

Results of Proficiency Test  
LPG Composition & sulfur  
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Organised by: Institute for Interlaboratory Studies  
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Author: ing. G.A. Oosterlaken-Buijs  
Correctors: dr. R.G. Visser & ing. R.J. Starink  
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## 1 INTRODUCTION

Since 2009, the Institute for Interlaboratory Studies organizes a proficiency test for the analysis of Liquefied Propane (composition only) every year. It was decided to continue the interlaboratory study for Liquefied Propane during the annual program 2017/2018. At the request of several participants, the Institute of Interlaboratory Studies decided to organise an interlaboratory study for Sulphur (total) in LPG in the 2017/2018 PT program.

Because iis has limited gas-handling facilities in place to prepare gas samples a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up for the Liquefied Propane PT (iis17S03P) and a co-operation with Praxair NV (Belgium) was set up for the Sulphur in LPG PT (iis17S03S). Both EffecTech and Praxair are fully equipped and have experience in the preparation of gas mixtures.

In the interlaboratory studies for Liquefied Propane (composition only) 52 laboratories in 28 different countries and for Sulphur (total) in LPG 10 laboratories in 6 different laboratories registered for participation. In this report, the results of the 2017 proficiency tests Liquefied Propane (composition only) and Sulphur (total) in LPG are presented and discussed. This report is also electronically available through the iis website [www.iisnl.com](http://www.iisnl.com).

## 2 SET UP

The Institute for Interlaboratory Studies (iis) in Spijkenisse, the Netherlands, was the organizer of this proficiency test (PT).

To optimise the costs for the participants for the Liquefied Propane PT (iis17S03P), it was decided to prepare one Liquefied Propane mixture for composition. The mixture was divided over a batch of 55 cylinders (1L cylinder with dip tube device). Each cylinder, filled with approx.. 200 grams of liquefied propane mixture, was labelled #17210 and uniquely coded.

For the Sulphur in LPG PT (iis17S03S) it was decided to use a batch of 12 cylinders, filled with approximately 1500 grams of LPG, each spiked with Dimethyl sulfide (DMS). Each cylinder (5L cylinder with dip tube device), was labelled #17211 and uniquely coded.

The limited cylinder sizes (1L and 5L) are chosen to optimise sample stability, cylinder costs, transport and handling costs.

The preparation and testing of the sample cylinders was subcontracted to ISO 17025 accredited laboratories. 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/IEC 17043:2010. 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 a regular basis by sending out questionnaires.

EffecTech is accredited in conformance ISO/IEC17043:2010 by UKAS (no. 4719), ISO guide 35:2006 and ISO 17025:2005. Praxair is accredited in conformance with ISO 9001-2008, ISO 14001-2004, ISO 17025-No 159 Cal and ISO TS 16949.

## 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](http://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

### LIQUEFIED PROPANE

In this proficiency test only one sample was used. One batch of 55 one litre cylinders with artificial Liquefied Propane mixture was prepared and tested for homogeneity by EffectTech (Uttoxeter, United Kingdom) in conformance with ISO guide 35:2006 and ISO 17025:2005 (job 17/1075, September 2017). Each cylinder was labelled #17210 and uniquely coded. 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 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 reproducibilities of the reference method in agreement with the procedure of ISO 13528, Annex B2 in the next table:

Component	$r(\text{observed})$ in %mol/mol	$0.3 * R(\text{D2163:14e1})$ in %mol/mol
Ethane	0.002	0.034
Propane	0.022	1.258
Propylene	0.004	0.068
Iso-Butane	0.007	0.066
n-Butane	0.008	0.057
1-Butene	0.002	0.018
iso-Butylene	0.002	0.017
n-Pentane	0.006	0.023

Table 1: homogeneity test results of samples #17210

Each calculated repeatability is equal or less than 0.3 times the corresponding reproducibility of the reference method ASTM D2163:14e1. Therefore, homogeneity of the subsamples #17210 was assumed.

### Sulphur

In this proficiency test one batch of twelve 5L cylinders with artificial LPG mixture (Dimethylsulfide in Propane/n-Butaan) was prepared and tested for homogeneity by Praxair NV (Belgium) in conformance with ISO 9001-2008, ISO 14001-2004, ISO 17025-No 159 Cal and ISO TS 16949 in September 2017. Each cylinder was labelled #17211 and uniquely coded.

	<i>Sulphur in mg/kg</i>
Sample #17211-1	40.5
Sample #17211-2	39.8
Sample #17211-3	39.8
Sample #17211-4	39.7
Sample #17211-5	40.5
Sample #17211-6	39.9
Sample #17211-7	40.3
Sample #17211-8	39.9
Sample #17211-9	40.1
Sample #17211-10	39.7
Sample #17211-11	39.5
Sample #17211-12	40.4

Table 2: homogeneity test results of subsamples #17211

From the above test results, the repeatability was calculated and compared with 0.3 times the corresponding reproducibility of the reference test method and in agreement with the procedure of ISO 13528, Annex B2 in the next table:

	<i>Sulphur in mg/kg</i>
r (observed)	0.9
reference test method	ASTM D6667:14
0.3 * R (ref. test method)	3.8

Table 3: evaluation of the repeatability of subsamples #17211

The calculated repeatability is equal or less than 0.3 times the corresponding reproducibility of the reference test method ASTM D6667:14. Therefore, homogeneity of the subsamples #17211 was assumed.

Depending on their registration to each of the participating laboratories one 1L cylinder of Liquefied Propane labelled #17210 and/or one 5L cylinder of Sulphur in LPG labelled #17211 was sent on October 4, 2017. Per cylinder one SDS was added to the sample package.

## 2.5 STABILITY OF THE SAMPLES

The shelf life time of the prepared gas cylinders is sufficient for the period of the proficiency test.

## 2.6 ANALYSES

The participants were asked to determine on the Liquefied Propane sample # 17210 the composition: Ethane, Propane, Propene, n-Butane, iso-Butane, 1-Butene, iso-Butene, n-Pentane and to calculate several physical parameters from the composition: Molar Mass, Relative Density at 60F, Absolute and Relative Vapour pressure at 100F, Absolute and Relative Vapour pressure at 40°C, MON, Ideal Gross Heating Value and Ideal Net Heating Value at 14.696 psi and 60F.

On the LPG sample #17211 the total Sulphur content was requested.

It was explicitly requested to treat the samples as if they were routine samples and to report the test results using the indicated units on the report form and not to round the test results, but report as much significant figures as possible. It was also requested not to report 'less than' 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/](http://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](http://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/](http://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 requirement 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 reproducibilities, the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation in 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:

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

The  $z_{(\text{target})}$  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, some problems were encountered with the dispatch of the samples. For the Liquefied Propane PT (iis17S03P), not all laboratories did report all test results requested and five participants didn't report any test result at all. In total 47 participants reported 536 numerical test results. Observed were 30 outlying test results, which is 5.6%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.

For the Sulphur in LPG PT (iis17S03S), two participants didn't report any result at all (one laboratory reported that DMS wasn't included in their calibration mixture). In total 8 participants reported 8 numerical test results. Observed was 1 outlying test result, which is 12.5%. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.

Not all original data sets proved to have 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 SAMPLE AND PER TEST

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

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

Because the majority of the participating laboratories used ASTM D2163 as test method for the determination of the Propane Composition, 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. In ASTM D2163 no reproducibilities of 1-butene and iso-butene are mentioned, the reproducibilities of n-butane were used to calculate the reproducibilities of these two components.

Three laboratories (337, 6018 and 6108) reported deviating results for many of the Propane composition test results and many of the eight test results appeared to be statistical outliers. As the eight test results are not independent, it was decided not to use any of the reported results of these three laboratories for the statistical evaluation. Also the reported physical test results of these three laboratories were excluded, since these values were calculated from the measured Propane composition.

#### **Liquefied Propane: sample #17210**

Ethane: 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 agreement with the requirements of ASTM D2163:14e1 and also with the reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).

Propane: The determination of this component was not problematic. Two statistical outliers were observed and two test results were excluded. However, the calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14e1 and in good agreement with the reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).

- Propene: The determination of this component was not problematic. Three statistical outliers were observed and one test result was excluded. However, the calculated reproducibility after rejection of the suspect data is in agreement with the requirements of ASTM D2163:14e1 and also with the reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).
- iso-Butane: The determination of this component was not problematic. Five statistical outliers were observed. However, the calculated reproducibility after rejection of the statistical outliers is in full agreement with the requirements of ASTM D2163:14e1 and in good agreement with the reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).
- n-Butane: The determination of this component may be problematic, depending on the test method used by the laboratory. Three statistical outliers were observed. The calculated reproducibility after rejection of the statistical outliers is not in agreement with the requirements of ASTM D2163:14e1. However, the calculated reproducibility is in good agreement with the less strict reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).
- 1-Butene: 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 agreement with the requirements of ASTM D2163:14e1 and also with the reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).
- Iso-Butene: 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 agreement with the requirements of ASTM D2163:14e1 and also with the reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).
- n-Pentane: The determination of this component may be problematic, depending on the test method used by the laboratory. Two statistical outliers were observed and one test result was excluded. The calculated reproducibility after rejection of the suspect data is not in agreement with the requirements of ASTM D2163:14e1. However, the calculated reproducibility is in agreement with the less strict reproducibility requirements of EN27941:93 (identical to IP405 and ISO7941).
- Molar Mass: This calculated parameter may not be problematic. The results vary over a range from 44.3 – 45.582 g/mol. One statistical outlier was observed, and three test results were excluded. The calculated reproducibility after

rejection of the suspect data is in agreement with the reproducibility observed in the previous iis16S03P (0.085 vs. 0.135).

Rel. Density at 60F: This calculated parameter may not be problematic. The results vary over a range from 0.5107 – 0.5156. No statistical outliers were present, but four test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility observed in the previous iis16S03P (0.00101 vs. 0.00229).

Abs. VP at 100F: As the reported results calculated via ASTM D2598 and ISO8973 are not identical, it was decided to calculate the absolute vapour pressure for each laboratory according to both test methods by using all reported components concentrations. When the result of the calculation method of ASTM D2598 is compared with the result of the calculation method of ISO8973, it is noticed that the difference in the means is significant, while the difference in the reproducibilities is not significant. See also the discussion in paragraph 5. The calculated reproducibilities after rejection of the five suspect test results are in agreement with the reproducibilities observed in the previous PT iis16S03P (0.872 vs 0.962 for ISO8973:97 and 0.956 vs 1.007 for ASTM D2598:16).

Rel. VP at 100F: As the reported results calculated via ASTM D2598 and ISO8973 are not identical, it was decided to calculate the relative vapour pressure for each laboratory according to both test methods by using all reported components concentrations. When the result of the calculation method of ASTM D2598 is compared with the result of the calculation method of ISO8973, it is noticed that the difference in the means is significant, while the difference in the reproducibilities is not significant. See also the discussion in paragraph 5. The calculated reproducibilities after rejection of the five suspect test results are in agreement with the reproducibilities observed in the previous PT iis16S03P (0.872 vs 0.962 for ISO8973:97 and 0.956 vs 1.007 for ASTM D2598:16).

Abs. VP at 40°C: This determination may be problematic for a number of laboratories. The range of the reported test results is large: from 1299 - 1327 kPa. One statistical outlier was observed and two test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility observed in the previous iis16S03P (3.91 vs.5.83).

Rel. VP at 40°C: This determination may be problematic for a number of laboratories. The range of the reported test results is large: from 1198 – 1227 kPa. One statistical outlier was observed and two test results were excluded. The calculated reproducibility after rejection of the suspect data is in agreement with the reproducibility observed in the previous iis16S03P (3.88 vs.6.64).

**MON:** As the reported results calculated via ASTM D2598 and EN589 are not identical, it was decided to calculate MON for each laboratory according to both test methods by using all reported components concentrations. When the result of the calculation method of ASTM D2598 is compared with the result of the calculation method of EN589, it is noticed that the difference in the means is significant and the difference in the precisions is also significant. See also the discussion in paragraph 5. The calculated reproducibilities after rejection of the suspect data are in agreement with the reproducibilities observed in the previous PT iis16S03P (0.038 vs 0.035 for EN589:08-A1:12 and 0.064 vs 0.069 for ASTM D2598:16). Unfortunately, method ASTM D2598:16 does not mention a MON factor for iso-Butene. Therefore, iis has used the value of cis-2-Butene (83.5) for iso-Butene.

