Results of Proficiency Test
Liquefied Butane Analysis
June 2018

Organised by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

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1   INTRODUCTION

Since 2009, the Institute for Interlaboratory Studies organizes a proficiency test for Liquefied Butane every year. Because iis has limited gas-handling facilities in place to prepare gas samples, a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up. This company is fully equipped and has experience in the preparation of synthetic gas samples for PT purposes. EffecTech maintains an ISO/IEC17043 accreditation for the preparation of PT samples in homogeneous and stable batches and an ISO17025 accreditation for the calibration and assignment of reference values for these samples.

In this interlaboratory study 51 laboratories in 28 different countries registered for participation. See appendix 2 for the number of participants per country. In this report, the results of the 2018 Liquefied Butane proficiency test are presented and discussed. This report is also electronically available through the iis website www.iisnl.com.

2   SET UP

The Institute for Interlaboratory Studies (iis) in Spijkenisse, the Netherlands, was the organizer of this proficiency test.
To optimise the costs for the participating laboratories, it was decided to prepare one Liquefied Butane mixture. The mixture was divided over a batch of 57 cylinders. Each cylinder was uniquely numbered. The cylinder size is a cost-effective one-litre cylinder with dip tube device. The limited cylinder size is chosen to optimise sample stability, cylinder costs, transport and handling costs. It was decided to send one cylinder of 1L (labelled #18100) filled with approx. 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 organisation 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 March 2017 (iis-protocol, version 3.4). This protocol is electronically available through the iis website www.iisnl.com, from the FAQ page.

2.3   CONFIDENTIALITY STATEMENT

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

2.4   SAMPLES

In this proficiency test one sample was used. One batch of 57 cylinders of one litre with an artificial Liquefied Butane mixture was prepared and tested for homogeneity by EffecTech (Uttoxeter, United Kingdom) in conformance with with ISO6142, ISO Guide 35:2006 and ISO17025:2005 (job 18/0584, starting in May 2018). Each cylinder was uniquely numbered. Every cylinder in the batch was analysed using replicate measurements. The within bottle and between bottle variations were then assessed in accordance with ISO Guide 35:2006 (section 7 & A.1). This evaluation showed that the between bottle variations were all small compared to the uncertainties on the reference values on each component. Hence, a single reference value could be safely assigned to the entire batch of samples.

The repeatability values (r) were calculated per component by multiplication of the respective standard deviation by 2.8. Subsequently, the calculated repeatabilities were compared with 0.3 times the reproducibility of the reference test method in agreement with the procedure of ISO13528, Annex B2 in the next table:

	r (observed) in %mol/mol	0.3 * R (ASTM D2163:14e1) in %mol/mol
Propane	0.004	0.064
Propylene	0.004	0.086
iso-Butane	0.023	0.276
n-Butane	0.033	0.093
1-Butene	0.014	0.068
iso-Butene	0.006	0.079
trans-2-Butene	0.022	0.068
cis-2-Butene	0.009	0.097
1,3-Butadiene	0.005	0.037
iso-Pentane	0.003	0.015

Table 1: evaluation of homogeneity test results of samples #18100

The calculated calculated repeatabilities were in agreement with 0.3 times the corresponding reproducibility of the reference test method ASTM D2163:14e1. Therefore, homogeneity of the subsamples #18100 was assumed.

To each of the participating laboratories one 1L cylinder labelled #18100 was sent on May 30, 2018. An SDS was added to the sample package.

2.5   STABILITY OF THE SAMPLES

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

2.6   ANALYSES

The participants were requested to determine on sample #18100: Propane, Propene, iso-Butane, n-Butane, 1-Butene, iso-Butene, trans-2-Butene, cis-2-Butene, 1,3-Butadiene, iso-Pentane, Molar Mass, Relative Density at 60/60F, Absolute and Relative Vapour pressure at 100F (in psi) and at 40°C (in kPa), Motor Octane Number (MON), Ideal Gross Heating Value and Ideal Net Heating Value both at 14.696psi and 60F.

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 reanalyses). 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 March 2017 (iis-protocol, version 3.4).

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 or ISO reproducibilities, the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation of this interlaboratory study.

The target standard deviation was calculated from the literature reproducibility by division with 2.8. In case no literature reproducibility was available, other target values were used. In some cases a reproducibility based on former iis proficiency tests could be used.

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

The z-scores were calculated according to:

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

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

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

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

4   EVALUATION

In this interlaboratory study, some problems with sample dispatch were encountered. All laboratories reported test results, four laboratories reported test results after the final reporting date. Not all laboratories were able to report all analyses requested. In total 51 participants reported 660 test results. Observed were 45 outlying test results, which is 6.8% of the numerical test results. In proficiency studies, outlier percentages of 3% - 7.5% are quite normal.

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

4.1 EVALUATION PER COMPONENT OR PER PARAMETER

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

Six laboratories reported deviating test results for the determination of iso-Butane and other components. As the test results of the composition are not independent, it was decided not to use any of the remaining reported results of these six laboratories for the statistical evaluation of the composition. Also, the reported physical test results of these six laboratories were excluded, since these values were calculated from the measured composition.

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

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

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

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

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

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

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

cis-2-Butene: The determination of this component may be problematic depending on the requirements of the test method used. Six statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the reproducibility of ASTM D2163:14e1, but it is in agreement with the requirements of EN27941:93(liq) (identical to IP 405 and ISO7941).

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

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

Molar Mass: This calculated parameter may not be problematic. One statistical outlier was observed and four other test results were excluded. The reported test results after rejection of the suspect data vary over a small range from 57.465 - 57.56 g/mol. The calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published relative molecular masses obtained from one test method (ISO8973:97/ IP432:00) over all reported component concentrations (0.058 *vs* 0.076). See also the discussion in paragraph 5.

<u>Relative Density at 60/60F</u>: This calculated parameter may be problematic. No statistical outliers were observed but four test results were excluded. The reported test results after rejection of the suspect data vary over a range from 0.5716 - 0.5731. The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published relative density at 60/60F obtained from one test method (ASTM D2598:16) over all reported component concentrations (0.0010 *vs* 0.0005). See also the discussion in paragraph 5.

Unfortunately, method ASTM D2598:16 does not mention a relative density factor for 1,3-Butadiene. Therefore, iis has used the value 0.6272 as given in ASTM D2163:14e1.

<u>Abs. Vapour Pres. at 100F</u>: This calculated parameter may be problematic depending on the requirements of the test method used (ISO8973:97 or ASTM D2598:16). One statistical outlier was observed in the ISO8973:97 test results and one other test result was excluded. In the ASTM D2598:16 test results no statistical outliers were observed. The reported ISO8973 test results vary after rejection of the suspect data over a range from 70.78 – 71.32548 psi. The reported D2598 test results vary over a range from 69.84 – 71.57 psi.

The calculated reproducibility after rejection of the suspect data is in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (ISO8973:97) over all reported component concentrations (0.52 *vs* 0.56 psi). However, the calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (ASTM D2598:16) over all reported component concentrations (1.57 *vs* 0.49 psi).

It was also observed that the test methods, after rejection of the suspect data, give different mean values (71.13 *vs* 70.54 psi) and different calculated reproducibilities (0.186 *vs* 0.562 psi). See also the discussion in paragraph 5.

<u>Rel. Vapour Pres. at 100F</u>: This calculated parameter may be problematic. One statistical outlier was observed in the ISO8973:97/IP432:00 test results and one other test result was excluded. In the ASTM D2598 test results one statistical outlier was observed. The reported ISO8973/IP432 test results vary after rejection of the suspect data over a range from 54.7 – 57 psi. The reported D2598 test results vary after rejection of the statistical outlier over a range from 55.14 – 56.2 psi.

The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (ISO8973:97) over all reported component concentrations (0.82 *vs* 0.56 psi). And the calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (ASTM D2598:16) over all reported component concentrations (1.02 *vs* 0.49 psi).

It was also observed that the test methods, after rejection of the suspect data, give different mean values (56.43 *vs* 55.73 psi) and different calculated reproducibilities (0.819 *vs* 1.02 psi). See also the discussion in paragraph 5.

Abs. Vapour Pres. at 40°C: This calculated parameter may be problematic. One statistical outlier was observed and three other test results were excluded. The reported test results after rejection of the suspect data vary from 503 – 517.3 kPa. The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (ISO8973:97/IP432:00) over all reported component concentrations (9.98 *vs* 3.98 kPa). See also the discussion in paragraph 5.

Rel. Vapour Pres. at 40°C: This calculated parameter may be problematic. One statistical outlier was observed and four other test results were excluded. The reported test results after rejection of the suspect data vary from 410.85 – 416.8 kPa. The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (ISO8973:97/IP432:00) over all reported component concentrations (4.95 *vs* 3.98 kPa). See also the discussion in paragraph 5.

MON: This calculated parameter may be problematic. One statistical outlier was observed in the EN589 test results and two other test results were excluded. In the ASTM D2598 test results no statistical outliers were observed. The reported EN589 test results vary after rejection of the suspect data over a range from 92.0 – 92.9. The reported D2598 test results vary over a range from 91.80 – 94.6.
The calculated reproducibility after rejection of the suspect data is not in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (e.g. EN598:08_A1:12 or ASTM D2598:16) over all reported component concentrations (0.83 *vs* 0.21 for EN and 3.12 *vs* 0.14 for ASTM). It was also observed that the test methods (EN vs ASTM), after rejection of the suspect data, give different mean values (92.61 *vs* 93.59) and different calculated reproducibilities (0.29 *vs* 1.15). See also the discussion in paragraph 5.
Unfortunately, method EN589:08_A1:12 does not mention a MON factor for 1,3-Butadiene. Therefore, iis did use an estimated value of 70 (in analogy of the MON factors of the other components). Method ASTM D2598:16 does not mention MON factors for iso-Butene, trans-2-Butene or 1,3-Butadiene. Therefore, iis has used for iso-Butene, trans-2-Butene the same value of cis-2-Butene (83.5) and 70 for 1,3-Butadiene.

Ideal Gross Heating Value at 14.696 psi / 60F: This calculated parameter may be problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the outlier is not 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 65.7 vs 2.8 kJ/mol). It was also observed that the effect of the different factors from ASTM D3588 and ISO6976 on the calculation is very small. See also the discussion in paragraph 5.

Unfortunately, method ASTM D3588:98(2017) does not mention a factor for 1,3-Butadiene. Therefore, iis has used the value 2542.03 as given in ISO6976:16(E).

Ideal Net Heating Value at 14.696 psi / 60F: This calculated parameter may be problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the outlier 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 (49.9 vs 3.4 kJ/mol).

It was also observed that the test methods after rejection of the suspect data give significant different mean values (2616.75 *vs* 2612.95 kJ/mol and different calculated reproducibilities (3.44 *vs* 3.16 kJ/mol). See also the discussion in paragraph 5.

Unfortunately, method ASTM D3588:98(2017) does not mention a factor for 1,3-Butadiene. Therefore, iis has used the value 2408.8 as given in ISO6976:95(96).

4.2   PERFORMANCE EVALUATION FOR THE GROUP OF LABORATORIES

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

Component	unit	n	average	2.8 * sd	R(D2163) in **%mol**	R(EN27941) liq.-inj. in **%mol**	R(EN27941) liq.-inj. in **%M/M**
Propane	%mol/mol	45	1.298	0.160	0.209	1.304	1
Propene	%mol/mol	45	0.949	0.158	0.275	1.367	1
iso-Butane	%mol/mol	45	72.97	1.04	0.92	1.48	1.5
n-Butane	%mol/mol	45	6.218	0.418	0.313	0.989	1
1-Butene	%mol/mol	45	3.016	0.194	0.226	1.025	1
iso-Butene	%mol/mol	45	4.185	0.271	0.262	1.025	1
trans-2-Butene	%mol/mol	45	3.077	0.196	0.228	1.025	1
cis-2-Butene	%mol/mol	45	6.795	0.398	0.326	1.025	1
1,3-Butadiene	%mol/mol	45	0.813	0.075	0.125	1.063	1
iso-Pentane	%mol/mol	44	0.673	0.083	0.048	0.797	1

Table 2: performance of the group in comparison with the reference test method reproducibilities

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

Parameter	unit	n	average	2.8 * sd over reported test results	2.8 * sd calc. overall results using one set of factors	2.8 * sd calc. overall results using one set of factors **June 2017**
Molar Mass	g/mol	21	57.51	0.058	0.076	0.032
Rel. Density at 60/60F		21	0.5722	0.0010	0.0005	0.0004
Abs. VP at 100F ISO/IP	psi	8	71.13	0.52	0.56	0.37
Abs. VP at 100F D2598	psi	7	70.54	1.57	0.49	0.24
Rel. VP at 100F ISO/IP	psi	8	56.43	0.82	0.56	0.37
Rel. VP at 100F D2598	psi	7	55.73	1.02	0.49	0.24
Abs. VP at 40°C	kPa	17	514.9	10.0	4.0	2.6
Rel. VP at 40°C	kPa	14	414.5	5.0	4.0	2.6
MON EN589_A1		7	92.61	0.83	0.21	0.13
MON D2598		6	93.60	3.12	0.14	0.07
IGHV D3588	kJ/mol	4	2827	66	3	n.a.
INHV D3588	kJ/mol	4	2615	50	3	n.a.

Table 3: performance of the group in comparison with the calculated reproducibilities using one set of factors.

Without further statistical calculations, it could be concluded that for many tests there is not a good compliance of the group of participating laboratories with the method reproducibilities calculated over all reported test results of this PT compared to 2017 PT. See also the discussion in paragraph 5.

4.3   COMPARISON OF THE PROFICIENCY TEST OF JUNE 2018 WITH PREVIOUS PTS

	June 2018	June 2017	June 2016	June 2015	June 2014
Number of reporting labs	51	49	49	46	38
Number of test results reported	660	623	627	538	467
Number of statistical outliers	45	30	63	45	33
Percentage outliers	6.8%	4.8%	10.0%	8.4%	7.1%

Table 4: comparison with previous proficiency tests

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

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

Component	June 2018	June 2017	June 2016	June 2015	June 2014
Propane	+	++	+	+	-
Propene	+	++	++	++	++
iso-Butane	-	-	+/-	-	-
n-Butane	-	+/-	-	-	--
1-Butene	+	+	+/-	+	-
iso-Butene	+/-	+	+/-	+/-	+/-
trans-2-Butene	+	+	+	+	+/-
cis-2-Butene	-	-	+/-	+/-	-
1,3-Butadiene	+	+	+	+	+
iso-Pentane	-	-	-	-	--

Table 5: comparison determinations against the requirements of ASTM D2163

The following performance categories were used in the above table:

- ++ : group performed much better than the reference test method
- + : group performed better than the reference test method
- +/- : group performance equals the reference test method
- - : group performed worse than the reference test method
- -- : group performed much worse than the reference test method

5 DISCUSSION

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

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

Component	Average values by EffecTech in %mol/mol	Consensus values from participants test results in %mol/mol	Absolute differences in %mol/mol	z-score
Propane	1.3365	1.298	0.0381	+0.50
Propene	1.0108	0.949	0.0617	+0.60
iso-Butane	73.2047	72.97	0.2338	+0.71
n-Butane	6.0166	6.218	-0.2015	-1.83
1-Butene	3.0018	3.016	-0.0140	-0.17
iso-Butene	4.2006	4.185	0.0155	+0.17
trans-2-Butene	2.9977	3.077	-0.0796	-0.99
cis-2-Butene	6.7280	6.795	-0.0673	-0.58
1,3-Butadiene	0.8055	0.813	-0.0073	-0.16
iso-Pentane	0.6978	0.673	0.0250	+1.45

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

A few laboratories reported traces of n-Pentane (ca. 0.05 %mol/mol). This component is probably present as impurity in one or more of the pure components that were used to prepare the iso-Butane mixture.

In principle no additional variation should be introduced when applying a calculation on the reported component concentrations. However, in practice a significant additional uncertainty is added in most cases. See the differences between the values from the test results as reported by the participating laboratories (each using its own calculation procedure) and the values as calculated by iis using one calculation procedure for each set of laboratory test results. Some test methods do not mention a factor of each component of the Butane mixture for calculation of some physical properties. In these cases iis used for example a factor from a comparable test method or an average value (see paragraph 4.1 and appendix 1).

