a normalized result. The results of these laboratories did not add up to 100% and would have been excluded, if they were not already excluded for outliers in the composition.

Propane: The determination was not problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data 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).

Propene: The determination of this component was not problematic. Two statistical outliers were observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data 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 was not problematic. One statistical outlier was observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data is in full 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-Butane: The determination of this component may be problematic depending on the requirements of the test method used. Two 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 is in agreement with the requirements of EN27941:93(liq) (identical to IP405 and ISO7941).

1-Butene: The determination of this component was not problematic. Two statistical outliers were observed and one other test result was excluded. The calculated reproducibility after rejection of the suspect data 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-Butene: The determination of this component was not problematic. Two statistical outlier were observed and one other test result was excluded. 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).

trans-2-Butene: The determination of this component was not problematic. One statistical outlier was observed and one other test result was excluded. 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).

cis-2-Butene: The determination of this component may be problematic depending on the requirements of the test method used. One statistical outlier was 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).

1,3-Butadiene The determination of this component was not problematic. No statistical outliers were observed but one test result was excluded. 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 are calculated.

iso-Pentane: The determination of this component may be problematic depending on the requirements of the test method used. Six 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%. Three calculated results were found to be higher or lower than 100%. 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 and four other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility calculated by iis using the published relative molecular masses obtained from one test method (ISO8973:97/ IP432:00) over all reported component concentrations (0.048 *vs* 0.048). See also the discussion in paragraph 5.

Relative Density at 60/60°F: This calculated parameter may not be problematic. Two statistical outliers were observed and five other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility calculated by iis using the published relative density at 60/60°F obtained from one test method (ASTM D2598:16) over all reported component concentrations (0.0004 *vs* 0.0004). See also the discussion in paragraph 5.

Abs. Vapor Pres. at 100°F: This calculated parameter may be problematic depending on the requirements of the test method used. No statistical outliers were observed in the ISO8973 test results but two test results were excluded. The calculated reproducibility after rejection of the statistical outlier is not in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (0.94 *vs* 0.47 psi).

In the ASTM D2598 test results one statistical outlier was observed and one other test result was excluded. The calculated reproducibility is in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from ASTM D2598:16 over all reported component concentrations (0.41 *vs* 0.40 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 two test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from ISO8973:97 over all reported component concentrations (0.45 *vs* 0.47 psi).
In the ASTM D2598 test results one statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is not in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from ASTM D2598:16 over all reported component concentrations (0.53 *vs* 0.40 psi). See also the discussion in paragraph 5.

Abs. Vapor Pres. at 40°C: This calculated parameter may not be problematic. Two statistical outliers were observed and four other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from one test method (ISO8973:97) over all reported component concentrations (2.75 *vs* 3.34 kPa). See also the discussion in paragraph 5.

Rel. Vapor Pres. at 40°C: This calculated parameter may not be problematic. Two statistical outliers were observed and seven other test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from one test method (ISO8973:97/IP432:00) over all reported component concentrations (2.21 *vs* 3.34 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 two test results were excluded. No statistical outliers were observed in the ASTM D2598 test results but three test results were excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from EN598:08_A1:12 over all reported component concentrations (1.60 *vs* 0.16). The calculated reproducibility after rejection of the suspect data is also not in agreement with the reproducibility calculated by iis using the published vapor pressure factors obtained from D2598:16 over all reported component concentrations (0.90 *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 the factor 83.5 for iso-Butene, trans-2-Butene the same value of cis-2-Butene and the factor 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 problematic. No statistical outliers were observed but one test result was excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility calculated by iis using the published Ideal Gross Heating Value factors obtained from one test method (ASTM D3588:98(2017)) over all reported component concentrations (36 *vs* 3 kJ/mol). Only a few laboratories reported test results, this may explain the variation in the test results. 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. No statistical outliers were observed but one test result was excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the reproducibility calculated by iis using the published Ideal Net Heating Value factors obtained from one test method (e.g. ASTM D3588:98(2017)) over all reported component concentrations (30 *vs* 2 kJ/mol). Only a few laboratories reported test results, this may explain the variation in the test results. 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 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) are presented in the next table.

Component	unit	n	average	2.8 * sd	R(D2163)	R(EN27941) liq.-inj.
Propane	%mol/mol	37	1.347	0.150	0.215	1.305
Propene	%mol/mol	36	0.955	0.133	0.277	1.367
iso-Butane	%mol/mol	37	74.800	0.959	0.927	1.485
n-Butane	%mol/mol	36	5.390	0.343	0.294	0.990

Component	unit	n	average	2.8 * sd	R(D2163)	R(EN27941) liq.-inj.
1-Butene	%mol/mol	36	4.603	0.216	0.274	1.025
iso-Butene	%mol/mol	36	3.759	0.199	0.250	1.025
trans-2-Butene	%mol/mol	37	2.270	0.129	0.199	1.025
cis-2-Butene	%mol/mol	37	5.177	0.334	0.288	1.025
1,3-Butadiene	%mol/mol	37	0.904	0.084	0.132	1.064
n-Pentane	%mol/mol	31	<0.1	n.e.	n.e.	n.e.
iso-Pentane	%mol/mol	32	0.790	0.070	0.050	0.797

Table 2: reproducibilities of the composition of sample #21090

Without further statistical calculations it can 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 **iis20S02B**
Molar Mass	g/mol	15	57.53	0.05	0.05	0.04
Rel. Density 60/60°F		16	0.5711	0.0004	0.0004	0.0007
Abs. VP 100°F ISO/IP	psi	8	71.68	0.94	0.47	0.55
Abs. VP 100°F D2598	psi	4	71.20	0.41	0.40	1.49
Rel. VP 100°F ISO/IP	psi	9	57.02	0.45	0.47	0.69
Rel. VP 100°F D2598	psi	5	56.56	0.53	0.40	0.54
Abs. VP 40°C	kPa	12	521.0	2.7	3.3	2.4
Rel. VP 40°C	kPa	13	419.6	2.2	3.3	3.1
MON EN589		9	93.07	1.60	0.16	1.15
MON D2598		3	94.47	0.90	0.11	0.83
IGHV D3588	kJ/mol	4	2829	36	3	13
INHV D3588	kJ/mol	5	2615	30	2	6

Table 3: reproducibilities of calculated physical properties of sample #21090 using one set of factors.

Without further statistical calculations it can 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 JUNE 2021 WITH PREVIOUS PTS

	June 2021	July 2020	June 2019	June 2018	June 2017
Number of reporting laboratories	40	47	41	51	49
Number of test results	549	665	549	660	623
Number of statistical outliers	28	41	53	45	30
Percentage of statistical outliers	5.1%	6.2%	9.7%	6.8%	4.8%

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	June 2021	July 2020	June 2019	June 2018	June 2017
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:

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

5 DISCUSSION

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). Not all methods mention a factor of each component of the Butane mixture for calculation of the 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. In ASTM D2598 the Vapor Pressure is calculated from the liquid volume percentage per component and a Vapor Pressure factor of that component.
For the MON, the calculation in Annex B from specification EN589 is used by iis on a molar basis, while ASTM D2598 describes the calculation of MON on a liquid volume basis.
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	1.362	1.347	0.015	0.20
Propene	0.998	0.955	0.043	0.43
iso-Butane	74.89	74.80	0.090	0.27
n-Butane	5.294	5.390	-0.096	-0.91
1-Butene	4.579	4.603	-0.024	-0.25
iso-Butene	3.791	3.759	0.032	0.36
trans-2-Butene	2.276	2.270	0.006	0.08
cis-2-Butene	5.133	5.177	-0.044	-0.43
1,3-Butadiene	0.894	0.904	-0.010	-0.21
iso-Pentane	0.785	0.790	-0.005	-0.28

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

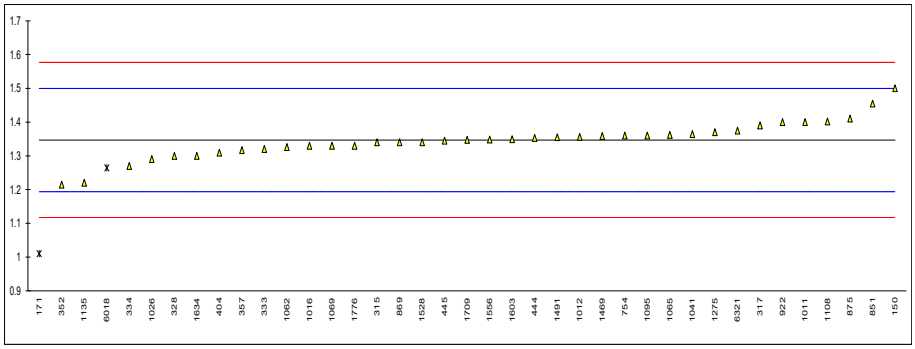
APPENDIX 1

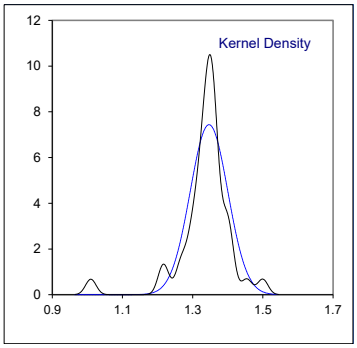
Determination of Propane on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.50		2.00	
171	D2163	1.01	R(0.01)	-4.40	
315	D2163	1.34		-0.09	
317	D2163	1.39		0.56	
323		-----		-----	
328		1.30		-0.61	
333	D2163	1.32		-0.35	
334	D2163	1.27		-1.00	
352	EN27941	1.2144		-1.73	
357	D2163	1.317		-0.39	
404	D2163	1.309		-0.49	
444	ISO7941	1.353		0.08	
445	D2163	1.345		-0.02	
508		-----		-----	
754	D2163	1.36		0.17	
851	D2163	1.454391		1.40	
869	D2163	1.34		-0.09	
875	D2163	1.41		0.82	
922	D2163	1.40		0.69	
1011	ISO7941	1.4		0.69	
1012	D2163	1.356		0.12	
1016	ISO7941	1.330		-0.22	
1026	ISO7941	1.29		-0.74	
1041	DIN51619	1.364		0.22	
1062	D2163	1.3258		-0.28	
1065	D2163	1.361922		0.20	
1069	D4423	1.33		-0.22	
1095	ISO7941	1.36		0.17	
1108	D2163	1.402		0.72	
1135	D2163	1.22	C	-1.66	first reported: 3.31
1275	EN27941	1.370		0.30	
1357		-----		-----	
1469	D2163	1.358267		0.15	
1491	ISO7941	1.355		0.11	
1528	EN27941	1.34		-0.09	
1556	EN27941	1.348		0.01	
1603	In house	1.3490		0.03	
1634	ISO7941	1.30		-0.61	
1709	D2163	1.347		0.00	
1720		-----		-----	
1776	EN27941	1.33		-0.22	
6018	EN27941	1.264	ex	-1.08	test result excluded, see §4.1
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 0.91
6321	D2163	1.375		0.37	

normality	not OK
n	37
outliers	1 (+1ex)
mean (n)	1.3469
st.dev. (n)	0.05368
R(calc.)	0.1503
st.dev.(D2163:14)	0.07661
R(D2163:14)	0.2145