**Ideal Gross Heating Value at 14.696 psi / 60F:**

This calculated parameter may be problematic for a number of laboratories. The results vary over a range from 2068.3493 – 2269.1 kJ/mol. As the effect of the different factors from ASTM D3588 and ISO6976 on the calculation is very small, it was decided to calculate Ideal Gross Heating Value according to ASTM D3588:98(2017). See also the discussion in paragraph 5.

**Ideal Net Heating Value at 14.696 psi / 60F:**

This calculated parameter may be problematic for a number of laboratories. The results vary over a range from 2049.74 – 2088.3 kJ/mol. As the effect of the different factors from ASTM D3588 and ISO6976 on the calculation is very small, it was decided to calculate Ideal Gross Heating Value according to ASTM D3588:98(2017). See also the discussion in paragraph 5.

**Sulphur in LPG: sample #17211**

**Sulphur, total:** The determination of this component was not problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier, is in good agreement with the requirements of ASTM D6667:14.

## 4.2 PERFORMANCE EVALUATION FOR THE GROUP OF LABORATORIES

A comparison has been made between the reproducibility as declared by the relevant standard and the reproducibility as found for the group of participating laboratories. The average results per sample, calculated reproducibilities and reproducibilities, derived from literature standards (in casu ASTM, ISO standards) are compared in the next tables.

Parameter	unit	n	average	2.8 * sd	R(D2163:14*1) in %mol	R(EN27941) liq.-inj. in %mol
Ethane	%mol/mol	43	0.184	0.040	0.107	0.298
Propane	%mol/mol	43	93.95	0.66	4.19	1.02
Propene	%mol/mol	42	0.701	0.076	0.225	0.213
iso-Butane	%mol/mol	42	2.10	0.21	0.22	0.39
n-Butane	%mol/mol	44	2.14	0.30	0.19	0.39
1-Butene	%mol/mol	42	0.150	0.022	0.059	0.160
Iso-Butene	%mol/mol	42	0.151	0.021	0.059	0.160
n-Pentane	%mol/mol	44	0.621	0.097	0.077	0.311
Molar Mass	g/mol	21	44.86	0.08	n.a.	n.a.
Rel. Density at 60F		25	0.5115	0.0010	n.a.	n.a.
Abs. VP at 100F-ISO	psi	41	185.2	0.9	n.a.	n.a.
Abs. VP at 100F-ASTM	psi	41	181.7	1.0	n.a.	n.a.
Rel. VP at 100F-ISO	psi	41	170.5	0.9	n.a.	n.a.
Rel. VP at 100F-ASTM	psi	41	167.0	1.0	n.a.	n.a.
Abs. VP at 40°C	kPa	18	1313.6	3.9	n.a.	n.a.
Rel. VP at 40°C	kPa	18	1212.3	3.9	n.a.	n.a.
MON – EN589		41	95.12	0.04	n.a.	n.a.
MON – D2598		43	96.53	0.06	n.a.	n.a.
Ideal Gross HV	kJ/mol	40	2256.1	3.8	n.a.	n.a.
Net Gross HV	kJ/mol	40	2076.4	3.5	n.a.	n.a.

Table 4: reproducibilities of tests on sample #17210

Parameter	unit	n	average	2.8 * sd	R(lit)
Sulphur, total	mg/kg	7	36.2	9.5	11.3

Table 5: reproducibility of test on sample #17211

Without further statistical calculations it can be concluded that for a large number of parameters there is a good compliance of the group of participating laboratories with the relevant reference test methods. The problematic tests have been discussed in paragraph 4.1.

### 4.3 COMPARISON OF THE PROFICIENCY TEST OF OCTOBER 2017 WITH PREVIOUS PTS

	Oct. 2017	Oct. 2016	Oct. 2015	Oct. 2014	Oct. 2013
Number of reporting labs	47	43	41	44	35
Number of test results reported	536	472	468	395	367
Statistical outliers	30	34	24	27	26
Percentage outliers	5.6%	7.2%	5.1%	6.8%	7.1%

Table 6: comparison with previous proficiency tests on Liquefied Propane (excluded Sulphur in LPG)

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 the respective standards. The conclusions are given the following tables:

Component	Oct. 2017	Oct. 2016	Oct. 2015	Oct. 2014	Oct. 2013
Ethane	++	++	++	-	--
Propane	++	++	++	+/-	+/-
Propene	++	++	+	+/-	-
iso-Butane	+/-	-	+	+/-	-
n-Butane	-	-	-	-	--
1-Butene	++	++	++	--	--
Iso-Butene	++	+	++	--	--
n-Pentane	-	-	-	--	--

Table 7: comparison determinations on Liquefied Propane against the requirements of the reference standards  
For 2013 against D2163:96 and for 2014 – 2017 against D2163:14e1.

Component	Oct. 2017
Sulphur, total	+

Table 8: comparison determinations on Sulphur in LPG against the requirements of the reference standard

The performance of the determinations against the requirements of the respective standards is listed in the above tables. The following performance categories were used:

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

## 5 DISCUSSION

Because several of the reproducibility requirements of ASTM D2163 differ significantly from the reproducibility requirements of EN27941 (for liquid injection), the outcome of the evaluation will be strongly dependent on the target 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 EffectTech, United Kingdom in the following table.

Parameter	Average values by EffectTech in %mol/mol	Consensus values from participants results in %mol/mol	Absolute differences in %mol/mol	calc. z-score
Ethane	0.200	0.184	-0.016	+0.41
Propane	94.103	93.953	-0.150	+0.10
Propene	0.706	0.701	-0.005	+0.06
iso-Butane	2.032	2.10	0.068	-0.86
n-Butane	2.065	2.14	0.075	-1.06
1-Butene	0.150	0.150	0.000	-0.00
Iso-Butene	0.148	0.151	0.003	-0.16
n-Pentane	0.597	0.621	0.024	-0.88

Table 9: comparison of consensus values with values determined by EffectTech

From this comparison it is clear that all consensus values as determined in this PT are in line with the values as determined by EffectTech during the preparation of the cylinders.

One laboratory reported traces of Cyclopropane. This component is probably present as impurity in one or more of the pure components that were used to prepare the Propane 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, Vapour Pressure, Motor Octane Number and 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 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.

It is remarkable to see that the results for Vapour Pressure from the ASTM D2598 calculation are significantly lower than the results from the ISO8973/IP432 calculation.



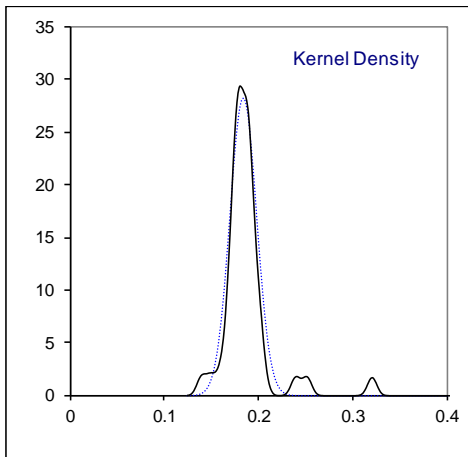
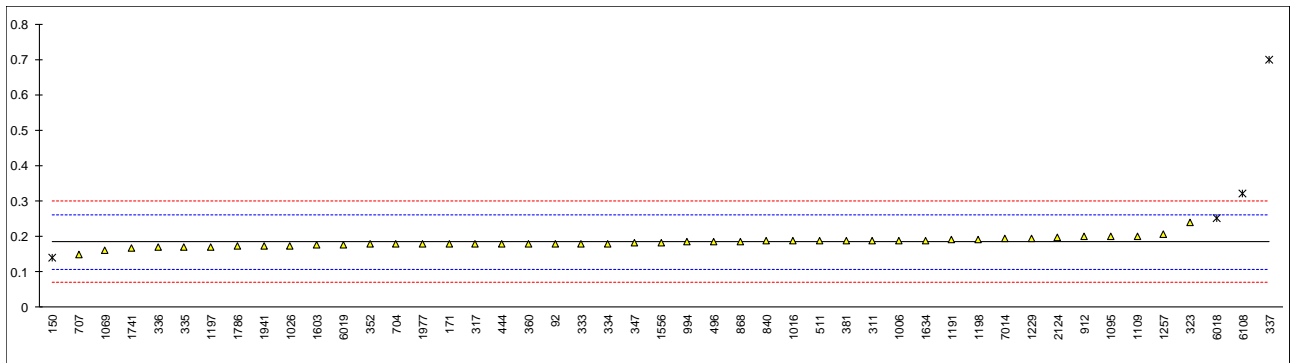
The observed difference is caused by a difference in the VP factor of Ethane. ASTM (Subcommittee D02.H) commented (see also Appendix 3, literature: 20):

*“The vapor pressure of ethane in D2598 was revised a few times prior to 2002. The current value, 611 psi, has remained the same for the last ten years. The revision of ethane was done because components in LPG blends do not necessarily behave as ideal gases. In particular, properties of ethane and ethylene appear to differ from ideality. Factors for these two components have been modified from ‘ideal gas’ values to make the calculated vapor pressure results more closely approximate actual measured vapor pressures of LPG blends. (i.e. D1267). Chapter 2 of Fuels and Lubricants Handbook (George Totten, © 2003), states that calculated vapor pressure were found to be biased high relative to experimental vapor pressure measured by D1267 for high ethane samples in earlier versions of D2598”.*

## APPENDIX 1

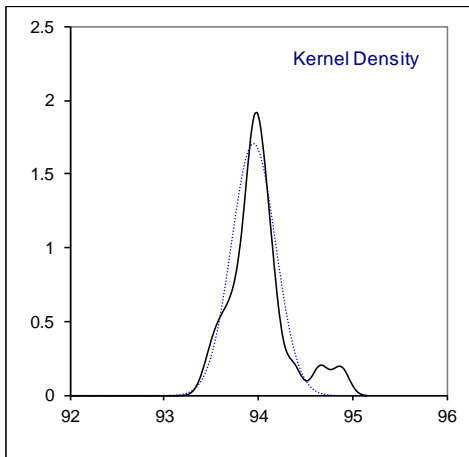
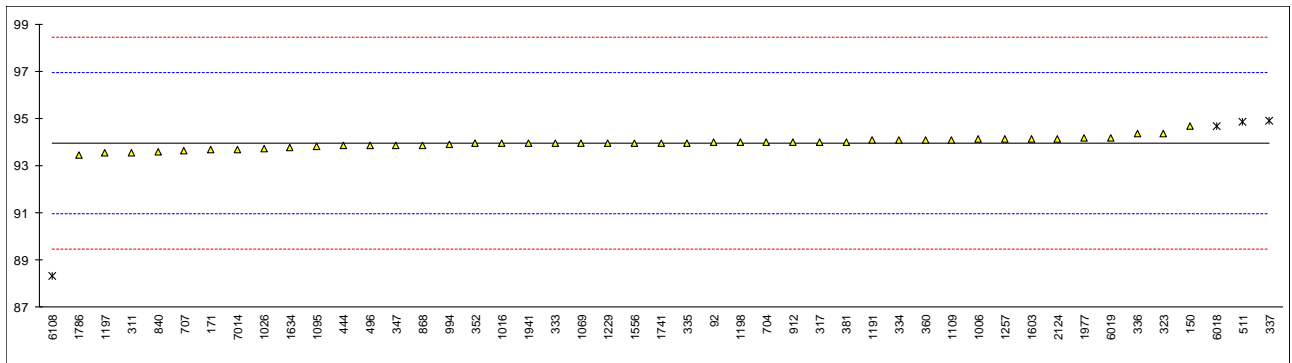
Determination of Ethane on sample #17210; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.18		-0.11	
150	D2163	0.14	R(0.01)	-1.16	
158		-----		-----	
171	D2163	0.18		-0.11	
311	D2163	0.19		0.15	
317	D2163	0.18		-0.11	
323	D2163	0.24		1.45	
333		0.18		-0.11	
334		0.18		-0.11	
335	D2163	0.17		-0.38	
336	D2163	0.17		-0.38	
337	D2163	0.7	C,R(0.01)	13.46	first reported 0.5
347	D2163	0.184		-0.01	
352	EN27941	0.1788		-0.15	
360	EN27941	0.18		-0.11	
381	EN27941	0.19		0.15	
444	D2163	0.180		-0.11	
496	D2163	0.187		0.07	
511	D2163	0.19		0.15	
529		-----		-----	
704	D2163	0.179		-0.14	
707	D2163	0.150		-0.90	
754		-----		-----	
823		-----		-----	
840	D2163	0.189		0.12	
868	D2163	0.187		0.07	
912	D2163	0.20		0.41	
994	D2163	0.186		0.04	
1006	D2163	0.190		0.15	
1016	ISO7941	0.189		0.12	
1026	D2163	0.1746		-0.26	
1069	D2712Mod.	0.16		-0.64	
1095	ISO7941	0.2		0.41	
1109	IP405	0.20		0.41	
1191	IP473	0.1915		0.19	
1197	D2163	0.172		-0.32	
1198	D2163	0.192		0.20	
1229	IP473	0.194		0.25	
1257	D2163	0.2056		0.55	
1556	EN27941	0.184		-0.01	
1575		-----		-----	
1603	In house	0.1752		-0.24	
1634	EN27941	0.19		0.15	
1741	EN27941	0.166		-0.48	
1786	D2163	0.173		-0.30	
1941	EN27941	0.1735		-0.28	
1977	D2712	0.1793		-0.13	
2124	D2163	0.1987		0.37	
6018	EN27941	0.252	R(0.01)	1.76	
6019	EN27941	0.176		-0.22	
6108	D2163	0.321	R(0.01)	3.57	
7014	D2163	0.1933		0.23	
	normality	not OK			
	n	43			
	outliers	4			
	mean (n)	0.1844			
	st.dev. (n)	0.01412			
	R(calc.)	0.0395			
	st.dev.(D2163:14e1)	0.03832			
	R(D2163:14e1)	0.1073			Compare R(EN27941:93(liq)) = 0.2984



