Results of Proficiency Test
Liquefied Butane Analysis
June 2017

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Appendices:

1   INTRODUCTION

Since 2009, the Institute for Interlaboratory Studies organizes a proficiency test for Liquefied Butane (composition only) 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 ISO17043 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 the 2017 proficiency test 54 laboratories in 30 different countries registered for participation. See appendix 2 for the number of participants per country. In this report the test results of the 2017 proficiency test on Liquefied Butane 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 56 cylinders.
The cylinder size is a cost-effective one-litre cylinder with dip tube device. Each cylinder, filled with approx 250 grams of liquefied Butane mixture, was uniquely numbered. The limited cylinder size is chosen to optimise sample stability, cylinder costs, transport and handling costs. 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 only one sample was used. One batch of 56 cylinders of one litre with artificial Liquefied Butane mixture was prepared and tested for homogeneity by EffecTech (Uttoxeter, United Kingdom) in conformance with ISO Guide 35: 2006 and ISO/IEC17043:2010 (job 17/0484) starting May, 2017. Each cylinder was uniquely numbered. Every cylinder in the batch was analysed using 5 replicate measurements. The within bottle and between bottle variations were then assessed in accordance with ISO Guide 35:2006 (Annex A.1). This procedure 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 between bottle 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 ISO 13528, Annex B2 in the next table:

Parameter	r (observed) in %mol/mol	0.3 x R(ref. test method) in %mol/mol
Propane	0.006	0.057
Propylene	0.007	0.105
iso-Butane	0.040	0.273
n-Butane	0.026	0.105
1-Butene	0.017	0.084
iso-Butene	0.007	0.084
trans-2-Butene	0.008	0.059
cis-2-Butene	0.012	0.085
1,3-Butadiene	0.006	0.037
iso-Pentane	0.005	0.015

Table 1: homogeneity test results of samples #17100 compared to reference test method ASTM D2163:14e1

Each of the calculated repeatabilities is far less than 0.3 times the corresponding reproducibility of the reference test method ASTM D2163:14e1. Therefore, homogeneity of the subsamples #17100 was assumed.

To each of the participating laboratories one 1L cylinder labelled #17100 was sent on May 31, 2017. 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 #17100: Propane, Propene (Propylene), 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(15.6/15.6°C), Absolute and Relative Vapour pressure at 100F(37.8°C) and at 40°C and Motor Octane Number (MON).

It was explicitly requested to treat the sample as if it was a routine sample. Therefore, each laboratory is advised to perform only those analyses that normally are done in daily routine (but the laboratories are allowed to do all analyses). Furthermore, it was requested to report the test results using the indicated units on the report form and not to round the test results more, 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 calculations.

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 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 reanalysis). 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 ISO 5725 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. When the uncertainty passed the evaluation, no remarks are made in the report. However, when the uncertainty failed the evaluation it is mentioned in the report and it will have consequences for the evaluation of the test results.

Finally, the reproducibilities were calculated from the standard deviations by multiplying them with a factor of 2.8.

3.2 GRAPHICS

In order to visualise 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 was projected over the Kernel Density Graph for reference.

3.3   Z-SCORES

To evaluate the performance of the participating laboratories the z-scores were calculated. As it was decided to evaluate the performance of the participants in this proficiency test (PT) against the literature requirements, e.g. ASTM, ISO or EN reproducibilities, the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation of this interlaboratory study.

The target standard deviation was calculated from the literature reproducibility by division with 2.8. In case no literature reproducibility was available, other targets 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 test result tables in 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, problems with sample dispatch were encountered for participants in India and Nigeria. Some participants receive the sample late or not at all. Five participants did not report any test results at all. Two other participants reported after the final reporting date. Not all laboratories were able to report all analyses requested. In total 49 participants reported 623 test results. Observed were 30 outlying test results, which is 4.8%. 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 AND PER TEST

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

In the iis PT reports, ASTM methods are referred to with a number (e.g. D2163) and an added designation for the year that the method was adopted or revised (e.g. D2163:14e1). If applicable, a designation in parentheses is added to designate the year of reapproval. In the test results tables of appendix 1 only the method number and year of adoption or revision (e.g. D2163:14e1) will be used.
Because the majority of the participating laboratories used ASTM D2163 as test method, it was decided to use the reproducibilities of this test method as target reproducibilities, and to mention the reproducibilities of EN27941 (identical to IP 405 and ISO 7941) for reference only.

Propane: The determination of this component was not problematic. Four 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 with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

Propylene: The determination of this component was not problematic. Three 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 with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

iso-Butane: The determination of this component may be problematic depending on 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 D2163:14e1, but it is in agreement with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

n-Butane: The determination of this component was not problematic. Two statistical outliers were observed and one other test result was excluded. However, the calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility of ASTM D2163:14e1 and with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

1-Butene: The determination of this component was not problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is in agreement with the reproducibility of ASTM D2163:14e1 and with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

Iso-Butene: The determination of this component was not problematic. Two statistical outliers were observed and one other test result was excluded. However, the calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility of ASTM D2163:14e1 and with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

trans-2-Butene: The determination of this component was problematic for a number of laboratories. Two statistical outliers were observed. However, the calculated reproducibility after rejection of the statistical outliers is in agreement with the reproducibility of ASTM D2163:14e1 and with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

cis-2-Butene: The determination of this component may be problematic depending on the test method used. Three statistical outliers were observed. However, 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 less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

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 D2163:14e1 and with the less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

iso-Pentane: The determination of this component may be problematic depending on 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 less strict reproducibility of EN27941:93 (identical to IP 405 and ISO 7941).

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 57.48 - 57.51 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 (IP432:99/ISO8973:97) over all reported component concentrations (0.0248 *vs* 0.0323). See also the discussion in paragraph 5.

Relative Density at 60/60F: 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 range from 0.5716 - 0.57239. The calculated reproducibility after rejection of the suspect data is 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 (0.0005 *vs* 0.0004). See also the discussion in paragraph 5.
Unfortunately, method ASTM D2598:16 does not mention a relative density for 1,3-Butadiene. This relative density is given in ASTM D2163:14e1.

Abs. Vapour Pres. at 100F: This calculated parameter may not be problematic when the test results are evaluated per test method (ISO8973(EN589) or ASTM D2598). Two statistical outliers were observed in the ISO8973/EN589 test results and one other test result was excluded. In the ASTM D2598 test results no statistical outliers were observed. The reported test results after rejection of the suspect data calculated from ISO8973/EN589 vary from 71 – 72.5 psi and calculated from ASTM D2598 vary from 70.65 – 70.93. In the PT of 2016 it was also observed that the test methods give after rejection of the suspect data different mean values (71.40 *vs* 70.80) and different calculated reproducibilities (0.162 *vs* 0.341). See also the discussion in paragraph 5.

Rel. Vapour Pres. at 100F: This calculated parameter may not be problematic when the test results are evaluated per test method (ISO8973(EN589/IP432) or ASTM D2598). One statistical outlier was observed in the ISO8973/EN589/ IP432 test results and one other test result was excluded. In the ASTM D2598 test results no statistical outliers were observed. The reported test results after rejection of the suspect data calculated from ISO8973/EN589/IP432 vary from 56 – 57 psi and calculated from ASTM D2598 vary from 55.95 – 56.23. In the PT of 2016 it was also observed that the test methods give after rejection of the suspect data different mean values (56.75 *vs* 56.11) and different calculated reproducibilities (0.472 *vs* 0.292). See also the discussion in paragraph 5.

Abs. Vapour Pres. at 40°C: 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 from 516 – 520 kPa. The calculated reproducibility after rejection of the suspect data is almost in agreement with the calculated reproducibility using the published vapour pressure factors obtained from one test method (IP432:99/ISO8973:97) over all reported component concentrations (2.97 *vs* 2.64). See also the discussion in paragraph 5.

Rel. Vapour Pres. at 40°C: This calculated parameter may be problematic. No statistical outliers were observed, but three test results were excluded. The reported test results after rejection of the suspect data vary over a range from 413.4 – 418.2 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 (IP432:99/ISO8973:97) over all reported component concentrations (3.91 *vs* 2.64). See also the discussion in paragraph 5.

MON: This calculated parameter may be problematic. No statistical outliers were observed, but two test results were excluded. The reported test results, after rejection of the suspect data, calculated from EN589 vary from 91.9 – 92.7. However when the MON values were calculated over all reported component concentrations according to the MON factors mentioned in either EN589 or in ASTM D2598 it appeared that after rejection of the suspect data both test methods give significant different mean values and different calculated reproducibilities (0.135 *vs* 0.073). 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.

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 average test results per sample, calculated reproducibilities and reproducibilities, derived from reference test methods (in casu ASTM D2163 and EN27941/ISO7941/IP405) are compared in the next table.

Component	unit	n	average	2.8 * sd	R(D2163) in %mol	R(EN27941) liq.-inj.n %mol	R(EN27941) liq.-inj.in %M/M
Propane	%mol/mol	45	1.111	0.085	0.187	1.304	1
Propylene	%mol/mol	46	1.310	0.162	0.341	1.366	1
iso-Butane	%mol/mol	46	70.99	1.04	0.91	1.48	1.5
n-Butane	%mol/mol	46	8.152	0.373	0.354	0.989	1
1-Butene	%mol/mol	47	4.791	0.244	0.279	1.025	1
iso-Butene	%mol/mol	45	4.862	0.246	0.280	1.025	1
trans-2-Butene	%mol/mol	47	2.192	0.125	0.196	1.025	1
cis-2-Butene	%mol/mol	46	4.980	0.337	0.283	1.025	1
1,3-Butadiene	%mol/mol	46	0.786	0.082	0.124	1.063	1
iso-Pentane	%mol/mol	43	0.804	0.061	0.050	0.797	1

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

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/tests 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 2016**
Molar Mass	g/mol	18	57.50	0.025	0.032	0.063
Rel. Density at 60/60F		21	0.5719	0.0005	0.0004	0.0007
Abs. VP at 100F ISO/IP	psi	7	71.40	0.16	0.37	0.50
Abs. VP at 100F D2598	psi	5	70.80	0.34	0.24	0.40
Rel. VP at 100F ISO/IP	psi	10	56.75	0.47	0.37	0.50
Rel. VP at 100F D2598	psi	7	56.11	0.29	0.24	0.40
Abs. VP at 40°C	kPa	15	518.3	3.0	2.6	3.5
Rel. VP at 40°C	kPa	18	416.6	3.9	2.6	3.5
MON EN589_A1		11	92.38	0.78	0.13	0.24
MON ASTM D2598		2	94.5	n.a.	0.07	0.12

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

Without further statistical calculations it can be concluded that for many parameters there is a good compliance of the group of participating laboratories with the method reproducibilities calculated over all reported test results of this PT compared to 2016 PT. See also the discussion in paragraph 5.

4.3 COMPARISON OF THE PROFICIENCY TEST OF JUNE 2017 WITH PREVIOUS PTS

	June 2017	June 2016	June 2015	June 2014	June 2013
Number of reporting labs	49	49	46	38	30
Number of test results reported	623	627	538	467	358
Statistical outliers	30	63	45	33	15
Percentage outliers	4.8%	10.0%	8.4%	7.1%	4.2%

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. For 2013 against D2163:96 and for 2014 – 2017 against D2163:14e1. The conclusions are given the following table:

Component	June 2017	June 2016	June 2015	June 2014	June 2013
Propane	++	+	+	-	--
Propylene	++	++	++	++	--
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	1.1439	1.1106	0.0333	+0.50
Propylene	1.3718	1.3096	0.0622	+0.51
iso-Butane	71.132	70.995	0.138	+0.42
n-Butane	7.9883	8.1521	-0.1638	-1.30
1-Butene	4.7942	4.7907	0.0035	+0.04
iso-Butene	4.8737	4.8622	0.0115	+0.12
trans-2-Butene	2.2052	2.1922	0.0130	+0.19
cis-2-Butene	4.9218	4.9803	-0.0584	-0.58
1,3-Butadiene	0.7834	0.7864	-0.0030	-0.07
iso-Pentane	0.7852	0.8036	-0.0185	-1.03

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

One laboratory reported traces of Propadiene (0.030 %mol/mol) and n-Pentane (0.004 %mol/mol). These components are 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.

For the calculation of the Molar Mass, Relative Density and Vapour Pressure and Motor Octane Number 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 ISO 8973 (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 and Motor Octane Number.