Compare R(EN27941:93(liq)) = 1.3047



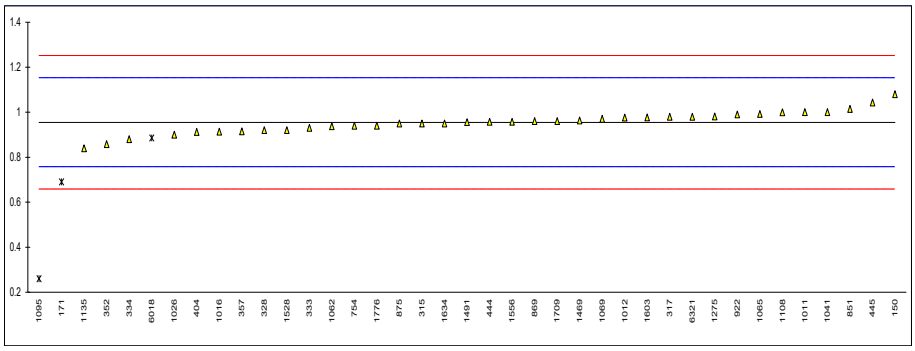


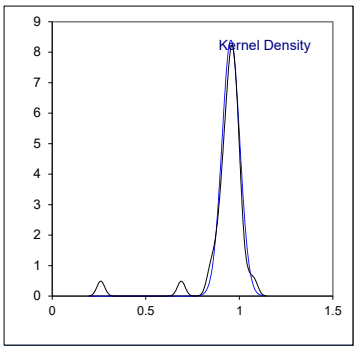
Determination of Propene on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	1.08		1.26	
171	D2163	0.69	R(0.01)	-2.69	
315	D2163	0.95		-0.05	
317	D2163	0.98		0.25	
323		-----		-----	
328		0.92		-0.36	
333	D2163	0.93		-0.26	
334	D2163	0.88		-0.76	
352	EN27941	0.8575		-0.99	
357	D2163	0.915		-0.41	
404	D2163	0.912		-0.44	
444	ISO7941	0.957		0.02	
445	D2163	1.043		0.89	
508		-----		-----	
754	D2163	0.94		-0.15	
851	D2163	1.014151		0.60	
869	D2163	0.96		0.05	
875	D2163	0.95		-0.05	
922	D2163	0.99		0.35	
1011	ISO7941	1.0		0.45	
1012	D2163	0.976		0.21	
1016	ISO7941	0.914		-0.42	
1026	ISO7941	0.90		-0.56	
1041	DIN51619	1.000		0.45	
1062	D2163	0.9373		-0.18	
1065	D2163	0.991701		0.37	
1069	D4423	0.97		0.15	
1095	ISO7941	0.26	R(0.01)	-7.04	
1108	D2163	0.999		0.44	
1135	D2163	0.84	C	-1.17	first reported: 2.89
1275	EN27941	0.981		0.26	
1357		-----		-----	
1469	D2163	0.962867		0.08	
1491	ISO7941	0.956		0.01	
1528	EN27941	0.92		-0.36	
1556	EN27941	0.957		0.02	
1603	In house	0.9766		0.22	
1634	ISO7941	0.95		-0.05	
1709	D2163	0.960		0.05	
1720		-----		-----	
1776	EN27941	0.94		-0.15	
6018	EN27941	0.885	ex	-0.71	test result excluded, see §4.1
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported 0.70
6321	D2163	0.980		0.25	

	normality	suspect
	n	36
	outliers	2 (+1ex)
	mean (n)	0.9553
	st.dev. (n)	0.04752
	R(calc.)	0.1330
	st.dev.(D2163:14)	0.09876
	R(D2163:14)	0.2765

Compare R(EN27941:93(liq)) = 1.3672



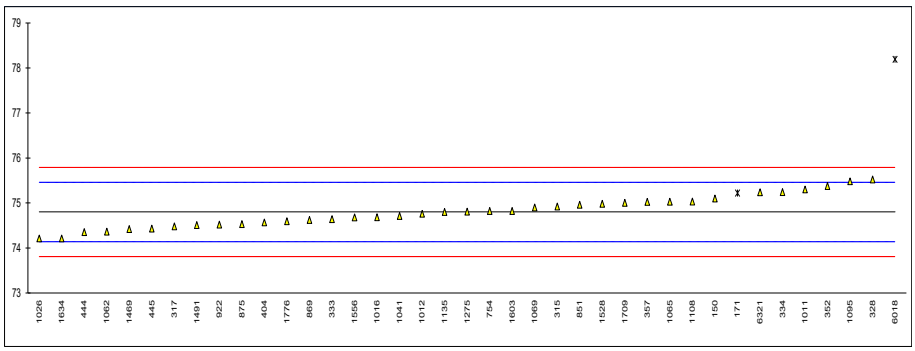


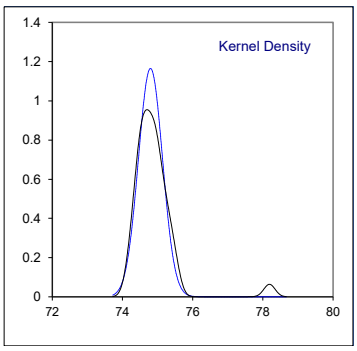
Determination of iso-Butane on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	75.10		0.91	
171	D2163	75.22	ex	1.27	test result excluded, see §4.1
315	D2163	74.92		0.36	
317	D2163	74.48		-0.97	
323		-----		-----	
328		75.52		2.17	
333	D2163	74.64		-0.48	
334	D2163	75.24		1.33	
352	EN27941	75.3744		1.73	
357	D2163	75.023		0.67	
404	D2163	74.567		-0.70	
444	ISO7941	74.353		-1.35	
445	D2163	74.428		-1.12	
508		-----		-----	
754	D2163	74.82		0.06	
851	D2163	74.957962		0.48	
869	D2163	74.62		-0.54	
875	D2163	74.53		-0.82	
922	D2163	74.52		-0.85	
1011	ISO7941	75.3		1.51	
1012	D2163	74.758		-0.13	
1016	ISO7941	74.683		-0.35	
1026	ISO7941	74.21		-1.78	
1041	DIN51619	74.712		-0.27	
1062	D2163	74.3631		-1.32	
1065	D2163	75.027802		0.69	
1069	D4423	74.90		0.30	
1095	ISO7941	75.48		2.05	
1108	D2163	75.029		0.69	
1135	D2163	74.80	C	0.00	first reported: 75.84
1275	EN27941	74.806		0.02	
1357		-----		-----	
1469	D2163	74.416133		-1.16	
1491	ISO7941	74.509		-0.88	
1528	EN27941	74.98		0.54	
1556	EN27941	74.679		-0.37	
1603	In house	74.82		0.06	
1634	ISO7941	74.21		-1.78	
1709	D2163	75.003		0.61	
1720		-----		-----	
1776	EN27941	74.59		-0.64	
6018	EN27941	78.189	R(0.01)	10.24	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 73.37
6321	D2163	75.238		1.32	

	normality	OK
	n	37
	outliers	1 (+1ex)
	mean (n)	74.8002
	st.dev. (n)	0.34235
	R(calc.)	0.9586
	st.dev.(D2163:14)	0.33105
	R(D2163:14)	0.9269

Compare R(EN27941:93(liq)) = 1.4848



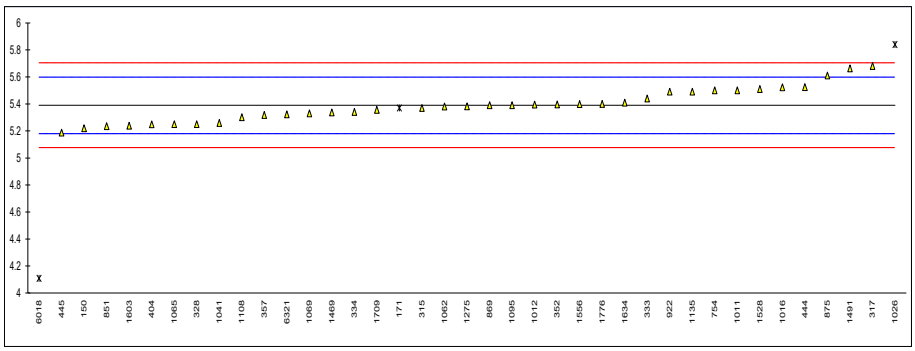


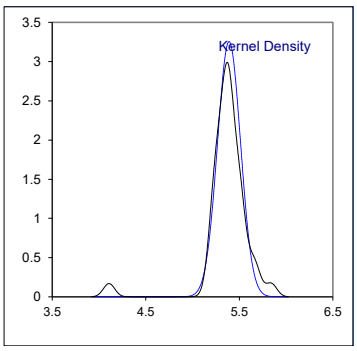
Determination of n-Butane on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	5.22		-1.62	
171	D2163	5.37	ex	-0.19	test result excluded, see §4.1
315	D2163	5.37		-0.19	
317	D2163	5.68		2.77	
323		-----		-----	
328		5.25		-1.33	
333	D2163	5.44		0.48	
334	D2163	5.34		-0.48	
352	EN27941	5.3964		0.06	
357	D2163	5.318		-0.69	
404	D2163	5.249		-1.34	
444	ISO7941	5.524		1.28	
445	D2163	5.187		-1.93	
508		-----		-----	
754	D2163	5.50		1.05	
851	D2163	5.2358083		-1.47	
869	D2163	5.39		0.00	
875	D2163	5.61		2.10	
922	D2163	5.49		0.95	
1011	ISO7941	5.5		1.05	
1012	D2163	5.395		0.05	
1016	ISO7941	5.523		1.27	
1026	ISO7941	5.84	R(0.05)	4.29	
1041	DIN51619	5.258		-1.26	
1062	D2163	5.3807		-0.09	
1065	D2163	5.249584		-1.34	
1069	D4423	5.33		-0.57	
1095	ISO7941	5.39		0.00	
1108	D2163	5.302		-0.84	
1135	D2163	5.49	C	0.95	first reported: 3.91
1275	EN27941	5.382		-0.08	
1357		-----		-----	
1469	D2163	5.336850		-0.51	
1491	ISO7941	5.663		2.60	
1528	EN27941	5.51		1.15	
1556	EN27941	5.398		0.08	
1603	In house	5.2390		-1.44	
1634	ISO7941	5.41		0.19	
1709	D2163	5.356		-0.32	
1720		-----		-----	
1776	EN27941	5.40		0.10	
6018	EN27941	4.107	R(0.01)	-12.23	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 5.92
6321	D2163	5.322		-0.65	

normality	OK
n	36
outliers	2 (+1ex)
mean (n)	5.3899
st.dev. (n)	0.12258
R(calc.)	0.3432
st.dev.(D2163:14)	0.10487
R(D2163:14)	0.2936