For the calculation of the Molar Mass, Relative Density and Vapour Pressure, Motor Octane Number, Ideal Gross Heating Value and Ideal Net Heating Value several standardized test methods are available, e.g. ASTM D2421 for the interconversion of the units to gas-volume, liquid-volume or mass basis. Also different test methods for the calculation of the Vapour Pressure do exist. In ISO8973 (identical to IP432) the Vapour Pressure is calculated from the mole fraction per component and a Vapour Pressure factor of that component (given for all components). In ASTM D2598 the Vapour Pressure is calculated from the liquid volume percentage per component and a Vapour Pressure factor of that component (given for only several components). Also the selection of the tables to be used for the calculations may cause additional uncertainty. This has been at least observed for Vapour pressure at 100F, Motor Octane Number and Ideal Net Heating Value.
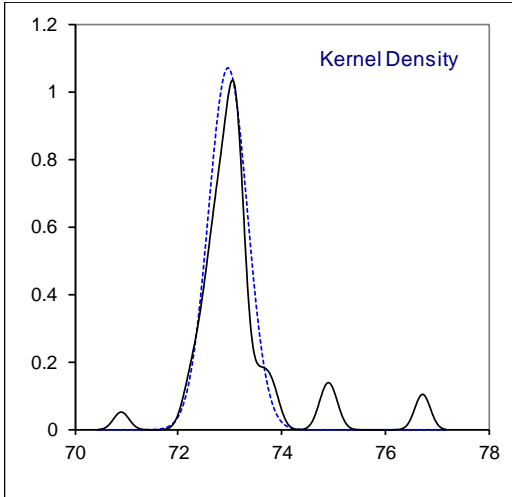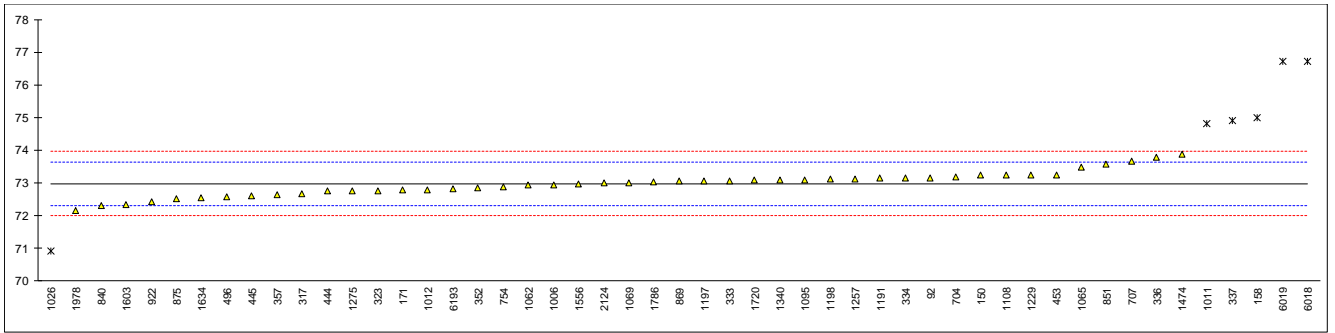
APPENDIX 1

Determination of Propane on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		1.2195		-1.06	
150	D2163	1.26		-0.51	
158	D2163	1.122885	ex	-2.35	excluded due to statistical outlier in iso-Butane
171		1.2566		-0.56	
317	D2163	1.38		1.09	
323	D2163	1.30		0.02	
333	D2163	1.34		0.56	
334	D2163	1.30		0.02	
336	D2163	1.28		-0.25	
337		3.22	R(0.01)	25.73	
352	EN27941	1.3531		0.73	
357	D2163	1.270		-0.38	
444	D2163	1.281		-0.23	
445	D2163	1.33		0.42	
453	D2163	1.371		0.97	
496	D2163	1.152	C	-1.96	first reported 2.880
704	D2163	1.314		0.21	
707	D2163	1.311		0.17	
754		1.34		0.56	
840	D2163	1.311		0.17	
851	D2163	1.352349		0.72	
869	D2163	1.249		-0.66	
875	D2163	1.25		-0.65	
922	D2163	1.23		-0.92	
1006	D2163	1.455		2.10	
1011		3.08	R(0.01)	23.86	
1012	D2163	1.3267		0.38	
1026	ISO7941	0.3832	R(0.01)	-12.26	
1062	D2163	1.3549		0.76	
1065	D2163	1.2360		-0.84	
1069	D2163	1.31		0.16	
1095	ISO7941	1.3		0.02	
1108	D2163	1.32		0.29	
1191		1.2997		0.02	
1197	D2163	1.202		-1.29	
1198	D2163	1.383		1.13	
1229		1.30		0.02	
1257	D2163	1.3332		0.47	
1275	EN27941	1.316		0.24	
1340	D2163	1.325		0.36	
1474	D2163	1.18	C	-1.59	first reported 1.08
1556	EN27941	1.32		0.29	
1603	In house	1.3391		0.55	
1634	ISO7941	1.295		-0.05	
1720	D2163	1.29		-0.11	
1786	D2163	1.232		-0.89	
1978	D2163	1.2272		-0.95	
2124	D2163	1.3126		0.19	
6018	EN27941	1.232	ex	-0.89	excluded due to statistical outlier in iso-Butane
6019	EN27941	1.213	ex	-1.14	excluded due to statistical outlier in iso-Butane
6193	D2163	1.32		0.29	

|			
normality	OK		
n	45		
outliers	3 (+3 ex)		
mean (n)	1.2984		
st.dev. (n)	0.05695		
R(calc.)	0.1595		
st.dev.(D2163:14e1)	0.07467		
R(D2163:14e1)	0.2091		compare R(EN27941:13(liq))=1.3040

Kernel Density
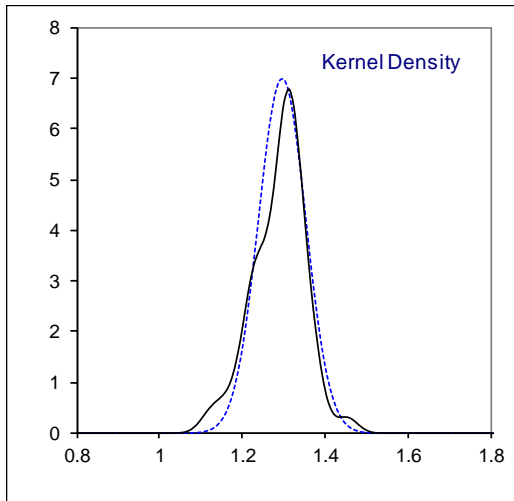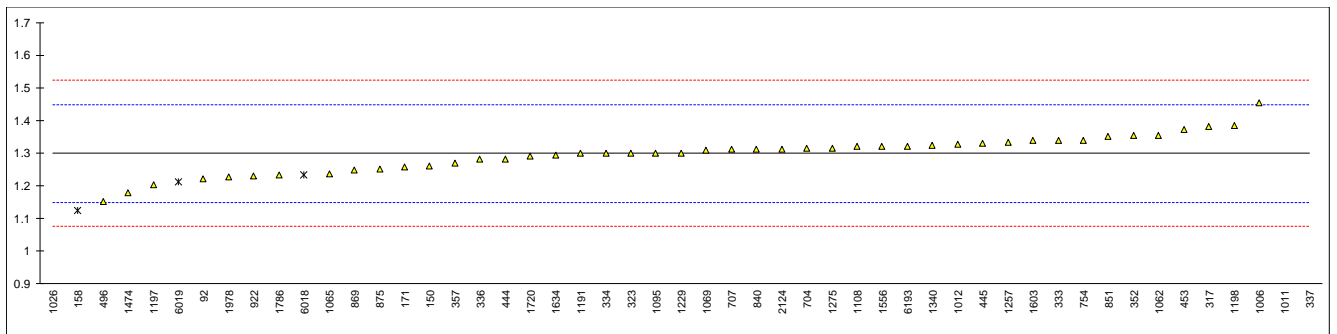
Determination of Propene on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		0.9321		-0.17	
150	D2163	0.88		-0.70	
158	D2163	0.761457	ex	-1.91	excluded due to statistical outlier in iso-Butane
171		0.9329		-0.16	
317	D2163	0.96		0.11	
323	D2163	0.95		0.01	
333	D2163	0.97		0.21	
334	D2163	0.96		0.11	
336	D2163	0.93		-0.19	
337		2.90	R(0.01)	19.84	
352	EN27941	0.9219		-0.28	
357	D2163	0.922		-0.28	
444	D2163	0.927		-0.22	
445	D2163	1.07		1.23	
453	D2163	1.025		0.77	
496	D2163	0.807	C	-1.44	first reported 2.488
704	D2163	0.964		0.15	
707	D2163	0.943		-0.06	
754		0.965		0.16	
840	D2163	0.961		0.12	
851	D2163	0.934228		-0.15	
869	D2163	0.902		-0.48	
875	D2163	0.88		-0.70	
922	D2163	0.86		-0.91	
1006	D2163	1.086		1.39	
1011		2.94	R(0.01)	20.25	
1012	D2163	0.9735		0.25	
1026		-----		-----	
1062	D2163	0.9690		0.20	
1065	D2163	0.9641		0.15	
1069	D2163	0.98		0.31	
1095	ISO7941	1.0		0.52	
1108	D2163	0.96		0.11	
1191		0.9645		0.16	
1197	D2163	0.874		-0.76	
1198	D2163	1.055		1.08	
1229		0.95		0.01	
1257	D2163	0.9947		0.46	
1275	EN27941	0.964		0.15	
1340	D2163	0.983		0.34	
1474	D2163	0.80	C	-1.52	first reported 0.73
1556	EN27941	0.97		0.21	
1603	In house	0.9985		0.50	
1634	ISO7941	0.975		0.26	
1720	D2163	0.92		-0.30	
1786	D2163	0.897		-0.53	
1978	D2163	0.9151		-0.35	
2124	D2163	0.9556		0.07	
6018	EN27941	0.873	ex	-0.77	excluded due to statistical outlier in iso-Butane
6019	EN27941	0.856	ex	-0.95	excluded due to statistical outlier in iso-Butane
6193	D2163	0.9625		0.14	

|			
normality	suspect		
n	45		
outliers	2 (+3 ex)		
mean (n)	0.9491		
st.dev. (n)	0.05632		
R(calc.)	0.1577		
st.dev.(D2163:14e1)	0.09833		
R(D2163:14e1)	0.2753		compare R(EN27941:13(liq))=1.3665

Kernel Density
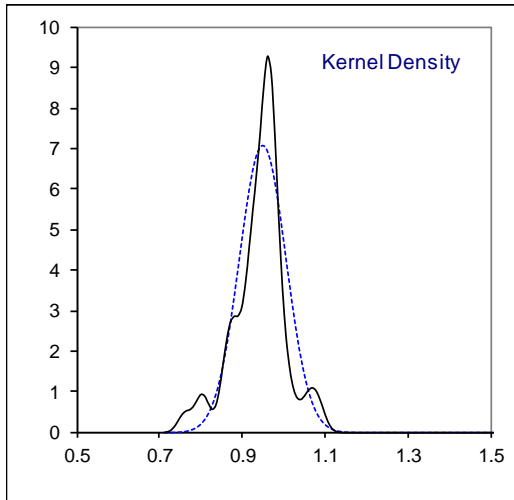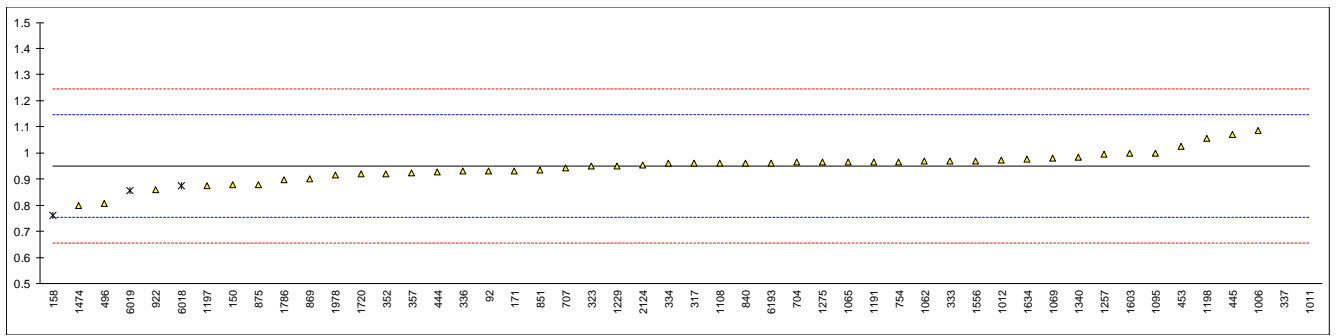
Determination of iso-Butane on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		73.1630		0.59	
150	D2163	73.24		0.82	
158	D2163	75.001846	R(0.01)	6.20	
171		72.7863		-0.56	
317	D2163	72.68		-0.89	
323	D2163	72.77		-0.61	
333	D2163	73.07		0.30	
334	D2163	73.16		0.58	
336	D2163	73.79		2.50	
337		74.90	R(0.01)	5.89	
352	EN27941	72.847		-0.38	
357	D2163	72.632		-1.03	
444	D2163	72.751		-0.67	
445	D2163	72.60		-1.13	
453	D2163	73.241		0.82	
496	D2163	72.582	C	-1.19	first reported 74.912
704	D2163	73.189		0.67	
707	D2163	73.674		2.15	
754		72.875		-0.29	
840	D2163	72.288	C	-2.08	first reported 71.447
851	D2163	73.574194		1.84	
869	D2163	73.057		0.26	
875	D2163	72.51		-1.41	
922	D2163	72.43		-1.65	
1006	D2163	72.951		-0.06	
1011		74.82	R(0.01)	5.64	
1012	D2163	72.7978		-0.53	
1026	ISO7941	70.9159	R(0.01)	-6.27	
1062	D2163	72.9252		-0.14	
1065	D2163	73.4863		1.57	
1069	D2163	72.99		0.06	
1095	ISO7941	73.1		0.39	
1108	D2163	73.24		0.82	
1191		73.1436		0.53	
1197	D2163	73.058		0.27	
1198	D2163	73.120		0.46	
1229		73.24		0.82	
1257	D2163	73.1287		0.48	
1275	EN27941	72.751		-0.67	
1340	D2163	73.09		0.36	
1474	D2163	73.87	C	2.74	first reported 75.55
1556	EN27941	72.96		-0.03	
1603	In house	72.3381		-1.93	
1634	ISO7941	72.535		-1.33	
1720	D2163	73.08		0.33	
1786	D2163	73.016		0.14	
1978	D2163	72.1665		-2.45	
2124	D2163	72.9868		0.05	
6018	EN27941	76.721	R(0.01)	11.44	
6019	EN27941	76.718	R(0.01)	11.43	
6193	D2163	72.8025		-0.51	

normality	OK		
n	45		
outliers	6		
mean (n)	72.9708		
st.dev. (n)	0.37279		
R(calc.)	1.0438		
st.dev.(D2163:14e1)	0.32778		
R(D2163:14e1)	0.9178		compare R(EN27941:13(liq))=1.4840