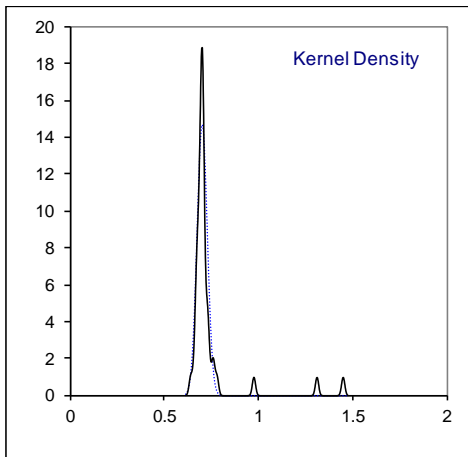
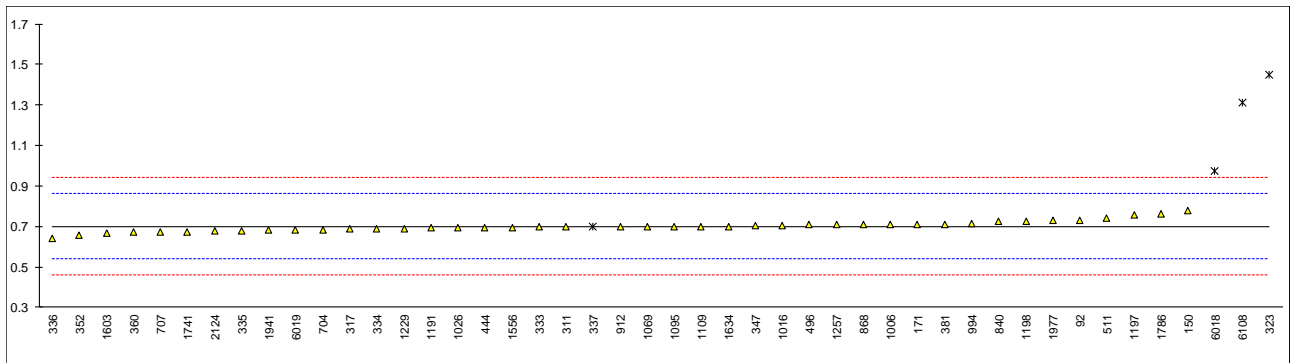
## Determination of Propane on sample #17210; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	93.99		0.02	
150	D2163	94.66		0.47	
158		-----		-----	
171	D2163	93.68		-0.18	
311	D2163	93.56		-0.26	
317	D2163	94.01		0.04	
323	D2163	94.38		0.29	
333		93.96		0.00	
334		94.07		0.08	
335	D2163	93.97		0.01	
336	D2163	94.37		0.28	
337	D2163	94.9	ex	0.63	excluded, see §4.1
347	D2163	93.855		-0.07	
352	EN27941	93.9334		-0.01	
360	EN27941	94.08		0.08	
381	EN27941	94.01		0.04	
444	D2163	93.839		-0.08	
496	D2163	93.843		-0.07	
511	D2163	94.86	R(0.05)	0.61	
529		-----		-----	
704	D2163	94.005		0.03	
707	D2163	93.642		-0.21	
754		-----		-----	
823		-----		-----	
840	D2163	93.580		-0.25	
868	D2163	93.866		-0.06	
912	D2163	94.01		0.04	
994	D2163	93.911		-0.03	
1006	D2163	94.117		0.11	
1016	ISO7941	93.934		-0.01	
1026	D2163	93.7351		-0.15	
1069	D2712Mod.	93.96		0.00	
1095	ISO7941	93.8		-0.10	
1109	IP405	94.09		0.09	
1191	IP473	94.0642		0.07	
1197	D2163	93.523		-0.29	
1198	D2163	93.997		0.03	
1229	IP473	93.96		0.00	
1257	D2163	94.1267		0.12	
1556	EN27941	93.963		0.01	
1575		-----		-----	
1603	In house	94.1287		0.12	
1634	EN27941	93.77		-0.12	
1741	EN27941	93.966		0.01	
1786	D2163	93.452		-0.34	
1941	EN27941	93.9355		-0.01	
1977	D2712	94.1928		0.16	
2124	D2163	94.1536		0.13	
6018	EN27941	94.662	ex	0.47	excluded, see §4.1
6019	EN27941	94.200		0.17	
6108	D2163	88.332	R(0.01)	-3.76	
7014	D2163	93.690		-0.18	
	normality	suspect			
	n	43			
	outliers	2 (+2 ex)			
	mean (n)	93.9531			
	st.dev. (n)	0.23399			
	R(calc.)	0.6552			
	st.dev.(D2163:14e1)	1.49556			
	R(D2163:14e1)	4.1876			Compare R(EN27941:93(liq)) = 1.017



Determination of Propene on sample #17210; results in %mol/mol

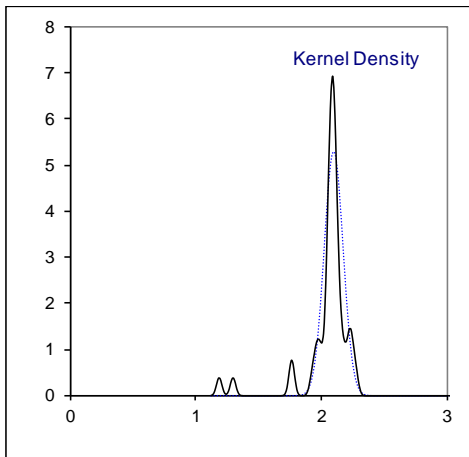
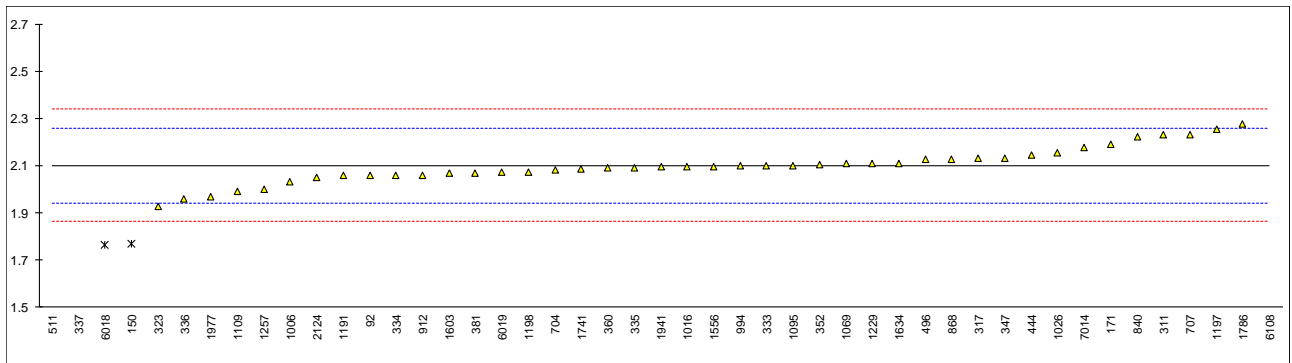
lab	method	value	mark	z(targ)	remarks
92	D2163	0.73		0.36	
150	D2163	0.78		0.98	
158		-----		-----	
171	D2163	0.71		0.11	
311	D2163	0.70		-0.02	
317	D2163	0.69		-0.14	
323	D2163	1.45	R(0.01)	9.30	
333		0.70		-0.02	
334		0.69		-0.14	
335	D2163	0.68		-0.26	
336	D2163	0.64		-0.76	
337	D2163	0.7	ex	-0.02	excluded, see §4.1
347	D2163	0.704		0.03	
352	EN27941	0.6573		-0.55	
360	EN27941	0.67		-0.39	
381	EN27941	0.71		0.11	
444	D2163	0.695		-0.08	
496	D2163	0.707		0.07	
511	D2163	0.74		0.48	
529		-----		-----	
704	D2163	0.684		-0.21	
707	D2163	0.670		-0.39	
754		-----		-----	
823		-----		-----	
840	D2163	0.727		0.32	
868	D2163	0.708		0.08	
912	D2163	0.70		-0.02	
994	D2163	0.713		0.15	
1006	D2163	0.709		0.10	
1016	ISO7941	0.704		0.03	
1026	D2163	0.6945		-0.08	
1069	D2712Mod.	0.70		-0.02	
1095	ISO7941	0.7		-0.02	
1109	IP405	0.70		-0.02	
1191	IP473	0.6933		-0.10	
1197	D2163	0.757		0.69	
1198	D2163	0.727		0.32	
1229	IP473	0.69		-0.14	
1257	D2163	0.7075		0.08	
1556	EN27941	0.695		-0.08	
1575		-----		-----	
1603	In house	0.6695		-0.39	
1634	EN27941	0.70		-0.02	
1741	EN27941	0.671		-0.38	
1786	D2163	0.762		0.75	
1941	EN27941	0.6806		-0.26	
1977	D2712	0.7296		0.35	
2124	D2163	0.6756		-0.32	
6018	EN27941	0.976	R(0.01)	3.41	
6019	EN27941	0.681		-0.25	
6108	D2163	1.311	R(0.01)	7.57	
7014		-----		-----	
	normality	suspect			
	n	42			
	outliers	3 (+1 ex)			
	mean (n)	0.7012			
	st.dev. (n)	0.02720			
	R(calc.)	0.0761			
	st.dev.(D2163:14e1)	0.08053			
	R(D2163:14e1)	0.2255			Compare R(EN27941:93(liq)) = 0.2132