Compare R(EN27941:93(liq)) = 0.9899



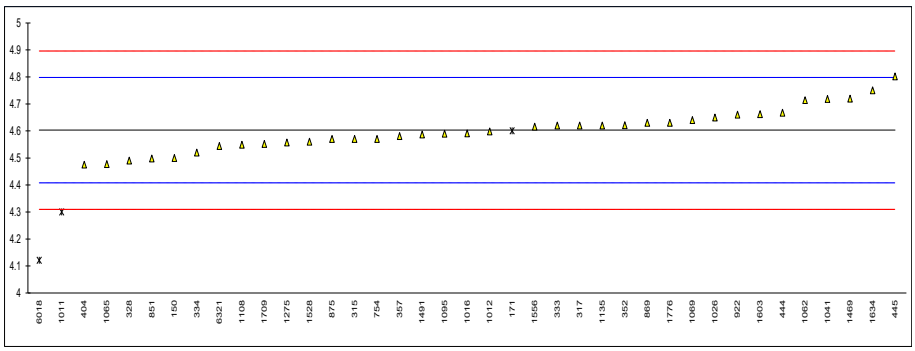


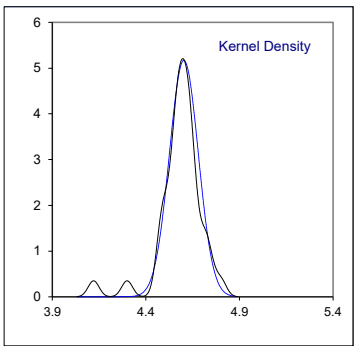
Determination of 1-Butene on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	4.50		-1.06	
171	D2163	4.60	ex	-0.03	test result excluded, see §4.1
315	D2163	4.57		-0.34	
317	D2163	4.62		0.17	
323		-----		-----	
328		4.49		-1.16	
333	D2163	4.62		0.17	
334	D2163	4.52		-0.85	
352	EN27941	4.6215		0.19	
357	D2163	4.581		-0.23	
404	D2163	4.475		-1.31	
444	ISO7941	4.667		0.65	
445	D2163	4.802		2.03	
508		-----		-----	
754	D2163	4.57		-0.34	
851	D2163	4.498092		-1.08	
869	D2163	4.63		0.27	
875	D2163	4.57		-0.34	
922	D2163	4.66		0.58	
1011	ISO7941	4.3	R(0.05)	-3.10	
1012	D2163	4.598		-0.05	
1016	ISO7941	4.591		-0.13	
1026	ISO7941	4.65		0.48	
1041	DIN51619	4.718		1.17	
1062	D2163	4.7137		1.13	
1065	D2163	4.476659		-1.30	
1069	D4423	4.64		0.38	
1095	ISO7941	4.59		-0.14	
1108	D2163	4.549		-0.56	
1135	D2163	4.62	C	0.17	first reported: 4.13
1275	EN27941	4.557		-0.47	
1357		-----		-----	
1469	D2163	4.719200		1.19	
1491	ISO7941	4.587		-0.17	
1528	EN27941	4.56		-0.44	
1556	EN27941	4.616		0.13	
1603	In house	4.6621		0.60	
1634	ISO7941	4.75		1.50	
1709	D2163	4.552		-0.52	
1720		-----		-----	
1776	EN27941	4.63		0.27	
6018	EN27941	4.121	R(0.01)	-4.94	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 4.45
6321	D2163	4.544		-0.61	

normality	OK
n	36
outliers	2 (+1ex)
mean (n)	4.6033
st.dev. (n)	0.07716
R(calc.)	0.2160
st.dev.(D2163:14)	0.09769
R(D2163:14)	0.2735

Compare R(EN27941:93(liq)) = 1.0254



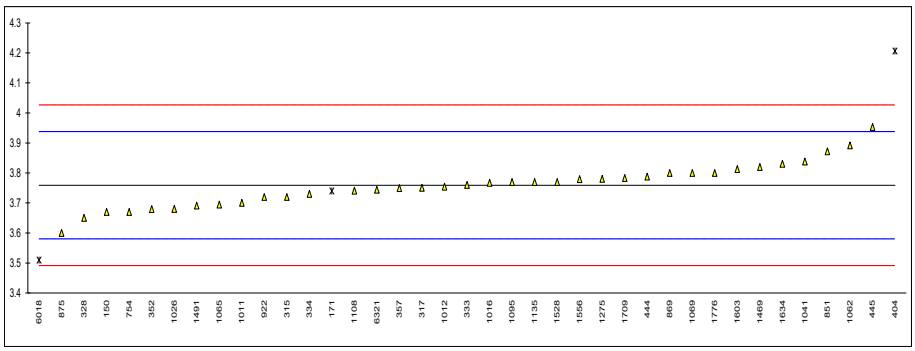


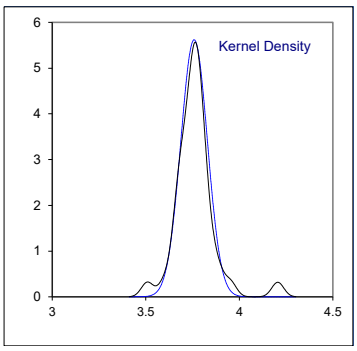
Determination of iso-Butene on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	3.67		-1.00	
171	D2163	3.74	ex	-0.21	test result excluded, see §4.1
315	D2163	3.72		-0.44	
317	D2163	3.75		-0.10	
323		-----		-----	
328		3.65		-1.22	
333	D2163	3.76		0.01	
334	D2163	3.73		-0.33	
352	EN27941	3.6793		-0.89	
357	D2163	3.749		-0.11	
404	D2163	4.206	R(0.01)	5.01	
444	ISO7941	3.788		0.32	
445	D2163	3.953		2.17	
508		-----		-----	
754	D2163	3.67		-1.00	
851	D2163	3.872196		1.27	
869	D2163	3.80		0.46	
875	D2163	3.60		-1.78	
922	D2163	3.72		-0.44	
1011	ISO7941	3.7		-0.66	
1012	D2163	3.754		-0.06	
1016	ISO7941	3.767		0.09	
1026	ISO7941	3.68		-0.89	
1041	DIN51619	3.838		0.88	
1062	D2163	3.8918		1.49	
1065	D2163	3.694445		-0.73	
1069	D4423	3.80		0.46	
1095	ISO7941	3.77		0.12	
1108	D2163	3.741		-0.20	
1135	D2163	3.77	C	0.12	first reported: 3.45
1275	EN27941	3.780		0.23	
1357		-----		-----	
1469	D2163	3.819967		0.68	
1491	ISO7941	3.691		-0.76	
1528	EN27941	3.77		0.12	
1556	EN27941	3.779		0.22	
1603	In house	3.8129		0.60	
1634	ISO7941	3.83		0.80	
1709	D2163	3.783		0.27	
1720		-----		-----	
1776	EN27941	3.80		0.46	
6018	EN27941	3.509	R(0.05)	-2.80	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported 3.78
6321	D2163	3.744		-0.17	

	normality	OK
	n	36
	outliers	2 (+1ex)
	mean (n)	3.7591
	st.dev. (n)	0.07096
	R(calc.)	0.1987
	st.dev.(D2163:14)	0.08918
	R(D2163:14)	0.2497

Compare R(EN27941:93(liq)) = 1.0254



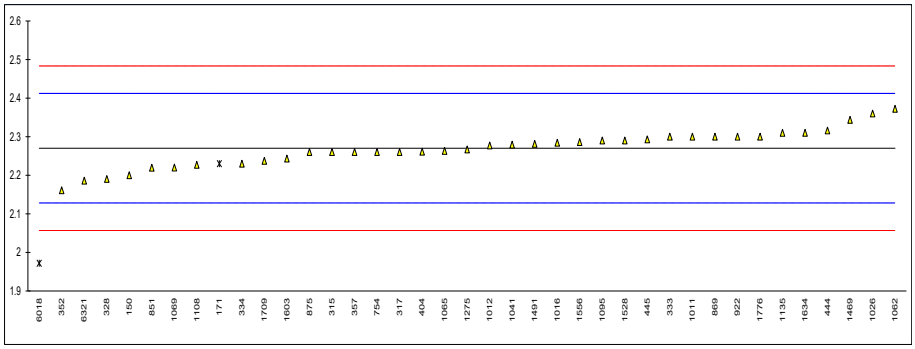


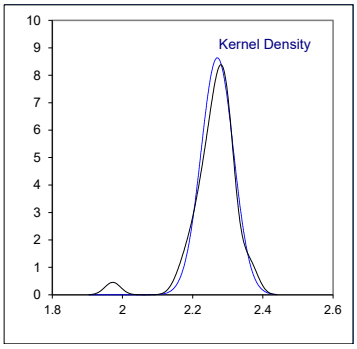
Determination of trans-2-Butene on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	2.20		-0.99	
171	D2163	2.23	ex	-0.57	test result excluded, see §4.1
315	D2163	2.26		-0.14	
317	D2163	2.26		-0.14	
323		-----		-----	
328		2.19		-1.13	
333	D2163	2.30		0.42	
334	D2163	2.23		-0.57	
352	EN27941	2.1611		-1.53	
357	D2163	2.260		-0.14	
404	D2163	2.261		-0.13	
444	ISO7941	2.316		0.64	
445	D2163	2.293		0.32	
508		-----		-----	
754	D2163	2.26		-0.14	
851	D2163	2.219598		-0.71	
869	D2163	2.30		0.42	
875	D2163	2.26		-0.14	
922	D2163	2.30		0.42	
1011	ISO7941	2.3		0.42	
1012	D2163	2.277		0.10	
1016	ISO7941	2.284		0.19	
1026	ISO7941	2.36		1.26	
1041	DIN51619	2.279		0.12	
1062	D2163	2.3720		1.43	
1065	D2163	2.262813		-0.10	
1069	D4423	2.22		-0.71	
1095	ISO7941	2.29		0.28	
1108	D2163	2.227		-0.61	
1135	D2163	2.31	C	0.56	first reported: 1.64
1275	EN27941	2.267		-0.04	
1357		-----		-----	
1469	D2163	2.343200		1.03	
1491	ISO7941	2.281		0.15	
1528	EN27941	2.29		0.28	
1556	EN27941	2.286		0.22	
1603	In house	2.2433		-0.38	
1634	ISO7941	2.31		0.56	
1709	D2163	2.237		-0.47	
1720		-----		-----	
1776	EN27941	2.30		0.42	
6018	EN27941	1.972	R(0.01)	-4.20	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 2.48
6321	D2163	2.186		-1.18	

normality	OK
n	37
outliers	1 (+1ex)
mean (n)	2.2702
st.dev. (n)	0.04621
R(calc.)	0.1294
st.dev.(D2163:14)	0.07107
R(D2163:14)	0.1990