Kernel Density

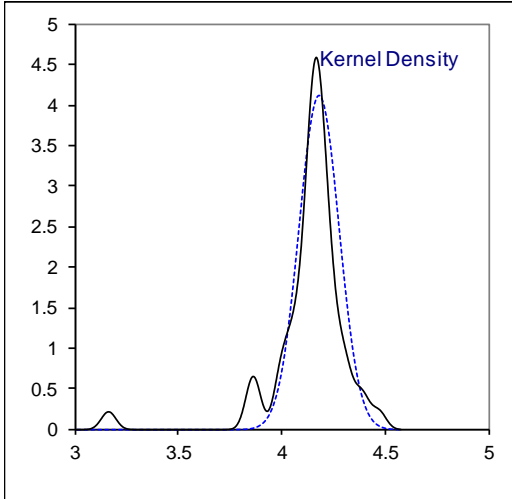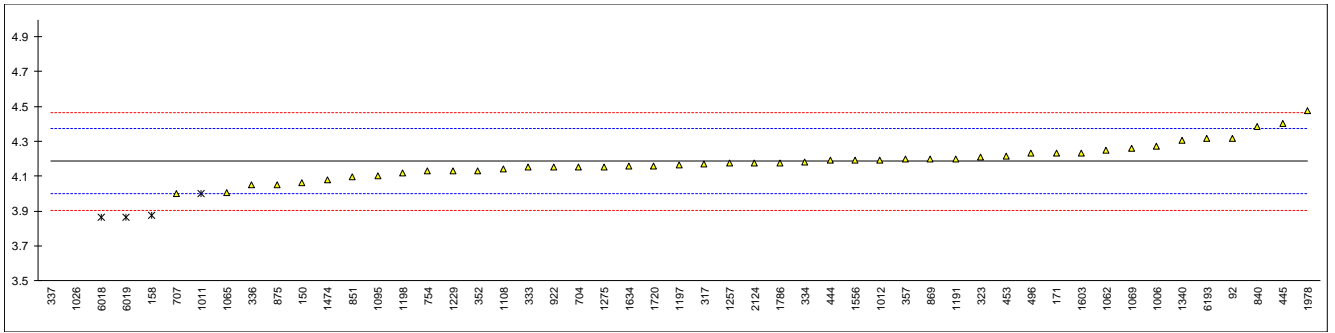## Determination of n-Butane on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		6.0703		-1.32	
150	D2163	6.19		-0.25	
158	D2163	6.116766	ex	-0.91	excluded due to statistical outlier in iso-Butane
171		6.1434		-0.67	
317	D2163	6.44		1.98	
323	D2163	6.23		0.11	
333	D2163	6.16		-0.52	
334	D2163	6.10		-1.06	
336	D2163	6.02		-1.77	
337		4.53	R(0.01)	-15.09	
352	EN27941	6.2917		0.66	
357	D2163	6.298		0.71	
444	D2163	6.260		0.37	
445	D2163	5.99		-2.04	
453	D2163	6.130		-0.79	
496	D2163	6.398	C	1.61	first reported 4.728
704	D2163	6.159		-0.53	
707	D2163	6.254		0.32	
754		6.34		1.09	
840	D2163	6.539		2.87	
851	D2163	6.233034		0.13	
869	D2163	6.177		-0.37	
875	D2163	6.57		3.15	
922	D2163	6.44		1.98	
1006	D2163	6.016		-1.81	
1011		4.54	R(0.01)	-15.00	
1012	D2163	6.2455		0.24	
1026	ISO7941	7.4039	R(0.01)	10.60	
1062	D2163	6.2685		0.45	
1065	D2163	6.1451		-0.65	
1069	D2163	6.04		-1.59	
1095	ISO7941	6.2		-0.16	
1108	D2163	6.12		-0.88	
1191		6.1109		-0.96	
1197	D2163	6.249		0.28	
1198	D2163	6.185		-0.30	
1229		6.11		-0.97	
1257	D2163	6.1390		-0.71	
1275	EN27941	6.199		-0.17	
1340	D2163	6.070		-1.32	
1474	D2163	6.01	C	-1.86	first reported 5.95
1556	EN27941	6.18		-0.34	
1603	In house	6.4265		1.86	
1634	ISO7941	6.625		3.64	
1720	D2163	6.36		1.27	
1786	D2163	6.235		0.15	
1978	D2163	6.0843		-1.20	
2124	D2163	6.2087		-0.08	
6018	EN27941	4.693	R(0.01)	-13.64	
6019	EN27941	4.703	R(0.01)	-13.55	
6193	D2163	6.155		-0.56	

|			
normality	OK		
n	45		
outliers	5 (+1 ex)		
mean (n)	6.2181		
st.dev. (n)	0.14913		
R(calc.)	0.4176		
st.dev.(D2163:14e1)	0.11184		
R(D2163:14e1)	0.3132		compare R(EN27941:13(liq))=0.9893

Kernel Density
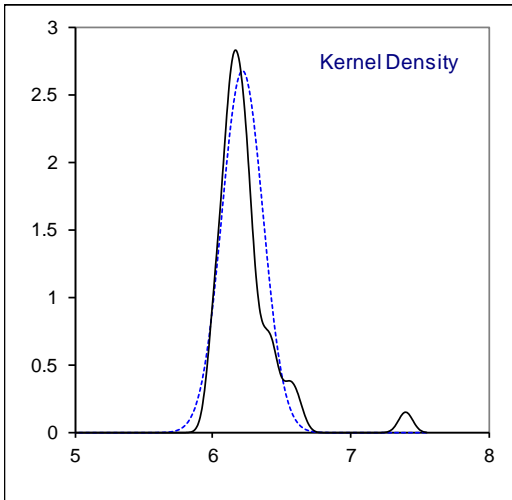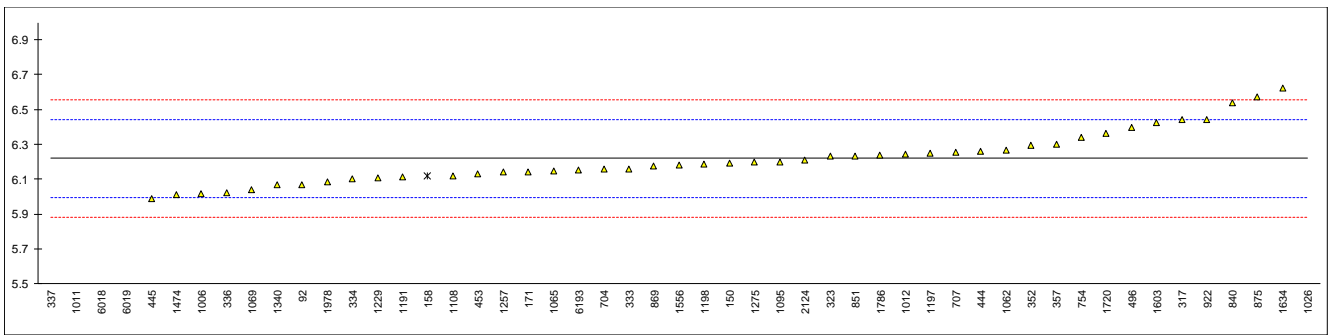
Determination of 1-Butene on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		3.1518		1.68	
150	D2163	2.97		-0.57	
158	D2163	2.794678	ex	-2.74	excluded due to statistical outlier in iso-Butane
171		3.1192		1.28	
317	D2163	3.05		0.42	
323	D2163	3.04		0.30	
333	D2163	3.00		-0.20	
334	D2163	2.99		-0.32	
336	D2163	2.91		-1.31	
337		2.27	R(0.01)	-9.24	
352	EN27941	3.0492		0.41	
357	D2163	3.049		0.41	
444	D2163	3.037		0.26	
445	D2163	3.14		1.54	
453	D2163	2.973		-0.53	
496	D2163	3.058	C	0.52	first reported 2.800
704	D2163	3.003		-0.16	
707	D2163	2.922		-1.16	
754		3.03		0.18	
840	D2163	3.193		2.19	
851	D2163	2.877978		-1.71	
869	D2163	3.009		-0.08	
875	D2163	3.02		0.05	
922	D2163	3.07		0.67	
1006	D2163	2.996		-0.25	
1011		2.77	ex	-3.04	
1012	D2163	3.0444		0.35	
1026	ISO7941	4.2246	R(0.01)	14.97	
1062	D2163	2.9429		-0.90	
1065	D2163	2.8832		-1.64	
1069	D2163	3.09		0.92	
1095	ISO7941	3.0		-0.20	
1108	D2163	2.97		-0.57	
1191		2.9852		-0.38	
1197	D2163	3.015		-0.01	
1198	D2163	3.000		-0.20	
1229		2.97		-0.57	
1257	D2163	3.0169		0.01	
1275	EN27941	2.982		-0.42	
1340	D2163	2.978		-0.47	
1474	D2163	2.89	C	-1.56	first reported 2.67
1556	EN27941	3.02		0.05	
1603	In house	3.0510		0.44	
1634	ISO7941	2.945		-0.88	
1720	D2163	3.04		0.30	
1786	D2163	3.019		0.04	
1978	D2163	3.1572		1.75	
2124	D2163	3.0297		0.17	
6018	EN27941	2.726	ex	-3.59	excluded due to statistical outlier in iso-Butane
6019	EN27941	2.727	ex	-3.58	excluded due to statistical outlier in iso-Butane
6193	D2163	3.025		0.11	

|			
	normality	OK	
	n	45	
	outliers	2 (+4 ex)	
	mean (n)	3.0158	
	st.dev. (n)	0.06912	
	R(calc.)	0.1935	
	st.dev.(D2163:14e1)	0.08076	
	R(D2163:14e1)	0.2261	compare R(EN27941:13(liq))=1.0249
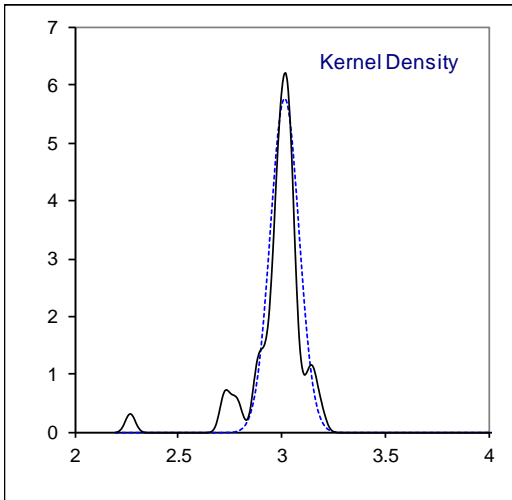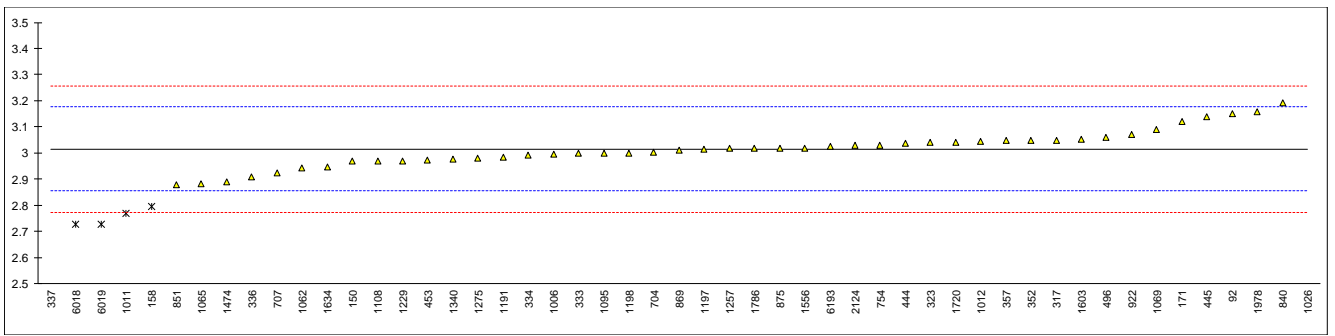
Determination of iso-Butene on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		4.3174		1.41	
150	D2163	4.06		-1.34	
158	D2163	3.872823	ex	-3.34	excluded due to statistical outlier in iso-Butane
171		4.2341		0.52	
317	D2163	4.17		-0.16	
323	D2163	4.21		0.27	
333	D2163	4.15		-0.38	
334	D2163	4.18		-0.05	
336	D2163	4.05		-1.44	
337		2.72	R(0.01)	-15.65	
352	EN27941	4.1318		-0.57	
357	D2163	4.197		0.13	
444	D2163	4.190		0.05	
445	D2163	4.40		2.30	
453	D2163	4.215		0.32	
496	D2163	4.232	C	0.50	first reported 3.965
704	D2163	4.151		-0.36	
707	D2163	3.998		-2.00	
754		4.13		-0.59	
840	D2163	4.383		2.11	
851	D2163	4.098696		-0.92	
869	D2163	4.198		0.14	
875	D2163	4.05		-1.44	
922	D2163	4.15		-0.38	
1006	D2163	4.273		0.94	
1011		4.00	ex	-1.98	excluded due to statistical outlier in iso-Butane
1012	D2163	4.1921		0.07	
1026	ISO7941	3.1671	R(0.01)	-10.88	
1062	D2163	4.2470		0.66	
1065	D2163	4.007		-1.90	
1069	D2163	4.26		0.80	
1095	ISO7941	4.1		-0.91	
1108	D2163	4.14		-0.48	
1191		4.1982		0.14	
1197	D2163	4.164		-0.23	
1198	D2163	4.121		-0.69	
1229		4.13		-0.59	
1257	D2163	4.1735		-0.12	
1275	EN27941	4.155		-0.32	
1340	D2163	4.307		1.30	
1474	D2163	4.08	C	-1.12	first reported 3.77
1556	EN27941	4.19		0.05	
1603	In house	4.2346		0.53	
1634	ISO7941	4.16		-0.27	
1720	D2163	4.16		-0.27	
1786	D2163	4.178		-0.08	
1978	D2163	4.4745		3.09	
2124	D2163	4.1756		-0.10	
6018	EN27941	3.863	ex	-3.44	excluded due to statistical outlier in iso-Butane
6019	EN27941	3.865	ex	-3.42	excluded due to statistical outlier in iso-Butane
6193	D2163	4.315		1.39	

|			
normality	suspect		
n	45		
outliers	2 (+4 ex)		
mean (n)	4.1851		
st.dev. (n)	0.09666		
R(calc.)	0.2706		
st.dev.(D2163:14e1)	0.09359		
R(D2163:14e1)	0.2621		compare R(EN27941:13(liq))=1.0249

Determination of trans-2-Butene on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		3.2140		1.68	
150	D2163	3.06		-0.21	
158	D2163	2.802008	R(0.05)	-3.38	
171		3.0711		-0.08	
317	D2163	3.06		-0.21	
323	D2163	3.11		0.40	
333	D2163	3.05		-0.33	
334	D2163	3.05		-0.33	
336	D2163	2.96		-1.44	
337		3.83	R(0.01)	9.24	
352	EN27941	3.0405		-0.45	
357	D2163	3.114		0.45	
444	D2163	3.115		0.46	
445	D2163	3.13		0.65	
453	D2163	2.987		-1.11	
496	D2163	3.173	C	1.18	first reported 2.349
704	D2163	3.042		-0.43	
707	D2163	2.968		-1.34	
754		3.05		-0.33	
840	D2163	3.244		2.05	
851	D2163	2.990165		-1.07	
869	D2163	3.085		0.10	
875	D2163	3.12		0.52	
922	D2163	3.18		1.26	
1006	D2163	3.044		-0.41	
1011		2.38	R(0.01)	-8.56	
1012	D2163	3.0855		0.10	
1026		-----		-----	
1062	D2163	2.9790		-1.21	
1065	D2163	3.0086		-0.84	
1069	D2163	3.09		0.16	
1095	ISO7941	3.1		0.28	
1108	D2163	3.07		-0.09	
1191		3.0583		-0.23	
1197	D2163	3.100		0.28	
1198	D2163	3.000		-0.95	
1229		3.02		-0.70	
1257	D2163	3.0337		-0.53	
1275	EN27941	3.126		0.60	
1340	D2163	3.065		-0.15	
1474	D2163	3.00	C	-0.95	first reported 2.73
1556	EN27941	3.07		-0.09	
1603	In house	3.1242		0.58	
1634	ISO7941	3.115		0.46	
1720	D2163	3.04		-0.46	
1786	D2163	3.097		0.24	
1978	D2163	3.3052		2.80	
2124	D2163	3.0706		-0.08	
6018	EN27941	2.666	R(0.01)	-5.05	
6019	EN27941	2.672	R(0.01)	-4.97	
6193	D2163	3.06		-0.21	

|			
normality	not OK		
n	45		
outliers	5		
mean (n)	3.0772		
st.dev. (n)	0.07009		
R(calc.)	0.1963		
st.dev.(D2163:14e1)	0.08150		
R(D2163:14e1)	0.2282		compare R(EN27941:13(liq))=1.0249