## Determination of iso-Butane on sample #17210; results in %mol/mol

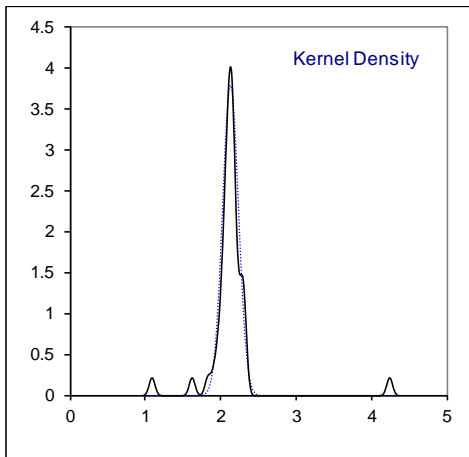
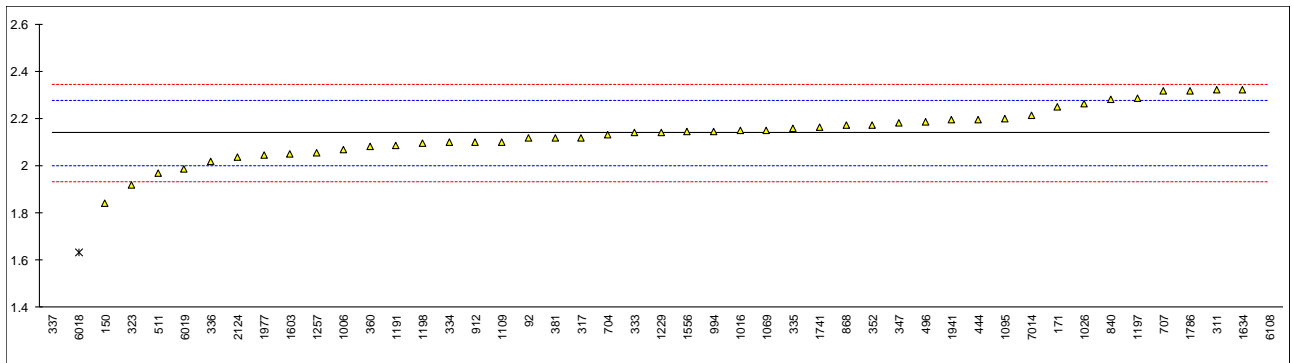
lab	method	value	mark	z(targ)	remarks
92	D2163	2.06		-0.51	
150	D2163	1.77	R(0.01)	-4.17	
158		-----		-----	
171	D2163	2.19		1.13	
311	D2163	2.23		1.63	
317	D2163	2.13		0.37	
323	D2163	1.93		-2.15	
333		2.10		-0.01	
334		2.06		-0.51	
335	D2163	2.09		-0.13	
336	D2163	1.96		-1.77	
337	D2163	1.3	C,R(0.01)	-10.10	first reported 1.7
347	D2163	2.131		0.38	
352	EN27941	2.1046		0.05	
360	EN27941	2.09		-0.13	
381	EN27941	2.07		-0.39	
444	D2163	2.145		0.56	
496	D2163	2.125		0.31	
511	D2163	1.19	R(0.01)	-11.48	
529		-----		-----	
704	D2163	2.082		-0.23	
707	D2163	2.233		1.67	
754		-----		-----	
823		-----		-----	
840	D2163	2.221		1.52	
868	D2163	2.126		0.32	
912	D2163	2.06		-0.51	
994	D2163	2.0996		-0.01	
1006	D2163	2.032		-0.86	
1016	ISO7941	2.095		-0.07	
1026	D2163	2.1563		0.70	
1069	D2712Mod.	2.11		0.12	
1095	ISO7941	2.1		-0.01	
1109	IP405	1.99		-1.39	
1191	IP473	2.0599		-0.51	
1197	D2163	2.254		1.93	
1198	D2163	2.074		-0.34	
1229	IP473	2.11		0.12	
1257	D2163	2.0026		-1.24	
1556	EN27941	2.097		-0.05	
1575		-----		-----	
1603	In house	2.0697		-0.39	
1634	EN27941	2.11		0.12	
1741	EN27941	2.088		-0.16	
1786	D2163	2.278		2.24	
1941	EN27941	2.0942		-0.08	
1977	D2712	1.9688		-1.66	
2124	D2163	2.0512		-0.62	
6018	EN27941	1.764	R(0.01)	-4.24	
6019	EN27941	2.071		-0.37	
6108	D2163	4.144	R(0.01)	25.77	
7014	D2163	2.1753		0.94	
	normality	OK			
	n	42			
	outliers	5			
	mean (n)	2.1006			
	st.dev. (n)	0.07520			
	R(calc.)	0.2106			
	st.dev.(D2163:14e1)	0.07930			
	R(D2163:14e1)	0.2220			Compare R(EN27941:93(liq)) = 0.3859





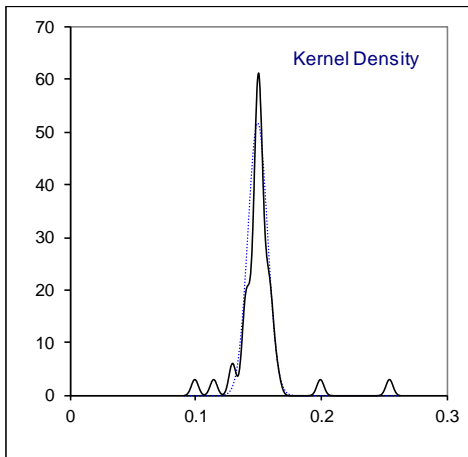
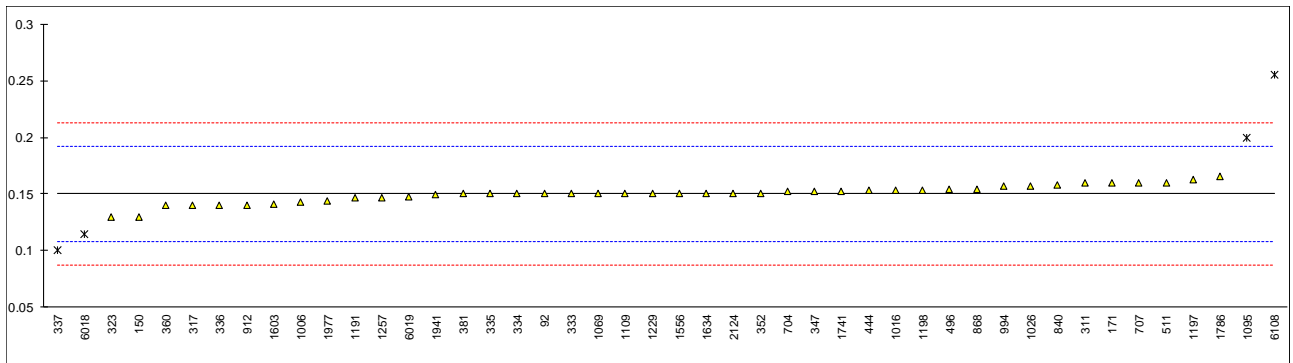
## Determination of n-Butane on sample #17210; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	2.12		-0.27	
150	D2163	1.84		-4.32	
158		-----		-----	
171	D2163	2.25		1.61	
311	D2163	2.32		2.62	
317	D2163	2.12		-0.27	
323	D2163	1.92		-3.16	
333		2.14		0.02	
334		2.10		-0.56	
335	D2163	2.16		0.31	
336	D2163	2.02		-1.71	
337	D2163	1.1	C,R(0.01)	-15.01	first reported 1.4
347	D2163	2.179		0.58	
352	EN27941	2.1728		0.49	
360	EN27941	2.08		-0.85	
381	EN27941	2.12		-0.27	
444	D2163	2.196		0.83	
496	D2163	2.184		0.66	
511	D2163	1.97		-2.44	
529		-----		-----	
704	D2163	2.132		-0.10	
707	D2163	2.317		2.58	
754		-----		-----	
823		-----		-----	
840	D2163	2.283		2.09	
868	D2163	2.172		0.48	
912	D2163	2.10		-0.56	
994	D2163	2.144		0.08	
1006	D2163	2.070		-0.99	
1016	ISO7941	2.148		0.14	
1026	D2163	2.2627		1.79	
1069	D2712Mod.	2.15		0.16	
1095	ISO7941	2.2		0.89	
1109	IP405	2.10		-0.56	
1191	IP473	2.0875		-0.74	
1197	D2163	2.285		2.12	
1198	D2163	2.094		-0.65	
1229	IP473	2.14		0.02	
1257	D2163	2.0552		-1.21	
1556	EN27941	2.143		0.06	
1575		-----		-----	
1603	In house	2.0492		-1.29	
1634	EN27941	2.32		2.62	
1741	EN27941	2.162		0.34	
1786	D2163	2.319		2.61	
1941	EN27941	2.1946		0.81	
1977	D2712	2.0445		-1.36	
2124	D2163	2.0349		-1.50	
6018	EN27941	1.631	R(0.01)	-7.34	
6019	EN27941	1.986		-2.21	
6108	D2163	4.246	R(0.01)	30.46	
7014	D2163	2.2144		1.10	
	normality	OK			
	n	44			
	outliers	3			
	mean (n)	2.1386			
	st.dev. (n)	0.10555			
	R(calc.)	0.2955			
	st.dev.(D2163:14e1)	0.06919			
	R(D2163:14e1)	0.1937			Compare R(EN27941:93(liq)) = 0.3859



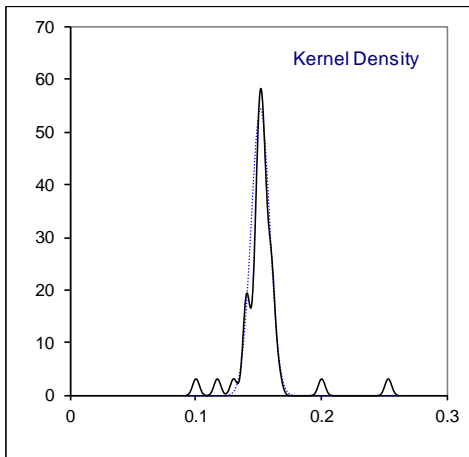
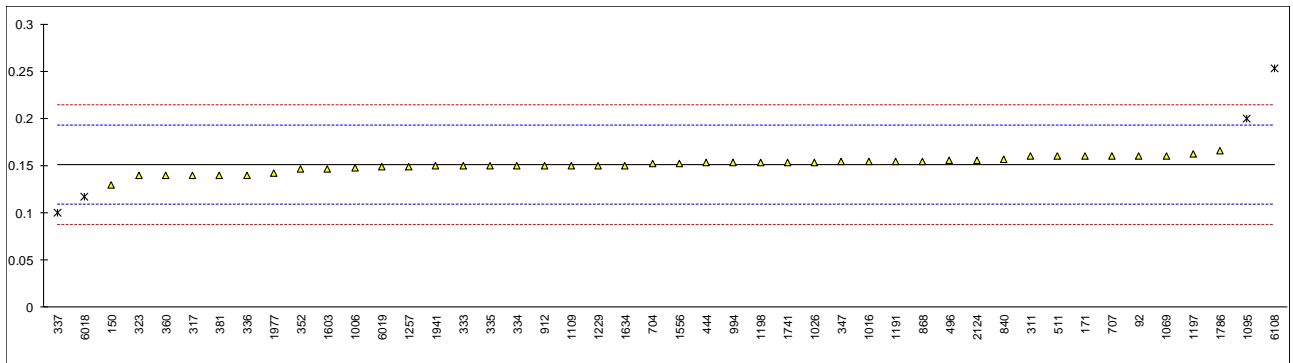
## Determination of 1-Butene on sample #17210; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.15		0.00	
150	D2163	0.13		-0.96	
158		-----		-----	
171	D2163	0.16		0.47	
311	D2163	0.16		0.47	
317	D2163	0.14		-0.48	
323	D2163	0.13		-0.96	
333		0.15		0.00	
334		0.15		0.00	
335	D2163	0.15		0.00	
336	D2163	0.14		-0.48	
337	D2163	0.1	R(0.01)	-2.39	
347	D2163	0.152		0.09	
352	EN27941	0.1506		0.02	
360	EN27941	0.14		-0.48	
381	EN27941	0.15		0.00	
444	D2163	0.153		0.14	
496	D2163	0.154		0.19	
511	D2163	0.16		0.47	
529		-----		-----	
704	D2163	0.152		0.09	
707	D2163	0.160		0.47	
754		-----		-----	
823		-----		-----	
840	D2163	0.158		0.38	
868	D2163	0.154		0.19	
912	D2163	0.14		-0.48	
994	D2163	0.157		0.33	
1006	D2163	0.143		-0.34	
1016	ISO7941	0.153		0.14	
1026	D2163	0.1571		0.34	
1069	D2712Mod.	0.15		0.00	
1095	ISO7941	0.2	R(0.01)	2.38	
1109	IP405	0.15		0.00	
1191	IP473	0.1463		-0.18	
1197	D2163	0.163		0.62	
1198	D2163	0.153		0.14	
1229	IP473	0.15		0.00	
1257	D2163	0.1465		-0.17	
1556	EN27941	0.150		0.00	
1575		-----		-----	
1603	In house	0.1414		-0.41	
1634	EN27941	0.15		0.00	
1741	EN27941	0.152		0.09	
1786	D2163	0.166		0.76	
1941	EN27941	0.1494		-0.03	
1977	D2712	0.1438		-0.30	
2124	D2163	0.1504		0.02	
6018	EN27941	0.115	R(0.01)	-1.68	
6019	EN27941	0.148		-0.10	
6108	D2163	0.255	R(0.01)	5.01	
7014		-----		-----	
	normality	OK			
	n	42			
	outliers	4			
	mean (n)	0.1501			
	st.dev. (n)	0.00773			
	R(calc.)	0.0217			
	st.dev.(D2163:14e1)	0.02093			
	R(D2163:14e1)	0.0586			Compare R(EN27941:93(liq)) = 0.1599