APPENDIX 1

Determination of Propane on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	1.111		0.01	
150	D2163	1.119		0.13	
171	D2163	1.021		-1.34	
311	D2163	1.11		-0.01	
317	D2163	1.15		0.59	
323	D2163	1.08		-0.46	
333	D2163	1.11		-0.01	
334	D2163	1.09		-0.31	
336	D2163	1.07		-0.61	
337	ISO7941	1.17	C	0.89	first reported: 0.83
352	EN27941	1.1336		0.34	
357	D2163	0.868	R(0.01)	-3.62	
444	D2163	1.120		0.14	
445	D2163	1.05		-0.91	
453	D2163	1.169		0.87	
704	D2163	1.114		0.05	
707	D2163	1.114		0.05	
754	D2163	1.125		0.21	
851	D2163	1.1291		0.28	
869	D2163	1.117		0.10	
875	D2163	1.11		-0.01	
912		-----		-----	
922	D2163	1.16		0.74	
1006	D2163	1.174		0.95	
1011	ISO7941	1.0	R(0.05)	-1.65	
1012		-----		-----	
1016	ISO7941	1.120		0.14	
1026		-----		-----	
1040	DIN51619	1.110		-0.01	
1062	D2163	1.1093		-0.02	
1065	D2163	0.944882	R(0.01)	-2.48	
1095	ISO7941	1.1		-0.16	
1108	D2163	1.12		0.14	
1197	D2163	1.116		0.08	
1198	D2163	1.093		-0.26	
1251		-----		-----	
1257	D2163	1.1348		0.36	
1259	EN27941	1.078		-0.49	
1272	EN27941	1.10		-0.16	
1491	ISO7941	1.089		-0.32	
1528	EN27941	1.123		0.19	
1556	EN27941	1.12		0.14	
1603	In house	1.067		-0.65	
1634	ISO7941	1.07		-0.61	
1720		-----		-----	
1764	D2163	1.092		-0.28	
1786	D2163	1.087		-0.35	
2124	D2163	1.1201		0.14	
6011	D2163	1.1217		0.17	
6018	EN27941	0.821	R(0.01)	-4.33	
6019	EN27941	1.077		-0.50	
6108	D2163	1.119		0.13	
6128	D2163	1.131		0.30	
6129	D2163	1.133		0.33	

|					
	normality	suspect			
	n	45			
	outliers	4			
	mean (n)	1.1106			
	st.dev. (n)	0.03047			
	R(calc.)	0.0853			
	R(D2163:14e1)	0.1874			compare EN27941(liq)=1.3037

Lab 1528 reported: we found also: -propadiene=0.030 % mol/mol -n pentane=0.004 % mol/mol that we used to normalized composition
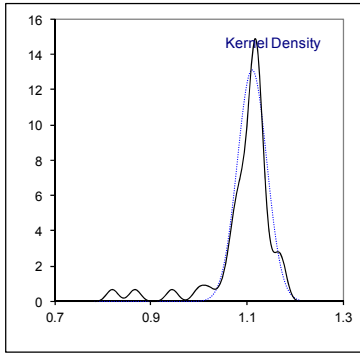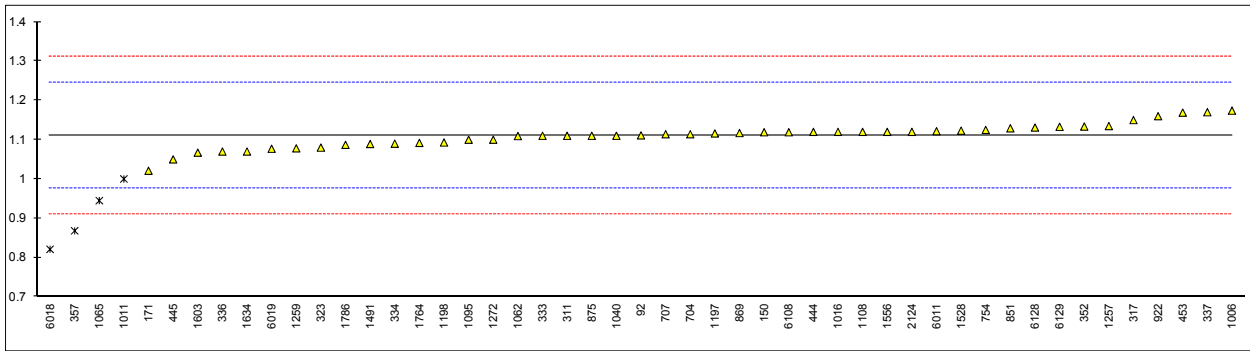
Determination of Propene on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	1.375		0.54	
150	D2163	1.351		0.34	
171	D2163	1.239		-0.58	
311	D2163	1.31		0.00	
317	D2163	1.34		0.25	
323	D2163	1.33		0.17	
333	D2163	1.30		-0.08	
334	D2163	1.31		0.00	
336	D2163	1.25		-0.49	
337	ISO7941	1.41	C	0.83	first reported: 0.93
352	EN27941	1.2739		-0.29	
357	D2163	1.030	R(0.01)	-2.30	
444	D2163	1.322		0.10	
445	D2163	1.31		0.00	
453	D2163	1.410		0.83	
704	D2163	1.304		-0.05	
707	D2163	1.303		-0.05	
754	D2163	1.315		0.04	
851	D2163	1.3298		0.17	
869	D2163	1.323		0.11	
875	D2163	1.27		-0.33	
912		-----		-----	
922	D2163	1.37		0.50	
1006	D2163	1.458		1.22	
1011	ISO7941	1.2		-0.90	
1012		-----		-----	
1016	ISO7941	1.328		0.15	
1026		-----		-----	
1040	DIN51619	1.316		0.05	
1062	D2163	1.3046		-0.04	
1065	D2163	1.153292		-1.29	
1095	ISO7941	1.3		-0.08	
1108	D2163	1.37		0.50	
1197	D2163	1.377		0.55	
1198	D2163	1.321		0.09	
1251		-----		-----	
1257	D2163	1.3841		0.61	
1259	EN27941	1.299		-0.09	
1272	EN27941	1.29		-0.16	
1491	ISO7941	1.288		-0.18	
1528	EN27941	1.302		-0.06	
1556	EN27941	1.33		0.17	
1603	In house	1.299		-0.09	
1634	ISO7941	1.25		-0.49	
1720		-----		-----	
1764	D2163	1.325		0.13	
1786	D2163	1.304		-0.05	
2124	D2163	1.3236		0.11	
6011	D2163	1.20435		-0.87	
6018	EN27941	0.756	R(0.01)	-4.55	
6019	EN27941	0.910	R(0.01)	-3.29	
6108	D2163	1.319		0.08	
6128	D2163	1.266		-0.36	
6129	D2163	1.186		-1.02	

normality	suspect		
n	46		
outliers	3		
mean (n)	1.3096		
st.dev. (n)	0.05777		
R(calc.)	0.1618		
R(D2163:14e1)	0.3405		compare EN27941(liq)=1.3661
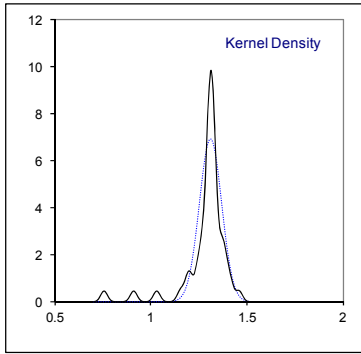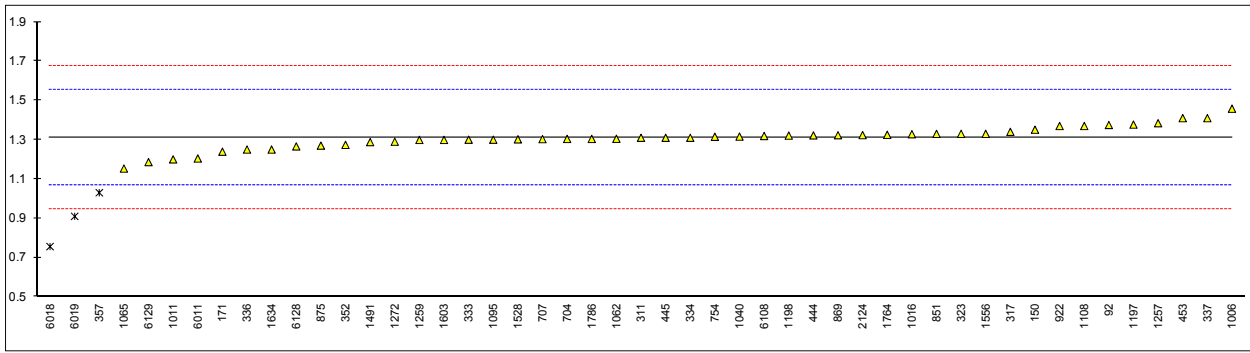
Determination of iso-Butane on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	70.809		-0.57	
150	D2163	71.016		0.07	
171	D2163	70.078	R(0.05)	-2.83	
311	D2163	71.18		0.57	
317	D2163	71.14		0.45	
323	D2163	70.25		-2.30	
333	D2163	71.10		0.32	
334	D2163	71.15		0.48	
336	D2163	71.71		2.21	
337	ISO7941	71.75	C	2.33	first reported: 70.02
352	EN27941	70.861		-0.41	
357	D2163	71.627		1.95	
444	D2163	70.797		-0.61	
445	D2163	71.53		1.65	
453	D2163	71.019		0.07	
704	D2163	71.287		0.90	
707	D2163	71.288		0.90	
754	D2163	71.035		0.12	
851	D2163	71.3216		1.01	
869	D2163	70.886		-0.34	
875	D2163	70.90		-0.29	
912		-----		-----	
922	D2163	70.75		-0.75	
1006	D2163	70.987		-0.02	
1011	ISO7941	70.5	C	-1.53	first reported: 70.3
1012		-----		-----	
1016	ISO7941	70.852		-0.44	
1026		-----		-----	
1040	DIN51619	71.186		0.59	
1062	D2163	70.8155		-0.55	
1065	D2163	71.035409		0.13	
1095	ISO7941	71.0		0.02	
1108	D2163	70.80		-0.60	
1197	D2163	70.979		-0.05	
1198	D2163	70.923		-0.22	
1251		-----		-----	
1257	D2163	71.8133		2.52	
1259	EN27941	70.837		-0.49	
1272	EN27941	71.53		1.65	
1491	ISO7941	70.764		-0.71	
1528	EN27941	70.737		-0.80	
1556	EN27941	70.97		-0.08	
1603	In house	70.697		-0.92	
1634	ISO7941	70.30		-2.14	
1720		-----		-----	
1764	D2163	70.830		-0.51	
1786	D2163	71.079		0.26	
2124	D2163	71.1245		0.40	
6011	D2163	70.16595		-2.56	
6018	EN27941	70.376	ex	-1.91	excluded due to statistical outliers in other components
6019	EN27941	71.150		0.48	
6108	D2163	70.992		-0.01	
6128	D2163	72.125	R(0.01)	3.49	
6129	D2163	70.284		-2.19	