Kernel Density
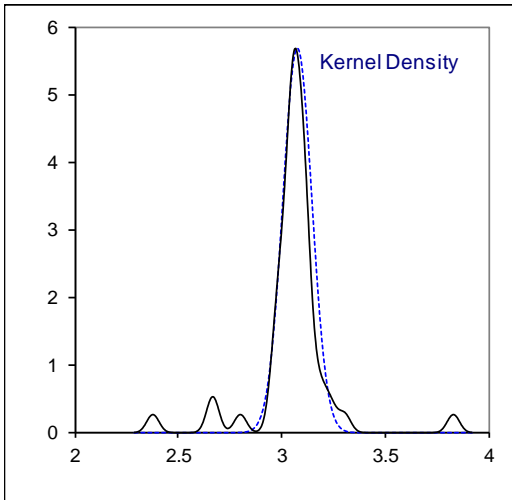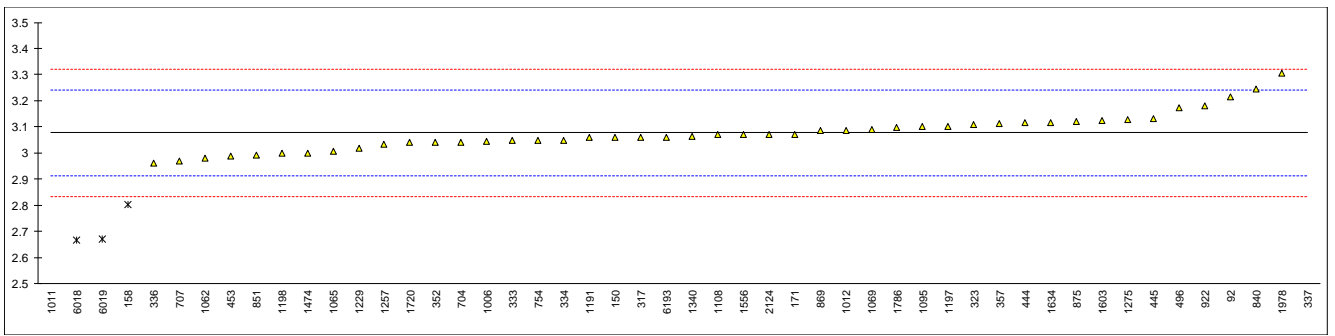
Determination of cis-2-Butene on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		7.0108		1.85	
150	D2163	6.81		0.13	
158	D2163	6.015648	R(0.01)	-6.70	
171		6.9158		1.04	
317	D2163	6.78		-0.13	
323	D2163	6.85		0.47	
333	D2163	6.74		-0.48	
334	D2163	6.75		-0.39	
336	D2163	6.64		-1.33	
337		4.63	R(0.01)	-18.60	
352	EN27941	6.8078		0.11	
357	D2163	6.933		1.18	
444	D2163	6.884		0.76	
445	D2163	6.80		0.04	
453	D2163	6.570		-1.94	
496	D2163	7.057	C	2.25	first reported 4.850
704	D2163	6.731		-0.55	
707	D2163	6.495		-2.58	
754		6.78		-0.13	
840	D2163	7.020	C	1.93	first reported 7.320
851	D2163	6.479639		-2.71	
869	D2163	6.806		0.09	
875	D2163	7.00		1.76	
922	D2163	7.06		2.27	
1006	D2163	6.723		-0.62	
1011		4.51	R(0.01)	-19.63	
1012	D2163	6.8003		0.04	
1026	ISO7941	8.4554	R(0.01)	14.26	
1062	D2163	6.8224		0.23	
1065	D2163	6.7266		-0.59	
1069	D2163	6.65		-1.25	
1095	ISO7941	6.7		-0.82	
1108	D2163	6.68		-0.99	
1191		6.7160		-0.68	
1197	D2163	6.860		0.56	
1198	D2163	6.710		-0.73	
1229		6.67		-1.08	
1257	D2163	6.7123		-0.71	
1275	EN27941	6.930		1.16	
1340	D2163	6.719		-0.66	
1474	D2163	6.65	C	-1.25	first reported 5.90
1556	EN27941	6.80		0.04	
1603	In house	6.9754		1.55	
1634	ISO7941	6.84		0.38	
1720	D2163	6.64		-1.33	
1786	D2163	6.825		0.26	
1978	D2163	7.0980		2.60	
2124	D2163	6.7832		-0.10	
6018	EN27941	5.763	R(0.01)	-8.87	
6019	EN27941	5.779	R(0.01)	-8.73	
6193	D2163	6.8375		0.36	

normality	OK		
n	45		
outliers	6		
mean (n)	6.7953		
st.dev. (n)	0.14216		
R(calc.)	0.3981		
st.dev.(D2163:14e1)	0.11640		
R(D2163:14e1)	0.3259		compare R(EN27941:13(liq))=1.0249
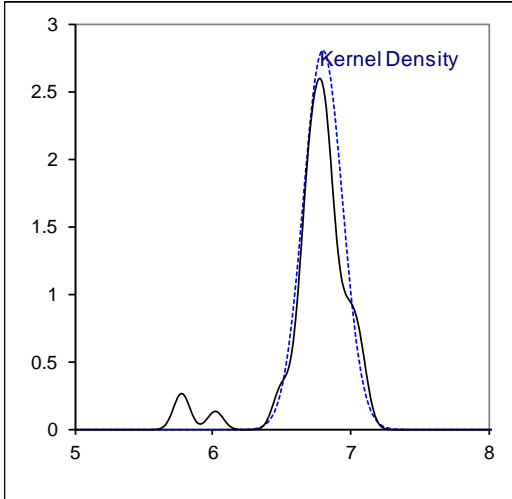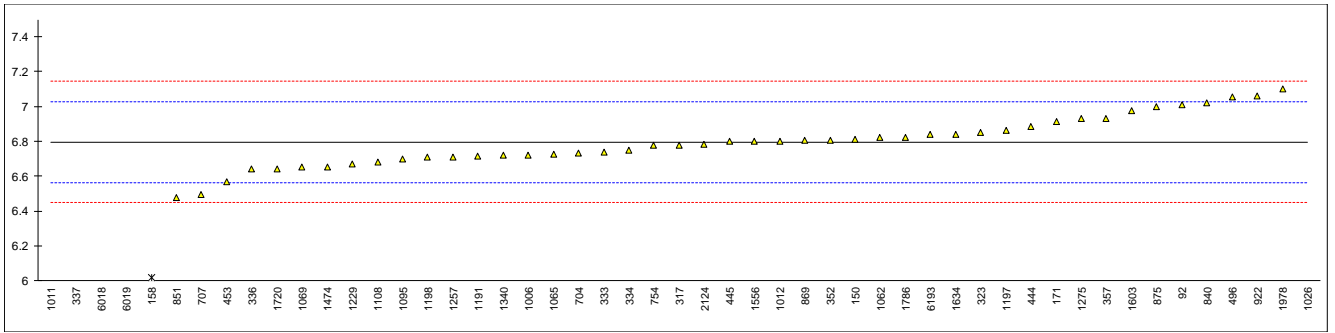
Determination of 1,3-Butadiene on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		0.8792		1.48	
150	D2163	0.82		0.16	
158	D2163	0.687265	R(0.05)	-2.80	
171		0.8104		-0.05	
317	D2163	0.79		-0.51	
323	D2163	0.81		-0.06	
333	D2163	0.81		-0.06	
334	D2163	0.80		-0.29	
336	D2163	0.76		-1.18	
337		0.81	ex	-0.06	excluded due to statistical outlier in iso-Butane
352	EN27941	0.8297		0.38	
357	D2163	0.814		0.03	
444	D2163	0.808		-0.11	
445	D2163	0.89		1.73	
453	D2163	0.784		-0.64	
496	D2163	0.814	C	0.03	first reported 0.807
704	D2163	0.790		-0.51	
707	D2163	0.787		-0.58	
754		0.79		-0.51	
840	D2163	0.849		0.81	
851	D2163	0.803731		-0.20	
869	D2163	0.795		-0.40	
875	D2163	0.79		-0.51	
922	D2163	0.81		-0.06	
1006	D2163	0.831		0.41	
1011		0.76	ex	-1.18	excluded due to statistical outlier in iso-Butane
1012	D2163	0.8074		-0.12	
1026	ISO7941	0.0104	R(0.01)	-17.92	
1062	D2163	0.7752		-0.84	
1065	D2163	0.8093		-0.08	
1069	D2163	0.85		0.83	
1095	ISO7941	0.8		-0.29	
1108	D2163	0.80		-0.29	
1191		0.8075		-0.12	
1197	D2163	0.803		-0.22	
1198	D2163	0.792		-0.46	
1229		0.87		1.28	
1257	D2163	0.8155		0.06	
1275	EN27941	0.844		0.70	
1340	D2163	0.791		-0.49	
1474	D2163	0.82	C	0.16	first reported 0.80
1556	EN27941	0.80		-0.29	
1603	In house	0.8146		0.04	
1634	ISO7941	0.80		-0.29	
1720	D2163	0.82		0.16	
1786	D2163	0.813		0.01	
1978	D2163	0.8690		1.26	
2124	D2163	0.8076		-0.12	
6018	EN27941	0.744	ex	-1.54	excluded due to statistical outlier in iso-Butane
6019	EN27941	0.745	ex	-1.51	excluded due to statistical outlier in iso-Butane
6193	D2163	0.8		-0.29	

normality	not OK		
n	45		
outliers	2 (+4 ex)		
mean (n)	0.8128		
st.dev. (n)	0.02678		
R(calc.)	0.0750		
st.dev.(D2163:14e1)	0.04477		
R(D2163:14e1)	0.1253		compare R(EN27941:13(liq))=1.0631
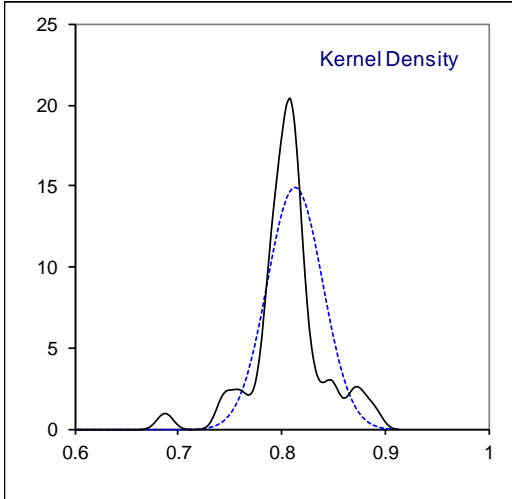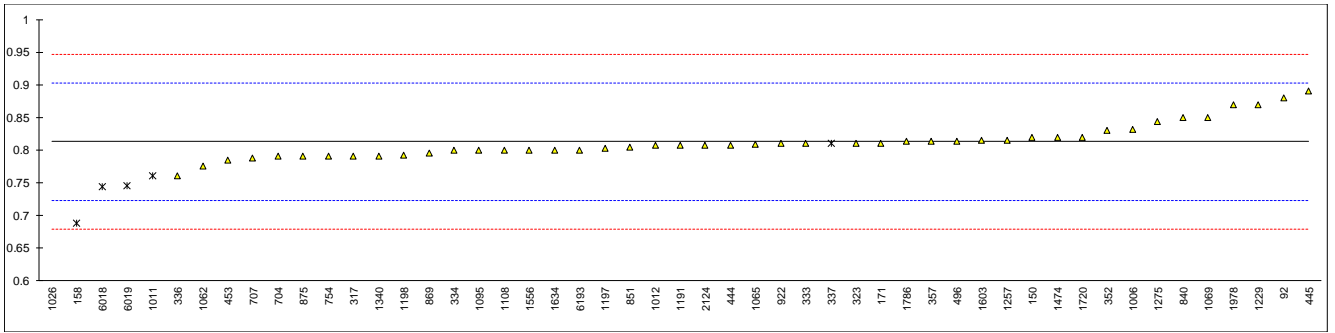
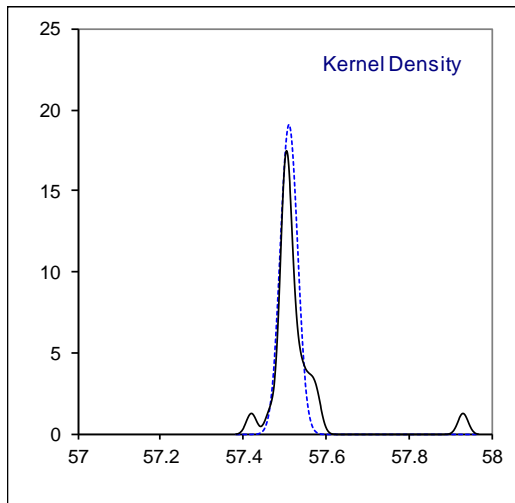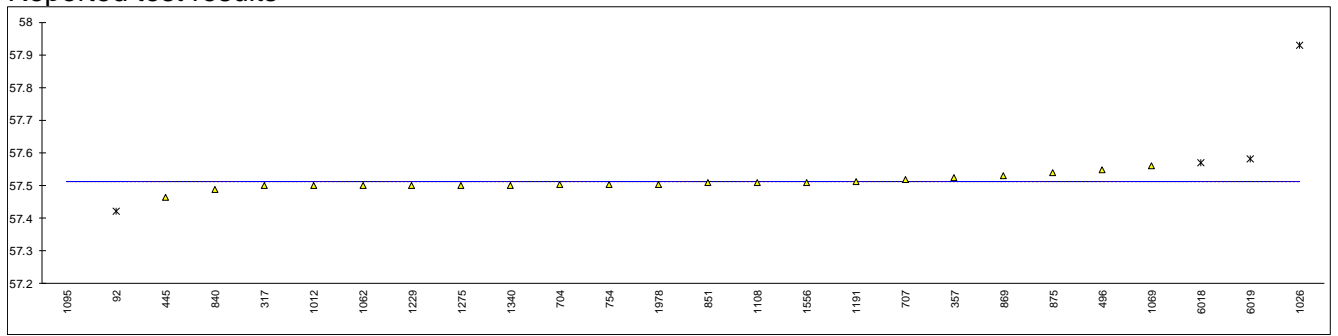## Determination of iso-Pentane on sample #18100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		0.0419	R(0.01)	-36.80	
150	D2163	0.69		1.00	
158	D2163	0.771348	ex	5.75	excluded due to statistical outlier in iso-Butane
171		0.6834		0.62	
317	D2163	0.65		-1.33	
323	D2163	0.68		0.42	
333	D2163	0.66		-0.75	
334	D2163	0.66		-0.75	
336	D2163	0.61		-3.66	
337		0.20	R(0.01)	-27.58	
352	EN27941	0.6791		0.37	
357	D2163	0.712		2.29	
444	D2163	0.694		1.24	
445	D2163	0.59		-4.83	
453	D2163	0.644		-1.68	
496	D2163	0.728	C	3.22	first reported 0.221
704	D2163	0.660		-0.75	
707	D2163	0.650		-1.33	
754		0.66		-0.75	
840	D2163	0.698		1.47	
851	D2163	0.655985		-0.98	
869	D2163	0.676		0.19	
875	D2163	0.75		4.50	
922	D2163	0.72	C	2.75	first reported 0.77
1006	D2163	0.625		-2.79	
1011		0.20	R(0.01)	-27.58	
1012	D2163	0.6807		0.46	
1026	ISO7941	0.6423	ex	-1.78	excluded due to statistical outlier in iso-Butane
1062	D2163	0.6698		-0.18	
1065	D2163	0.6810		0.48	
1069	D2163	0.69		1.00	
1095	ISO7941	0.7		1.59	
1108	D2163	0.65		-1.33	
1191		0.6697		-0.18	
1197	D2163	0.670		-0.16	
1198	D2163	0.630		-2.50	
1229		0.69		1.00	
1257	D2163	0.6525		-1.19	
1275	EN27941	0.680		0.42	
1340	D2163	0.661		-0.69	
1474	D2163	0.70	C	1.59	first reported 0.82
1556	EN27941	0.67		-0.16	
1603	In house	0.6981		1.47	
1634	ISO7941	0.67		-0.16	
1720	D2163	0.65		-1.33	
1786	D2163	0.683		0.59	
1978	D2163	0.7031		1.77	
2124	D2163	0.6696		-0.19	
6018	EN27941	0.661	ex	-0.69	excluded due to statistical outlier in iso-Butane
6019	EN27941	0.665	ex	-0.46	excluded due to statistical outlier in iso-Butane
6193	D2163	0.66		-0.75	

normality	suspect		
n	44		
outliers	3 (+4 ex)		
mean (n)	0.6728		
st.dev. (n)	0.02965		
R(calc.)	0.0830		
st.dev.(D2163:14e1)	0.01714		
R(D2163:14e1)	0.0480		compare R(EN27941:13(liq))=0.7970