## Determination of iso-Butene on sample #17210; results in %mol/mol

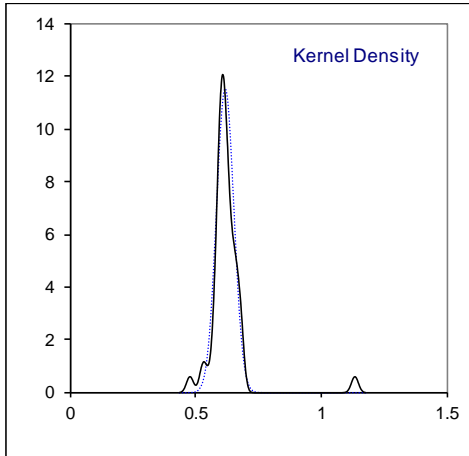
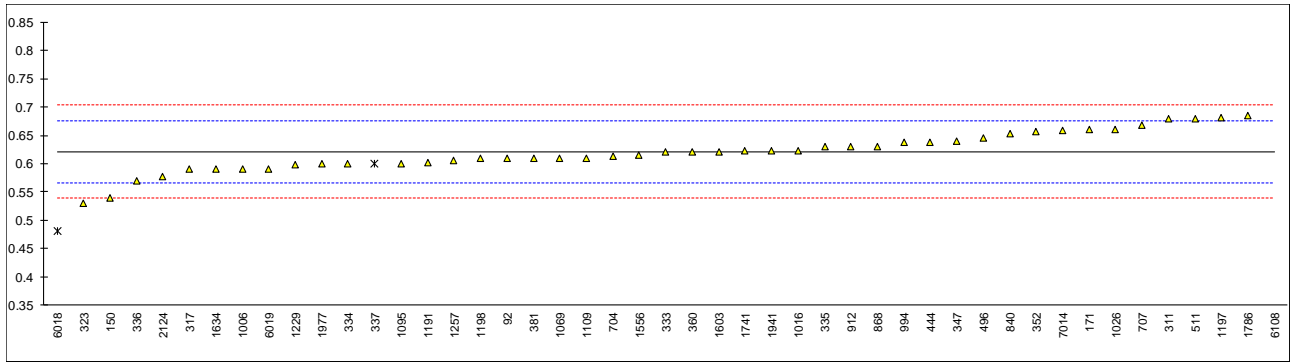
lab	method	value	mark	z(targ)	remarks
92	D2163	0.16		0.41	
150	D2163	0.13		-1.01	
158		-----		-----	
171	D2163	0.16		0.41	
311	D2163	0.16		0.41	
317	D2163	0.14		-0.54	
323	D2163	0.14		-0.54	
333		0.15		-0.06	
334		0.15		-0.06	
335	D2163	0.15		-0.06	
336	D2163	0.14		-0.54	
337	D2163	0.1	R(0.01)	-2.44	
347	D2163	0.154		0.13	
352	EN27941	0.1461		-0.25	
360	EN27941	0.14		-0.54	
381	EN27941	0.14		-0.54	
444	D2163	0.153		0.08	
496	D2163	0.156		0.22	
511	D2163	0.16		0.41	
529		-----		-----	
704	D2163	0.152		0.03	
707	D2163	0.160		0.41	
754		-----		-----	
823		-----		-----	
840	D2163	0.157		0.27	
868	D2163	0.155		0.18	
912	D2163	0.15		-0.06	
994	D2163	0.153		0.08	
1006	D2163	0.148		-0.16	
1016	ISO7941	0.154		0.13	
1026	D2163	0.1531		0.09	
1069	D2712Mod.	0.16		0.41	
1095	ISO7941	0.2	R(0.01)	2.32	
1109	IP405	0.15		-0.06	
1191	IP473	0.1540		0.13	
1197	D2163	0.163		0.56	
1198	D2163	0.153		0.08	
1229	IP473	0.15		-0.06	
1257	D2163	0.1494		-0.09	
1556	EN27941	0.152		0.03	
1575		-----		-----	
1603	In house	0.1461		-0.25	
1634	EN27941	0.15		-0.06	
1741	EN27941	0.153		0.08	
1786	D2163	0.166		0.70	
1941	EN27941	0.1499		-0.07	
1977	D2712	0.1416		-0.46	
2124	D2163	0.1560		0.22	
6018	EN27941	0.117	R(0.01)	-1.63	
6019	EN27941	0.149		-0.11	
6108	D2163	0.253	R(0.01)	4.84	
7014		-----		-----	
	normality	OK			
	n	42			
	outliers	4			
	mean (n)	0.1513			
	st.dev. (n)	0.00734			
	R(calc.)	0.0206			
	st.dev.(D2163:14e1)	0.02101			
	R(D2163:14e1)	0.0588			Compare R(EN27941:93(liq)) = 0.1599



## Determination of n-Pentane on sample #17210; results in %mol/mol

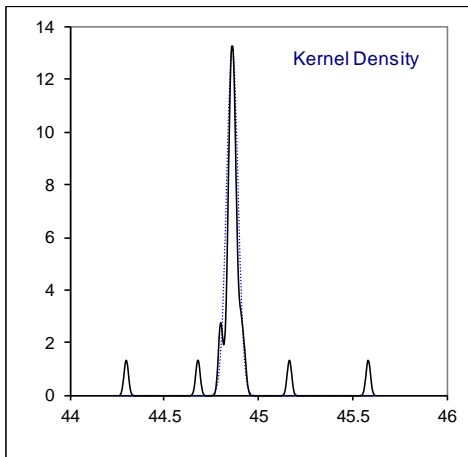
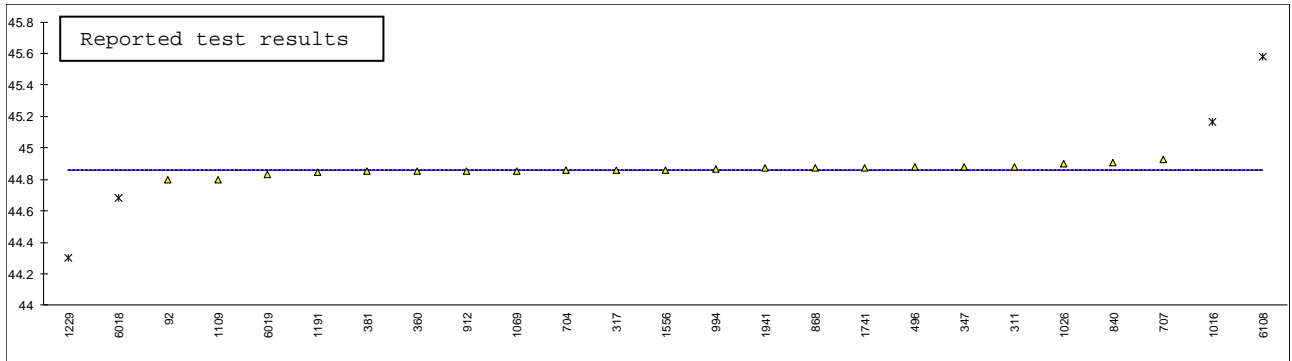
lab	method	value	mark	z(targ)	remarks
92	D2163	0.61		-0.40	
150	D2163	0.54		-2.95	
158		-----		-----	
171	D2163	0.66		1.42	
311	D2163	0.68		2.15	
317	D2163	0.59		-1.13	
323	D2163	0.53		-3.32	
333		0.62		-0.04	
334		0.60		-0.77	
335	D2163	0.63		0.33	
336	D2163	0.57		-1.86	
337	D2163	0.6	ex	-0.77	excluded, see §4.1
347	D2163	0.640		0.69	
352	EN27941	0.6565		1.29	
360	EN27941	0.62		-0.04	
381	EN27941	0.61		-0.40	
444	D2163	0.638		0.62	
496	D2163	0.645		0.87	
511	D2163	0.68		2.15	
529		-----		-----	
704	D2163	0.614		-0.26	
707	D2163	0.668		1.71	
754		-----		-----	
823		-----		-----	
840	D2163	0.653		1.16	
868	D2163	0.631		0.36	
912	D2163	0.63		0.33	
994	D2163	0.637		0.58	
1006	D2163	0.591		-1.10	
1016	ISO7941	0.623		0.07	
1026	D2163	0.6601		1.42	
1069	D2712Mod.	0.61		-0.40	
1095	ISO7941	0.6		-0.77	
1109	IP405	0.61		-0.40	
1191	IP473	0.6024		-0.68	
1197	D2163	0.682		2.22	
1198	D2163	0.609		-0.44	
1229	IP473	0.598		-0.84	
1257	D2163	0.6065		-0.53	
1556	EN27941	0.616		-0.18	
1575		-----		-----	
1603	In house	0.6202		-0.03	
1634	EN27941	0.59		-1.13	
1741	EN27941	0.622		0.03	
1786	D2163	0.684		2.29	
1941	EN27941	0.6223		0.05	
1977	D2712	0.5997		-0.78	
2124	D2163	0.5780		-1.57	
6018	EN27941	0.481	R(0.05)	-5.10	
6019	EN27941	0.591		-1.10	
6108	D2163	1.137	R(0.01)	18.79	
7014	D2163	0.659		1.38	
	normality	OK			
	n	44			
	outliers	2 (+1 ex)			
	mean (n)	0.6211			
	st.dev. (n)	0.03462			
	R(calc.)	0.0969			
	st.dev.(D2163:14e1)	0.02745			
	R(D2163:14e1)	0.0769			Compare R(EN27941:93(liq)) = 0.3109





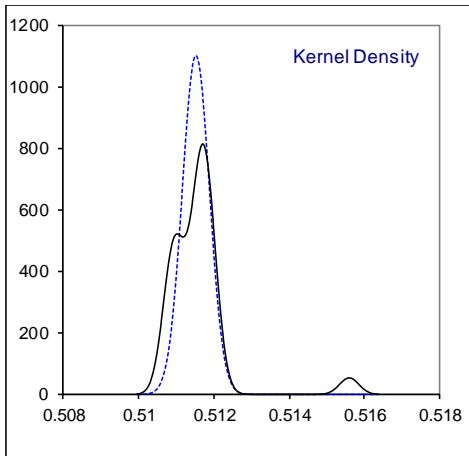
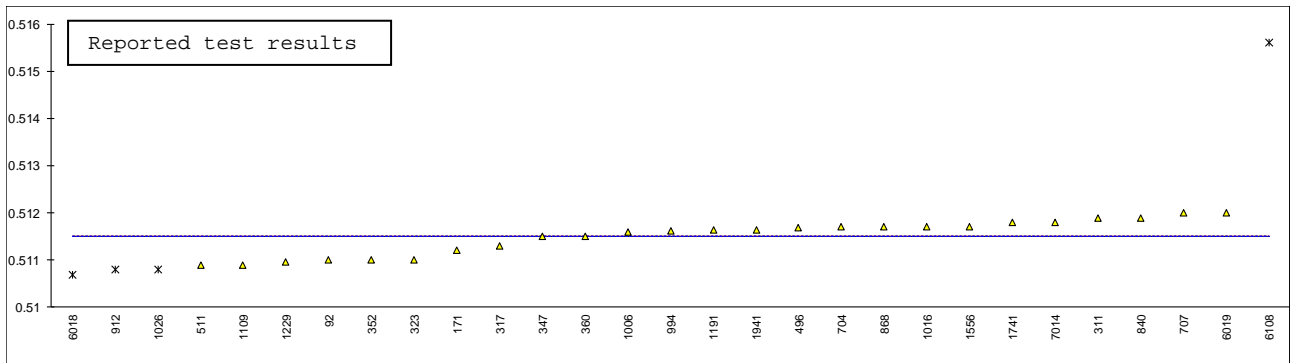
Determination of Molar Mass on sample #17210; results in g/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	44.8		----	
150		----		----	
158		----		----	
171		----		----	
311	INH-407	44.88		----	
317	INH-001	44.86		----	
323		----		----	
333		----		----	
334		----		----	
335		----		----	
336		----		----	
337		----		----	
347	D2598	44.88		----	
352		----		----	
360	ISO8973	44.85		----	
381	ISO8973	44.8499		----	
444		----		----	
496	D2163	44.878		----	
511		----		----	
529		----		----	
704	D2421	44.8568		----	
707	D2421	44.9252		----	
754		----		----	
823		----		----	
840	D2598	44.908		----	
868	D2598	44.87		----	
912	D2598	44.85		----	
994	D2163	44.867		----	
1006		----		----	
1016	EN27941	45.1645	ex,E	----	excluded, iis calculated 44.8617 (D2421)
1026	ISO8973	44.90		----	
1069	D2712Mod.	44.850		----	
1095		----		----	
1109	ISO8973	44.8		----	
1191	ISO6976	44.8432		----	
1197		----		----	
1198		----		----	
1229	ISO8973	44.3	R(0.01)	----	
1257		----		----	
1556	Calculated	44.86		----	
1575		----		----	
1603		----		----	
1634		----		----	
1741	D2421	44.8714		----	
1786		----		----	
1941	D2421	44.8696		----	
1977		----		----	
2124		----		----	
6018	ISO8973	44.68	ex	----	excluded, see §4.1
6019	ISO8973	44.83		----	
6108	D2598	45.582	ex	----	excluded, see §4.1
7014		----		----	
					Calc.by iis from ALL rep. composition results (acc. to D2421:13)
	normality	OK			OK
	n	21			40
	outliers	1 (+3 ex)			3 (+3 ex)
	mean (n)	44.862			44.863
	st.dev. (n)	0.0303			0.0291
	R(calc.)	0.085			0.082
Comp.	R(iis16S03P)	0.135			



