

**Results of Proficiency Test
Liquefied Propane
November 2011**

Organised by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

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1 INTRODUCTION

During the last years, with increasing frequency, requests were received by iis from laboratories that participated in the iis PT program, to organize also a proficiency test for the Liquefied Propane Analysis. Beginning 2008, iis started an investigation for the feasibility of such a PT. Because iis has limited gas-handling facilities in place to prepare gas samples, Scott Specialty Gases (Breda, the Netherlands) was contacted. This company is fully equipped and has a broad experience in the preparation of synthetic Liquefied Propane samples for PT purposes. Together with this company, it was decided to organize a first proficiency study for Liquefied Propane (composition only) in 2009.

This interlaboratory study was repeated in 2011, in which now 30 laboratories from 20 different countries have participated. See appendix 3 for the number of participants per country.

In this report the results of the proficiency test on Liquefied Propane are presented and discussed.

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 Propane mixture. The mixture was divided over a batch of 31 cylinders.

The cylinder size is a cost-effective two-litre cylinder with dip tube device.

Each cylinder was uniquely numbered. The limited cylinder size is chosen to optimise transport and handling costs.

Participants were requested to report rounded and unrounded results, both in %M/M and in %mol/mol. The unrounded 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 guide 43, ISO 17043:2010 and ILAC-G13:2007. This ensures 100% confidentiality of participant's data. Also customer's satisfaction is measured on regular basis by the distribution of questionnaires.

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 January 2010 (iis-protocol, version 3.2), that can be downloaded from the iis web site <http://www.iisnl.com>.

2.3 CONFIDENTIALITY STATEMENT

All data present 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. A batch of two-litre cylinders with dip-tube containing artificial Liquefied Propane mixture was prepared and tested for homogeneity by Scott Specialty Gases (Breda, the Netherlands) in conformance with ISO 6143 and ISO Guide 35.

A batch of 31 cylinders (lot 86114) was prepared on October 10, 2011. Regrettably this batch was rejected as the between cylinders spread was too large to allow use in the PT.

Therefore a new batch of 31 cylinders (lot 86114R) was prepared on October 27, 2011. Each cylinder was labelled #11095 and also uniquely numbered. The cylinders were all tested in fivefold to check the homogeneity of the batch. By ANOVA analysis on the test results in accordance with ISO 6143 the in-between bottle standard deviation was calculated. 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 corresponding target reproducibilities in agreement with the procedure of ISO 13528, Annex B2 in the next table:

Parameter	conc. in %mol/mol	r (observed) in %mol/mol	0.3 X R(D2163) in %mol/mol
Ethane	0.1183	0.0039	0.0041
Propane	95.4488	0.0667	0.2863
Propylene	0.7782	0.0042	0.0269
n-Butane	1.0491	0.0404	0.0711
iso-Butane	2.0574	0.0173	0.0362
n-Pentane	0.5482	0.0163	0.0191
1-Butene	n/a	n/a	n/a
iso-Butene	n/a	n/a	n/a

Table 1: homogeneity test results

Each of the calculated repeatabilities is less than 0.3 times the corresponding reproducibility of the reference method ASTM D2163.

Therefore, homogeneity of the subsamples #11095 was assumed.

To each of the participating laboratories one 2L cylinder was sent on November 10, 2011.

2.5 STABILITY OF THE SAMPLES

Scott Specialty Gases (Breda, the Netherlands) declares that the prepared sample cylinders have a shelf life of at least 6 months. This is sufficient for the proficiency testing purposes.

2.6 ANALYSES

The participants were asked to determine the composition: Ethane, Propane, Propylene, n-Butane, iso-Butane, n-Pentane, 1-Butene, iso-Butene and some physical parameters calculated from the composition: Molar Mass, Relative Density @60F and Absolute and Relative Vapour pressure @100F. Also some method details were requested to be reported. To get comparable results a detailed report form, on which the units were prescribed, was sent together with each set of samples. Also a letter of instructions and a SDS were added to the package.

Participants are also requested to send a remark if other components were found e.g. Helium or/and iso-Pentane or some other impurity.

3 RESULTS

During four weeks after sample despatch, the results of the individual laboratories were gathered. The original results are tabulated per determination in the appendix 1 of this report. The laboratories are presented by their code numbers.

Directly after the deadline the available results were screened for suspect data. A 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 results. Additional or corrected data are put under 'Remarks' in the result tables in appendix 1. Results that came in after deadline were not taken into account in the screening for suspect data and thus these participants were not requested for checks.

3.1 STATISTICS

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 January 2010 (iis-protocol, version 3.2).

For the statistical evaluation the *unrounded* (when available) figures were used instead of the rounded results. 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. After removal of outliers this check was repeated. In case a data set does not have a normal distribution, the results of the statistical evaluation should be used with due care.

In accordance with ISO 5725 (1986 and 1994) the original results per determination were submitted subsequently to Dixon and Grubbs outlier tests. Outliers are marked by D(0.01) for the Dixon test and by G(0.01) or DG(0.01) for the Grubbs test. Stragglers are marked by D(0.05) for the Dixon test and by G(0.05) or DG(0.05) for the Grubbs test. Both outliers and stragglers were not included in the calculations of the averages and the standard deviations.

Finally the reproducibilities were calculated from the standard deviations by multiplying these 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 analysis results are plotted. The corresponding laboratory numbers are under 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 standard. 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 method is producing a smooth density approximation to a set of data that avoids some problems associated with histograms (see appendix 3; nr.14 and 15).