Kernel Density
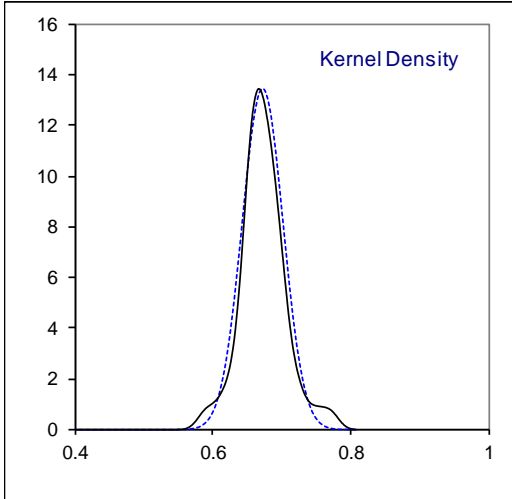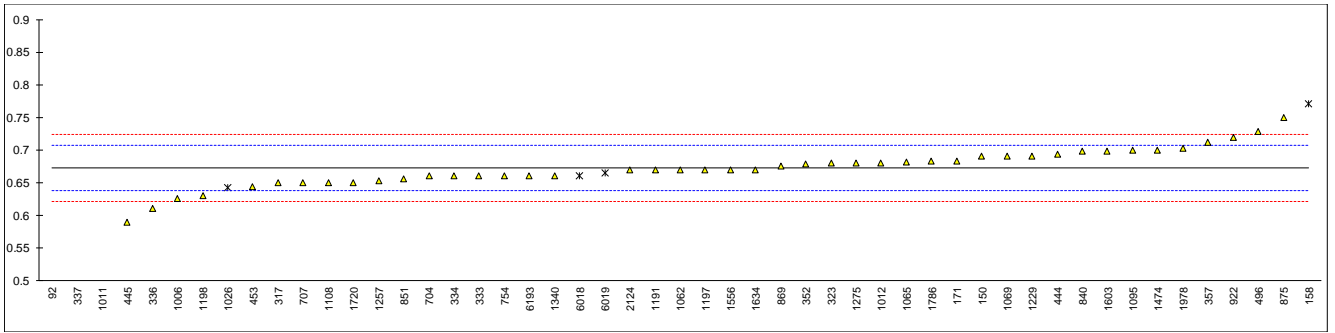
Determination of Molar Mass on sample #18100; results in g/mol
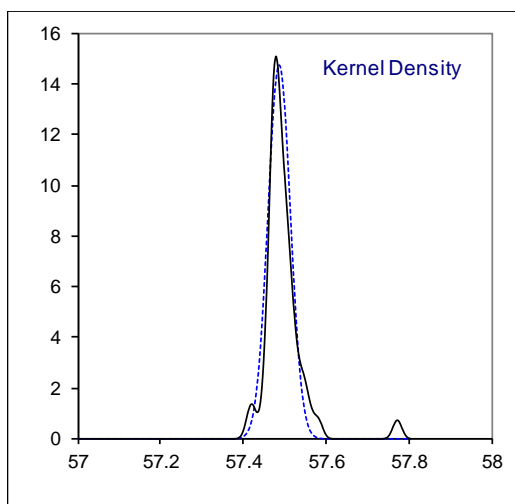
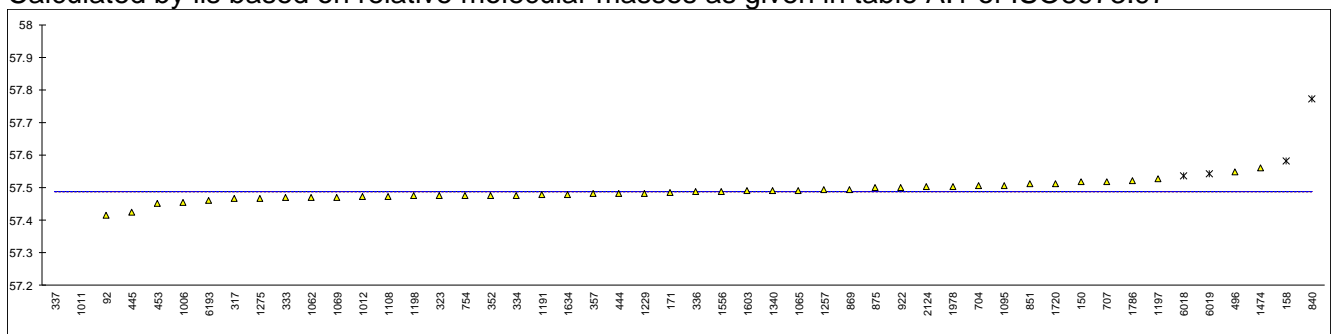| lab	method	value	mark	z(targ)	remarks
92	D2163	57.42	R(0.01)	-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	INH-001	57.5		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	57.524		-----	
444		-----		-----	
445	D2163	57.465		-----	
453		-----		-----	
496	D2598	57.547	C	-----	first reported 57.036
704	D2421	57.5022		-----	
707	D2421	57.5167		-----	
754	ISO8973	57.5035		-----	
840	D2598	57.487	E	-----	iis calc.57.771, first reported composition results gives 57.451 (ISO8973)
851	D2598	57.51		-----	
869	D2598	57.53		-----	
875	ISO8973	57.54		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		57.5		-----	
1026	ISO8973	57.93	ex	-----	excluded due to statistical outlier in iso-Butane
1062	D2163	57.50		-----	
1065		-----		-----	
1069	D2163	57.56		-----	iis calc 57.4710 (acc. to ISO8973)
1095	ISO8973	0.5719	ex	-----	excluded: unit error?, iis calc 57.5055 (acc. to ISO8973)
1108	D2163	57.51		-----	
1191	ISO6976	57.5122		-----	
1197		-----		-----	
1198		-----		-----	
1229	ISO8973	57.50		-----	
1257		-----		-----	
1275	EN589	57.500		-----	
1340		57.50		-----	
1474		-----		-----	
1556		57.51		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1786		-----		-----	
1978	D2598	57.504		-----	
2124		-----		-----	
6018	ISO8973	57.57	ex	-----	excluded due to statistical outlier in iso-Butane
6019	ISO8973	57.58	ex	-----	excluded due to statistical outlier in iso-Butane
6193		-----		-----	

					iis calculated from all reported composition results *)
	normality	suspect			not OK
	n	21			44
	outliers	1 (+4 ex)			1 (+5 ex)
	mean (n)	57.511			57.487
	st.dev. (n)	0.0209	RSD=0.04%		0.0270 RSD=0.05%
	R(calc.)	0.058			0.076

*) Calculated by iis based on relative molecular masses as given in table A.1 of ISO8973:97
NB. Effect of different factors from ISO8973:97 and ASTM D2421:13 on the calculation is very small

Reported test results

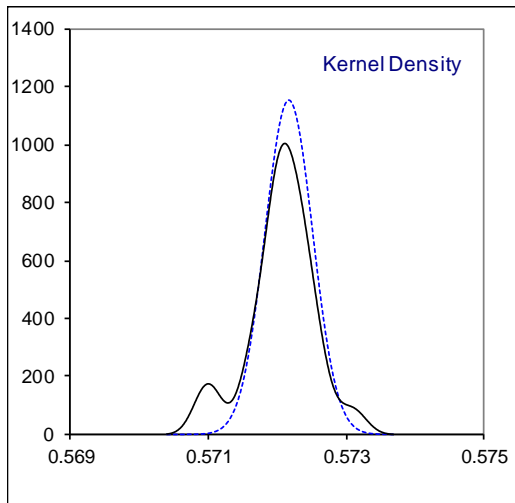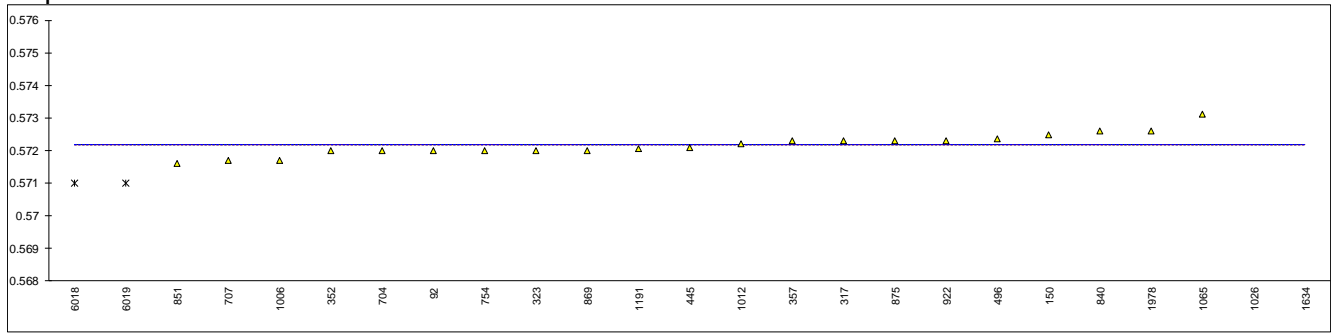Calculated by iis based on relative molecular masses as given in table A.1 of ISO8973:97

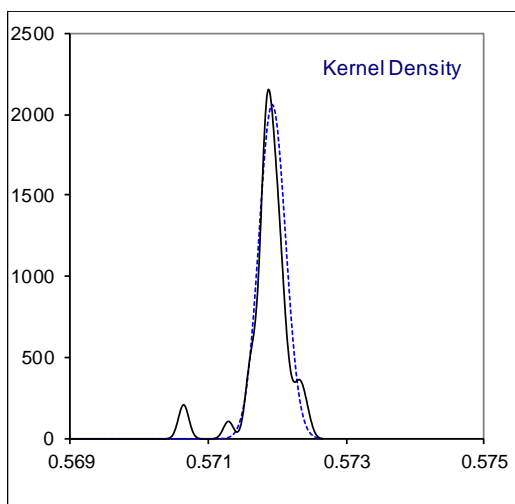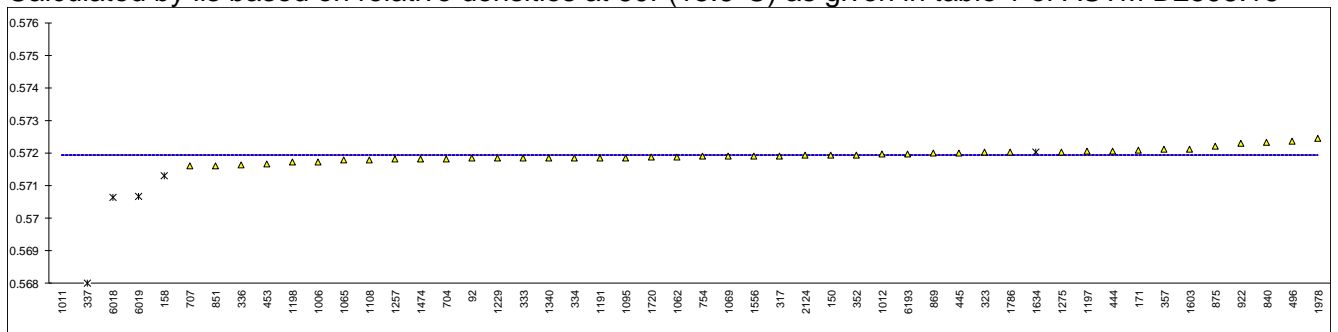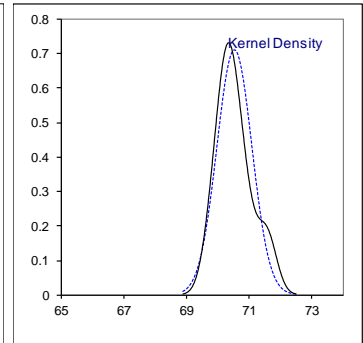## Determination of Relative Density at 60/60F on sample #18100; unitless results

lab	method	value	mark	z(targ)	remarks
92	D2598	0.5720		-----	
150	D2598	0.57248		-----	
158		-----		-----	
171		-----		-----	
317	INH-001	0.5723		-----	
323	D2598	0.5720		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	ISO8973	0.572		-----	
357	D2598	0.5723		-----	
444		-----		-----	
445	IP432	0.5721		-----	
453		-----		-----	
496	D2598	0.57237	C	-----	first reported 0.56849
704	D2598	0.5720		-----	
707	D2598	0.5717		-----	
754	D2598	0.572		-----	
840	D2598	0.5726		-----	
851	D2598	0.5716		-----	
869	D2598	0.5720		-----	
875	ISO8973	0.5723		-----	
922	D2598	0.5723		-----	
1006	D2598	0.5717		-----	
1011		-----		-----	
1012		0.5722		-----	
1026	ISO8973	563.6	ex	-----	excluded due to statistical outlier in iso-Butane, unit error?
1062		-----		-----	
1065		0.5731	E	-----	iis calc.0.5718 (acc. to D2598)
1069		-----		-----	
1095		-----		-----	
1108		-----		-----	
1191	D2598	0.572042		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275		-----		-----	
1340		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	ISO8973	572.1	ex, E	-----	excluded: unit error? iis calc. 0.5720 (acc. to D2598)
1720		-----		-----	
1786		-----		-----	
1978	D2598	0.5726		-----	
2124		-----		-----	
6018	ISO8973	0.571	ex	-----	excluded due to statistical outlier in iso-Butane
6019	ISO8973	0.571	ex	-----	excluded due to statistical outlier in iso-Butane
6193		-----		-----	

					iis calculated from all reported composition results *)
	normality	suspect			OK
	n	21			45
	outliers	0 (+4 ex)			0 (+5 ex)
	mean (n)	0.5722			0.5719
	st.dev. (n)	0.00035	RSD=0.06%		0.00019 RSD=0.03%
	R(calc.)	0.0010			0.0005

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

Reported test results

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

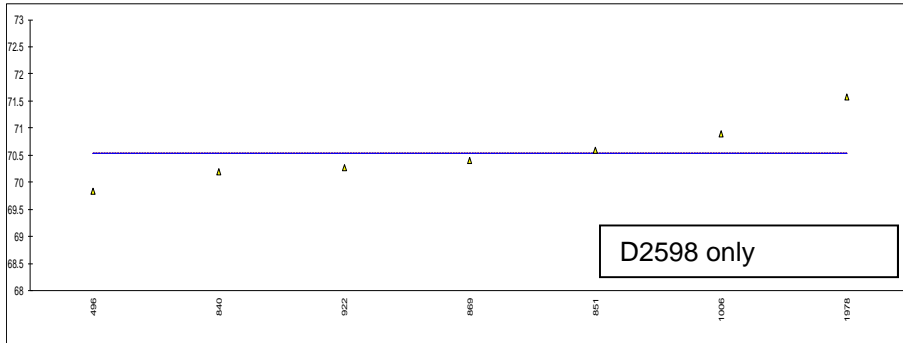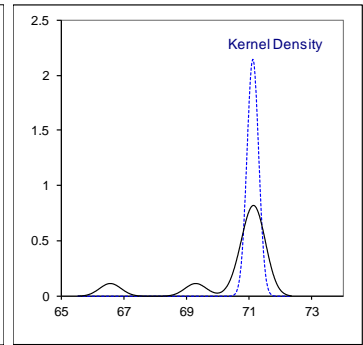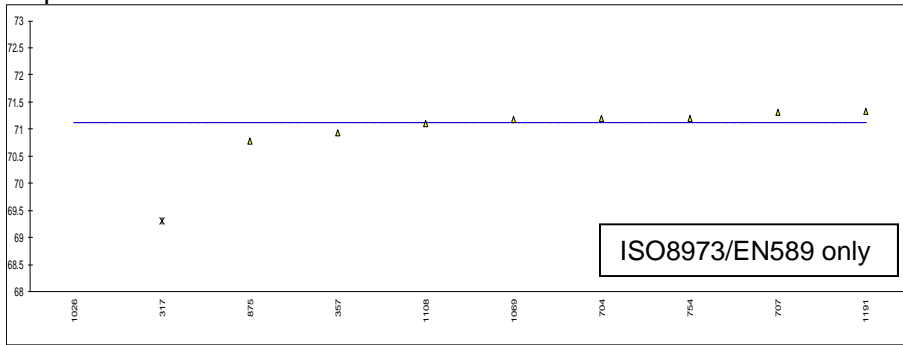## Determination of Abs. Vapour Pressure at 100F on sample #18100; results in psi

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	ISO8973	69.3	D(0.01), E	-----	iis calc.71.2 (acc. to ISO8973)
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	70.93		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
496	D2598	69.84	C	-----	first reported 75.07
704	ISO8973	71.2		-----	
707	ISO8973	71.3		-----	
754	ISO8973	71.2		-----	
840	D2598	70.2		-----	
851	D2598	70.6		-----	
869	D2598	70.4		-----	
875	ISO8973	70.78		-----	
922	D2598	70.27		-----	
1006	D2598	70.9		-----	
1011		-----		-----	
1012		-----		-----	
1026	ISO8973	66.57	ex	-----	excluded due to statistical outlier in iso-Butane
1062		-----		-----	
1065		-----		-----	
1069	ISO8973	71.18		-----	
1095		-----		-----	
1108	ISO8973	71.1		-----	
1191	ISO8973	71.32548		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275		-----		-----	
1340		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1786		-----		-----	
1978	D2598	71.57	E	-----	iis calc.70.21 (acc. to D2598)
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6193		-----		-----	