Determination of Relative Density at 60/60F on sample #17210; unitless results

lab	method	value	mark	z(targ)	remarks
92	D2598	0.511		----	
150		----		----	
158		----		----	
171	D2421	0.5112		----	
311	INH-407	0.5119		----	
317	INH-001	0.5113		----	
323	D2598	0.5110		----	
333		----		----	
334		----		----	
335		----		----	
336		----		----	
337		----		----	
347	D2598	0.5115		----	
352	ISO8973	0.511		----	
360	D2598	0.5115		----	
381		----		----	
444		----		----	
496	D2598	0.51168		----	
511	D2598	0.5109		----	
529		----		----	
704	D2598	0.5117		----	
707	D2598	0.5120		----	
754		----		----	
823		----		----	
840	D2598	0.5119		----	
868	D2598	0.5117		----	
912	D2598	0.5108	ex, E	----	excluded, iis calculated 0.5115 (ASTM D2598)
994	D2598	0.51162		----	
1006	D2598	0.5116		----	
1016	ISO8973	0.5117		----	
1026		0.5108	ex, E	----	excluded, iis calculated 0.5118 (ASTM D2598)
1069		----		----	
1095		----		----	
1109	D2598	0.5109		----	
1191	D2598	0.511633		----	
1197		----		----	
1198		----		----	
1229	ISO8973	0.51097	C	----	reported 510.97
1257		----		----	
1556	ISO8973	0.5117	C	----	reported 511.7
1575		----		----	
1603		----		----	
1634		----		----	
1741	IOS8973	0.51180		----	
1786		----		----	
1941	D2598	0.51164		----	
1977		----		----	
2124		----		----	
6018	ISO8973	0.5107	ex	----	excluded, see §4.1
6019	ISO8973	0.512		----	
6108	D2598	0.5156	ex	----	excluded, see §4.1
7014	D2598	0.5118		----	
	normality	OK			Calc.by iis from ALL rep. composition results (acc. to D2598:16)
	n	25			suspect
	outliers	0 (+4 ex)			43
	mean (n)	0.51151			0 (+3 ex)
	st.dev. (n)	0.000361			0.51156
	R(calc.)	0.00101			0.000225
Comp.	R(iis16S03P)	0.00229			0.00063



Determination of Absolute Vapour Pressure at 100F on sample #17210; results in psi

lab	method	value	mark	-----	remarks
92		-----		-----	
150		-----		-----	
158		-----		-----	
171		-----		-----	
311	ISO8973	185.3		-----	
317	ISO8973	185.5		-----	
323		-----		-----	
333		-----		-----	
334		-----		-----	
335		-----		-----	
336		-----		-----	
337		-----		-----	
347	D2598	181.6		-----	
352		-----		-----	
360	ISO8973	185.5		-----	
381		-----		-----	
444		-----		-----	
496	D2598	181.57		-----	
511	D2598	169	ex,E	-----	excluded, iis calculated 183.1 (D2598), mix up with Rel. Vap. Pres.?
529		-----		-----	
704	ISO8973	185.4		-----	
707	ISO8973	184.7		-----	
754		-----		-----	
823		-----		-----	
840	D2598	181.3		-----	
868	D2598	181.6		-----	
912		-----		-----	
994	D2598	185.3	ex,E	-----	excluded, iis calc.181.7 (D2598), however iis calc. 185.2 (ISO8973)
1006	D2598	182.0		-----	
1016		185.4024		-----	
1026		179.1	ex,E	-----	excluded, iis calculated 181.3 (D2598) and iis calc. 184.8 (ISO8973)
1069		-----		-----	
1095	ISO8973	183.9	ex,E	-----	excluded, iis calculated 185.09 (ISO8973) and iis calc. 181.6 (D2598)
1109	ISO8973	185.5		-----	
1191	ISO8973	185.584		-----	
1197		-----		-----	
1198		-----		-----	
1229		-----		-----	
1257		-----		-----	
1556		-----		-----	
1575		-----		-----	
1603		-----		-----	
1634		-----		-----	
1741	ISO8973	185.22		-----	
1786		-----		-----	
1941	ISO8973	185.255		-----	
1977		-----		-----	
2124		-----		-----	
6018		-----		-----	
6019	ISO8973	1280	ex	-----	excluded, unit error? (kPa?)
6108	D2598	158.0	ex,E	-----	excluded, see §4.1, iis calculated 175.1 (D2598)
7014		-----		-----	

Calculated by iis from ALL reported composition results

ISO8973:97/IP432

D2598:16

normality

OK

suspect

n

41

41

outliers

2 (+3 ex)

2 (+3 ex)

mean (n)

185.176

181.704

st.dev. (n)

0.3114

0.3315

R(calc.)

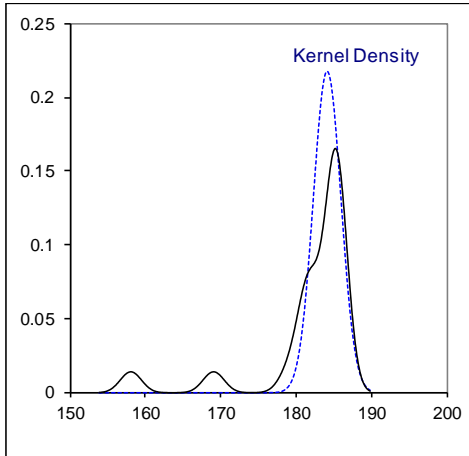
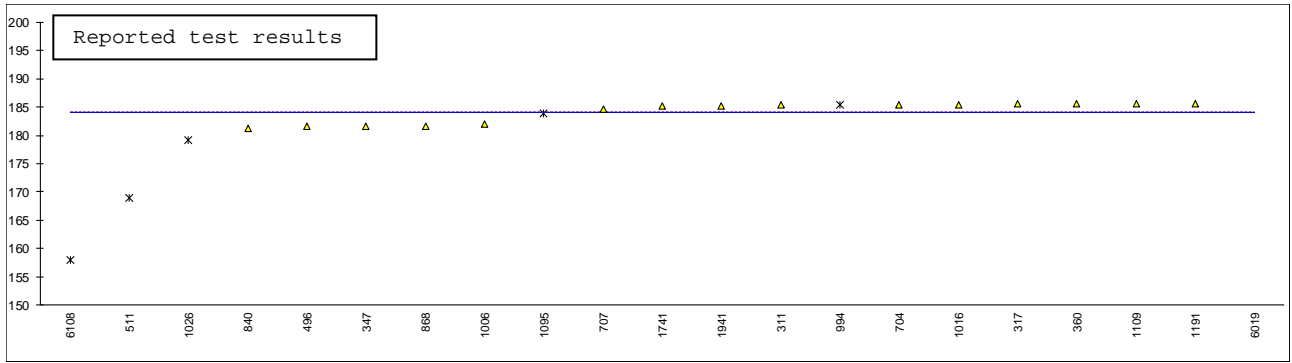
0.872

0.956

Comp. R(iis16S03P)

0.962

1.007



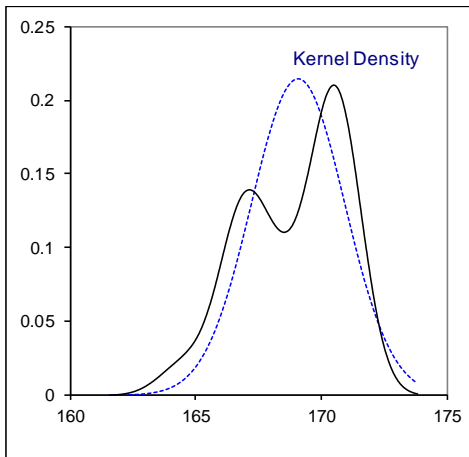
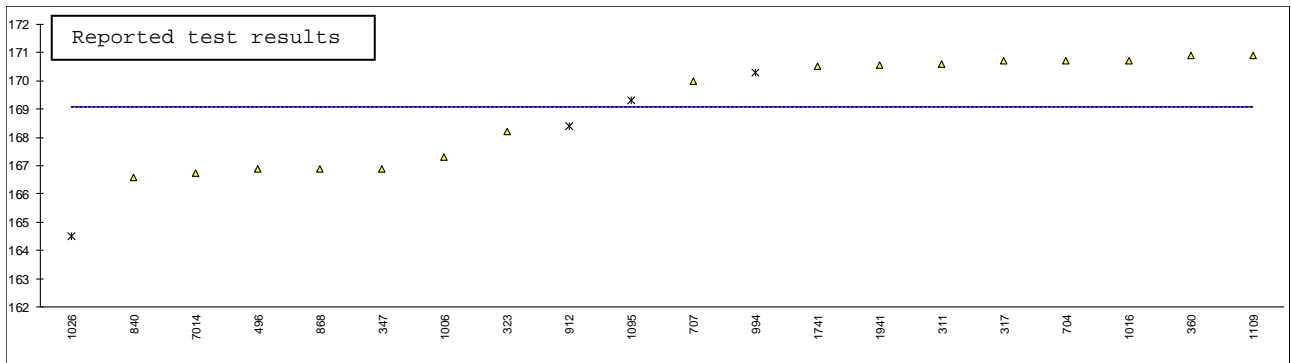
Determination of Relative Vapour Pressure at 100F on sample #17210; results in psi

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
158		----		----	
171		----		----	
311	ISO8973	170.6		----	
317	ISO8973	170.7		----	
323	D2598	168.2		----	
333		----		----	
334		----		----	
335		----		----	
336		----		----	
337		----		----	
347	D2598	166.9		----	
352		----		----	
360	ISO8973	170.9		----	
381		----		----	
444		----		----	
496	D2598	166.87		----	
511		----		----	
529		----		----	
704	ISO8973	170.7		----	
707	ISO8973	170.0		----	
754		----		----	
823		----		----	
840	D2598	166.6		----	
868	D2598	166.9		----	
912	D2598	168.4	ex,E	----	excluded, iis calculated 167.2 (D2598)
994	D2598	170.3	ex,E	----	excluded, iis calculated 167.0 (D2598)
1006	D2598	167.3		----	
1016		170.7064		----	
1026		164.5	ex,E	----	excluded, iis calc. 166.6 (D2598) and iis calc. 170.1 (ISO8973)
1069		----		----	
1095	ISO8973	169.3	ex,E	----	excluded, iis calculated 170.4 (ISO8973)
1109	ISO8973	170.9		----	
1191		----		----	
1197		----		----	
1198		----		----	
1229		----		----	
1257		----		----	
1556		----		----	
1575		----		----	
1603		----		----	
1634		----		----	
1741	ISO8973	170.52		----	
1786		----		----	
1941	ISO8973	170.559		----	
1977		----		----	
2124		----		----	
6018		----		----	
6019		----		----	
6108		----		----	
7014	D2598	166.75		----	