Compare R(EN27941:93(liq)) = 1.0254



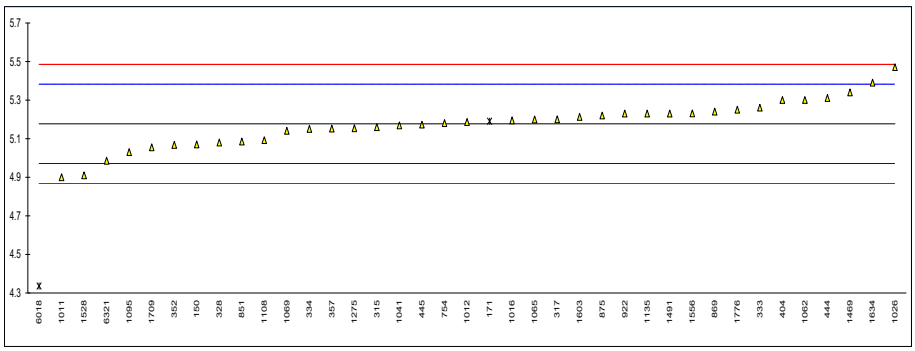


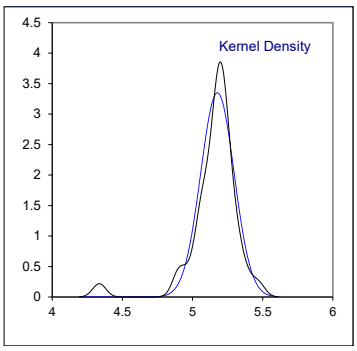
Determination of cis-2-Butene on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	5.07		-1.04	
171	D2163	5.19	ex	0.13	test result excluded, see §4.1
315	D2163	5.16		-0.16	
317	D2163	5.20		0.22	
323		-----		-----	
328		5.08		-0.94	
333	D2163	5.26		0.81	
334	D2163	5.15		-0.26	
352	EN27941	5.0676		-1.06	
357	D2163	5.152		-0.24	
404	D2163	5.300		1.20	
444	ISO7941	5.310		1.29	
445	D2163	5.172		-0.05	
508		-----		-----	
754	D2163	5.18		0.03	
851	D2163	5.084817		-0.89	
869	D2163	5.24		0.61	
875	D2163	5.22		0.42	
922	D2163	5.23		0.52	
1011	ISO7941	4.9		-2.69	
1012	D2163	5.186		0.09	
1016	ISO7941	5.194		0.17	
1026	ISO7941	5.47		2.85	
1041	DIN51619	5.169		-0.08	
1062	D2163	5.3003		1.20	
1065	D2163	5.199680		0.22	
1069	D4423	5.14		-0.36	
1095	ISO7941	5.03		-1.43	
1108	D2163	5.092		-0.82	
1135	D2163	5.23	C	0.52	first reported: 3.45
1275	EN27941	5.154		-0.22	
1357		-----		-----	
1469	D2163	5.339700		1.58	
1491	ISO7941	5.230		0.52	
1528	EN27941	4.91		-2.59	
1556	EN27941	5.231		0.53	
1603	In house	5.2134		0.35	
1634	ISO7941	5.39		2.07	
1709	D2163	5.055		-1.18	
1720		-----		-----	
1776	EN27941	5.25		0.71	
6018	EN27941	4.335	R(0.01)	-8.17	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 5.89
6321	D2163	4.985		-1.86	

normality	OK
n	37
outliers	1 (+1ex)
mean (n)	5.1769
st.dev. (n)	0.11919
R(calc.)	0.3337
st.dev.(D2163:14)	0.10299
R(D2163:14)	0.2884

Compare R(EN27941:93(liq)) = 1.0254



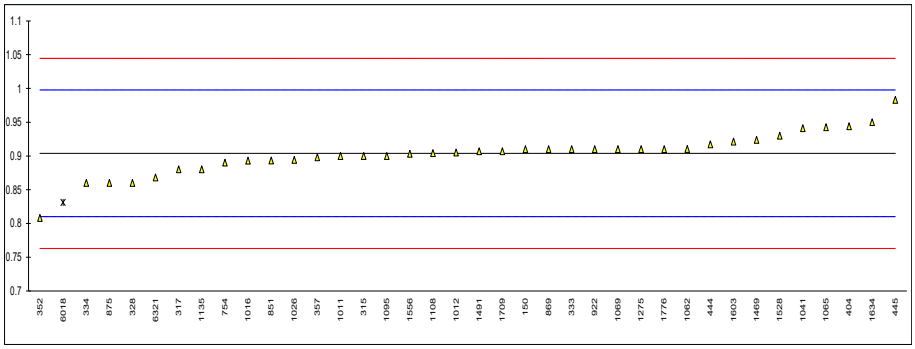


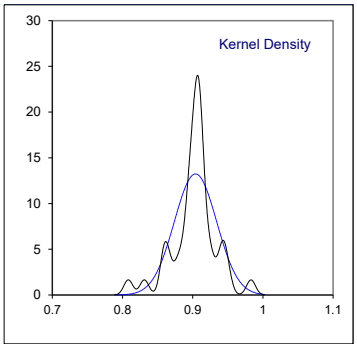
Determination of 1,3-Butadiene on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.91		0.13	
171	D2163	<0.01	f-?	<-19.03	possibly a false negative test result?
315	D2163	0.90		-0.08	
317	D2163	0.88		-0.51	
323		-----		-----	
328		0.86		-0.93	
333	D2163	0.91		0.13	
334	D2163	0.86		-0.93	
352	EN27941	0.8081		-2.04	
357	D2163	0.898		-0.13	
404	D2163	0.944		0.85	
444	ISO7941	0.917		0.28	
445	D2163	0.983		1.69	
508		-----		-----	
754	D2163	0.89	C	-0.30	first reported: 0.84
851	D2163	0.893182		-0.23	
869	D2163	0.91		0.13	
875	D2163	0.86		-0.93	
922	D2163	0.91		0.13	
1011	ISO7941	0.9		-0.08	
1012	D2163	0.905		0.02	
1016	ISO7941	0.893		-0.23	
1026	ISO7941	0.8942	C	-0.21	first reported: 0
1041	DIN51619	0.941		0.79	
1062	D2163	0.9102	C	0.13	first reported: 0.7949
1065	D2163	0.942483		0.82	
1069	D4423	0.91		0.13	
1095	ISO7941	0.90		-0.08	
1108	D2163	0.904		0.00	
1135	D2163	0.88	C	-0.51	first reported: 0
1275	EN27941	0.910		0.13	
1357		-----		-----	
1469	D2163	0.923867		0.43	
1491	ISO7941	0.907		0.07	
1528	EN27941	0.93		0.56	
1556	EN27941	0.903		-0.02	
1603	In house	0.9212		0.37	
1634	ISO7941	0.95		0.98	
1709	D2163	0.907		0.07	
1720		-----		-----	
1776	EN27941	0.91		0.13	
6018	EN27941	0.831	ex	-1.55	test result excluded, see §4.1
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 0.98
6321	D2163	0.868		-0.76	

	normality	not OK
	n	37
	outliers	0 (+1ex)
	mean (n)	0.9039
	st.dev. (n)	0.03015
	R(calc.)	0.0844
	st.dev.(D2163:14)	0.04696
	R(D2163:14)	0.1315

Compare R(EN27941:93(liq)) = 1.0637





Determination of n-Pentane on sample #21090; results in %mol/mol

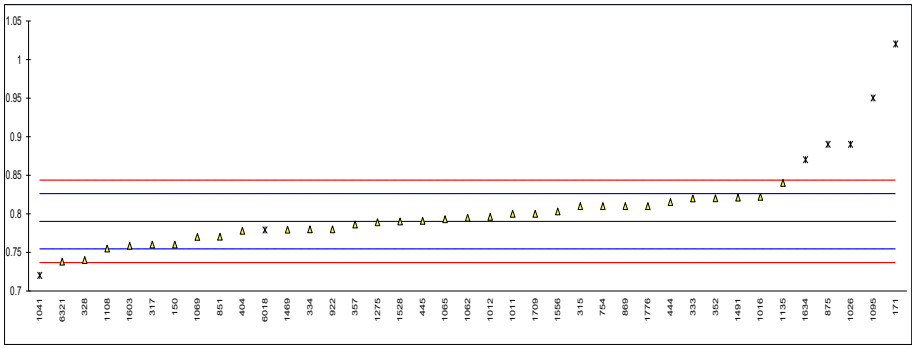
lab	method	value	mark	z(targ)	remarks
150	D2163	<0.01		-----	
171	D2163	0.91	f+?	-----	possibly a false positive test result?
315	D2163	<0.01		-----	
317	D2163	<0.01		-----	
323		-----		-----	
328		<0.01		-----	
333	D2163	<0.01		-----	
334	D2163	<0.01		-----	
352		-----		-----	
357	D2163	0.001		-----	
404	D2163	0.0		-----	
444	ISO7941	0.0002		-----	
445	D2163	<0.01		-----	
508		-----		-----	
754		-----		-----	
851	D2163	<0.10		-----	
869	D2163	0.00		-----	
875	D2163	0.01		-----	
922	D2163	<0.01		-----	
1011	ISO7941	<0,1		-----	
1012	D2163	<0.01		-----	
1016	ISO7941	<0.1		-----	
1026	ISO7941	0	C	-----	first reported: 0.72
1041	DIN51619	<0,01		-----	
1062	D2163	0		-----	
1065		-----		-----	
1069	D4423	0.00		-----	
1095		-----		-----	
1108	D2163	0		-----	
1135	D2163	0		-----	
1275	EN27941	0.000		-----	
1357		-----		-----	
1469	D2163	0.000400		-----	
1491	ISO7941	0.000		-----	
1528		-----		-----	
1556		-----		-----	
1603	In house	N.N.		-----	
1634	ISO7941	<0.01	C	-----	first reported: 0.9
1709	D2163	0.000		-----	
1720		-----		-----	
1776	EN27941	0		-----	
6018	EN27941	<0,1		-----	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 0
6321	D2163	<0.1		-----	
	n	31			
	mean (n)	<0.1			