normality	OK		
n	46		
outliers	2+1ex		
mean (n)	70.9947		
st.dev. (n)	0.37076		
R(calc.)	1.0381		
R(D2163:14e1)	0.9078		compare EN27941(liq)=1.4836
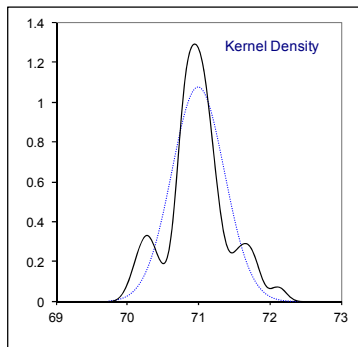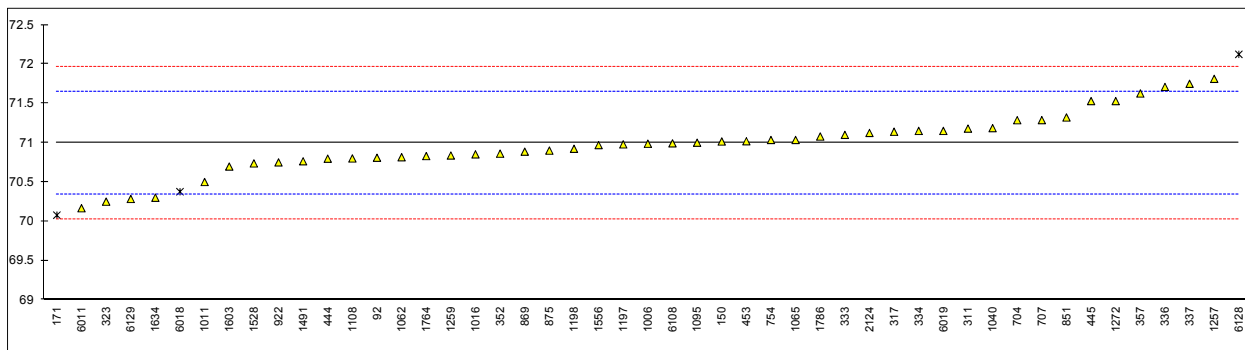
Determination of n-Butane on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	7.873		-2.21	
150	D2163	7.980		-1.36	
171	D2163	8.457		2.41	
311	D2163	8.10		-0.41	
317	D2163	8.18		0.22	
323	D2163	8.17		0.14	
333	D2163	8.12		-0.25	
334	D2163	8.06		-0.73	
336	D2163	8.06		-0.73	
337	ISO7941	8.16	C	0.06	first reported: 8.76
352	EN27941	8.2313		0.63	
357	D2163	8.222		0.55	
444	D2163	8.161		0.07	
445	D2163	7.91		-1.92	
453	D2163	8.055		-0.77	
704	D2163	8.186		0.27	
707	D2163	8.186		0.27	
754	D2163	8.250		0.78	
851	D2163	8.0512		-0.80	
869	D2163	8.175		0.18	
875	D2163	8.25	C	0.78	first reported: 8.55
912		-----		-----	
922	D2163	8.26		0.85	
1006	D2163	8.108		-0.35	
1011	ISO7941	8.2		0.38	
1012		-----		-----	
1016	ISO7941	8.214		0.49	
1026		-----		-----	
1040	DIN51619	8.099		-0.42	
1062	D2163	8.1702		0.14	
1065	D2163	8.397364		1.94	
1095	ISO7941	8.2		0.38	
1108	D2163	8.11		-0.33	
1197	D2163	8.004		-1.17	
1198	D2163	8.114		-0.30	
1251		-----		-----	
1257	D2163	7.7759		-2.98	
1259	EN27941	8.095		-0.45	
1272	EN27941	8.15		-0.02	
1491	ISO7941	8.407		2.02	
1528	EN27941	8.379		1.80	
1556	EN27941	8.16		0.06	
1603	In house	8.403		1.99	
1634	ISO7941	8.90	R(0.01)	5.92	
1720		-----		-----	
1764	D2163	8.047		-0.83	
1786	D2163	8.136		-0.13	
2124	D2163	8.0429		-0.86	
6011	D2163	8.208		0.44	
6018	EN27941	8.028	ex	-0.98	excluded due to statistical outliers in other components
6019	EN27941	8.197		0.36	
6108	D2163	8.112		-0.32	
6128	D2163	8.169		0.13	
6129	D2163	8.626	R(0.05)	3.75	

normality	suspect		
n	46		
outliers	2+1ex		
mean (n)	8.1521		
st.dev. (n)	0.13323		
R(calc.)	0.3731		
R(D2163:14e1)	0.3537		compare EN27941(liq)=0.9891
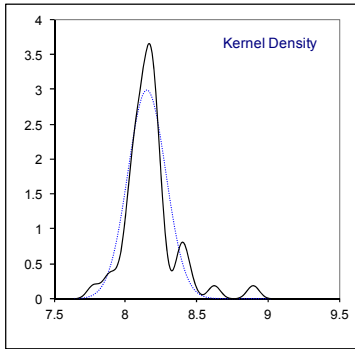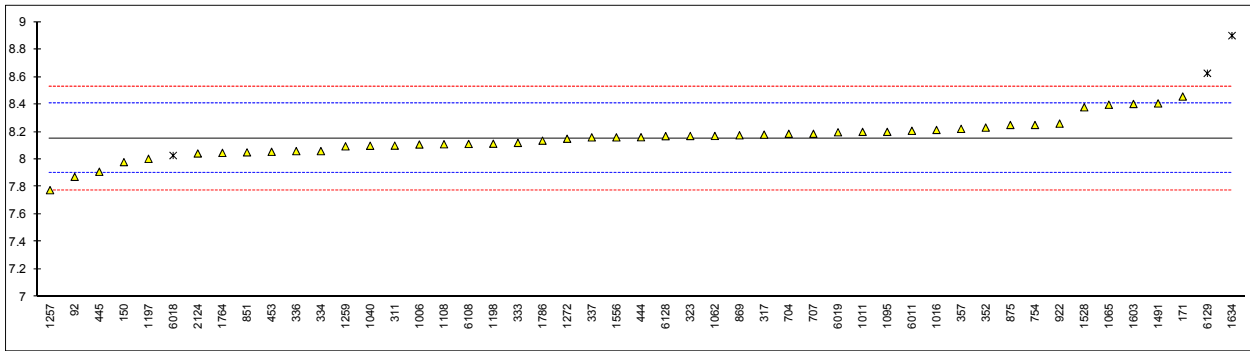
Determination of 1-Butene on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	4.889		0.99	
150	D2163	4.718		-0.73	
171	D2163	4.987		1.97	
311	D2163	4.76		-0.31	
317	D2163	4.76		-0.31	
323	D2163	4.98		1.90	
333	D2163	4.78		-0.11	
334	D2163	4.77		-0.21	
336	D2163	4.69		-1.01	
337	ISO7941	4.78	C	-0.11	first reported: 2.35
352	EN27941	4.8696		0.79	
357	D2163	4.766		-0.25	
444	D2163	4.854		0.64	
445	D2163	4.79		-0.01	
453	D2163	4.765		-0.26	
704	D2163	4.729		-0.62	
707	D2163	4.729		-0.62	
754	D2163	4.785		-0.06	
851	D2163	4.8185		0.28	
869	D2163	4.814		0.23	
875	D2163	4.75		-0.41	
912		-----		-----	
922	D2163	4.85		0.60	
1006	D2163	4.741		-0.50	
1011	ISO7941	5.0		2.10	
1012		-----		-----	
1016	ISO7941	4.811		0.20	
1026		-----		-----	
1040	DIN51619	4.757		-0.34	
1062	D2163	4.6335		-1.58	
1065	D2163	4.644338		-1.47	
1095	ISO7941	4.8		0.09	
1108	D2163	4.83		0.40	
1197	D2163	4.800		0.09	
1198	D2163	4.868		0.78	
1251		-----		-----	
1257	D2163	4.6968		-0.94	
1259	EN27941	4.700		-0.91	
1272	EN27941	4.87		0.80	
1491	ISO7941	4.756		-0.35	
1528	EN27941	4.730		-0.61	
1556	EN27941	4.80		0.09	
1603	In house	4.836		0.46	
1634	ISO7941	4.82		0.29	
1720		-----		-----	
1764	D2163	4.838		0.48	
1786	D2163	4.771		-0.20	
2124	D2163	4.7876		-0.03	
6011		-----		-----	
6018	EN27941	5.229	R(0.01)	4.41	
6019	EN27941	4.780		-0.11	
6108	D2163	4.782		-0.09	
6128	D2163	4.536		-2.56	
6129	D2163	4.940		1.50	

normality	suspect	
n	47	
outliers	1	
mean (n)	4.7907	
st.dev. (n)	0.08729	
R(calc.)	0.2444	
R(D2163:14e1)	0.2785	compare EN27941(liq)=1.0246

Lab 6011 reported: We can't separate isobutene, 1-butene and 1,3-butadiene (about 12.12 %mol) because our product and raw material don't have alkene component. So, we don't have the standard material to calibrate our gas chromatograph and we can't report normalized composition.
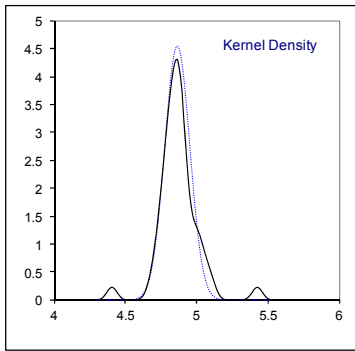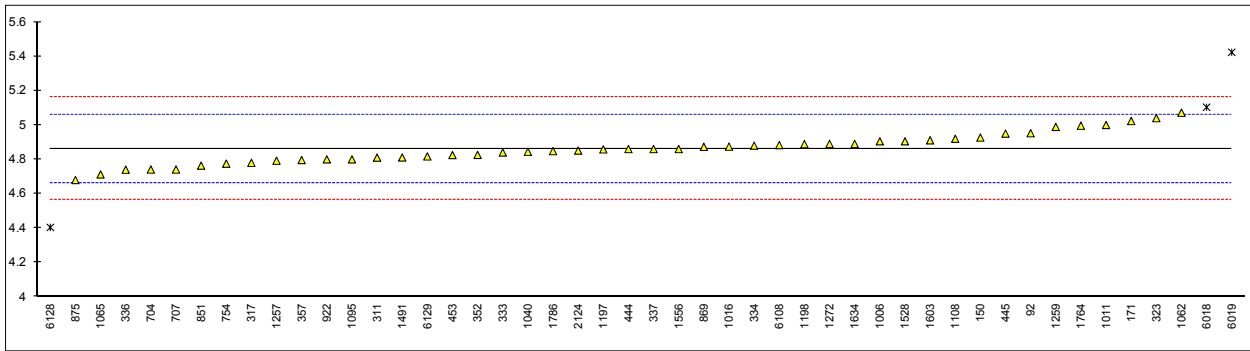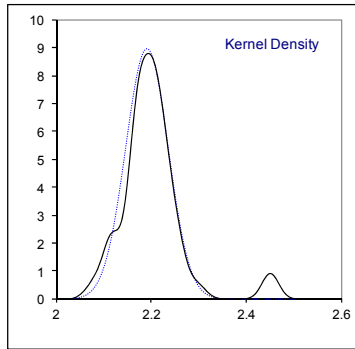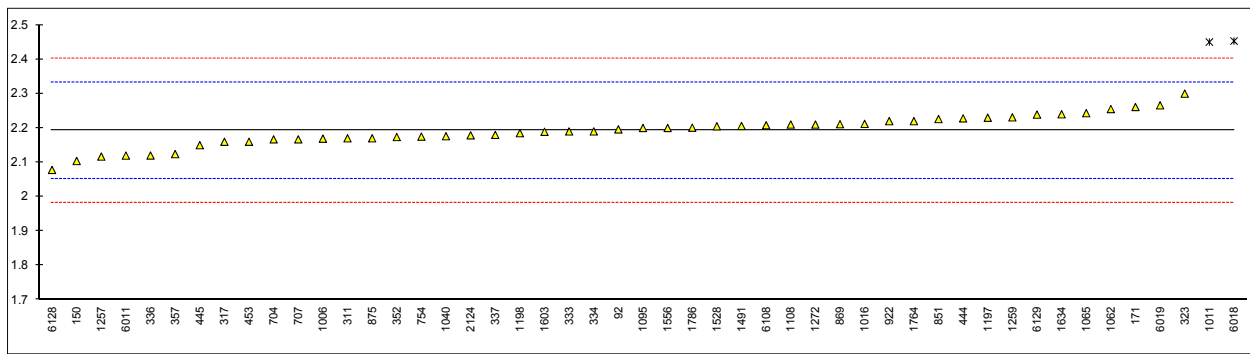
Kernel Density
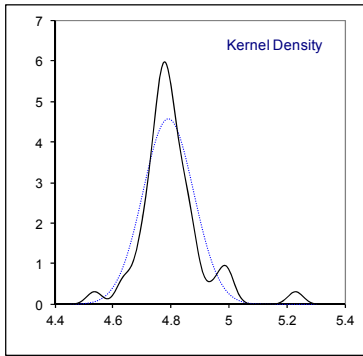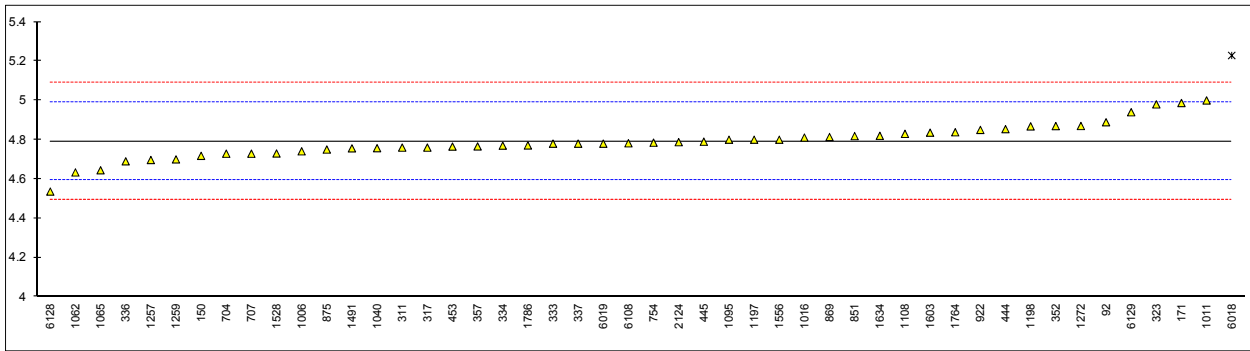
Determination of iso-Butene on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	4.952		0.90	
150	D2163	4.927		0.65	
171	D2163	5.023		1.61	
311	D2163	4.81		-0.52	
317	D2163	4.78		-0.82	
323	D2163	5.04		1.78	
333	D2163	4.84		-0.22	
334	D2163	4.88		0.18	
336	D2163	4.74		-1.22	
337	ISO7941	4.86		-0.02	
352	EN27941	4.8260		-0.36	
357	D2163	4.796		-0.66	
444	D2163	4.860		-0.02	
445	D2163	4.95		0.88	
453	D2163	4.825		-0.37	
704	D2163	4.741		-1.21	
707	D2163	4.741		-1.21	
754	D2163	4.775		-0.87	
851	D2163	4.7636		-0.98	
869	D2163	4.873		0.11	
875	D2163	4.68		-1.82	
912		-----		-----	
922	D2163	4.80		-0.62	
1006	D2163	4.905		0.43	
1011	ISO7941	5.0		1.38	
1012		-----		-----	
1016	ISO7941	4.874		0.12	
1026		-----		-----	
1040	DIN51619	4.844		-0.18	
1062	D2163	5.0715		2.09	
1065	D2163	4.71229		-1.50	
1095	ISO7941	4.8		-0.62	
1108	D2163	4.92		0.58	
1197	D2163	4.858		-0.04	
1198	D2163	4.889		0.27	
1251		-----		-----	
1257	D2163	4.7922		-0.70	
1259	EN27941	4.989		1.27	
1272	EN27941	4.89		0.28	
1491	ISO7941	4.811		-0.51	
1528	EN27941	4.905		0.43	
1556	EN27941	4.86		-0.02	
1603	In house	4.911		0.49	
1634	ISO7941	4.89		0.28	
1720		-----		-----	
1764	D2163	4.996		1.34	
1786	D2163	4.848		-0.14	
2124	D2163	4.8510		-0.11	
6011		-----		-----	
6018	EN27941	5.103	ex	2.40	excluded due to statistical outliers in other components
6019	EN27941	5.423	R(0.01)	5.60	
6108	D2163	4.883		0.21	
6128	D2163	4.404	R(0.01)	-4.58	
6129	D2163	4.817		-0.45	