Calculated by iis from ALL reported composition results

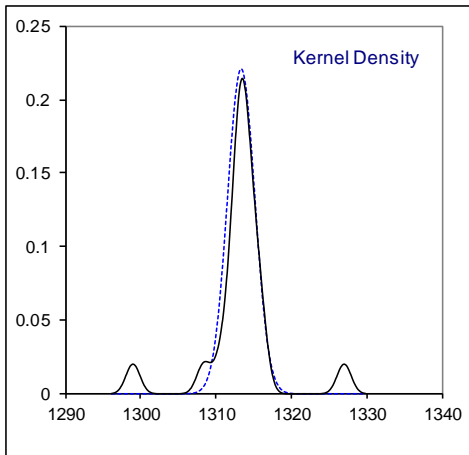
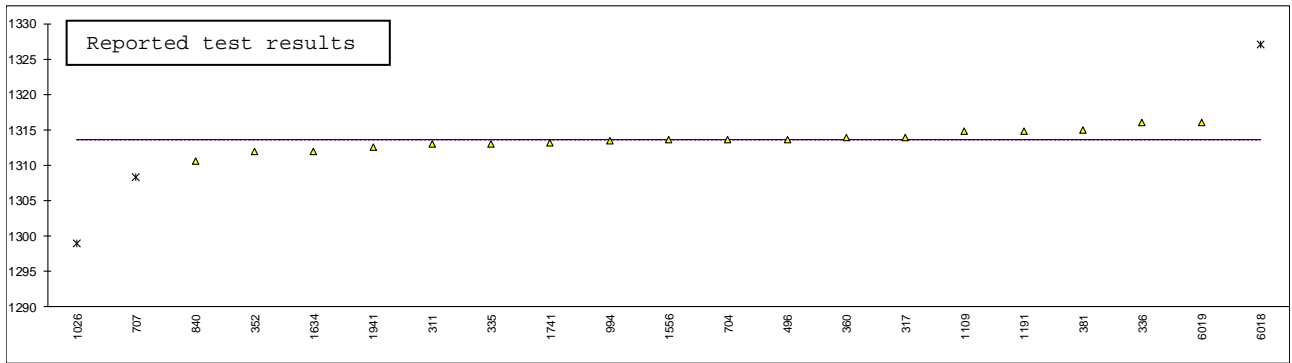
	<u>ISO8973:97/IP432</u>	<u>D2598:16</u>
normality	OK	suspect
n	41	41
outliers	2 (+3 ex)	2 (+3 ex)
mean (n)	170.480	167.008
st.dev. (n)	0.3114	0.3415
R(calc.)	0.872	0.956
Comp. R(iis16S03P)	0.962	1.007





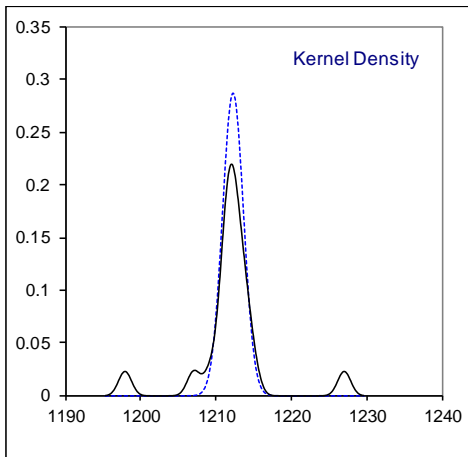
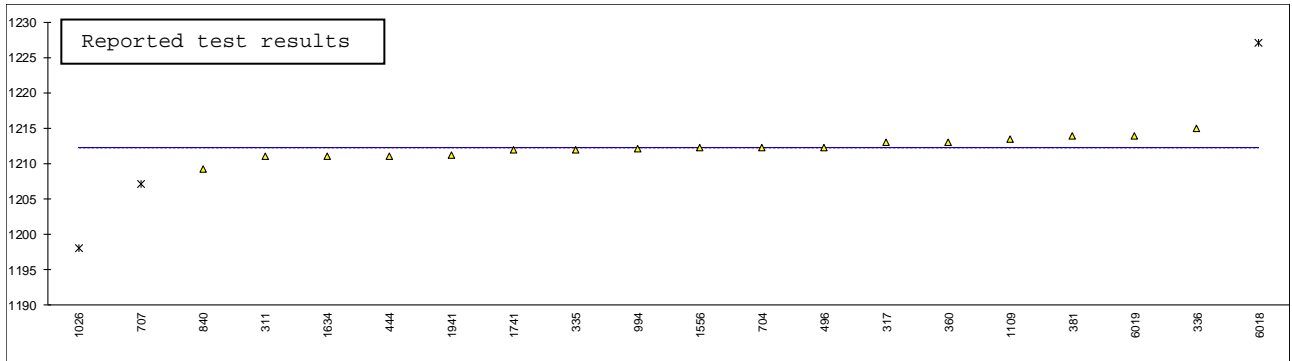
## Determination of Absolute Vapour Pressure at 40°C on sample #17210; results in kPa

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
158		----		----	
171		----		----	
311	ISO8973	1313		----	
317	ISO8973	1314		----	
323		----		----	
333		----		----	
334		----		----	
335	ISO8973	1313		----	
336	ISO8973	1316		----	
337		----		----	
347		----		----	
352	ISO8973	1312		----	
360	ISO8973	1314		----	
381	ISO8973	1315		----	
444		----		----	
496	ISO8973	1313.64		----	
511		----		----	
529		----		----	
704	ISO8973	1313.6		----	
707	ISO8973	1308.4	G(0.05)	----	
754		----		----	
823		----		----	
840	ISO8973	1310.6		----	
868		----		----	
912		----		----	
994	ISO8973	1313.4		----	
1006		----		----	
1016		----		----	
1026		1299	ex,E	----	excluded, iis calculated 1311 (ISO8973)
1069		----		----	
1095		----		----	
1109	ISO8973	1314.8		----	
1191	ISO8973	1314.90		----	
1197		----		----	
1198		----		----	
1229		----		----	
1257		----		----	
1556	ISO8973	1313.56		----	
1575		----		----	
1603		----		----	
1634	ISO8973	1312		----	
1741	ISO8973	1313.21		----	
1786		----		----	
1941	ISO8973	1312.54		----	
1977		----		----	
2124		----		----	
6018	ISO8973	1327	ex	----	excluded, see §4.1
6019	ISO8973	1316		----	
6108		----		----	
7014		----		----	
	normality	OK			
	n	18			
	outliers	1 (+2 ex)			
	mean (n)	1313.63			
	st.dev. (n)	1.395			
	R(calc.)	3.91			
Comp.	R(iis16S03P)	5.83			



## Determination of Relative Vapour Pressure at 40°C on sample #17210; results in kPa

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
158		----		----	
171		----		----	
311	ISO8973	1211		----	
317	ISO8973	1213		----	
323		----		----	
333		----		----	
334		----		----	
335	ISO8973	1212		----	
336	ISO8973	1215		----	
337		----		----	
347		----		----	
352		----		----	
360	ISO8973	1213		----	
381	ISO8973	1214		----	
444	ISO8973	1211.1		----	
496	ISO8973	1212.32		----	
511		----		----	
529		----		----	
704	ISO8973	1212.3		----	
707	ISO8973	1207.1	G(0.05)	----	
754		----		----	
823		----		----	
840	ISO8973	1209.3		----	
868		----		----	
912		----		----	
994	ISO8973	1212.1		----	
1006		----		----	
1016		----		----	
1026		1198	ex,E	----	excluded, iis calculated 1209 (ISO8973)
1069		----		----	
1095		----		----	
1109	ISO8973	1213.5		----	
1191		----		----	
1197		----		----	
1198		----		----	
1229		----		----	
1257		----		----	
1556	ISO8973	1212.24		----	
1575		----		----	
1603		----		----	
1634	ISO8973	1211		----	
1741	ISO8973	1211.89		----	
1786		----		----	
1941	ISO8973	1211.22		----	
1977		----		----	
2124		----		----	
6018	ISO8973	1227	ex	----	excluded, see §4.1
6019	ISO8973	1214		----	
6108		----		----	
7014		----		----	
	normality	OK			
	n	18			
	outliers	1 (+2 ex)			
	mean (n)	1212.29			
	st.dev. (n)	1.387			
	R(calc.)	3.88			
Comp.	R(iis16S03P)	6.64			

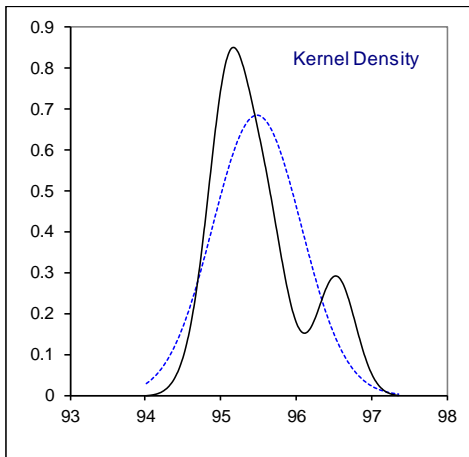
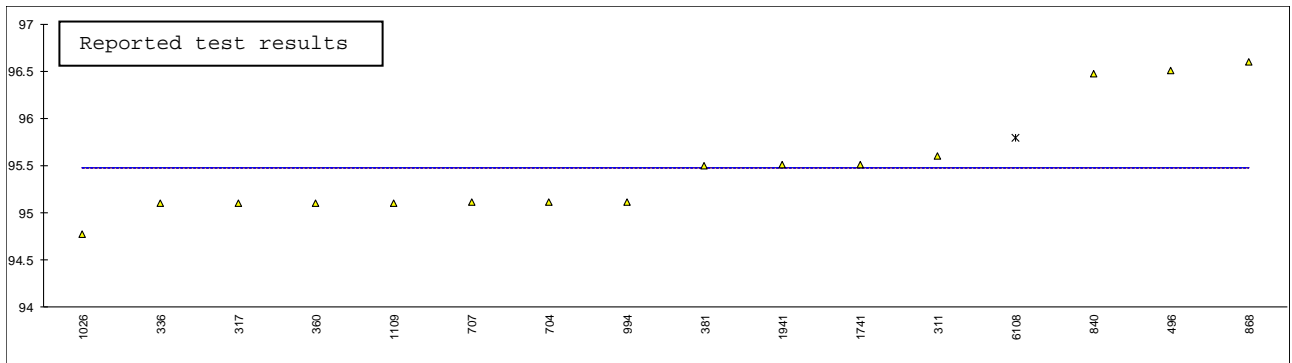


Determination of Motor Octane Number, MON on sample #17210;

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
158		----		----	
171		----		----	
311	EN589	95.6		----	
317	EN589	95.1		----	
323		----		----	
333		----		----	
334		----		----	
335		----		----	
336	EN589	95.1		----	
337		----		----	
347		----		----	
352		----		----	
360	EN589	95.1		----	
381	EN589	95.5		----	
444		----		----	
496	D2598	96.510		----	
511		----		----	
529		----		----	
704	EN589	95.12		----	
707	EN589	95.11		----	
754		----		----	
823		----		----	
840	D2598	96.47		----	
868	D2598	96.6		----	
912		----		----	
994	D2598	95.12		----	method used is probably EN598?
1006		----		----	
1016		----		----	
1026		94.77		----	
1069		----		----	
1095		----		----	
1109	EN589	95.1		----	
1191		----		----	
1197		----		----	
1198		----		----	
1229		----		----	
1257		----		----	
1556		----		----	
1575		----		----	
1603		----		----	
1634		----		----	
1741	EN589	95.510		----	
1786		----		----	
1941	EN589	95.509		----	
1977		----		----	
2124		----		----	
6018		----		----	
6019		----		----	
6108	D2598	95.8	ex	----	excluded, see §4.1
7014		----		----	