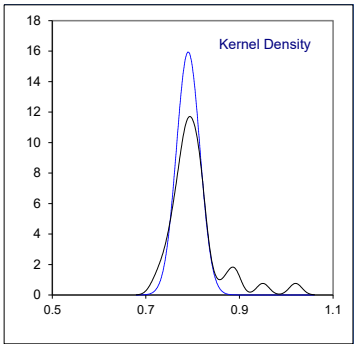
Determination of iso-Pentane on sample #21090; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
150	D2163	0.76		-1.70	
171	D2163	1.02	R(0.01)	12.87	
315	D2163	0.81		1.10	
317	D2163	0.76		-1.70	
323		-----		-----	
328		0.74		-2.82	
333	D2163	0.82		1.66	
334	D2163	0.78		-0.58	
352	EN27941	0.8202		1.67	
357	D2163	0.786		-0.24	
404	D2163	0.778		-0.69	
444	ISO7941	0.815		1.38	
445	D2163	0.791		0.04	
508		-----		-----	
754	D2163	0.81	C	1.10	first reported: 1.01
851	D2163	0.770269		-1.12	
869	D2163	0.81		1.10	
875	D2163	0.89	C,R(0.05)	5.59	first reported: 0.99
922	D2163	0.78		-0.58	
1011	ISO7941	0.8		0.54	
1012	D2163	0.796		0.32	
1016	ISO7941	0.822		1.77	
1026	ISO7941	0.89	R(0.05)	5.59	
1041	DIN51619	0.720	R(0.05)	-3.94	
1062	D2163	0.7949	C	0.26	first reported: 0.9102
1065	D2163	0.792911		0.15	
1069	D4423	0.77		-1.14	
1095	ISO7941	0.95	R(0.01)	8.95	
1108	D2163	0.755		-1.98	
1135	D2163	0.84	C	2.78	first reported: 0.24
1275	EN27941	0.789		-0.07	
1357		-----		-----	
1469	D2163	0.779550		-0.60	
1491	ISO7941	0.821		1.72	
1528	EN27941	0.79		-0.02	
1556	EN27941	0.803		0.71	
1603	In house	0.7585		-1.78	
1634	ISO7941	0.87	C,R(0.05)	4.46	first reported: <0.01
1709	D2163	0.800		0.54	
1720		-----		-----	
1776	EN27941	0.81		1.10	
6018	EN27941	0.779	ex	-0.63	test result excluded, see §4.1
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 1.52
6321	D2163	0.738		-2.93	

	normality	OK
	n	32
	outliers	6 (+1ex)
	mean (n)	0.7903
	st.dev. (n)	0.02504
	R(calc.)	0.0701
	st.dev.(D2163:14)	0.01785
	R(D2163:14)	0.0500

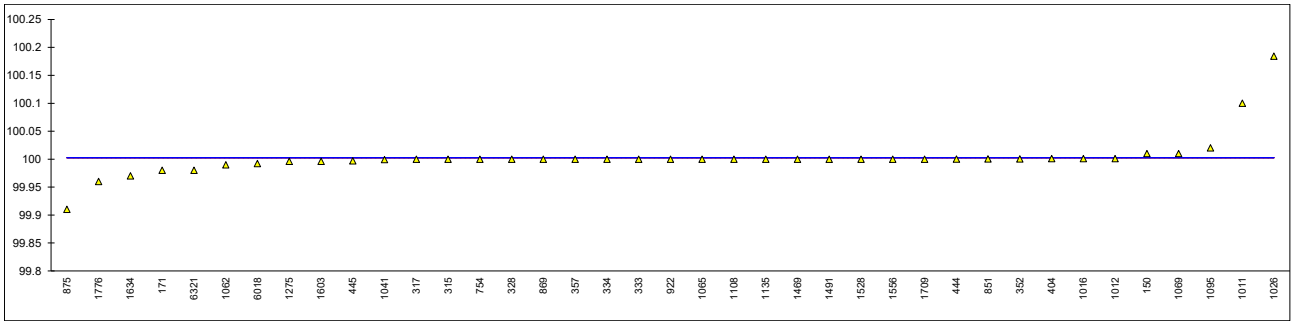
Compare R(EN27941:93(liq)) = 0.7974





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

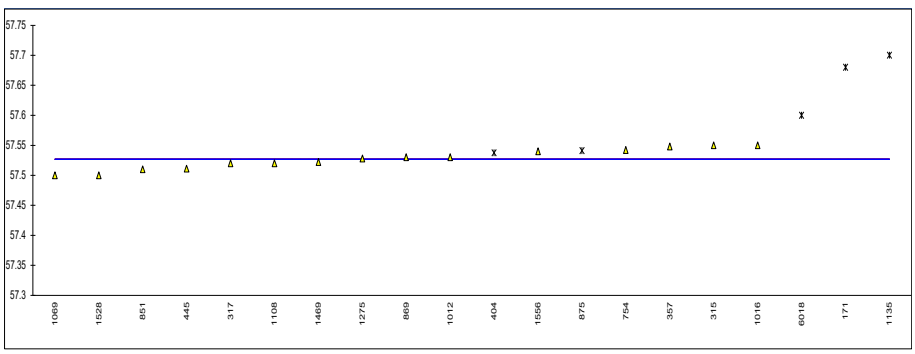
lab	method	reported		iis calc.	remarks
150	D2163	-----		100.01	
171	D2163	-----		99.98	
315	D2163	100.00		100.00	
317	D2163	100.00		100.00	
323		-----		-----	
328		100.0		100.00	
333	D2163	100.00		100.00	
334	D2163	100.00		100.00	
352	EN27941	-----		100.00	
357	D2163	100.000		100.00	
404	D2163	-----		100.00	
444	ISO7941	100.00		100.00	
445	D2163	-----		100.00	
508		-----		-----	
754	D2163	100		100.00	
851	D2163	100		100.00	
869	D2163	100.00		100.00	
875	D2163	-----		**99.91**	not 100%
922	D2163	100		100.00	
1011	ISO7941	100.1		**100.10**	not 100%
1012	D2163	-----		100.00	
1016	ISO7941	-----		100.00	
1026	ISO7941	100		**100.18**	not 100%
1041	DIN51619	100		100.00	
1062	D2163	99.9898		99.99	
1065	D2163	-----		100.00	
1069	D4423	99.99		100.01	
1095	ISO7941	-----		100.02	
1108	D2163	100.00		100.00	
1135	D2163	100	C	100.00	first reported: 98.86
1275	EN27941	99.996		100.00	
1357		-----		-----	
1469	D2163	-----		100.00	
1491	ISO7941	-----		100.00	
1528	EN27941	100		100.00	
1556	EN27941	-----		100.00	
1603	In house	-----		100.00	
1634	ISO7941	100		99.97	
1709	D2163	100.000		100.00	
1720		-----		-----	
1776	EN27941	99.96		99.96	
6018	EN27941	100.000		99.99	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 100
6321	D2163	-----		99.98	

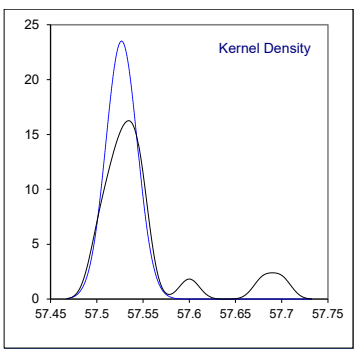


Determination of Molar Mass on sample #21090; results in g/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171	D2598	57.68	ex	-----	test result excluded, see §4.1
315	D2163	57.55		-----	
317	INH-001	57.52		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
352		-----		-----	
357	ISO8973	57.548		-----	
404	ISO8973	57.5375	ex,C	-----	test result excluded, see §4.1, first reported: 57537.5
444		-----		-----	
445	D2163	57.511		-----	
508		-----		-----	
754	D2421	57.542		-----	
851	D2598	57.51		-----	
869	D2598	57.53		-----	
875	D2598	57.541	ex	-----	test result excluded, see §4.1
922		-----		-----	
1011		-----		-----	
1012	D2598	57.53		-----	
1016	EN27941	57.5500		-----	
1026		-----		-----	
1041		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069	ISO8973	57.5		-----	
1095		-----		-----	
1108	ISO8973	57.52		-----	
1135	D2598	57.7	C,G(0.01)	-----	first reported: 75.1
1275	EN589	57.528		-----	
1357		-----		-----	
1469	D2421	57.52229		-----	
1491		-----		-----	
1528	D2421	57.5	C	-----	first reported: 57.921
1556	ISO8973	57.54		-----	
1603		-----		-----	
1634		-----		-----	
1709		-----		-----	
1720		-----		-----	
1776		-----		-----	
6018	ISO8973	57.60	ex	-----	test result excluded, see §4.1,
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 57.72
6321		-----		-----	
					iis calculated from all reported composition results: *)
	normality	OK			suspect
	n	15			29
	outliers	1 (+4ex)			1 (+9ex)
	mean (n)	57.527			57.534
	st.dev. (n)	0.0170	RSD = 0.03%		0.0171 RSD = 0.03%
	R(calc.)	0.048			0.048
comp	R(iis20S02B)	0.037			0.069

*) 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

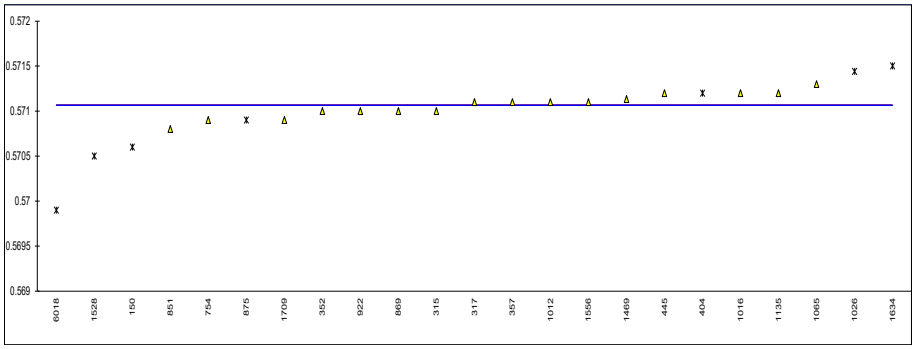


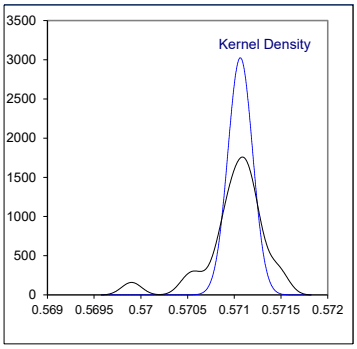


Determination of Relative Density at 60/60°F on sample #21090; unitless results

lab	method	value	mark	z(targ)	remarks
150	D2598	0.5706	DG(0.05)	-----	
171		-----		-----	
315	ISO8973	0.5710		-----	
317	INH-001	0.5711		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
352	ISO8973	0.5710		-----	
357	D2598	0.5711		-----	
404	ISO8973	0.5712	ex,C	-----	test result excluded, see §4.1, first reported: 571.2
444		-----		-----	
445	ISO8973	0.5712		-----	
508		-----		-----	
754	D2598	0.5709		-----	
851	D2598	0.5708		-----	
869	D2598	0.5710		-----	
875	D2598	0.5709	ex	-----	test result excluded, see §4.1
922	D2598	0.5710		-----	
1011		-----		-----	
1012	D2598	0.5711		-----	
1016	ISO8973	0.5712		-----	
1026	ISO8973	0.57144	ex,C	-----	test result excluded, see §4.1, first reported: 571.5
1041		-----		-----	
1062		-----		-----	
1065	Calculated	0.5713		-----	
1069		-----		-----	
1095		-----		-----	
1108		-----		-----	
1135	D2598	0.5712	C	-----	first reported: 0.5672
1275		-----		-----	
1357		-----		-----	
1469	D2598	0.571133		-----	
1491		-----		-----	
1528	ISO8973	0.57050	DG(0.05)	-----	
1556	ISO8973	0.5711		-----	
1603		-----		-----	
1634	ISO8973	0.5715	ex	-----	test result excluded, see §4.1
1709	D2598	0.5709		-----	
1720		-----		-----	
1776		-----		-----	
6018	ISO8973	0.5699	ex	-----	test result excluded, see §4.1
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 0.5719
6321		-----		-----	
					iis calculated from all reported composition results: *)
	normality	OK			OK
	n	16			28
	outliers	2 (+5ex)			2 (+9ex)
	mean (n)	0.5711			0.5710
	st.dev. (n)	0.00013	RSD = 0.02%		0.00013 RSD = 0.02%
	R(calc.)	0.0004			0.0004
comp	R(iis20S02B)	0.0007			0.0006

*) 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.