normality	OK		
n	45		
outliers	2+1ex		
mean (n)	4.8622		
st.dev. (n)	0.08780		
R(calc.)	0.2459		
R(D2163:14e1)	0.2803		compare EN27941(liq)=1.0246

Determination of trans-2-Butene on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	2.196		0.05	
150	D2163	2.104		-1.26	
171	D2163	2.261		0.98	
311	D2163	2.17		-0.32	
317	D2163	2.16		-0.46	
323	D2163	2.30		1.54	
333	D2163	2.19		-0.03	
334	D2163	2.19		-0.03	
336	D2163	2.12		-1.03	
337	ISO7941	2.18	C	-0.17	first reported: 4.91
352	EN27941	2.1737		-0.26	
357	D2163	2.124		-0.97	
444	D2163	2.228		0.51	
445	D2163	2.15		-0.60	
453	D2163	2.160		-0.46	
704	D2163	2.167		-0.36	
707	D2163	2.167		-0.36	
754	D2163	2.175		-0.25	
851	D2163	2.2260		0.48	
869	D2163	2.211		0.27	
875	D2163	2.17		-0.32	
912		-----		-----	
922	D2163	2.22		0.40	
1006	D2163	2.169		-0.33	
1011	ISO7941	2.45	C,R(0.01)	3.69	first reported: 2.5
1012		-----		-----	
1016	ISO7941	2.212		0.28	
1026		-----		-----	
1040	DIN51619	2.176		-0.23	
1062	D2163	2.2551		0.90	
1065	D2163	2.243061		0.73	
1095	ISO7941	2.2		0.11	
1108	D2163	2.21		0.26	
1197	D2163	2.230		0.54	
1198	D2163	2.185		-0.10	
1251		-----		-----	
1257	D2163	2.1169		-1.08	
1259	EN27941	2.231		0.56	
1272	EN27941	2.21		0.26	
1491	ISO7941	2.206		0.20	
1528	EN27941	2.205		0.18	
1556	EN27941	2.20		0.11	
1603	In house	2.189		-0.05	
1634	ISO7941	2.24		0.68	
1720		-----		-----	
1764	D2163	2.220		0.40	
1786	D2163	2.201		0.13	
2124	D2163	2.1787		-0.19	
6011	D2163	2.1198		-1.03	
6018	EN27941	2.453	R(0.01)	3.73	
6019	EN27941	2.266		1.06	
6108	D2163	2.208		0.23	
6128	D2163	2.078		-1.63	
6129	D2163	2.239		0.67	

	normality	OK	
	n	47	
	outliers	2	
	mean (n)	2.1922	
	st.dev. (n)	0.04459	
	R(calc.)	0.1249	
	R(D2163:14e1)	0.1959	compare EN27941(liq)=1.0246

Kernel Density

Determination of cis-2-Butene on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	5.111		1.29	
150	D2163	5.151		1.69	
171	D2163	5.253		2.69	
311	D2163	4.95		-0.30	
317	D2163	4.92		-0.60	
323	D2163	5.11		1.28	
333	D2163	4.97		-0.10	
334	D2163	4.97		-0.10	
336	D2163	4.86		-1.19	
337	ISO7941	4.93	C	-0.50	first reported: 5.40
352	EN27941	4.9955		0.15	
357	D2163	4.836		-1.43	
444	D2163	5.050		0.69	
445	D2163	4.83		-1.48	
453	D2163	4.938		-0.42	
704	D2163	4.905		-0.74	
707	D2163	4.904		-0.75	
754	D2163	4.960		-0.20	
851	D2163	4.7768		-2.01	
869	D2163	4.993		0.13	
875	D2163	4.98		0.00	
912		-----		-----	
922	D2163	5.00		0.20	
1006	D2163	4.882		-0.97	
1011	ISO7941	5.2		2.17	
1012		-----		-----	
1016	ISO7941	4.983		0.03	
1026		-----		-----	
1040	DIN51619	4.927		-0.53	
1062	D2163	5.1295		1.47	
1065	D2163	5.152646		1.70	
1095	ISO7941	5.0		0.20	
1108	D2163	5.01		0.29	
1197	D2163	5.055		0.74	
1198	D2163	5.016		0.35	
1251		-----		-----	
1257	D2163	4.7407		-2.37	
1259	EN27941	5.136		1.54	
1272	EN27941	4.70	C	-2.77	first reported: 4.44
1491	ISO7941	5.060		0.79	
1528	EN27941	4.971		-0.09	
1556	EN27941	4.98		0.00	
1603	In house	5.020		0.39	
1634	ISO7941	4.86		-1.19	
1720		-----		-----	
1764	D2163	5.049		0.68	
1786	D2163	4.976		-0.04	
2124	D2163	4.9867		0.06	
6011	D2163	4.261	R(0.01)	-7.11	
6018	EN27941	5.524	R(0.01)	5.37	
6019	EN27941	4.589	R(0.05)	-3.87	
6108	D2163	5.008		0.27	
6128	D2163	4.738		-2.39	
6129	D2163	5.118		1.36	

	normality	OK			
	n	46			
	outliers	3			
	mean (n)	4.9803			
	st.dev. (n)	0.12020			
	R(calc.)	0.3366			
	R(D2163:14e1)	0.2834		compare EN27941(liq)=1.0246	

Kernel Density
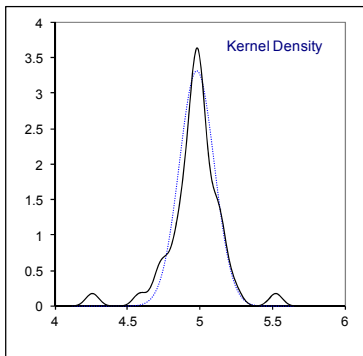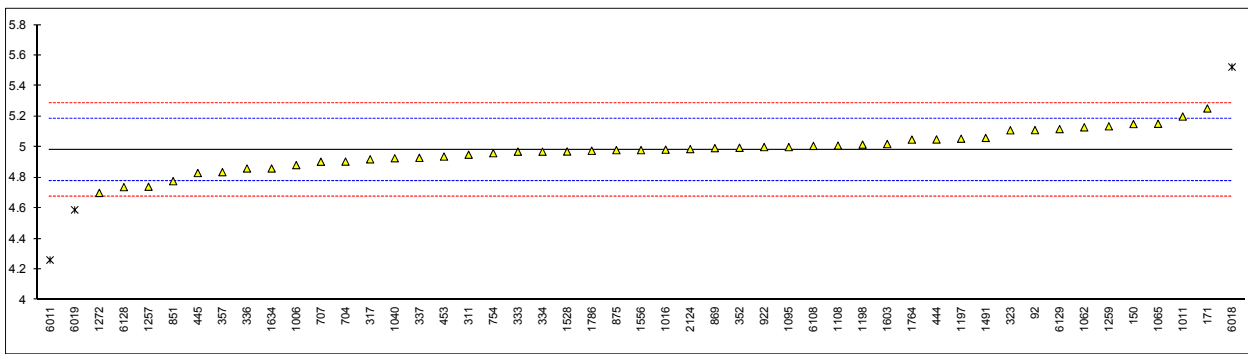
Determination of 1,3-Butadiene on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.842		1.26	
150	D2163	0.816		0.67	
171	D2163	0.807		0.47	
311	D2163	0.78		-0.14	
317	D2163	0.77		-0.37	
323	D2163	0.84		1.22	
333	D2163	0.78		-0.14	
334	D2163	0.78		-0.14	
336	D2163	0.74		-1.05	
337	ISO7941	<0.01	C	<-17.60	first reported: 0.95; possibly a false negative test result?
352	EN27941	0.8109		0.56	
357	D2163	0.775		-0.26	
444	D2163	0.791		0.11	
445	D2163	0.77		-0.37	
453	D2163	0.793		0.15	
704	D2163	0.765		-0.48	
707	D2163	0.766		-0.46	
754	D2163	0.780		-0.14	
851	D2163	0.8077		0.48	
869	D2163	0.789		0.06	
875	D2163	0.76		-0.60	
912		-----		-----	
922	D2163	0.80		0.31	
1006	D2163	0.798		0.26	
1011	ISO7941	0.7		-1.96	
1012		-----		-----	
1016	ISO7941	0.787		0.01	
1026		-----		-----	
1040	DIN51619	0.782		-0.10	
1062	D2163	0.7097		-1.74	
1065	D2163	0.827053		0.92	
1095	ISO7941	0.8		0.31	
1108	D2163	0.85		1.44	
1197	D2163	0.793		0.15	
1198	D2163	0.771		-0.35	
1251		-----		-----	
1257	D2163	0.7845		-0.04	
1259	EN27941	0.777		-0.21	
1272	EN27941	0.765		-0.48	
1491	ISO7941	0.772		-0.33	
1528	EN27941	0.800		0.31	
1556	EN27941	0.78		-0.14	
1603	In house	0.796		0.22	
1634	ISO7941	0.82		0.76	
1720		-----		-----	
1764	D2163	0.8005		0.32	
1786	D2163	0.792		0.13	
2124	D2163	0.7895		0.07	
6011		-----		-----	
6018	EN27941	0.804	ex	0.40	excluded due to statistical outliers in other components
6019	EN27941	0.800		0.31	
6108	D2163	0.775		-0.26	
6128	D2163	0.738		-1.10	
6129	D2163	0.803		0.38	