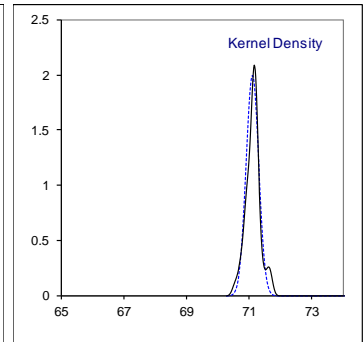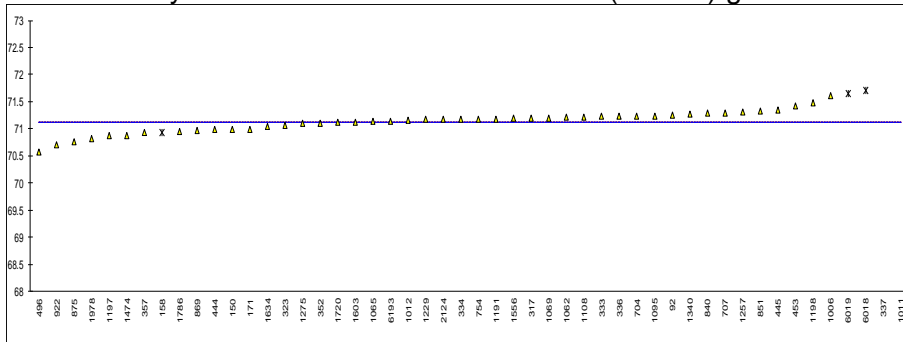| Evaluated over ISO8973 test results only			iis calculated from all test results *)	
normality	OK		suspect	
n	8		45	
outliers	1 (+1 ex)		0 (+5 ex) (excluded due to statistical outlier in iso-Butane)	
mean (n)	71.1269		71.1278	
st.dev. (n)	0.18622	RSD=0.26%	0.19974	RSD=0.28%
R(calc.)	0.5214		0.5593	
Evaluated over D2598 test results only			**iis calculated from all test results **)**	
normality	unknown		OK	
n	7		45	
outliers	0		0 (+5 ex) (excluded due to statistical outlier in iso-Butane)	
mean (n)	70.5400		70.4888	
st.dev. (n)	0.56158	RSD=0.80%	0.17359	RSD=0.25%
R(calc.)	1.5724		0.4861	

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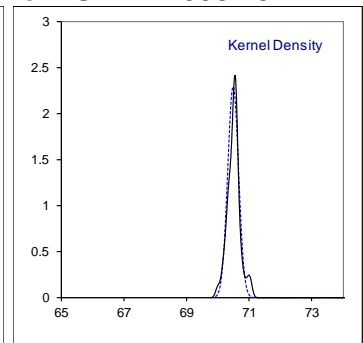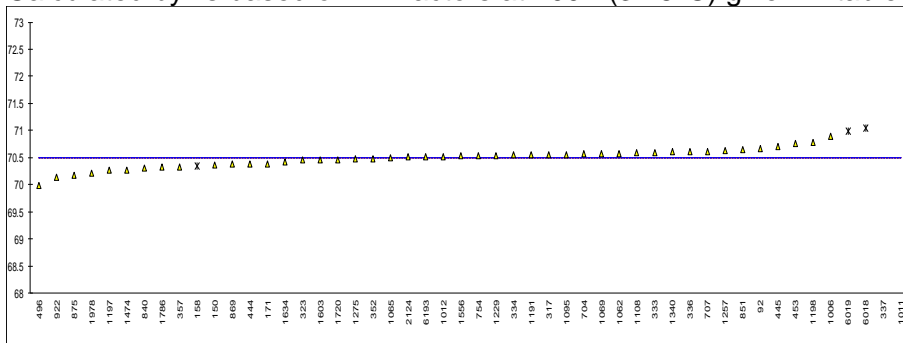
Reported test results

ISO8973/EN589 only

D2598 only

Calculated by iis based on VP factors at 100F (37.8°C) given in table A.1 of IP432:99 / ISO8973:97

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

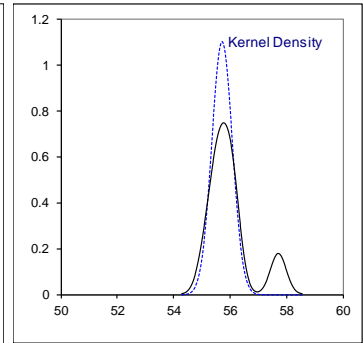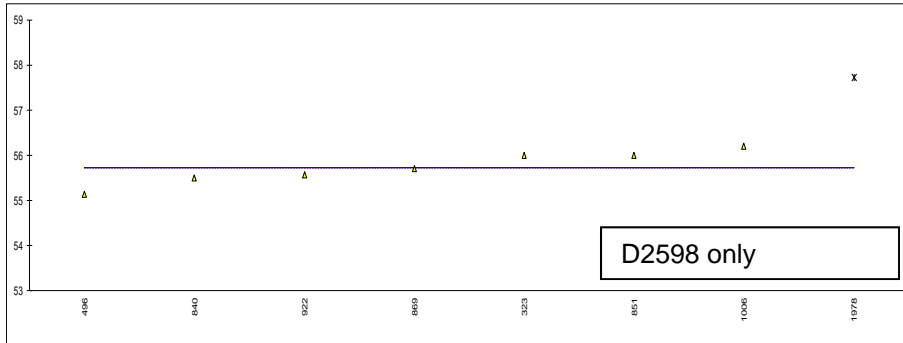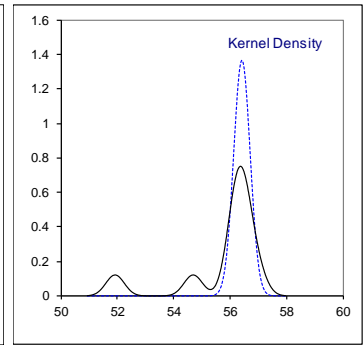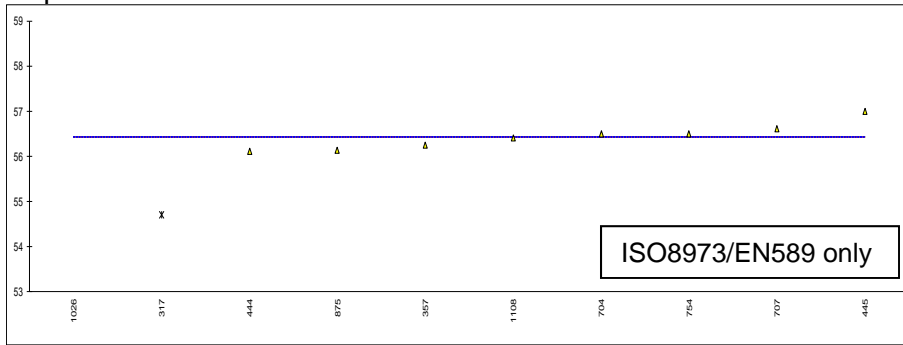## Determination of Rel. Vapour Pressure at 100F on sample #18100; results in psi

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	ISO8973	54.7	D(0.01), E	-----	iis calc.56.5 (acc. to ISO8973)
323	D2598	55.99		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	56.24		-----	
444	ISO8973	56.1		-----	
445	IP432	57		-----	
453		-----		-----	
496	D2598	55.14	C	-----	first reported 60.37
704	ISO8973	56.5		-----	
707	ISO8973	56.6		-----	
754	ISO8973	56.5		-----	
840	D2598	55.5		-----	
851	D2598	56.0		-----	
869	D2598	55.7		-----	
875	ISO8973	56.13		-----	
922	D2598	55.57		-----	
1006	D2598	56.2		-----	
1011		-----		-----	
1012		-----		-----	
1026	ISO8973	51.92	ex	-----	excluded due to statistical outlier in iso-Butane
1062		-----		-----	
1065		-----		-----	
1069		-----		-----	
1095		-----		-----	
1108	ISO8973	56.4		-----	
1191		-----		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275		-----		-----	
1340		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1786		-----		-----	
1978	D2598	57.72	D(0.05), E	-----	iis calc.55.51 (acc. to D2598)
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6193		-----		-----	

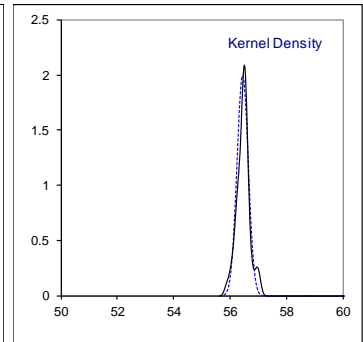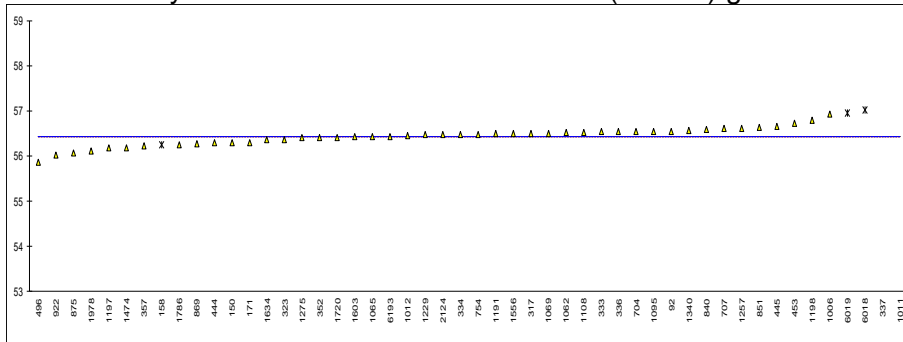| Evaluated over ISO8973/ IP432 test results only			iis calculated from all test results *)	
normality	OK		suspect	
n	8		45	
outliers	1 (+1 ex)		0 (+5 ex) (excluded due to statistical outlier in iso-Butane)	
mean (n)	56.4338		56.4318	
st.dev. (n)	0.29262	RSD=0.52%	0.19974	RSD=0.35%
R(calc.)	0.8193		0.5593	
Evaluated over D2598 test results only			**iis calculated from all test results **)**	
normality	unknown		OK	
n	7		45	
outliers	1		0 (+5 ex) (excluded due to statistical outlier in iso-Butane)	
mean (n)	55.7286		55.7928	
st.dev. (n)	0.36260	RSD=0.65%	0.17359	RSD=0.31%
R(calc.)	1.0153		0.4861	

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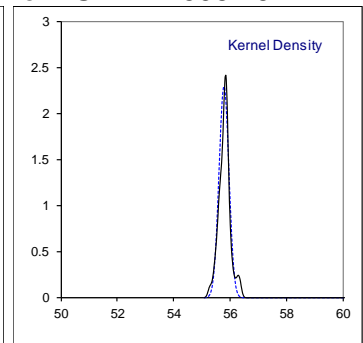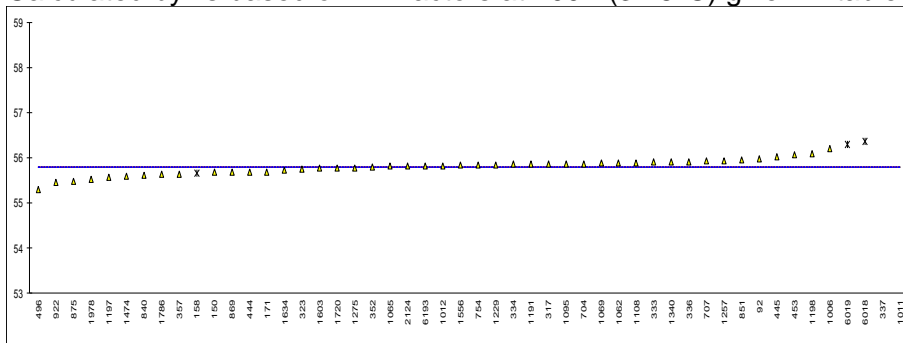
Reported test results

ISO8973/EN589 only

D2598 only

Calculated by iis based on VP factors at 100F (37.8°C) given in table A.1 of IP432:99 / ISO8973:97

Calculated by iis based on VP factors at 100F (37.8°C) given in table 1 of ASTM D2598:16
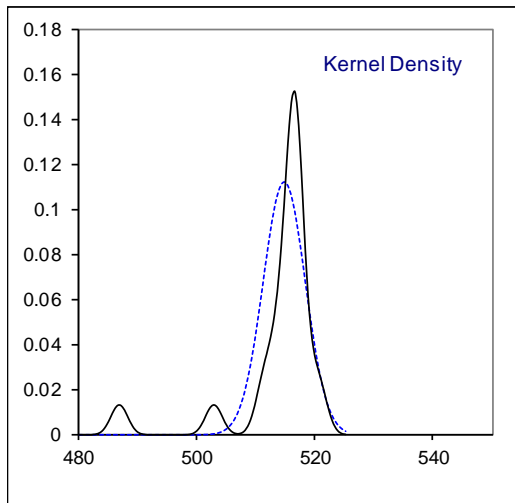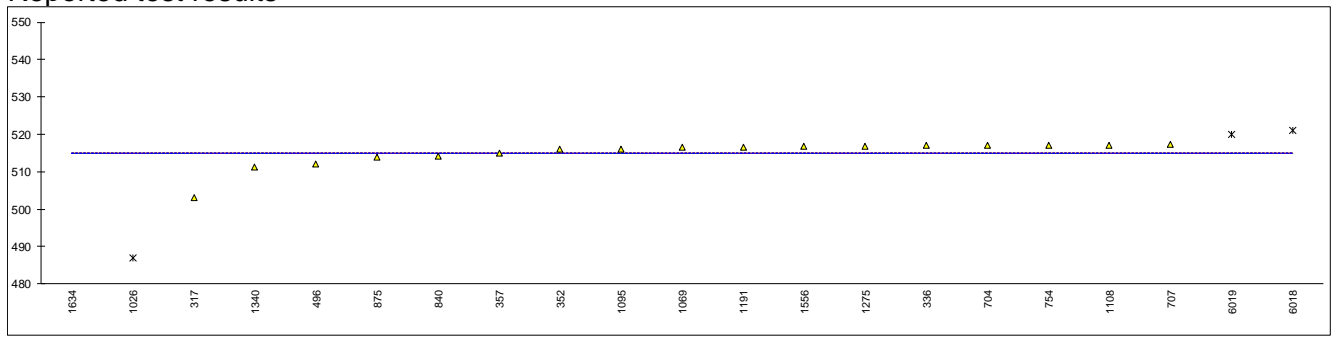
Determination of Abs. Vapour Pressure at 40°C on sample #18100; results in kPa
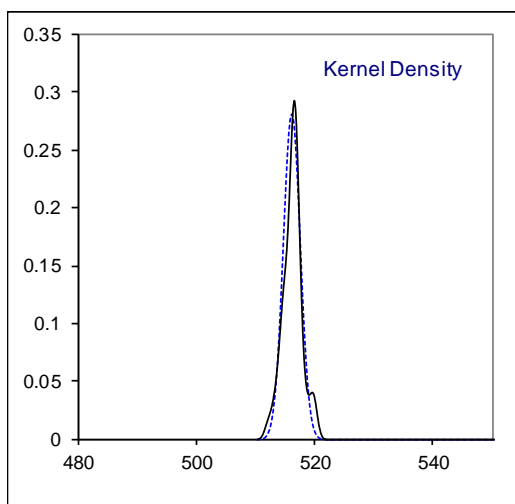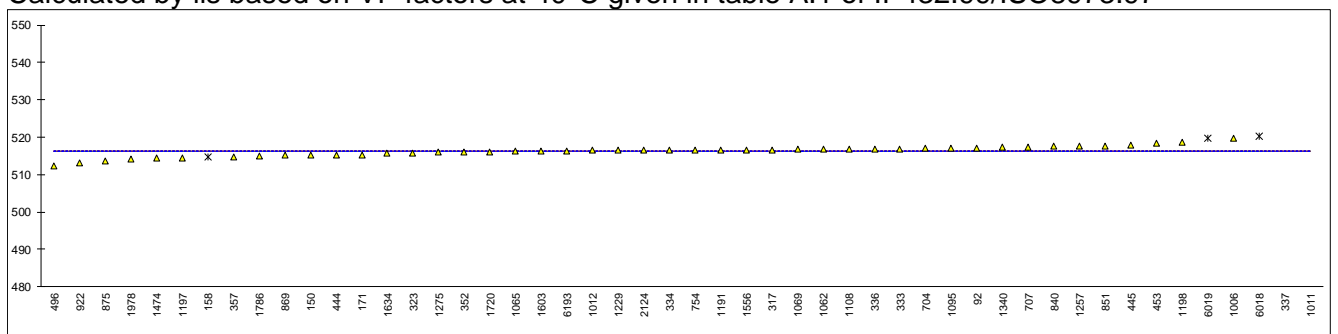
lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	ISO8973	503	E	-----	iis calc.517 (acc. to ISO8973)
323		-----		-----	
333		-----		-----	
334		-----		-----	
336	ISO8973	517		-----	
337		-----		-----	
352	ISO8973	516		-----	
357	ISO8973	514.9	C	-----	first reported 74.67
444		-----		-----	
445	IP432	-----	C	-----	reported test result corrected to Rel. Vapour Pressure at 40°C
453		-----		-----	
496	ISO8973	512.17	C	-----	first reported 555.93
704	ISO8973	517.0		-----	
707	ISO8973	517.3		-----	
754	ISO8973	517		-----	
840	ISO8973	514.1	E	-----	iis calc.517.5, first reported composition results give 514.0 (ISO8973:97)
851		-----		-----	
869		-----		-----	
875	ISO8973	514		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1026	ISO8973	487	ex	-----	excluded due to statistical outlier in iso-Butane
1062		-----		-----	
1065		-----		-----	
1069	ISO8973	516.6		-----	
1095	ISO8973	516		-----	
1108	ISO8973	517		-----	
1191	ISO8973	516.65		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275	EN589	516.9	E	-----	iis calc.516 (acc. to ISO8973)
1340	ISO8973	511.2	E	-----	iis calc.517.2 (acc. to ISO8973)
1474		-----		-----	
1556	ISO8973	516.7		-----	
1603		-----		-----	
1634	ISO8973	414	G(0.05), E	-----	possibly Rel. Vapour Pressure at 40°C?, iis calc.516 (acc. to ISO8973)
1720		-----		-----	
1786		-----		-----	
1978		-----		-----	
2124		-----		-----	
6018	ISO8973	521	ex, E	-----	ex. due to statistical outlier in iso-Butane, iis calc.520 (acc. to ISO8973)
6019	ISO8973	520	ex	-----	excluded due to statistical outlier in iso-Butane
6193		-----		-----	