Determination of Abs. Vapor Pressure at 100°F on sample #21090; results in psi

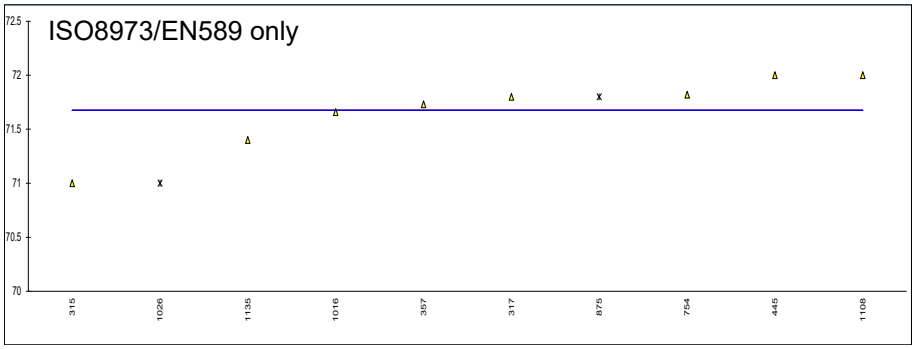
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171	D2598	-----		-----	71	ex, E	-----	*)
315	ISO8973	71		-----	-----	E	-----	calculation difference, iis calc. 71.8
317	ISO8973	71.8		-----	-----		-----	
323		-----		-----	-----		-----	
328		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	D2598	-----		-----	56.7	G(0.01), E	-----	calculation difference, iis calc. 70.96
352		-----		-----	-----		-----	
357	ISO8973	71.73		-----	-----		-----	
404		-----		-----	-----		-----	
444		-----		-----	-----		-----	
445	ISO8973	72		-----	-----		-----	
508		-----		-----	-----		-----	
754	ISO8973	71.819		-----	-----		-----	
851	D2598	-----		-----	71.3		-----	
869	D2598	-----		-----	71.0		-----	
875	ISO8973	71.800	ex	-----	-----		-----	test result excluded, see §4.1
922	D2598	-----		-----	71.32		-----	
1011		-----		-----	-----		-----	
1012		-----		-----	-----		-----	
1016	EN589	71.658		-----	-----		-----	
1026	ISO8973	71	ex, E	-----	-----		-----	*)
1041		-----		-----	-----		-----	
1062		-----		-----	-----		-----	
1065		-----		-----	-----		-----	
1069		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1108	ISO8973	72.0		-----	-----		-----	
1135	ISO8973	71.4	C	-----	-----		-----	first reported: 77.8
1275		-----		-----	-----		-----	
1357		-----		-----	-----		-----	
1469	D2598	-----		-----	71.16667		-----	
1491		-----		-----	-----		-----	
1528		-----		-----	-----		-----	
1556		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1709		-----		-----	-----		-----	
1720		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
6018		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6262		-----		-----	-----		-----	
6321		-----		-----	-----		-----	

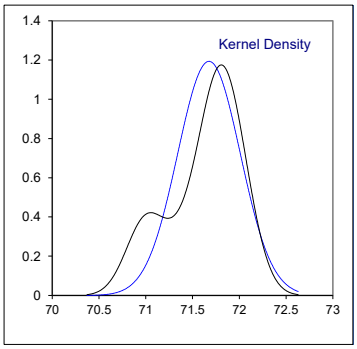
*) Lab 171 test result excluded, see §4.1, calculation difference, iis calc. 69.91
Lab 1026 test result excluded, see §4.1, calculation difference, iis calc. 71.53

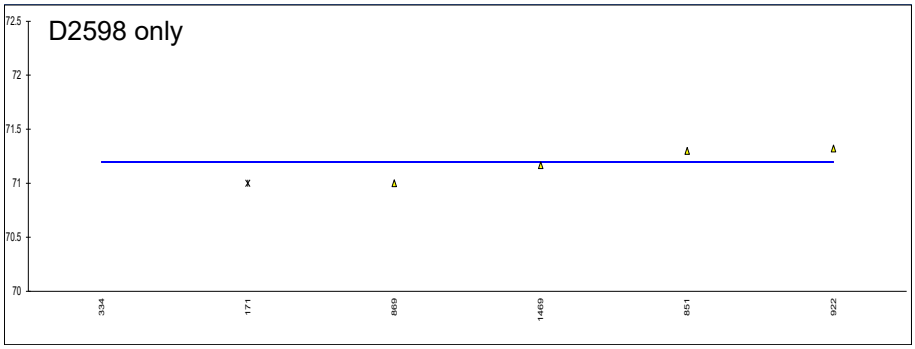
	ISO8973/IP432		D2598	
normality	suspect		unknown	
n	8		4	
outliers	0 (+2ex)		1 (+1ex)	
mean (n)	71.6759		71.1967	
st.dev. (n)	0.33427	RSD = 0.5%	0.14772	RSD = 0.2%
R(calc.)	0.9360		0.4136	
compare				
R(iis20S02B)	0.5466		1.4892	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	not OK		not OK	
n	30		30	
outliers	0 (+9ex)		0 (+9ex)	
mean (n)	71.7980		71.0833	
st.dev. (n)	0.16772	RSD = 0.2%	0.14215	RSD = 0.2%
R(calc.)	0.4696		0.3980	
compare				
R(iis20S02B)	0.5802		0.4966	

*) 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 #21090; results in psi

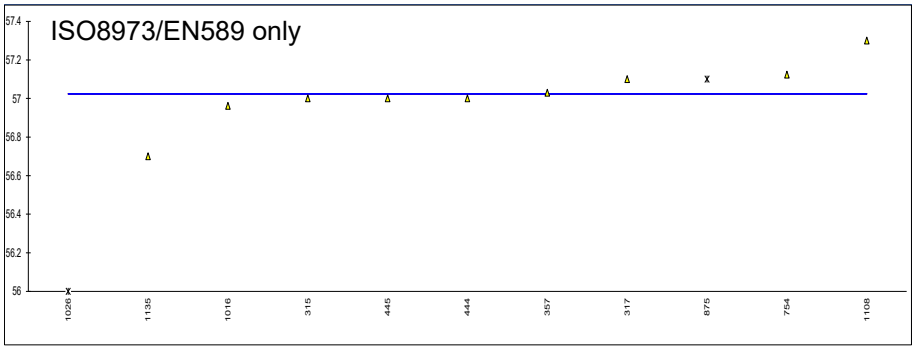
lab	method	ISO8973	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171		-----		-----	-----		-----	
315	ISO8973	57		-----	-----		-----	
317	ISO8973	57.1		-----	-----		-----	
323		-----		-----	-----		-----	
328		-----		-----	-----		-----	
333		-----		-----	-----		-----	
334	D2598	-----		-----	42.0	G(0.01), E	-----	calculation difference, iis calc. 56.26
352		-----		-----	-----		-----	
357	ISO8973	57.03		-----	-----		-----	
404		-----		-----	-----		-----	
444	ISO8973	57.0		-----	-----		-----	
445	ISO8973	57		-----	-----		-----	
508		-----		-----	-----		-----	
754	ISO8973	57.123		-----	-----		-----	
851	D2598	-----		-----	56.6		-----	
869	D2598	-----		-----	56.3		-----	
875	ISO8973	57.100	ex	-----	-----		-----	test result excluded, see §4.1
922	D2598	-----		-----	56.62		-----	
1011		-----		-----	-----		-----	
1012		-----		-----	-----		-----	
1016	EN589	56.961		-----	-----		-----	
1026	ISO8973	56	ex, E	-----	-----		-----	*)
1041		-----		-----	-----		-----	
1062		-----		-----	-----		-----	
1065		-----		-----	-----		-----	
1069		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1108	ISO8973	57.3		-----	-----		-----	
1135	ISO8973	56.7	C	-----	-----		-----	first reported: 63.1
1275		-----		-----	-----		-----	
1357		-----		-----	-----		-----	
1469	D2598	-----		-----	56.46667		-----	
1491		-----		-----	-----		-----	
1528		-----		-----	-----		-----	
1556		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1709	D2598	-----		-----	56.81		-----	
1720		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
6018		-----		-----	-----		-----	
6193		-----		-----	-----		-----	
6262		-----		-----	-----	W	-----	test result withdrawn, reported: 55.08
6321		-----		-----	-----		-----	

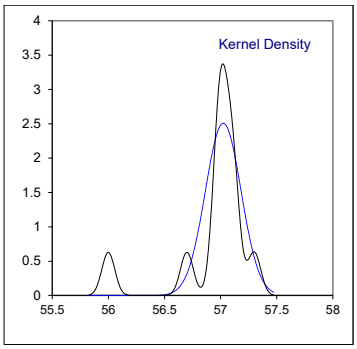
*) Lab 1026 test result excluded, see §4.1, calculation difference, iis calc. 56.83

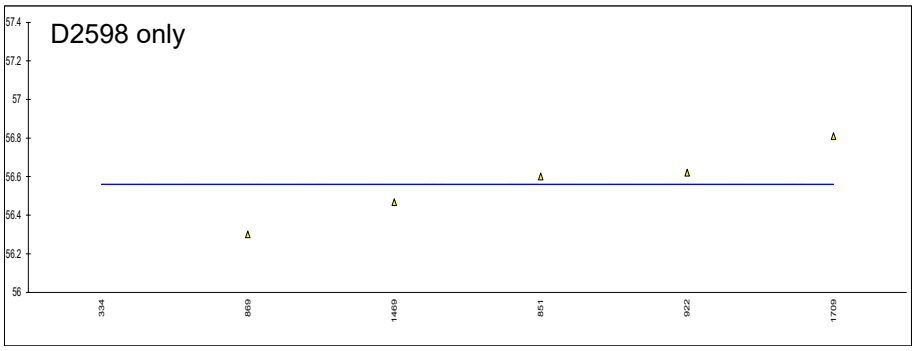
	ISO8973/IP432		D2598	
normality	not OK		unknown	
n	9		5	
outliers	0 (+2ex)		1	
mean (n)	57.0238		56.5593	
st.dev. (n)	0.15908	RSD = 0.3%	0.18974	RSD = 0.3%
R(calc.)	0.4454		0.5313	
compare R(iis20S02B)	0.6913		0.5422	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	not OK		not OK	
n	30		30	
outliers	0 (+9ex)		0 (+9ex)	
mean (n)	57.1020		56.3873	
st.dev. (n)	0.16772	RSD = 0.3%	0.14215	RSD = 0.3%
R(calc.)	0.4696		0.3980	
compare R(iis20S02B)	0.5802		0.4966	

*) 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.