normality	suspect	
n	46	
outliers	0+1ex	
mean (n)	0.7864	
st.dev. (n)	0.02913	
R(calc.)	0.0816	
R(D2163:14e1)	0.1235	compare EN27941(liq)=1.0628
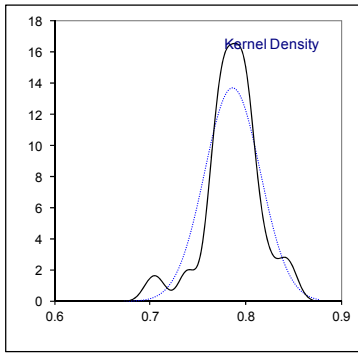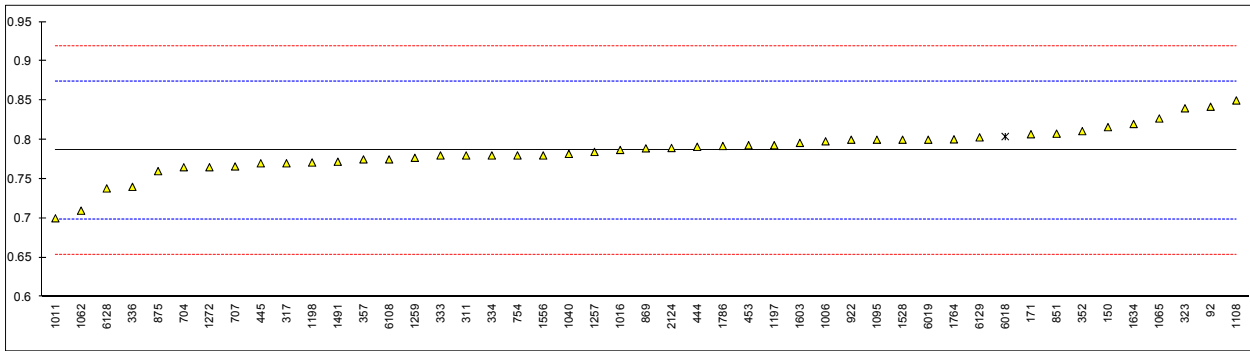
Determination of iso-Pentane on sample #17100; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.844		2.25	
150	D2163	0.786		-0.98	
171	D2163	0.869	R(0.05)	3.65	
311	D2163	0.80		-0.20	
317	D2163	0.80		-0.20	
323	D2163	0.83		1.47	
333	D2163	0.81		0.36	
334	D2163	0.80		-0.20	
336	D2163	0.76		-2.43	
337	ISO7941	0.78	C	-1.32	first reported: 0.98
352	EN27941	0.8198		0.90	
357	D2163	0.947	R(0.01)	8.00	
444	D2163	0.818		0.80	
445	D2163	0.71	R(0.05)	-5.22	
453	D2163	0.793		-0.59	
704	D2163	0.802		-0.09	
707	D2163	0.802		-0.09	
754	D2163	0.800		-0.20	
851	D2163	0.7758		-1.55	
869	D2163	0.812		0.47	
875	D2163	0.81		0.36	
912		-----		-----	
922	D2163	0.79		-0.76	
1006	D2163	0.781		-1.26	
1011	ISO7941	0.9	C,R(0.05)	5.38	first reported: 1.0
1012		-----		-----	
1016	ISO7941	0.814		0.58	
1026		-----		-----	
1040	DIN51619	0.804		0.02	
1062	D2163	0.7968		-0.38	
1065	D2163	0.876992	R(0.05)	4.09	
1095	ISO7941	0.8		-0.20	
1108	D2163	0.78		-1.32	
1197	D2163	0.784		-1.10	
1198	D2163	0.814		0.58	
1251		-----		-----	
1257	D2163	0.7608		-2.39	
1259	EN27941	0.857		2.98	
1272	EN27941	0.78	C	-1.32	first reported: 0.75
1491	ISO7941	0.845		2.31	
1528	EN27941	0.814		0.58	
1556	EN27941	0.80		-0.20	
1603	In house	0.783		-1.15	
1634	ISO7941	0.84		2.03	
1720		-----		-----	
1764	D2163	0.7970		-0.37	
1786	D2163	0.802		-0.09	
2124	D2163	0.7955		-0.45	
6011	D2163	0.80065		-0.17	
6018	EN27941	0.899	R(0.05)	5.32	
6019	EN27941	0.808		0.24	
6108	D2163	0.802		-0.09	
6128	D2163	0.811		0.41	
6129	D2163	0.854		2.81	

|					
	normality	OK			
	n	43			
	outliers	6			
	mean (n)	0.8036			
	st.dev. (n)	0.02190			
	R(calc.)	0.0613			
	R(D2163:14e1)	0.0502			compare EN27941(liq)=0.7968
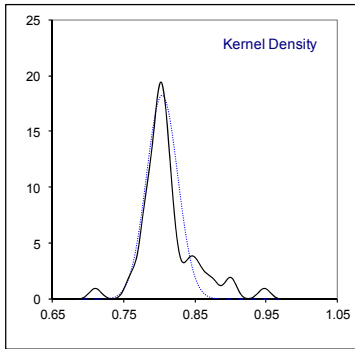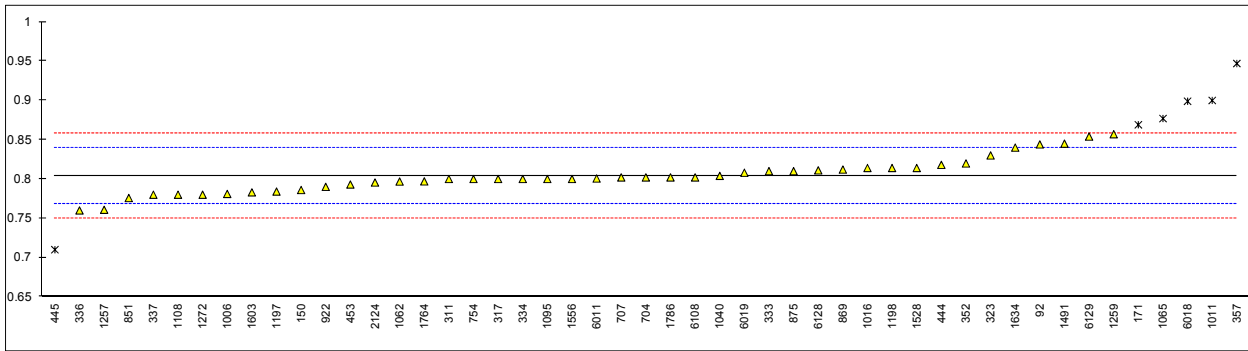
## Determination of Molar Mass on sample #17100; results in g/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	57.48		-----	
150		-----		-----	
171	D2421	57.64	E, ex	-----	iis calc. 57.51 (acc. to D2421), ex ->statistical outliers in comp. analysis
311	ISO8973	57.50		-----	
317	INH-F001	57.5		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	57.606	ex	-----	test result excluded due to statistical outliers in composition analysis
444		-----		-----	
445	D2163	57.498		-----	
453		-----		-----	
704	D2421	57.5049		-----	
707	D2421	57.5049		-----	
754	ISO8973	57.499		-----	
851	D2598	57.49		-----	
869	D2598	57.50		-----	
875	D2163	57.51	E	-----	iis calc. 57.33 (acc. to D2421)
912		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1016	EN27941	57.4958		-----	
1026		-----		-----	
1040		-----		-----	
1062	D2163	57.4975		-----	
1065		-----		-----	
1095		-----		-----	
1108	D2163	57.48		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	ISO8973	57.51		-----	
1272		-----		-----	
1491	ISO8973	57.51		-----	
1528	ISO8973	57.612	E, D(0.01)	-----	iis calc. 57.480 (acc. to ISO8973)
1556		57.5		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1764	D2421	57.490		-----	
1786		-----		-----	
2124		-----	W	-----	reported: 58.07
6011		-----		-----	
6018	ISO8973	57.6	ex	-----	test result excluded due to statistical outliers in composition analysis
6019	ISO8973	57.56	ex	-----	test result excluded due to statistical outliers in composition analysis
6108	D2598	57.496		-----	
6128		-----		-----	
6129		-----		-----	

					iis calculated from all test results *)
	normality	OK			OK
	n	18			33
	outliers	1+4ex			4+10ex (excluded due to statistical outlier(s) in composition analysis)
	mean (n)	57.4981			57.4938
	st.dev. (n)	0.00884	RSD=0.02%		0.01154 RSD=0.02%
	R(calc.)	0.0248			0.0323

*) 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
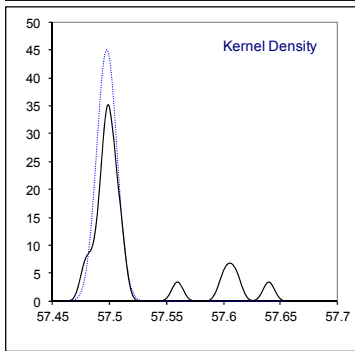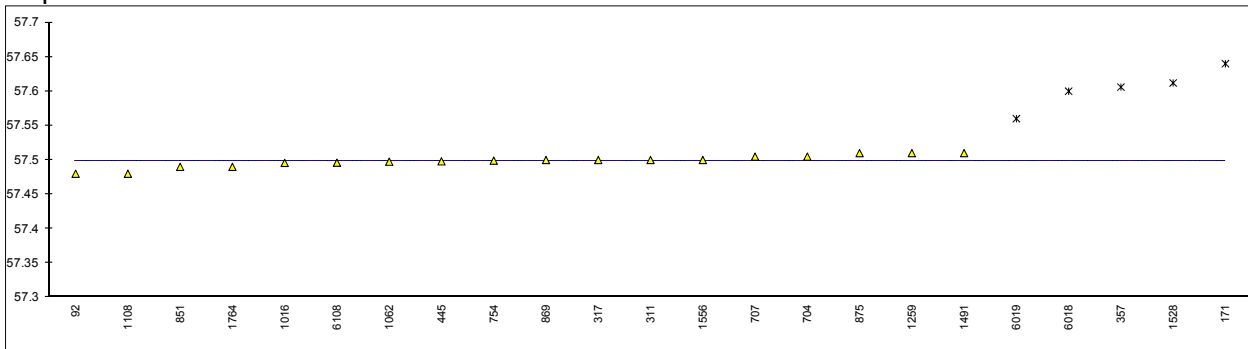
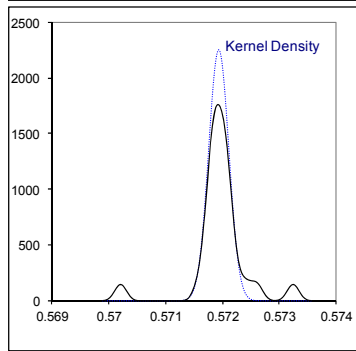## Calculated by iis based on relative molecular masses as given in table A.1 of ISO8973:97
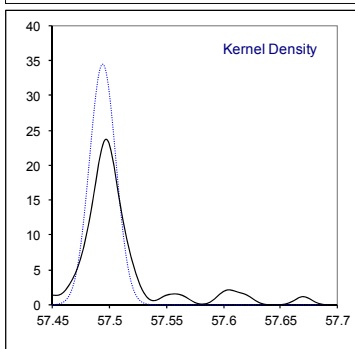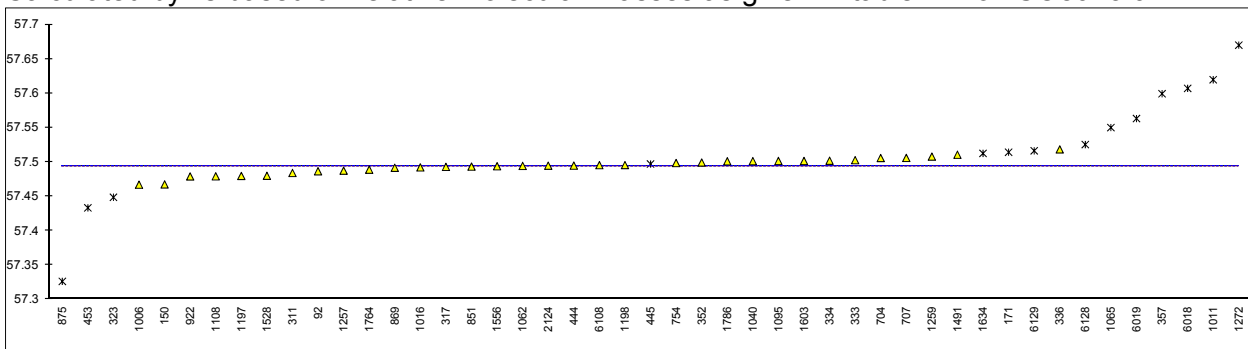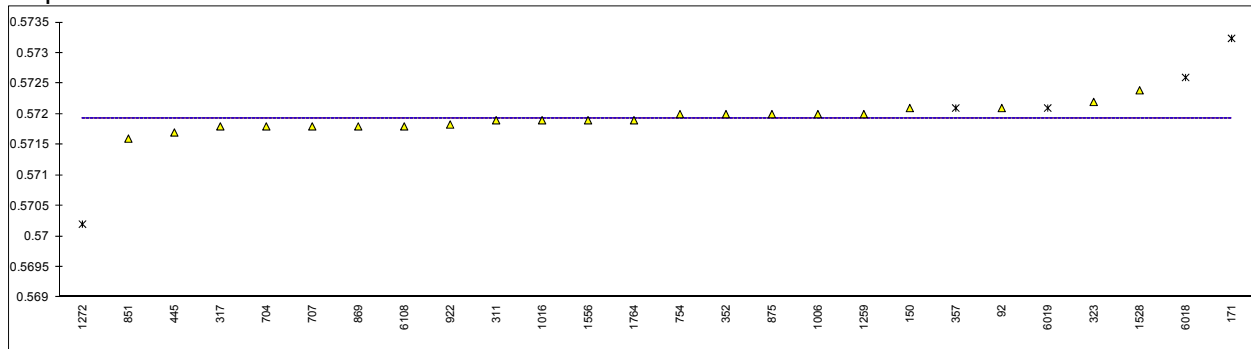
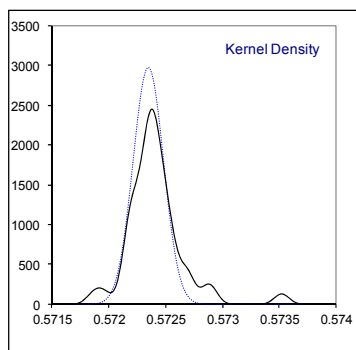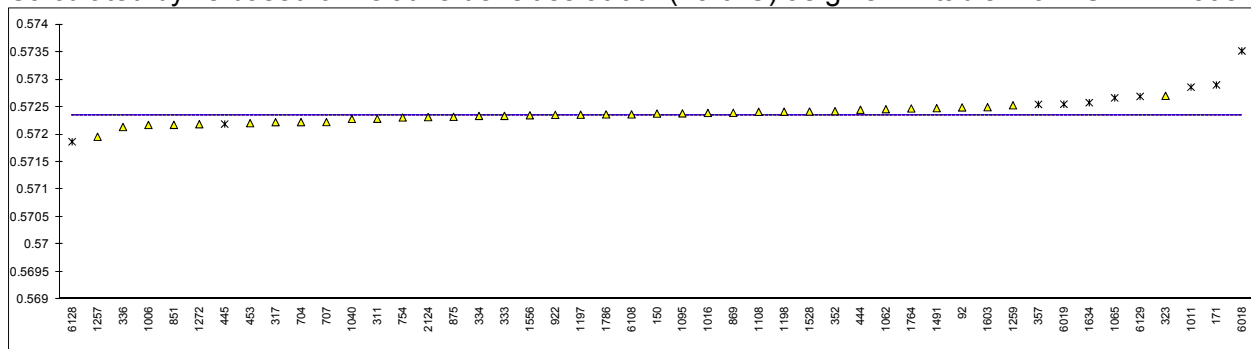## Determination of Relative Density at 60/60F on sample #17100; unitless results