					iis calculated from all reported composition results *)
	normality	not OK			OK
	n	17			45
	outliers	1 (+3 ex)			0 (+5 ex) (excluded due to statistical outlier in iso-Butane)
	mean (n)	514.9130			516.2333
	st.dev. (n)	3.56382	RSD=0.69%		1.42318 RSD=0.28%
	R(calc.)	9.9787			3.9849

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

Reported test results

Calculated by iis based on VP factors at 40°C given in table A.1 of IP432:99/ISO8973:97

## Determination of Rel. Vapour Pressure at 40°C on sample #18100; results in kPa

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	ISO8973	401	G(0.01), E	-----	iis calc.415 (acc. to ISO8973)
323	ISO8973	413	E	-----	iis calc.414 (acc. to ISO8973)
333		-----		-----	
334		-----		-----	
336	ISO8973	416		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	413.5	C	-----	first reported 59.98
444	ISO8973	414.9	E	-----	iis calc.413.9 (acc. to ISO8973)
445	IP432	416.8		-----	first reported as Abs. Vapour Pressure at 40°C
453		-----		-----	
496	ISO8973	410.85		-----	
704	ISO8973	415.7		-----	
707	ISO8973	416.0		-----	
754	ISO8973	415		-----	
840	ISO8973	412.8	E	-----	iis calc.416.2, first reported composition results give 412.7 (ISO8973:97)
851		-----		-----	
869		-----		-----	
875	ISO8973	412		-----	
922		-----		-----	
1006		-----		-----	
1011	ISO8973	464	ex, E	-----	ex. due to statistical outlier in iso-Butane, iis calc.462 (acc. to ISO8973)
1012		-----		-----	
1026	ISO8973	386	ex	-----	excluded due to statistical outlier in iso-Butane
1062		-----		-----	
1065		-----	W	-----	first reported 514.60
1069		-----		-----	
1095	ISO8973	415		-----	
1108	ISO8973	416		-----	
1191		-----		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275		-----		-----	
1340		-----		-----	
1474		-----		-----	
1556	ISO8973	415.4		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1786		-----		-----	
1978		-----		-----	
2124		-----		-----	
6018	ISO8973	421	ex, E	-----	ex. due to statistical outlier in iso-Butane, iis calc.419 (acc. to ISO8973)
6019	ISO8973	420	ex, E	-----	ex. due to statistical outlier in iso-Butane, iis calc.418 (acc. to ISO8973)
6193		-----		-----	

					iis calculated from all reported composition results *)
	normality	OK			OK
	n	14			45
	outliers	1 (+4 ex)			0 (+5 ex) (excluded due to statistical outlier in iso-Butane)
	mean (n)	414.4964			414.9085
	st.dev. (n)	1.76858	RSD=0.43%		1.42318 RSD=0.34%
	R(calc.)	4.9520			3.9849

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

Reported test results
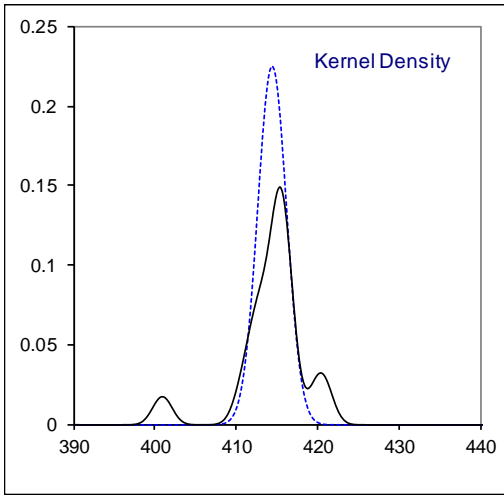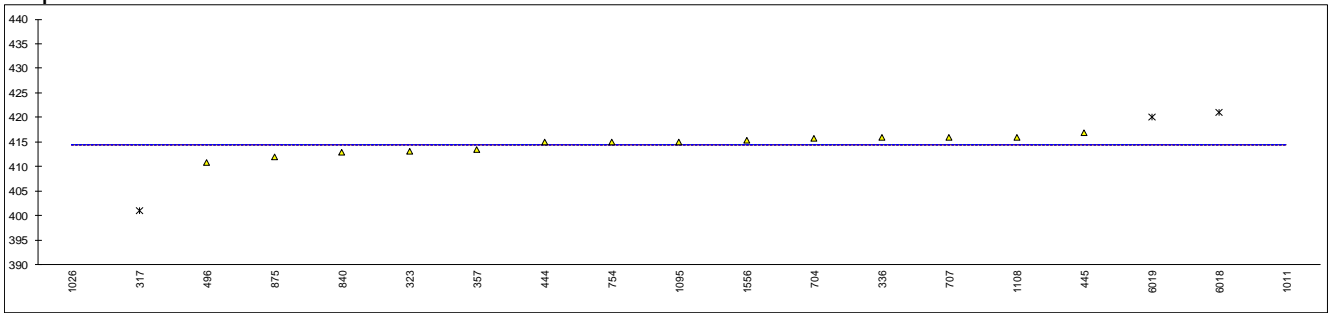
Calculated by iis based on VP factors at 40°C given in table A.1 of IP432:99/ISO8973:97
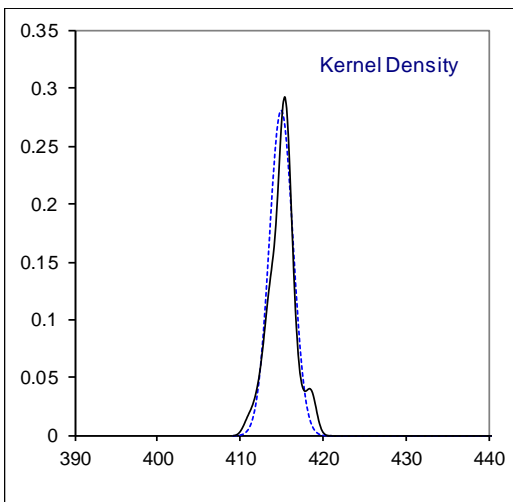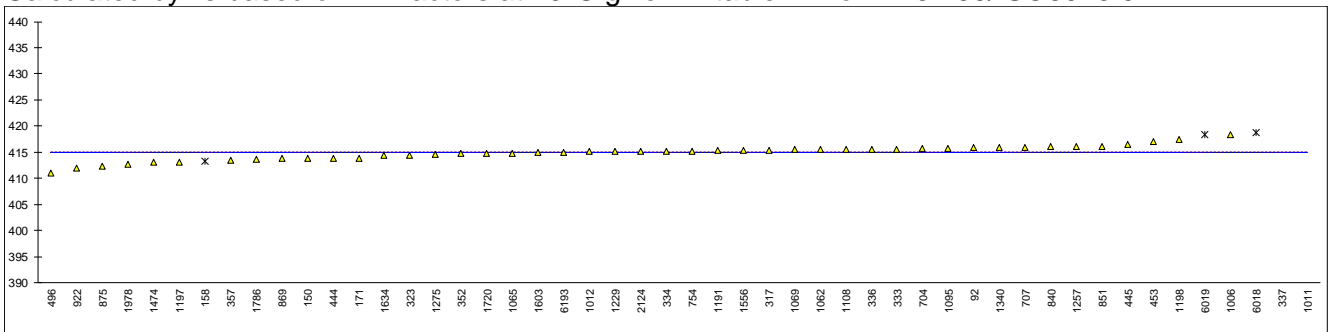
Determination of Motor Octane Number, MON on sample #18100;

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	EN589	89.7	G(0.01), E	-----	iis calc.92.6 (acc. to EN589)
323		-----		-----	
333		-----		-----	
334		-----		-----	
336	EN589	92.7		-----	
337		-----		-----	
352		-----		-----	
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
496	D2598	93.81	C, E	-----	first reported 94.29, iis calc.94.43 (acc. to D2589)
704	D2598	92.70	E	-----	iis calc.94.52 (acc. to D2589) and 92.65 (acc. to EN589)
707	EN589	92.82		-----	
754	EN589	92.7		-----	
840	D2598	94.16		-----	
851	D2598	94.6		-----	
869	D2598	94.5		-----	
875	EN589	92.6		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1026	EN589	91.25	ex	-----	excluded due to statistical outlier in iso-Butane
1062		-----		-----	
1065		93.5254	ex, E	-----	ex. method is not specified, iis calc. 92.66 (EN589) and 94.55 (D2589)
1069		-----		-----	
1095		-----		-----	
1108	EN589	92.7		-----	
1191		-----		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275	EN589	92.0		-----	
1340	EN589	92.9		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1786		-----		-----	
1978	D2598	91.80		-----	iis calc.94.36 (acc. to D2589) and 92.40 (acc. to EN589)
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6193		-----		-----	

Evaluated over EN589 test results only			iis calculated from all test results *)		
normality	OK		suspect		
n	7		44		
outliers	1 (+2 ex)		0 (+5 ex) (excluded due to statistical outlier in iso-Butane)		
mean (n)	92.6131		92.5872		
st.dev. (n)	0.29481	RSD=0.32%	00.07588	RSD=0.08%	
R(calc.)	0.8255		0.2125		
Evaluated over D2598 test results only			**iis calculated from all test results **)**		
normality	unknown		OK		
n	6		45		
outliers	0		0 (+5 ex) (excluded due to statistical outlier in iso-Butane)		
mean (n)	93.5950		94.4889		
st.dev. (n)	1.11513	RSD=1.19%	0.05035	RSD=0.05%	
R(calc.)	3.1224		0.1410		

*) calculated by iis based on MON factors given in EN589:08_A1:12; table B.1
EN589:08_A1:12 does not mention a MON factor for 1,3 –Butadiene. For this component an estimated value of 70 is used in calculations in analogy of the MON factors of the other components.
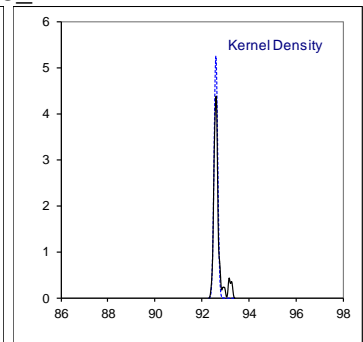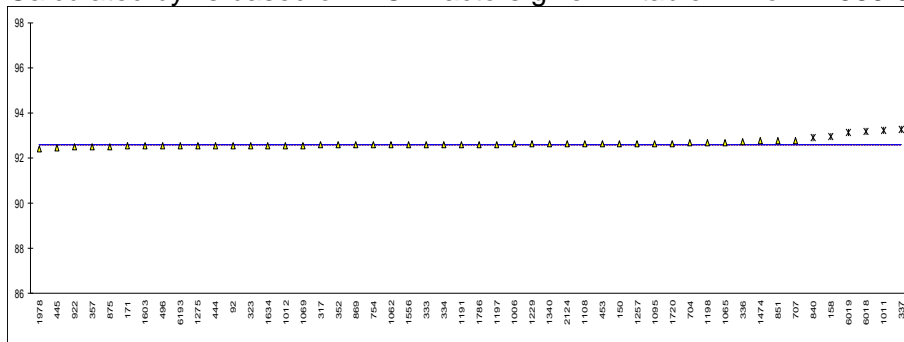**) calculated by iis based on MON factors given in ASTM D2598:16; table 1
ASTM D2598:16 does not mention MON factors for iso-Butene, trans-2-Butene or 1,3 –Butadiene. For iso-Butene and trans-2-Butene the value of 83.5 of cis-2-Butene are used in analogy of EN589 and for 1,3 –Butadiene an estimated value of 70 is used in calculations in analogy of the MON factors of the other components.
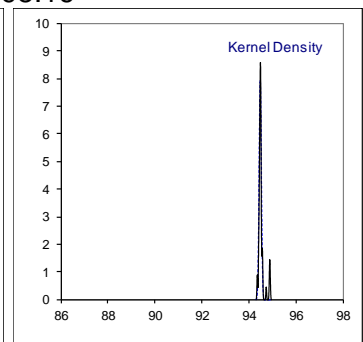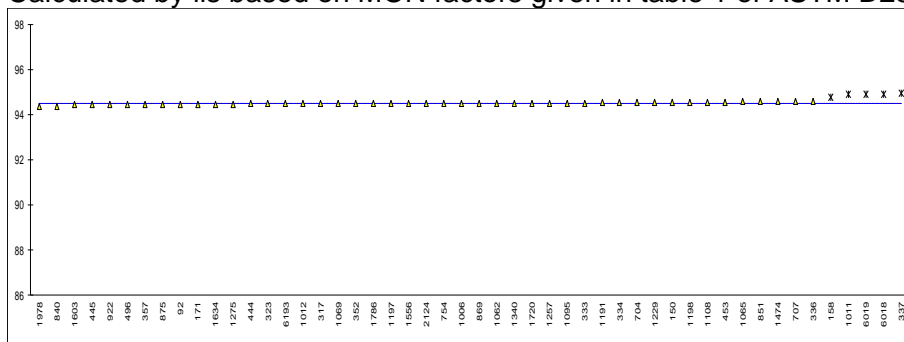***) excluded due to statistical outlier in iso-Butane