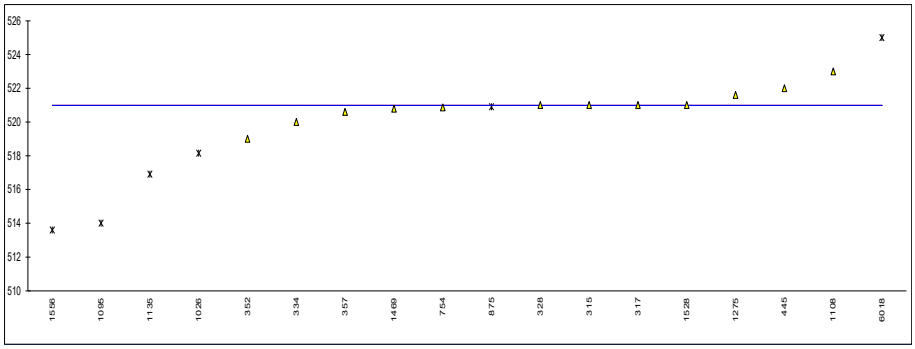


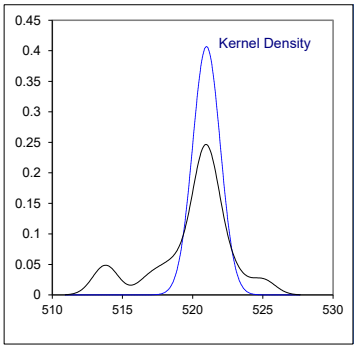
Determination of Abs. Vapor Pressure at 40°C on sample #21090; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	521		-----	
317	ISO8973	521		-----	
323		-----		-----	
328	ISO8973	521		-----	
333		-----		-----	
334	ISO8973	520		-----	
352	ISO8973	519		-----	
357	ISO8973	520.6		-----	
404		-----		-----	
444		-----		-----	
445	ISO8973	522.0		-----	
508		-----		-----	
754	ISO8973	520.863		-----	
851		-----		-----	
869		-----		-----	
875	ISO8973	520.90	ex,E	-----	test result excluded, see §4.1, calculation difference, iis calc. 520.39
922		-----		-----	
1011		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026	ISO8973	518.15	ex,C,E	-----	test result excl., see §4.1, first reported: 516, calc. diff., iis calc. 519.19
1041		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1095	ISO8973	514	ex,E	-----	test result excluded, see §4.1, calculation difference, iis calc. 513.08
1108	ISO8973	523		-----	
1135	ISO8973	516.9	C,G(0.05),E	-----	first reported: 535.9, calculation difference, iis calc. 518.21
1275	EN589	521.6		-----	
1357		-----		-----	
1469	IP432	520.7857		-----	
1491		-----		-----	
1528	ISO8973	521	C	-----	first reported: 529
1556	ISO8973	513.6	G(0.01),E	-----	calculation difference, iis calc. 520.88
1603		-----		-----	
1634		-----		-----	
1709		-----		-----	
1720		-----		-----	
1776		-----		-----	
6018	ISO8973	525	ex,E	-----	test result excluded, see §4.1, calculation difference, iis calc. 524.28
6193		-----		-----	
6262		-----		-----	
6321		-----		-----	

				iis calculated from all reported test results *):	
	normality	suspect		not OK	
	n	12		30	
	outliers	2 (+4ex)		0 (+9ex)	
	mean (n)	520.9874		521.0929	
	st.dev. (n)	0.98085	RSD = 0.2%	1.19183	RSD = 0.2%
	R(calc.)	2.7464		3.3371	
comp	R(iis20S02B)	2.4169		3.2963	

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

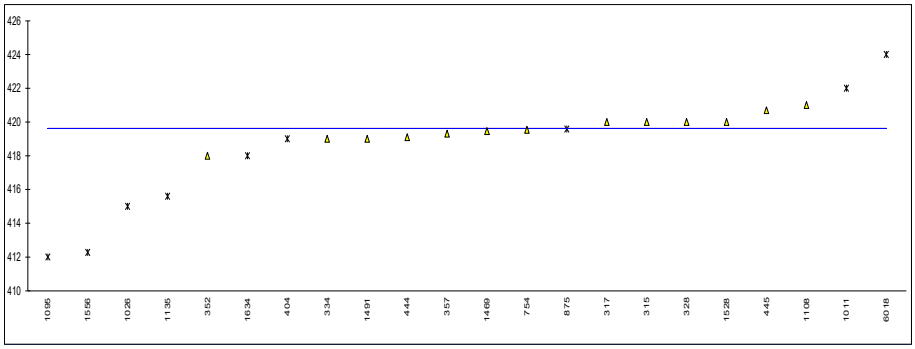


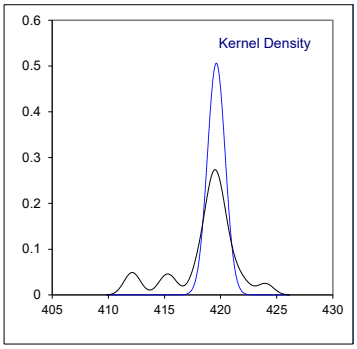


Determination of Rel. Vapor Pressure at 40°C on sample #21090; results in kPa

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315	ISO8973	420		-----	
317	ISO8973	420		-----	
323		-----		-----	
328	ISO8973	420		-----	
333		-----		-----	
334	ISO8973	419		-----	
352	ISO8973	418		-----	
357	ISO8973	419.3		-----	
404	ISO8973	419	ex	-----	test result excluded, see §4.1
444	ISO8973	419.1		-----	
445	ISO8973	420.7		-----	
508		-----		-----	
754	ISO8973	419.538		-----	
851		-----		-----	
869		-----		-----	
875	ISO8973	419.58	ex, E	-----	test result excluded, see §4.1, calculation difference, iis calc. 419.06
922		-----		-----	
1011	ISO8973	422	ex	-----	test result excluded, see §4.1
1012		-----		-----	
1016		-----		-----	
1026	ISO8973	415	ex, E	-----	test result excluded, see §4.1, calculation difference, iis calc. 417.86
1041		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1095	ISO8973	412	ex	-----	test result excluded, see §4.1
1108	ISO8973	421		-----	
1135	ISO8973	415.6	C,G(0.01),E	-----	first reported: 455.6, calculation difference, iis calc. 416.89
1275		-----		-----	
1357		-----		-----	
1469	IP432	419.4607		-----	
1491	ISO8973	419		-----	
1528	ISO8973	420	C	-----	first reported: 428
1556	ISO8973	412.275	G(0.01),E	-----	calculation difference, iis calc. 419.56
1603		-----		-----	
1634	ISO8973	418	ex	-----	test result excluded, see §4.1
1709		-----		-----	
1720		-----		-----	
1776		-----		-----	
6018	ISO8973	424	ex,E	-----	test result excluded, see §4.1, calculation difference, iis calc. 422.96
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 407
6321		-----		-----	
					<u>iis calculated from all reported test results *):</u>
	normality	OK			not OK
	n	13			30
	outliers	2 (+7ex)			0 (+9ex)
	mean (n)	419.6230			419.7679
	st.dev. (n)	0.78774	RSD = 0.2%		1.19183 RSD = 0.3%
	R(calc.)	2.2057			3.3371
comp	R(iis20S02B)	3.1300			3.2963

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





Determination of Motor Octane Number, MON on sample #21090;

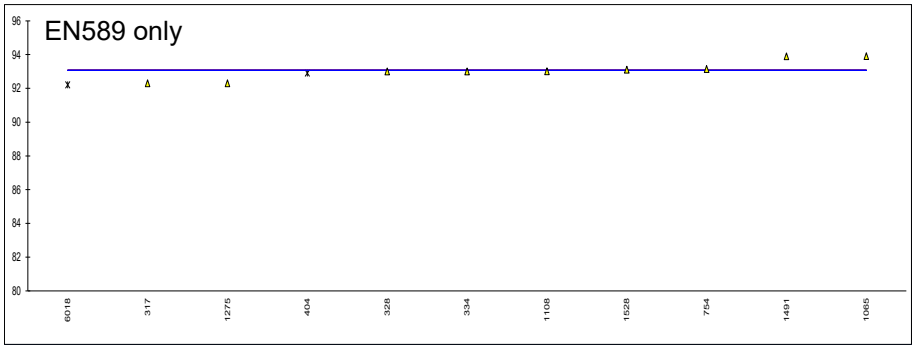
lab	method	EN589	mark	z(targ)	D2598	mark	z(targ)	remarks
150		-----		-----	-----		-----	
171	D2598	-----		-----	86.5	ex,E	-----	test result excl, see §4.1, calc. diff., iis calc. 94.52
315	D2598	-----		-----	89.5	G(0.05), E	-----	calculation difference, iis calc. 94.33,
317	EN589	92.3	E	-----	-----		-----	calculation difference *), iis calc. 92.89
323		-----		-----	-----		-----	
328	EN589	93.0		-----	-----		-----	
333		-----		-----	-----		-----	
334	EN589	93.0		-----	-----		-----	
352		-----		-----	-----		-----	
357		-----		-----	-----		-----	
404	EN589	92.9	ex	-----	-----		-----	test result excluded, see §4.1
444		-----		-----	-----		-----	
445		-----		-----	-----		-----	
508		-----		-----	-----		-----	
754	EN589	93.14		-----	-----		-----	
851	D2598	-----		-----	94.7		-----	
869	D2598	-----		-----	94.6		-----	
875	D2598	-----		-----	93.1	ex, E	-----	test result excl, see §4.1, calc. diff **), iis calc. 92.84
922		-----		-----	-----		-----	
1011		-----		-----	-----		-----	
1012		-----		-----	-----		-----	
1016		-----		-----	-----		-----	
1026		-----		-----	-----		-----	
1041		-----		-----	-----		-----	
1062		-----		-----	-----		-----	
1065	ISO8973	93.9075	E	-----	-----		-----	calculation difference, iis calc. 92.95
1069		-----		-----	-----		-----	
1095		-----		-----	-----		-----	
1108	EN589	93.01		-----	-----		-----	
1135	D2598	-----		-----	94.1	C, E	-----	first rep. 94.5, calculation diff. *), iis calc. 94.63
1275	EN589	92.3	E	-----	-----		-----	calculation difference *), iis calc. 92.92
1357		-----		-----	-----		-----	
1469		-----		-----	-----		-----	
1491	EN589	93.9	E	-----	-----		-----	calculation difference, iis calc. 92.89
1528	EN589	93.1		-----	-----		-----	
1556		-----		-----	-----		-----	
1603		-----		-----	-----		-----	
1634		-----		-----	-----		-----	
1709		-----		-----	-----		-----	
1720		-----		-----	-----		-----	
1776		-----		-----	-----		-----	
6018	EN589	92.2	ex,E	-----	-----		-----	test result excl, see §4.1, calc. diff **), iis calc. 93.44
6193		-----		-----	-----		-----	
6262		-----		-----	-----		-----	
6321		-----		-----	-----		-----	