lab	method	value	mark	z(targ)	remarks
92	D2598	0.5721		-----	
150	D2598	0.5721		-----	
171	D2598	0.57324	ex	-----	test result excluded due to statistical outliers in composition analysis
311	ISO8973	0.5719		-----	
317	INH-F001	0.5718		-----	
323	D2598	0.5722		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352	ISO8973	0.572		-----	
357	D2598	0.5721	ex	-----	test result excluded due to statistical outliers in composition analysis
444		-----		-----	
445	IP432	0.5717		-----	
453		-----		-----	
704	D2598	0.5718		-----	
707	D2598	0.5718		-----	
754	ISO8973	0.572		-----	
851	D2598	0.5716		-----	
869	D2598	0.5718		-----	
875	D2598	0.5720		-----	
912		-----		-----	
922	D2598	0.57183		-----	
1006	D2598	0.572		-----	
1011		-----		-----	
1012		-----		-----	
1016	ISO8973	0.5719		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095		-----		-----	
1108		-----		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	ISO8973	0.572		-----	
1272	ISO8973	0.5702	R(0.01), E	-----	iis calc. 0.5722 (acc. to ISO8973)
1491		-----		-----	
1528	D2598	0.57239		-----	
1556	ISO8973	0.5719	C	-----	reported: Relative Density expressed as 15/15°C. first reported: 571.9
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1764	D2598	0.5719		-----	
1786		-----		-----	
2124		-----	W	-----	reported: 0.447
6011		-----		-----	
6018	ISO8973	0.5726	ex	-----	test result excluded due to statistical outliers in composition analysis
6019	ISO8973	0.5721	ex	-----	test result excluded due to statistical outliers in composition analysis
6108	D2598	0.5718		-----	
6128		-----		-----	
6129		-----		-----	

					iis calculated from all test results *)
	normality	suspect			suspect
	n	21			37
	outliers	1+4ex			0+10ex (excluded due to statistical outlier(s) in composition analysis)
	mean (n)	0.5719			0.5723
	st.dev. (n)	0.00018	RSD=0.03%		0.00013 RSD=0.02%
	R(calc.)	0.0005			0.0004

*) 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 at 60F (15.6°C) for 1,3 –Butadiene. For this component the value of 0.6272 is taken from AST 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 #17100; results in psi

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
171		-----		-----	
311	ISO8973	71	DG(0.01)	-----	iis calc 71.4 (acc. to ISO8973)
317	ISO8973	71.5		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	70.64	ex	-----	test result excluded due to statistical outliers in composition analysis
444		-----		-----	
445		-----		-----	
453		-----		-----	
704	ISO8973	71.4		-----	
707	ISO8973	71.4		-----	
754	ISO8973	71.4		-----	
851	D2598	70.8		-----	
869	D2598	70.7		-----	
875	ISO8973	71.3		-----	
912		-----		-----	
922	D2598	70.93		-----	
1006	D2598	70.9		-----	
1011		-----		-----	
1012		-----		-----	
1016	EN589 Annex	71.393		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095		-----		-----	
1108	ISO8973	71.4		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	ISO8973	71	DG(0.01)	-----	iis calc 71.3 (acc. to ISO8973)
1272		-----		-----	
1491		-----		-----	
1528		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1764	D2598	70.65		-----	
1786		-----		-----	
2124		-----		-----	
6011		-----		-----	
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6128		-----		-----	
6129		-----		-----	

Evaluated over ISO8973/EN589 test results only			**iis calculated from all test results *)**	
normality	not OK		suspect	
n	7		37	
outliers	2+1ex		0+10ex (excluded due to statistical outlier(s) in composition analysis)	
mean (n)	71.3990		71.4104	
st.dev. (n)	0.05779	RSD=0.08%	0.13215	RSD=0.19%
R(calc.)	0.1618		0.3700	

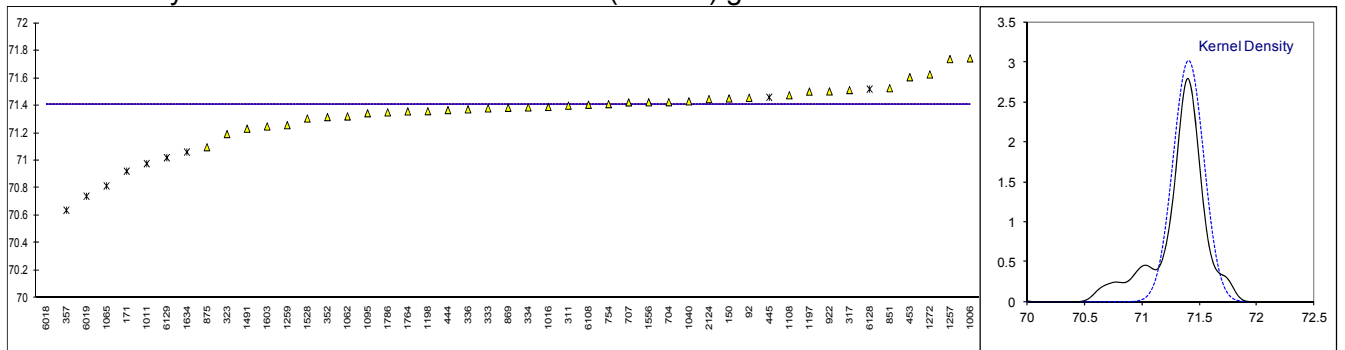| **Evaluated over D2598 test results only**			**iis calculated from all test results **)**	
normality	OK		suspect	
n	5		35	
outliers	0		2+10ex (excluded due to statistical outlier(s) in composition analysis)	
mean (n)	70.7960		71.0294	
st.dev. (n)	0.12178	RSD=0.17%	0.08662	RSD=0.12%
R(calc.)	0.3410		0.2425	

*) 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). The conversion from psia to psig was done as follows: 59.46 psia – (101.325 kPa * 0.145038) = 44.76 = 45 psig.
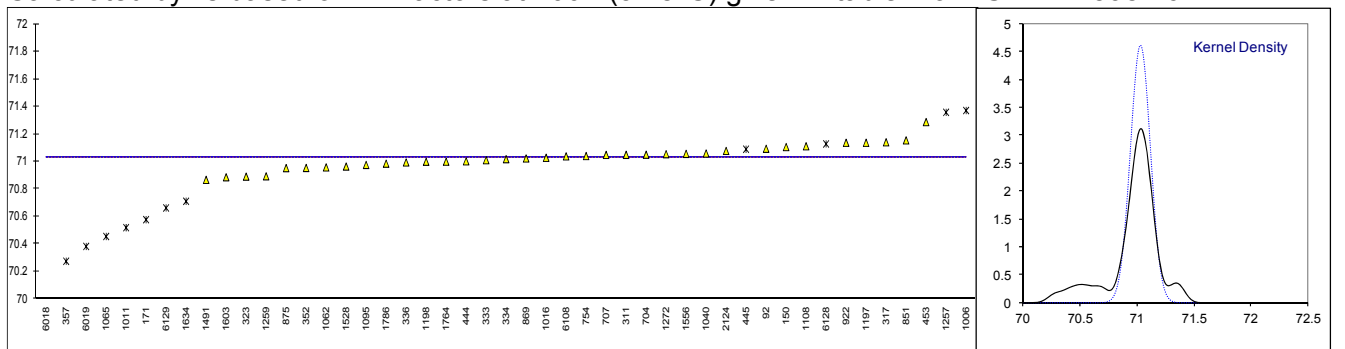
Reported test results

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

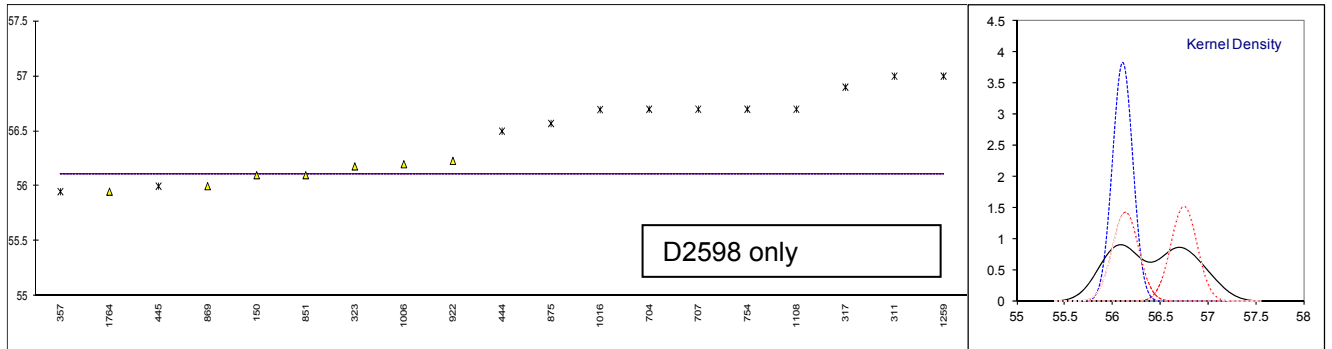## Calculated by iis based on VP factors at 100F (37.8°C) given in table 1 of ASTM D2598:16
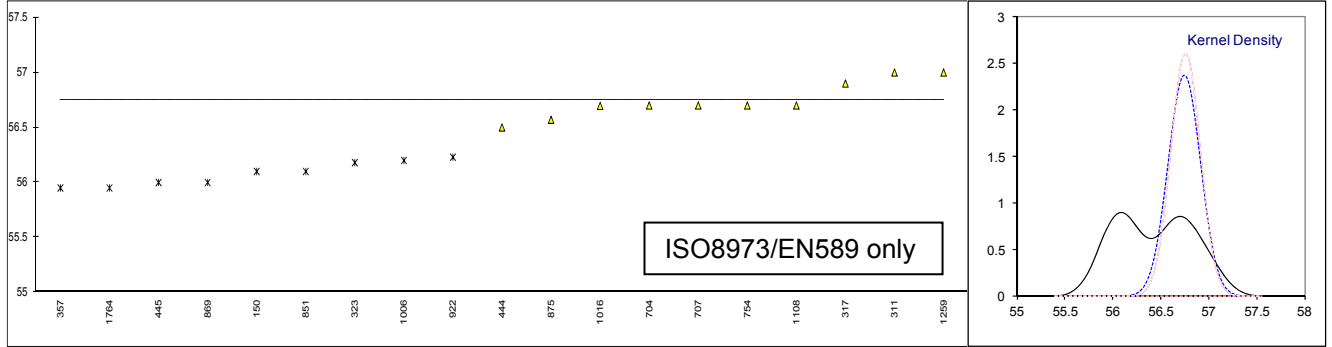
Determination of Rel. Vapour Pressure at 100F on sample #17100; results in psi