Reported test results

EN589 only

D2598 only
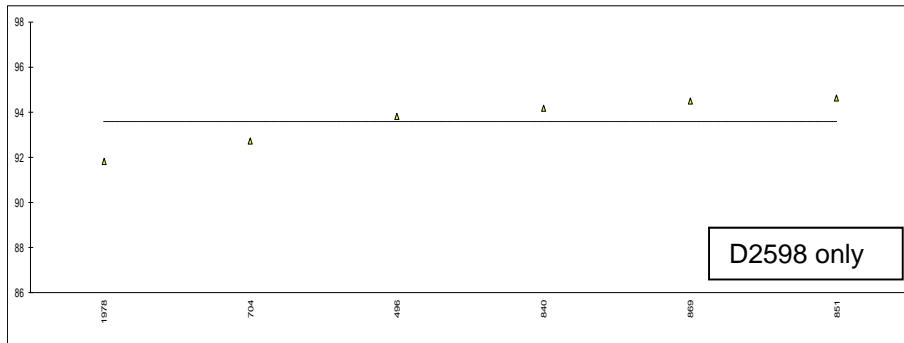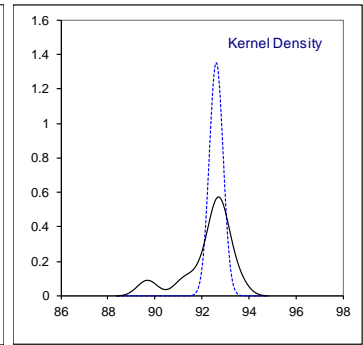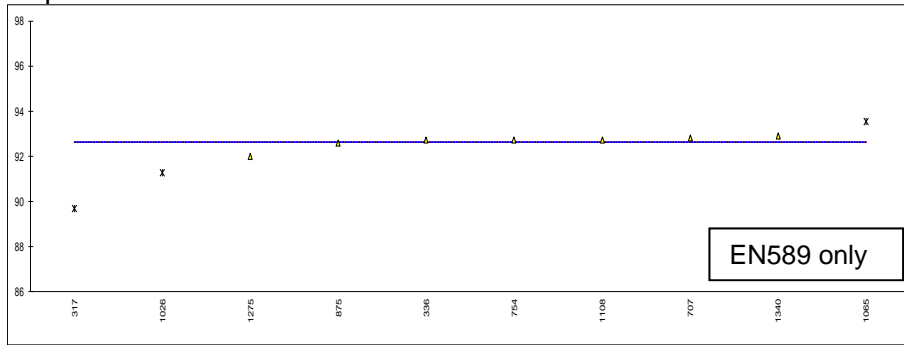
Calculated by iis based on MON factors given in table B.1 of EN589:08_A1:12

Calculated by iis based on MON factors given in table 1 of ASTM D2598:16

Determination of Ideal Gross Heating Value at 14.696psi/60F on sample #18100; results in kJ/mol

| lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	D3588	2809.83		-----	iis calc. 2828.50 (acc. to D3588:98)
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	D3588	2860.39		-----	iis calc. 2828.84 (acc. to D3588:98)
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
496	D3588	2811.40	C	-----	first reported 2788.73, iis calc. 2832.12 (acc. to D3588:98)
704		-----		-----	
707		-----		-----	
754		-----		-----	
840	ISO6976	2827.9		-----	iis calc. 2841.4 (acc. to ISO6976:16(E))
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1026		-----		-----	
1062		-----		-----	
1065		-----	W	-----	first reported 49216.74
1069		-----		-----	
1095		-----		-----	
1108		-----		-----	
1191		-----		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275		-----		-----	
1340		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	2322.2	D(0.01)	-----	iis calc. 2829.0 (acc. to D3588:98)
1720		-----		-----	
1786		-----		-----	
1978		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6193		-----		-----	

				iis calculated from all test results	
				D3588:98(2017) *)	ISO6976:16(E) **)
normality	unknown			OK	OK
n	4			41	41
outliers	1			4 (+5 ex) ***)	4 (+5 ex) ***)
mean (n)	2827.38			2829.46	2828.43
st.dev. (n)	23.475	RSD=0.83%		1.016 RSD=0.04%	1.019 RSD=0.04%
R(calc.)	65.731			2.84	2.85

*) calculated by iis based on Ideal Gross Heating Value at 14.696psi/60F factors given in D3588:98(2017); table 1. Unfortunately D3588:98(2017) does not mention an Ideal Gross Heating Value factor for 1,3 –Butadiene. The factor 2542.03 from ISO6976:95(96); table 3 is used for 1,3-butadiene for calculation
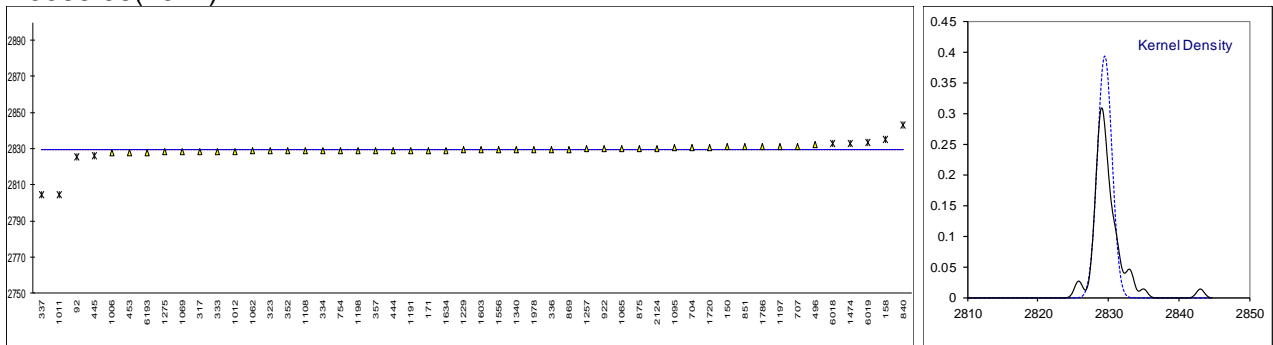**) calculated by iis based on Ideal Gross Heating Value at 14.696psi/60F factors given in ISO6976:16(E); table 3
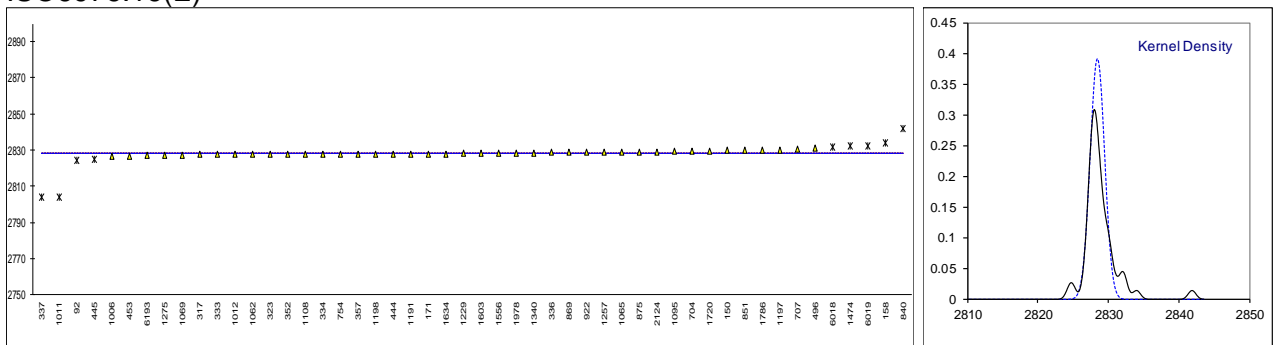***) excluded due to statistical outlier in iso-Butane
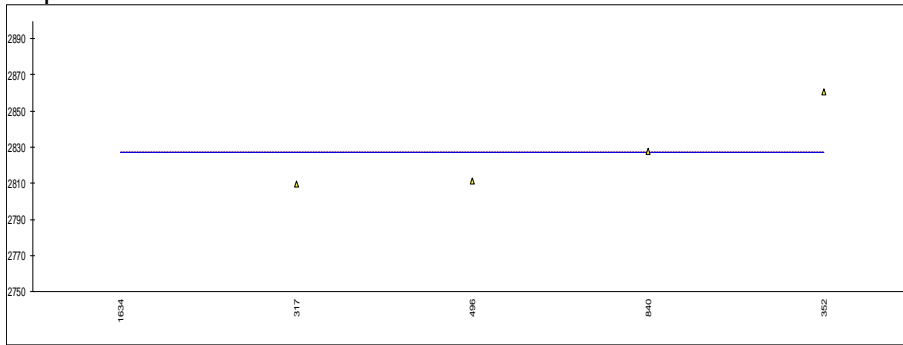
Reported test results

Calculated by iis based on Ideal Gross Heating Value at 14.696psi/60F factors given in table 1 of D3588:98(2017)

Calculated by iis based on Ideal Gross Heating Value at 14.696psi/60F factors given in table 3 of ISO6976:16(E)

Determination of Ideal Net Heating Value at 14.696psi/60F on sample #18100; results in kJ/mol

| lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
317	D3588	2598.21		-----	iis calc. 2615.93 (acc. to D3588:98)
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	D3588	2639.47		-----	iis calc. 2616.25 (acc. to D3588:98)
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
496	D3588	2606.69	C	-----	first reported 2585.55, iis calc. 2619.41 (acc. to D3588:98)
704		-----		-----	
707		-----		-----	
754		-----		-----	
840	ISO6976	2615.6		-----	iis calc. 2626.8 (acc. to ISO6976:16(E))
851		-----		-----	
869		-----		-----	
875		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1026		-----		-----	
1062		-----		-----	
1065		-----	W	-----	first reported 45523.67
1069		-----		-----	
1095		-----		-----	
1108		-----		-----	
1191		-----		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1275		-----		-----	
1340		-----		-----	
1474		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634	D3588	2142.8	D(0.01)	-----	iis calc. 2616.5 (acc. to D3588:98)
1720		-----		-----	
1786		-----		-----	
1978		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019		-----		-----	
6193		-----		-----	

			iis calculated from all test results	
			D3588:98(2017) *)	**ISO6976:16(E) **)**
normality	unknown		suspect	suspect
n	4		44	44
outliers	1		6	1 (+5 ex) ***
mean (n)	2614.99		2616.75	2612.95
st.dev. (n)	17.796	RSD=0.68%	1.227 RSD=0.05%	1.129 RSD=0.04%
R(calc.)	49.83		3.44	3.16

*) calculated by iis based on Ideal Net Heating Value at 14.696psi/60F factors given in D3588:98(2017); table 1. Unfortunately
D3588:98(2017) does not mention an Ideal Net Heating Value factor for 1,3 –Butadiene. The factor 2408.8 from ISO6976:95(96); table 3 is
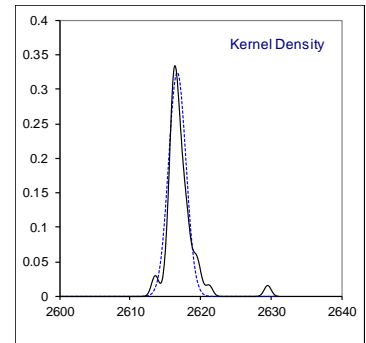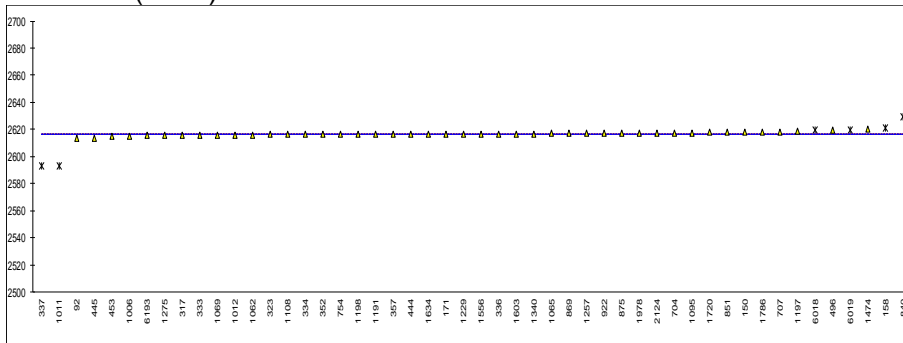used for 1,3-butadiene for calculation.
**) calculated by iis based on Ideal Net Heating Value at 14.696psi/60F factors given in ISO6976:16(E); table 1
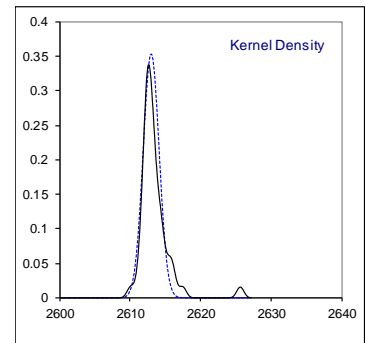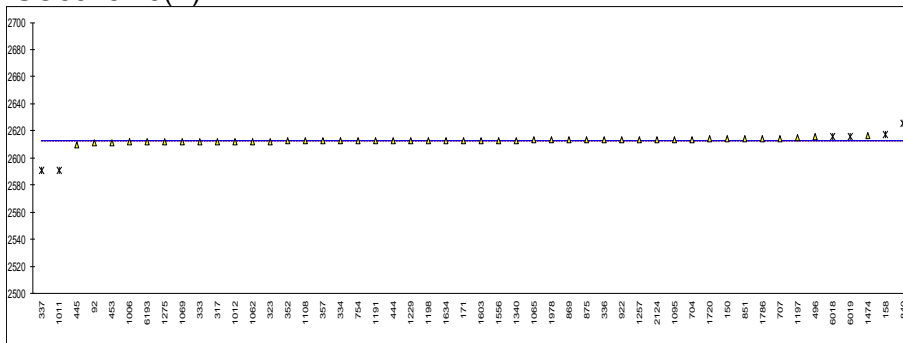***) excluded due to statistical outlier in iso-Butane
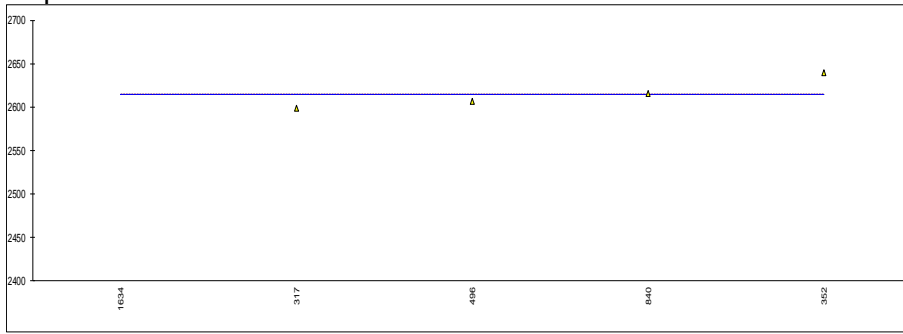
Reported test results

Calculated by iis based on Ideal Net Heating Value at 14.696psi/60F factors given in table 1 of D3588:98(2017)

Calculated by iis based on Ideal Net Heating Value at 14.696psi/60F factors given in table 1 of ISO6976:16(E)

APPENDIX 2

Number of participants per country

1 lab in AUSTRALIA

2 labs in BELGIUM

1 lab in BOSNIA and HERZEGOVINA

1 lab in CANADA

1 lab in CHILE

1 lab in CHINA, People's Republic

1 lab in DENMARK

4 labs in FINLAND

4 labs in FRANCE

2 labs in GERMANY

1 lab in GREECE

1 lab in HONG KONG

1 lab in ISRAEL

3 labs in MALAYSIA

1 lab in MEXICO

2 labs in NETHERLANDS

1 lab in NIGERIA

1 lab in PAKISTAN

6 labs in PORTUGAL

2 labs in RUSSIAN FEDERATION

1 lab in SUDAN

1 lab in SWEDEN

1 lab in TAIWAN

2 labs in UKRAINE

1 lab in UNITED ARAB EMIRATES

4 labs in UNITED KINGDOM

3 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	= probably 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, March 2017

2   prNEN 12766-2:00

3   ASTM E178:16

4   ASTM E130:95(2003)

5   ISO 5725:86(1994)

6   ISO 5725, parts 1-6:94

7   M. Thompson and R. Wood, J. AOAC Int, 76, 926, (1993)

8   W.J. Youden and E.H. Steiner, Statistical Manual of the AOAC, (1975)

9   IP 367:84

10   DIN 38402 T41/42

11   P.L. Davies, Fr. Z. Anal. Chem, 331, 513, (1988)

12   J.N. Miller, Analyst, 118, 455, (1993)

13   Analytical Methods Committee Technical Brief, No 4 January 2001

14   P.J. Lowthian and M. Thompson, The Royal Society of Chemistry, Analyst 2002, 127, 1359-1364 (2002)

15   ISO17043

16   EN27941

17   ASTM D2163

18   ASTM D2421

19   Bernard Rosner, Percentage Points for a Generalized ESD Many-Outlier Procedure, *Technometrics*, 25(2), 165-172, (1983)

20   J.B. Maxwell, Data book on Hydrocarbons, 5th edition, 3 (1958)