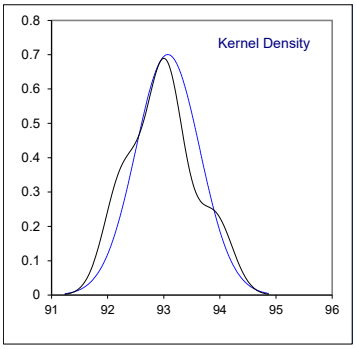
*) participant has calculated without 1,3-butadiene factor (see comments next page)
**) participant has calculated without 1,3-butadiene and iso-pentane factors (see comments next page)

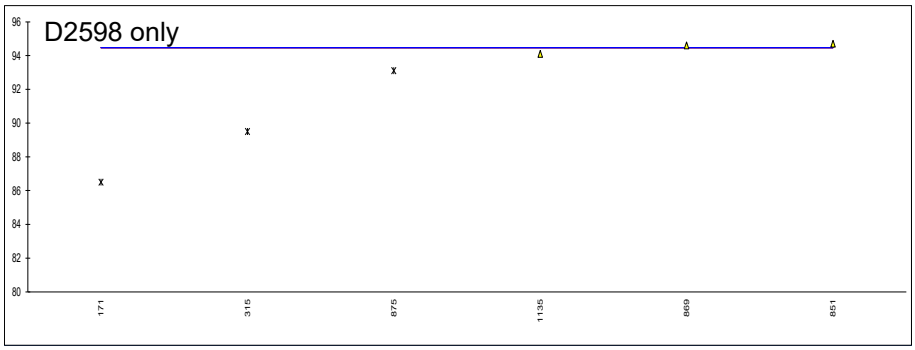
	EN589		D2598	
normality	OK		unknown	
n	9		3	
outliers	0(+2ex)		1 (+2ex)	
mean (n)	93.073		94.467	
st.dev. (n)	0.5696	RSD = 0.6%	0.3215	RSD = 0.3%
R(calc.)	1.595		0.900	
compare R(iis20S02B)	1.150		0.832	

	iis calc. based on ALL *) reported composition results		iis calc. based on ALL **) reported composition results	
normality	OK		OK	
n	30		30	
outliers	0 (+9ex)		0 (+9ex)	
mean (n)	92.915		94.646	
st.dev. (n)	0.0587	RSD = 0.06%	0.0394	RSD = 0.04%
R(calc.)	0.164		0.110	
compare R(iis20S02B)	0.270		0.191	

*) 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.



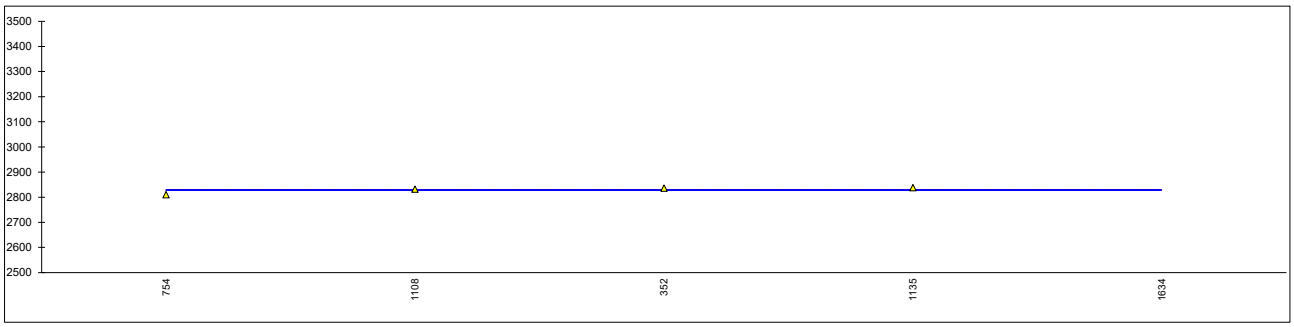




Determination of Ideal Gross Heating Value at 14.696 psia/60°F on sample #21090; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315		-----		-----	
317		-----		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
352	D3588	2836.296		-----	
357		-----		-----	
404		-----		-----	
444		-----		-----	
445		-----		-----	
508		-----		-----	
754	D3588	2810.2		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1011		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1041		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1095		-----		-----	
1108	D3588	2831.64		-----	
1135	D3588	2838	C	-----	first reported 2812
1275		-----		-----	
1357		-----		-----	
1469		-----		-----	
1491		-----		-----	
1528		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	11770	ex	-----	test result excluded, see §4.1, calculation difference, iis calc. 2831.42
1709		-----		-----	
1720		-----		-----	
1776		-----		-----	
6018		-----		-----	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 2986
6321		-----		-----	
					iis calculated from all reported test results *)
	normality	unknown			OK
	n	4			30
	outliers	0 (+1ex)			0 (+9ex)
	mean (n)	2829.03			2832.26
	st.dev. (n)	12.841	RSD = 0.45%		0.968 RSD = 0.03%
	R(calc.)	35.95			2.71
comp	R(iis20S02B)	12.79			3.63

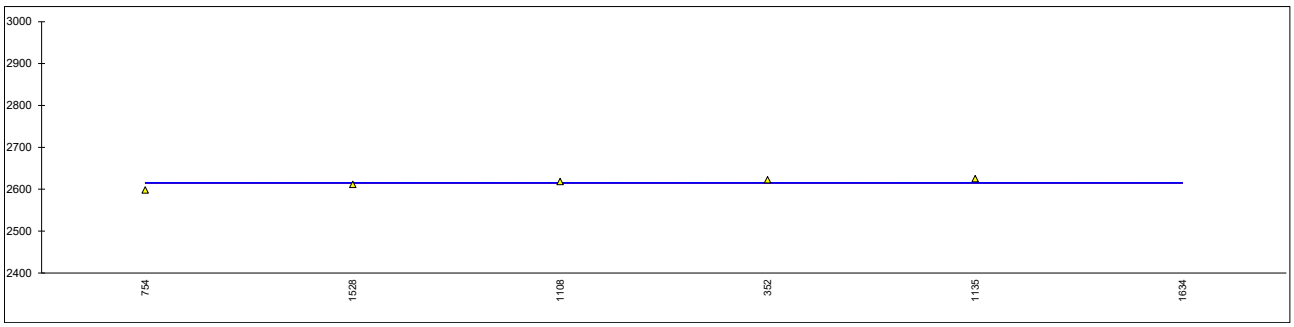
*) Calculated by iis based on the Ideal Gross Heating Value at 14.696 psia/60°F factors given in table 1 of ASTM D3588:98(2017). Unfortunately, this method does not mention an Ideal Gross Heating Value factor for 1,3-Butadiene. For the calculation, iis has used the factor 2542.03 from table 3 of ISO6976:16.



Determination of Ideal Net Heating Value at 14.696 psia/60°F on sample #21090; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
150		-----		-----	
171		-----		-----	
315		-----		-----	
317		-----		-----	
323		-----		-----	
328		-----		-----	
333		-----		-----	
334		-----		-----	
352	D3588	2622.492		-----	
357		-----		-----	
404		-----		-----	
444		-----		-----	
445		-----		-----	
508		-----		-----	
754	D3588	2598		-----	
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1011		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1041		-----		-----	
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1095		-----		-----	
1108	D3588	2618.45		-----	
1135	D3588	2625	C	-----	first reported: 2600
1275		-----		-----	
1357		-----		-----	
1469		-----		-----	
1491		-----		-----	
1528	In house	2611.3		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	10883	ex	-----	test result excluded, see §4.1, calculation difference, iis calc. 2618.49
1709		-----		-----	
1720		-----		-----	
1776		-----		-----	
6018		-----		-----	
6193		-----		-----	
6262		-----	W	-----	test result withdrawn, reported: 2762
6321		-----		-----	
					iis calculated from all reported test results *):
	normality	unknown			OK
	n	5			30
	outliers	0 (+1ex)			0(+9ex)
	mean (n)	2615.05			2619.07
	st.dev. (n)	10.848	RSD = 0.41%		0.850 RSD = 0.03%
	R(calc.)	30.37			2.38
comp	R(iis20S02B)	6.339			3.15

*) 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.



APPENDIX 2

Number of participants per country

4 labs in BELGIUM
1 lab in CHINA, People's Republic
1 lab in DENMARK
1 lab in EGYPT
2 labs in FINLAND
3 labs in FRANCE
2 labs in GERMANY
1 lab in GREECE
1 lab in HONG KONG
1 lab in ISRAEL
4 labs in NETHERLANDS
1 lab in NIGERIA
1 lab in OMAN
1 lab in PAKISTAN
1 lab in PANAMA
6 labs in PORTUGAL
2 labs in ROMANIA
2 labs in RUSSIAN FEDERATION
1 lab in SUDAN
2 labs in SWEDEN
1 lab in TAIWAN
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 Organisation, Statistics & Evaluation, June 2018
2 ISO5725:86
3 ISO5725 parts 1-6:94
4 ISO13528:05
5 M. Thompson and R. Wood, J. AOAC Int, 76, 926, (1993)
6 W.J. Youden and E.H. Steiner, Statistical Manual of the AOAC, (1975)
7 P.L. Davies, Fr. Z. Anal. Chem, 331, 513, (1988)
8 J.N. Miller, Analyst, 118, 455, (1993)
9 Analytical Methods Committee, Technical Brief, No 4, January 2001
10 P.J. Lowthian and M. Thompson, The Royal Society of Chemistry, Analyst, 127, 1359-1364, (2002)
11 W. Horwitz and R. Albert, J. AOAC Int, 79.3, 589-621, (1996)
12 Bernard Rosner, Percentage Points for a Generalized ESD Many-Outlier Procedure, Technometrics, 25(2), 165-172, (1983)
13 J.B. Maxwell, Data book on Hydrocarbons, 5th edition, 3 (1958)