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150	D2598	56.1		-----	
171		-----		-----	
311	ISO8973	57		-----	
317	ISO8973	56.9		-----	
323	D2598	56.18		-----	
333		-----		-----	
334		-----		-----	
336		-----		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	55.95	ex	-----	test result excluded due to statistical outliers in composition analysis
444	ISO8973	56.5		-----	
445	IP432	56	G(0.05), E	-----	iis calc. 56.8
453		-----		-----	
704	ISO8973	56.7		-----	
707	ISO8973	56.7		-----	
754	ISO8973	56.7		-----	
851	D2598	56.1		-----	
869	D2598	56.0		-----	
875	ISO8973	56.57		-----	
912		-----		-----	
922	D2598	56.23		-----	
1006	D2598	56.2		-----	
1011		-----		-----	
1012		-----		-----	
1016	EN589 Annex	56.696		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095		-----		-----	
1108	ISO8973	56.7		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	ISO8973	57		-----	
1272		-----		-----	
1491		-----		-----	
1528		-----		-----	
1556		-----		-----	
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1764	D2598	55.95		-----	
1786		-----		-----	
2124		-----		-----	
6011		-----		-----	
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6128		-----		-----	
6129		-----		-----	

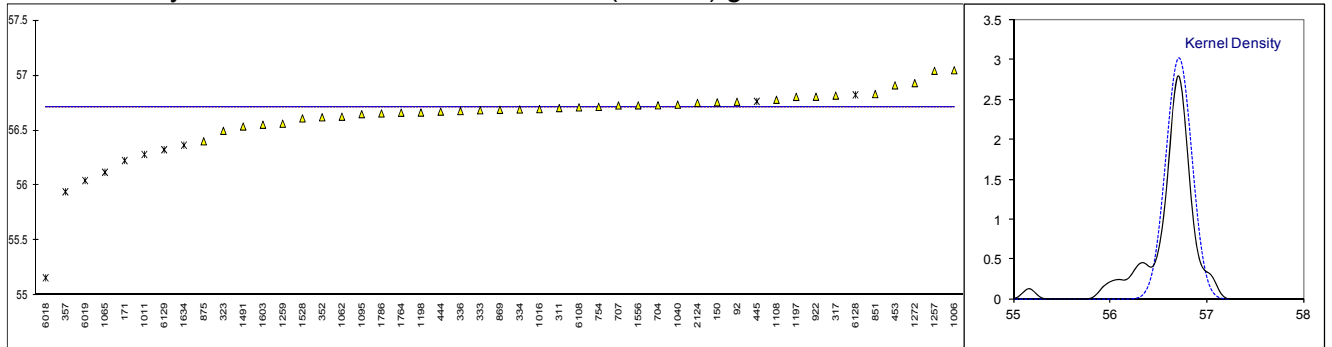| **Evaluated over ISO8973/ IP432/ EN589 test results only**			**iis calculated from all test results *)**	
normality	OK		suspect	
n	10		37	
outliers	1+1ex		0+10ex (excluded due to statistical outlier(s) in composition analysis)	
mean (n)	56.7466		56.7145	
st.dev. (n)	0.16839	RSD=0.30%	0.13215	RSD=0.23%
R(calc.)	0.4715		0.3700	
Evaluated over D2598 test results only			**iis calculated from all test results **)**	
normality	OK		suspect	
n	7		35	
outliers	0		2+10ex (excluded due to statistical outlier(s) in composition analysis)	
mean (n)	56.1086		56.3334	
st.dev. (n)	0.10431	RSD=0.19%	0.08662	RSD=0.15%
R(calc.)	0.2921		0.2425	

*) 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). The conversion from psia to psig was done as follows: 59.46 psia – (101.325 kPa * 0.145038) = 44.76 = 45 psig.
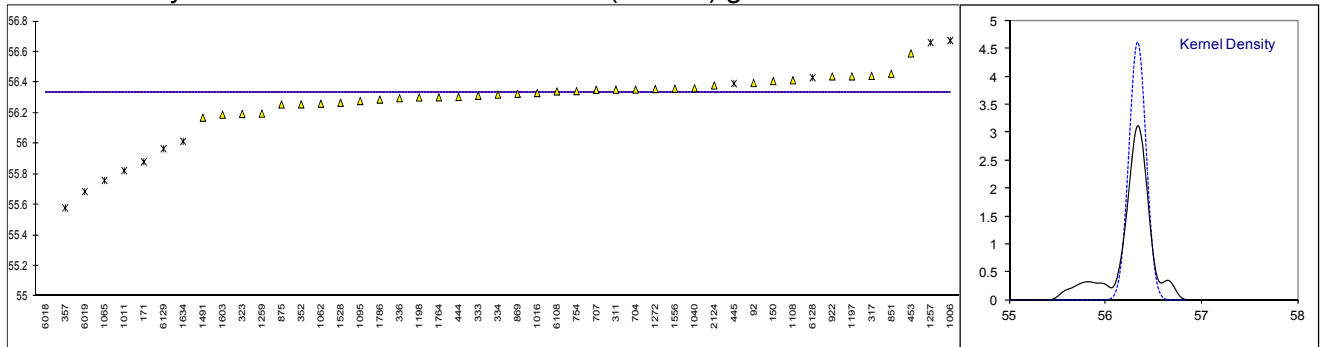
Reported test results

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

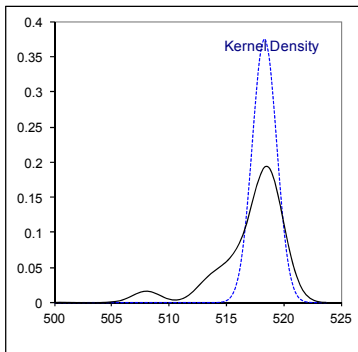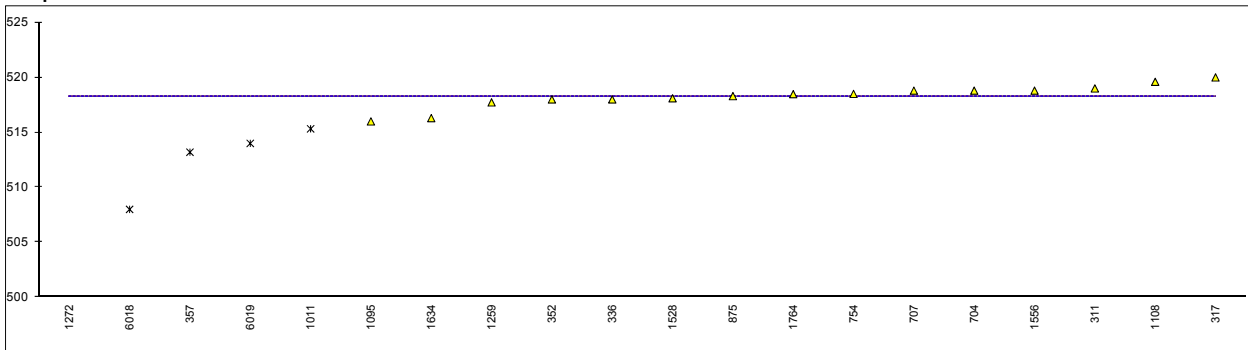## Calculated by iis based on VP factors at 100F (37.8°C) given in table 1 of ASTM D2598:16

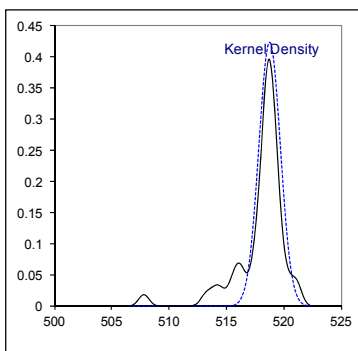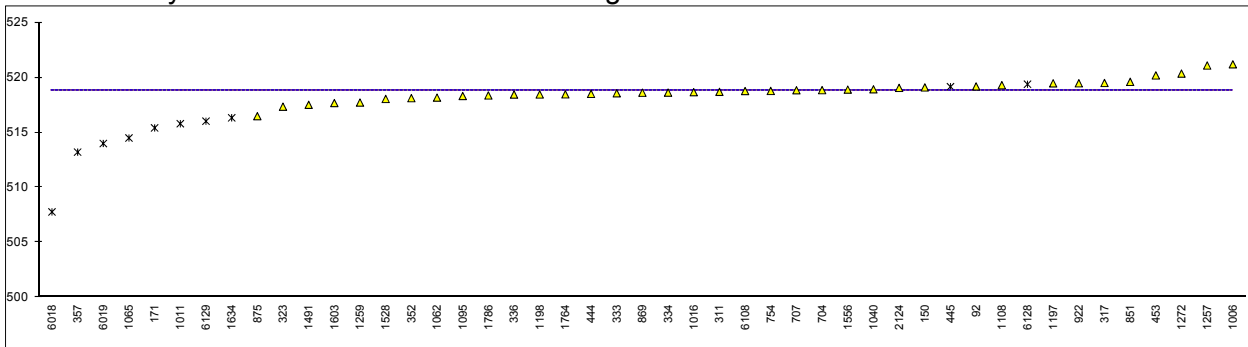Determination of Abs. Vapour Pressure at 40°C on sample #17100; results in kPa

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
171		-----		-----	
311	ISO8973	519		-----	
317	ISO8973	520		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336	ISO8973	518		-----	
337		-----		-----	
352	ISO8973	518		-----	
357	ISO8973	513.2	ex	-----	test result excluded due to statistical outliers in composition analysis
444		-----		-----	
445		-----		-----	
453		-----		-----	
704	ISO8973	518.8		-----	
707	ISO8973	518.8		-----	
754	ISO8973	518.5		-----	
851		-----		-----	
869		-----		-----	
875	ISO8973	518.30	E	-----	iis calc. 516.49
912		-----		-----	
922		-----		-----	
1006		-----		-----	
1011	ISO8973	515.325	ex, C	-----	test result excluded -> statistical outliers in comp. analysis; f.r. 415
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095	ISO8973	516	E	-----	iis calc. 518.32
1108	ISO8973	519.6		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	ISO8973	517.73		-----	
1272	ISO8973	422.0	E,C,G(0.01)	-----	iis calc. 520.36; first reported: 436.66
1491		-----		-----	
1528	ISO8973	518.1		-----	
1556	ISO8973	518.8		-----	
1603		-----		-----	
1634	ISO8973	516.3		-----	
1720		-----		-----	
1764	ISO8973	518.48		-----	
1786		-----		-----	
2124		-----		-----	
6011		-----		-----	
6018	ISO8973	508	ex	-----	test result excluded due to statistical outliers in composition analysis
6019	ISO8973	514	ex	-----	test result excluded due to statistical outliers in composition analysis
6108		-----		-----	
6128		-----		-----	
6129		-----		-----	
					iis calculated from all test results *)
	normality	suspect			suspect
	n	15			37
	outliers	1+4ex			0+10ex (excluded due to statistical outlier(s) in composition analysis)
	mean (n)	518.2940			518.7969
	st.dev. (n)	1.05988	RSD=0.20%		0.94213 RSD=0.18%
	R(calc.)	2.9677			2.6380

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

Reported test results

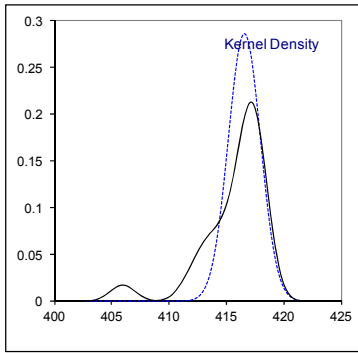## Calculated by iis based on VP factors at 40°C given in table A.1 of IP432:99/ISO8973:97

## Determination of Rel. Vapour Pressure at 40°C on sample #17100; results in kPa

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
171		-----		-----	
311	ISO8973	417		-----	
317	ISO8973	418		-----	
323	ISO8973	414		-----	
333		-----		-----	
334		-----		-----	
336	ISO8973	417		-----	
337		-----		-----	
352		-----		-----	
357	ISO8973	411.9	ex	-----	test result excluded due to statistical outliers in composition analysis
444	ISO8973	418.2		-----	
445	IP432	413.4	E	-----	iis calc 417.84
453		-----		-----	
704	ISO8973	417.5		-----	
707	ISO8973	417.5		-----	
754	ISO8973	417.5		-----	
851		-----		-----	
869		-----		-----	
875	ISO8973	416.38	E	-----	iis calc 415.16 (lab corrected some comp. test values)
912		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095	ISO8973	415	E	-----	iis calc. 416.99
1108	ISO8973	418.1		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	ISO8973	416.40		-----	
1272		-----		-----	
1491	ISO8973	416		-----	
1528	ISO8973	416.8		-----	
1556	ISO8973	417.5		-----	
1603		-----		-----	
1634	ISO8973	415		-----	
1720		-----		-----	
1764	ISO8973	417.15		-----	
1786		-----		-----	
2124		-----		-----	
6011		-----		-----	
6018	ISO8973	406	ex	-----	test result excluded due to statistical outliers in composition analysis
6019	ISO8973	413	ex	-----	test result excluded due to statistical outliers in composition analysis
6108		-----		-----	
6128		-----		-----	
6129		-----		-----	
					iis calculated from all test results *)
	normality	OK			suspect
	n	18			37
	outliers	0+3ex			0+10ex (excluded due to statistical outlier(s) in composition analysis)
	mean (n)	416.5794			417.4720
	st.dev. (n)	1.39818	RSD=0.34%		0.94213 RSD=0.23%
	R(calc.)	3.9149			2.6380