Calculated by iis from ALL reported composition results

	<u>EN589:08-A1:12</u>	<u>D2598:16</u>
normality	suspect	OK
n	41	43
outliers	2 (+3 ex)	0 (+3 ex)
mean (n)	95.118	96.529
st.dev. (n)	0.0136	0.0228
R(calc.)	0.038	0.064
Comp. R(iis16S03P)	0.035	0.069



Determination of Ideal Gross Heating Value at 14.696psi/60F on sample #17210; in kJ/mol

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
158		----		----	
171		----		----	
311		----		----	
317	D3588	2256.01		----	
323		----		----	
333		----		----	
334		----		----	
335		----		----	
336		----		----	
337		----		----	
347		----		----	
352		----		----	
360	ISO6976	2255.64		----	
381		----		----	
444		----		----	
496	D3588	2256.79		----	
511		----		----	
529		----		----	
704		----		----	
707		----		----	
754		----		----	
823		----		----	
840		----		----	
868		----		----	
912		----		----	
994		----		----	
1006		----		----	
1016		----		----	
1026		----		----	
1069		----		----	
1095		----		----	
1109	D3588	2269.1	ex,E	----	excluded, iis calculated 2254.58 (D5388)
1191		----		----	
1197		----		----	
1198		----		----	
1229		----		----	
1257		----		----	
1556		----		----	
1575		----		----	
1603	In house	2068.3493	ex, E	----	excluded, iis calculated 2255.27 (D5388)
1634	D3588	2227.38	ex, E	----	excluded, iis calculated 2256.39 (D5388)
1741		----		----	
1786		----		----	
1941		----		----	
1977		----		----	
2124		----		----	
6018		----		----	
6019		----		----	
6108		----		----	
7014		----		----	

Calculated by iis from ALL reported composition results

D3588:98

normality

OK

n

40

outliers

3 (+3 ex)

mean (n)

2256.14

st.dev. (n)

1.346

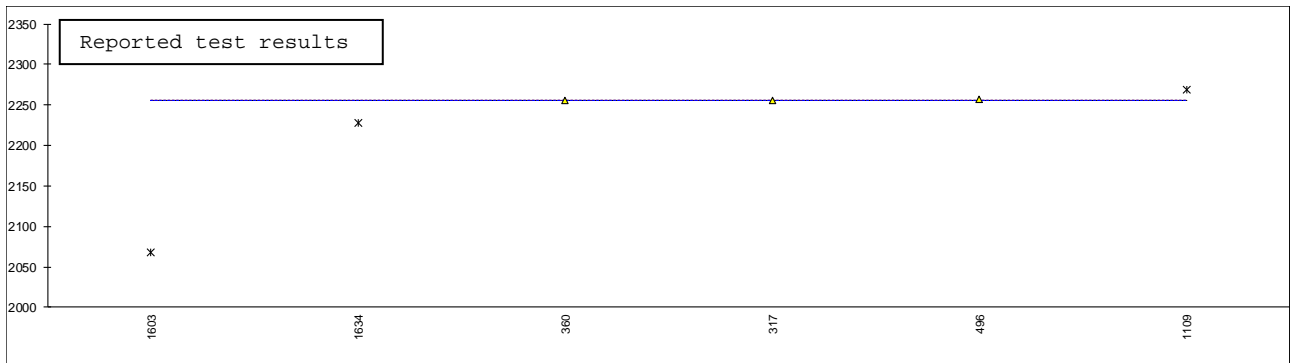
R(calc.)

3.77

R(target)

n.a.





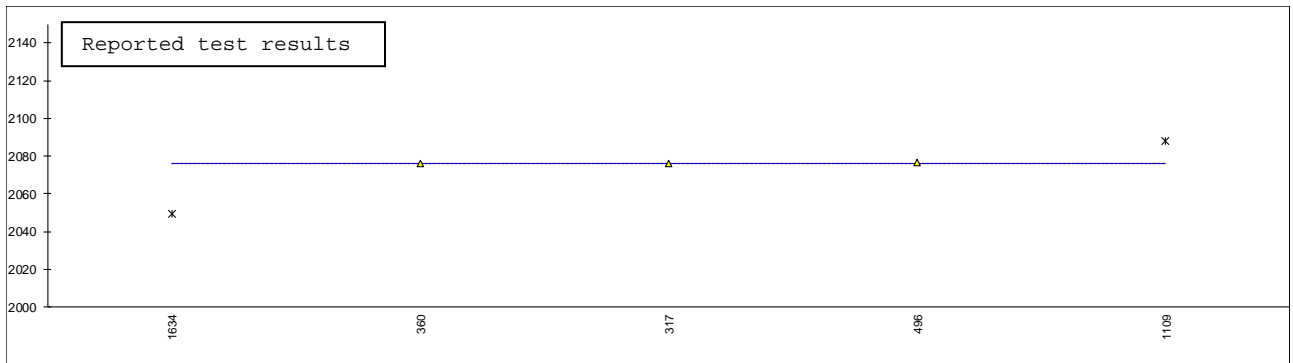
Determination of Ideal Net Heating Value at 14.696 psi/60F on sample #17210; results in kJ/mol

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
158		----		----	
171		----		----	
311		----		----	
317	D3588	2076.12		----	
323		----		----	
333		----		----	
334		----		----	
335		----		----	
336		----		----	
337		----		----	
347		----		----	
352		----		----	
360	ISO6976	2075.89		----	
381		----		----	
444		----		----	
496	D3588	2076.54		----	
511		----		----	
529		----		----	
704		----		----	
707		----		----	
754		----		----	
823		----		----	
840		----		----	
868		----		----	
912		----		----	
994		----		----	
1006		----		----	
1016		----		----	
1026		----		----	
1069		----		----	
1095		----		----	
1109	D3588	2088.3	ex, E	----	excluded, iis calculated 2074.95 (D5388)
1191		----		----	
1197		----		----	
1198		----		----	
1229		----		----	
1257		----		----	
1556		----		----	
1575		----		----	
1603		----		----	
1634	D3588	2049.74	ex, E	----	excluded, iis calculated 2076.64 (D5388)
1741		----		----	
1786		----		----	
1941		----		----	
1977		----		----	
2124		----		----	
6018		----		----	
6019		----		----	
6108		----		----	
7014		----		----	

Calculated by iis from ALL reported composition results

D3588:98

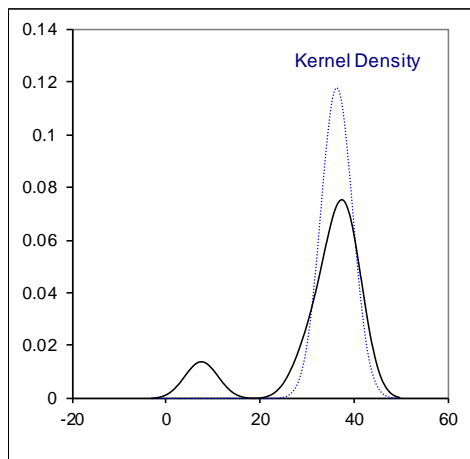
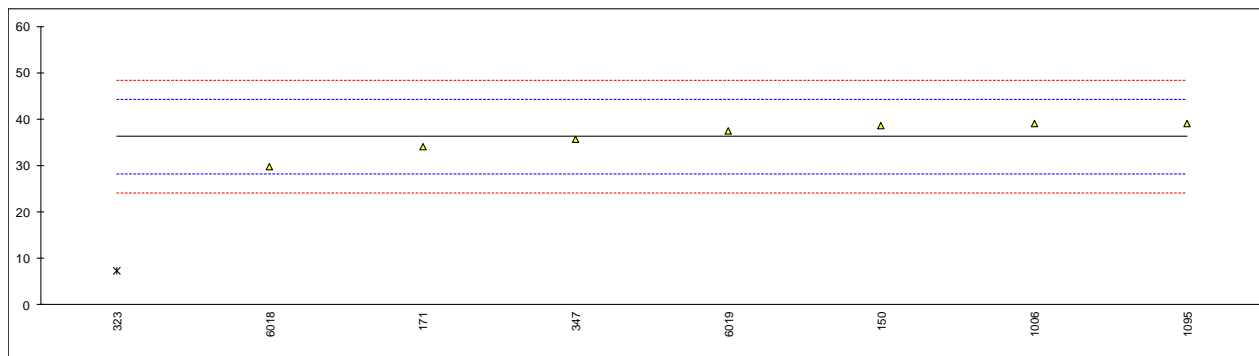
normality	OK
n	40
outliers	3 (+3 ex)
mean (n)	2076.41
st.dev. (n)	1.261
R(calc.)	3.53
R(target)	n.a.



Determination of Sulphur, total on sample #17211; results in mg/kg

lab	method	value	mark	z(targ)	remarks
150	D6667	38.6	C	0.58	first reported: 4.6
158		----		----	
171	D6667	34		-0.55	
323	D6667	7.4	C,D(0.05)	-7.12	first reported: 6.5
347	D6667	35.7		-0.13	
1006	D6667	39		0.68	
1095	D6667	39		0.68	
2124		----		----	
6018	D6667	29.84		-1.58	
6019	D6228	37.5	C	0.31	first reported: 72.6 mg DMS/kg

normality unknown  
n 7  
outliers 1  
mean (n) 36.23  
st.dev. (n) 3.383  
R(calc.) 9.47  
st.dev.(D6667:14) 4.050  
R(D6667:14) 11.34



## APPENDIX 2

### Number of participants per country in the Propane PT iis17S03P

2 labs in AUSTRALIA  
1 lab in AZERBAIJAN  
1 lab in BELGIUM  
1 lab in BULGARIA  
1 lab in CANADA  
1 lab in CHINA, People's Republic  
1 lab in COSTA RICA  
3 labs in FINLAND  
5 labs in FRANCE  
2 labs in GERMANY  
1 lab in INDIA  
1 lab in IRAN, Islamic Republic of  
3 labs in MALAYSIA  
1 lab in MEXICO  
4 labs in NETHERLANDS  
1 lab in PERU  
5 labs in PORTUGAL  
1 lab in RUSSIAN FEDERATION  
4 labs in SERBIA  
1 lab in SOUTH KOREA  
1 lab in SPAIN  
1 lab in SWEDEN  
1 lab in TAIWAN  
2 labs in UKRAINE  
1 lab in UNITED ARAB EMIRATES  
1 lab in UNITED KINGDOM  
3 labs in UNITED STATES OF AMERICA  
2 labs in VIETNAM

### Number of participants per country in the Sulphur in LPG PT iis17S03S

1 lab in AUSTRALIA  
1 lab in BELGIUM  
3 labs in PORTUGAL  
1 lab in SPAIN  
1 lab in TAIWAN  
3 labs in UNITED STATES OF AMERICA

### APPENDIX 3

#### Abbreviations:

C	= final 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
ex	= test result excluded from the statistical evaluation
n.a.	= not applicable
n.e.	= not evaluated
fr.	= first reported
SDS	= safety data sheet

#### Literature:

- 1 iis Interlaboratory Studies, Protocol for the Organization, Statistics and Evaluation, March 2017
- 2 ASTM D2163:14e1
- 3 ASTM D2421:13
- 4 ISO 5725:86
- 5 ISO 5725, parts 1-6, 1994
- 6 M. Thompson and R. Wood, J. AOAC Int, 76, 926, (1993)
- 7 W.J. Youden and E.H. Steiner, Statistical Manual of the AOAC, (1975)
- 8 IP 367:84
- 9 DIN 38402 T41/42
- 10 P.L. Davies, First reported Z. Anal. Chem, 331, 513, (1988)
- 11 J.N. Miller, Analyst, 118, 455, (1993)
- 12 Analytical Methods Committee Technical Brief, No4 January 2001
- 13 P.J. Lowthian and M. Thompson, The Royal Society of Chemistry, Analyst, 127, 1359-1364 (2002)
- 14 ISO 17043:2010
- 15 EN 27941:1993 = ISO 7941:88 = IP 405:94
- 16 ASTM D2598:16
- 17 IP 432:2000 = ISO 8973:1997
- 18 ASTM D2598:16
- 19 EN 589:08-A1:12
- 20 Private communication ASTM Subcommittee D02.H
- 21 ASTM D3588:98(2017)
- 22 ISO 6976:95(1996)
- 23 ISO 6976:16
- 24 Bernard Rosner, Percentage Points for a Generalized ESD Many-Outlier Procedure, Technometrics, 25(2), pp. 165-172, (1983)