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

Reported test results
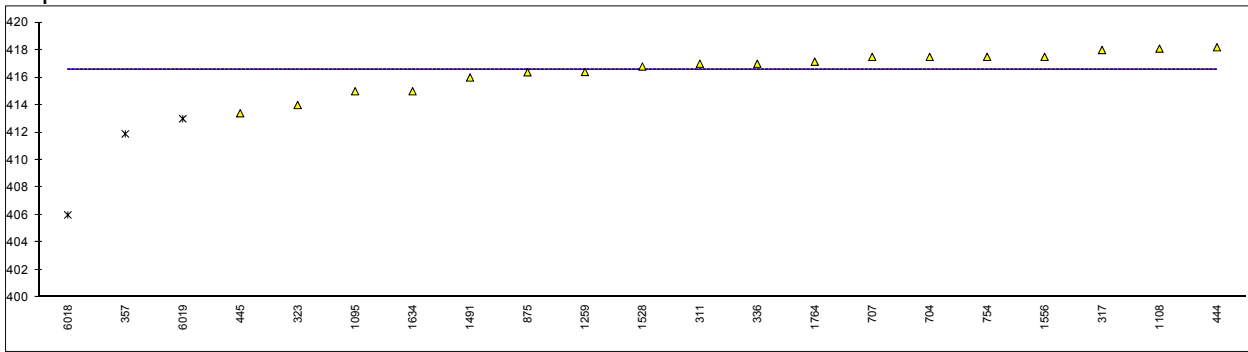
Calculated by iis based on VP factors at 40°C given in table A.1 of IP432:99/ISO8973:97
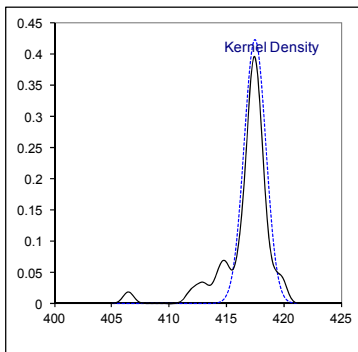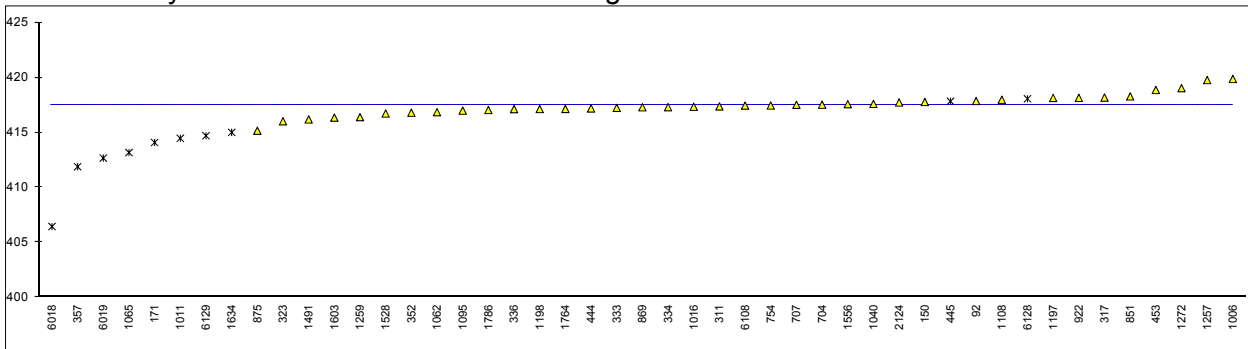
## Determination of Motor Octane Number, MON on sample #17100;

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
171		-----		-----	
311	EN589	91.9	E?	-----	iis calc 92.5; possible used 0 as factor for 1,3-Butadiene
317	EN589	92.0		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
336	EN589	92.6		-----	
337		-----		-----	
352		-----		-----	
357		-----		-----	
444		-----		-----	
445		-----		-----	
453		-----		-----	
704	EN589	92.57		-----	
707	EN589	92.57		-----	
754	EN589	92.5		-----	
851	D2598	94.3	ex,C	-----	calc with other factors than EN589, no calc error; f.r. 94.7
869	D2598	94.7	ex	-----	calc with other factors than EN589, no calc error (see below)
875	EN589	92.0		-----	
912		-----		-----	
922		-----		-----	
1006		-----		-----	
1011		-----		-----	
1012		-----		-----	
1016		-----		-----	
1026		-----		-----	
1040		-----		-----	
1062		-----		-----	
1065		-----		-----	
1095		-----		-----	
1108	EN589	92.5		-----	
1197		-----		-----	
1198		-----		-----	
1251		-----		-----	
1257		-----		-----	
1259	EN589	92.7		-----	
1272		-----		-----	
1491		-----		-----	
1528	EN589	92.41		-----	
1556		-----	W	-----	reported: 96
1603		-----		-----	
1634		-----		-----	
1720		-----		-----	
1764	EN589	92.40		-----	
1786		-----		-----	
2124		-----		-----	
6011		-----		-----	
6018		-----		-----	
6019		-----		-----	
6108		-----		-----	
6128		-----		-----	
6129		-----		-----	

				iis calculated from all test results	
				EN589 *)	**ASTM D2598 **)**
	normality	OK		suspect	OK
	n	11		34	34
	outliers	0+2ex		3+10ex ***)	3+10ex ***)
	mean (n)	92.3773		92.4538	93.9967
	st.dev. (n)	0.27789	RSD=0.30%	0.04809 RSD=0.05%	0.02591 RSD=0.03%
	R(calc.)	0.7781		0.1347	0.0725

*) 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.
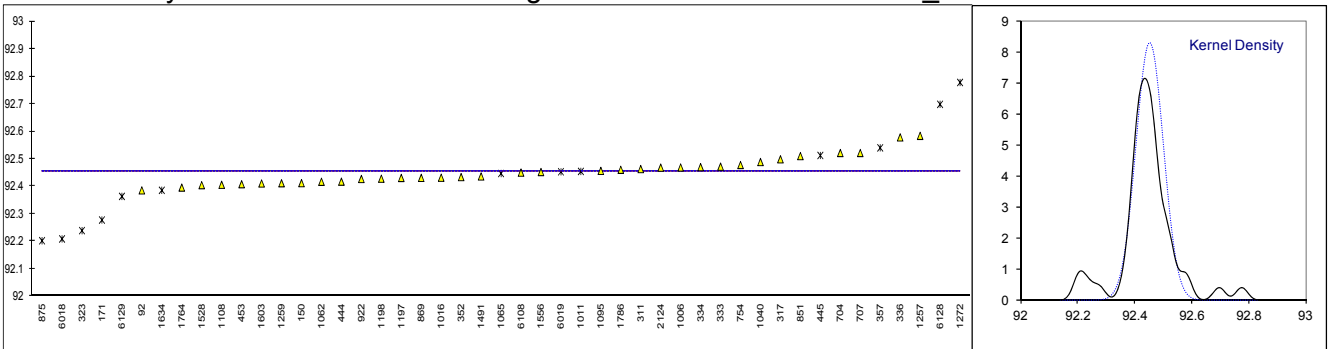***) excluded due to statistical outlier(s) in composition analysis

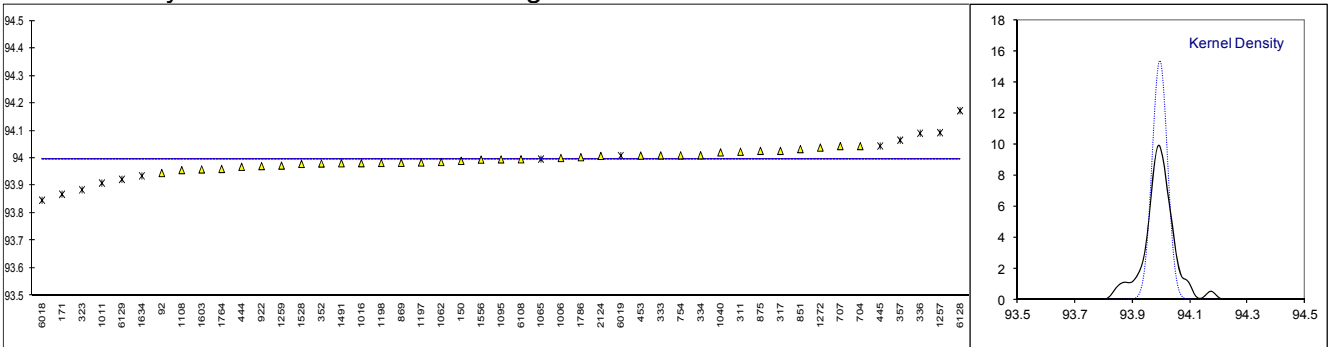Lab 869 reported to use respectively for iso-Butene, trans-2-Butene and 1,3 –Butadiene: 104.2; 82.3 and 0

Reported test results
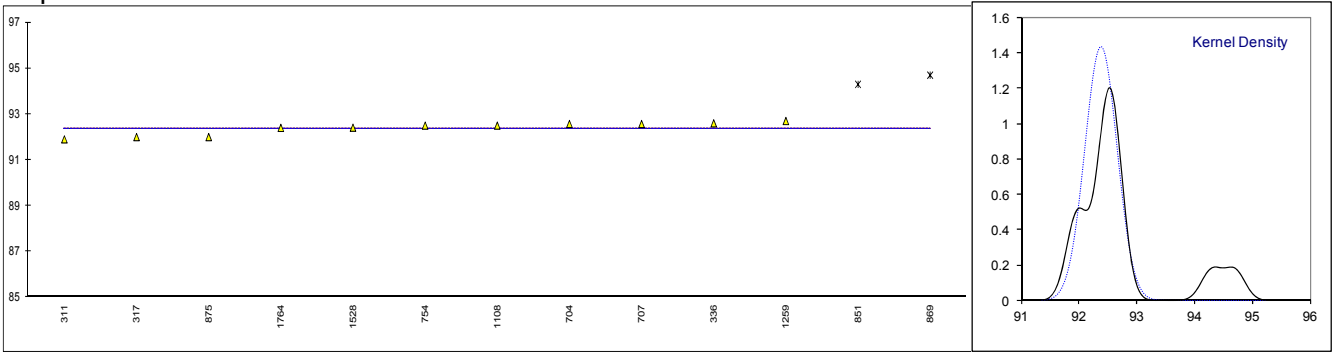
Calculated by iis based on MON factors given in table B.1 of EN589:08_A1:12

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

APPENDIX 2

Number of participants per country

1 lab in AUSTRALIA

2 labs in BELGIUM

1 lab in CANADA

1 lab in CHINA, People's Republic

1 lab in CROATIA

1 lab in FINLAND

4 labs in FRANCE

2 labs in GERMANY

1 lab in GREECE

1 lab in HONG KONG

1 lab in INDIA

1 lab in ISRAEL

1 lab in ITALY

3 labs in MALAYSIA

5 labs in NETHERLANDS

1 lab in NIGERIA

1 lab in PAKISTAN

7 labs in PORTUGAL

1 lab in ROMANIA

4 labs in RUSSIAN FEDERATION

1 lab in SERBIA

1 lab in SUDAN

1 lab in SWEDEN

1 lab in TAIWAN

1 lab in THAILAND

2 labs in UKRAINE

1 lab in UNITED ARAB EMIRATES

3 labs in UNITED KINGDOM

2 labs in UNITED STATES OF AMERICA

1 lab in VIETNAM

APPENDIX 3

Abbreviations:

C   = final test result after checking of first reported suspect test result
D(0.01)   = outlier in Dixon's outlier test
D(0.05)   = straggler in Dixon's outlier test
G(0.01)   = outlier in Grubbs' outlier test
G(0.05)   = straggler in Grubbs' outlier test
DG(0.01) = outlier in Double Grubbs' outlier test
DG(0.05) = straggler in Double Grubbs' outlier test
R(0.01)   = outlier in Rosner's outlier test
R(0.05)   = straggler in Rosner's outlier test
E   = probably an error in calculations
U   = test result probably reported in a different unit
W   = test result withdrawn on request participant
ex   = test result excluded from statistical evaluation
n.a.   = not applicable
n.e.   = not evaluated
n.d.   = not detected
fr.   = first reported
SDS   = 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 2002, 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)