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. EN-, ISO-, IP reproducibilities, the z-scores were calculated using a target standard deviation. This target standard deviation was calculated from the literature reproducibility by division with 2.8. The z-scores were calculated according to:

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

The z(target) scores are listed in the result tables in appendix 1. Absolute values for $z < 2$ are very common and absolute values for $z > 3$ are very rare. Therefore the usual interpretation of z-scores is as follows:

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

4 EVALUATION

In this proficiency test several problems were encountered with sample transport. Due to these problems three cylinders did not reach the laboratory in time to test the cylinder and to report results before the deadline of reporting.

In total seven laboratories reported the test results after the final reporting date. Not all laboratories did report all test results requested.

In total 28 participating laboratories reported 231 numerical test results. Observed were 19 outlying test results, which is 8.2% of all numerical results. In proficiency studies outlier percentages of 3% - 7.5% are quite normal.

4.1 EVALUATION PER TEST/COMPONENT

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

Not all original data sets proved to have a normal distribution. For ethane and for absolute vapor pressure a non Gaussian data distribution was found and the statistical evaluation should be used with due care.

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. Regrettably in the last version ASTM D2163:07 only repeatabilities, but no reproducibilities are mentioned. Therefore the precision data from the previous version ASTM D2163:96 (estimated from figure 3) were used.

Because 21 laboratories reported both results in %mol/mol as well as in %M/M, it has been possible to check the calculations of these 21 laboratories. A good correlation between the results reported in %mol/mol and the results reported in %M/M was found, as expected.

Ethane: The determination of this component may be problematic. Two statistical outliers were detected and the calculated reproducibility, after exclusion of the statistical outliers, is not at all in agreement with the requirements of ASTM D2163:96. However, the calculated reproducibility is in agreement with the much less strict reproducibility of EN27941 (identical to IP 405 and ISO 7941).

Propane: Analytical problems were observed for a small number of laboratories. Two statistical outliers were detected. However, the calculated reproducibility, after exclusion of the two statistical outliers, is in full agreement with the requirements of ASTM D2163:96 and also with the reproducibility of EN27941 (identical to IP 405 and ISO 7941).

- Propylene: Analytical problems were observed for a number of laboratories. Three statistical outliers were detected. However, the calculated reproducibility, after exclusion of the statistical outliers, is in agreement with the requirements of ASTM D2163:96 and also with the reproducibility of EN27941 (identical to IP 405 and ISO 7941).
- n-Butane: Analytical problems were observed for a number of laboratories. Five statistical outliers were detected. However, the calculated reproducibility, after exclusion of the statistical outliers, is in full agreement with the requirements of ASTM D2163:96 and also with the reproducibility of EN27941 (identical to IP 405 and ISO 7941).
- iso-Butane: The determination of this component may be problematic. Two statistical outliers were detected. The calculated reproducibility, after exclusion of the statistical outliers, is not in agreement with the requirements of ASTM D2163:96. However, the calculated reproducibility is in agreement with the much less strict reproducibility of EN27941 (identical to IP 405 and ISO 7941).
- n-Pentane: The determination of this component was problematic. Four statistical outliers were detected. The calculated reproducibility, after exclusion of the statistical outliers, is not at all in agreement with the requirements of ASTM D2163:96. It is however almost in agreement with the less strict reproducibility of EN27941 (identical to IP 405 and ISO 7941).
- 1-Butene: This component was not present in a detectable concentration. Therefore no conclusions could be drawn.
- Iso-Butene: This component was not present in a detectable concentration. Therefore no conclusions could be drawn.
- Molar Mass: This calculated parameter may be not problematic. The results vary over a range from 44.6 – 44.796. No statistically significant outliers were present. See also the discussion in 4.3.
- Rel. Density @60F: This calculated parameter may be problematic. The results vary over a range from 0.50805 – 0.511 and one statistically significant outlier was present (in 20 test results). Probably 5 laboratories reported the relative density @15°C, as IP432 or ISO8973 were used, methods that use 15°C in stead of 60F. However, the difference in relative density between 15°C and 60F is less than 0.0001 and therefore this cannot explain for the observed spread.

Abs. Vapour Press.: This calculated parameter may be problematic. The results vary over a large range (183 – 187.27 psi). No statistically significant outliers were observed. Two participants may have made a calculation error. The data appear to be bimodally distributed. This suggests that two different calculation procedures were used by the participants. All ISO8973/IP432 results except one are higher than all ASTM D2598 results. See also the discussion in 4.3.

Rel. Vapour Press.: This calculated parameter may be problematic. The results vary over a large range (168 – 172.57 psi). No statistically significant outliers were observed. Two participants may have made a calculation error. The data appear to be bimodally distributed. This suggests that two different calculation procedures were used by the participants. All ISO8973/IP432 results except one are higher than all ASTM D2598 results. See also the discussion in 4.3.

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 D2163 and EN27941/ISO7941/IP405) are compared in the next table.

Parameter	unit	n	cons. value	2.8 * sd	R(D2163) in %mol	R(EN27941) liq.-inj. in %mol	R(EN27941) liq.-inj. in %M/M
Ethane	%mol/mol	26	0.120	0.043	0.014	0.296	0.2
Propane	%mol/mol	26	95.368	0.668	0.954	1.013	1
Propylene	%mol/mol	25	0.788	0.102	0.090	0.213	0.2
n-Butane	%mol/mol	23	2.065	0.149	0.239	0.382	0.5
iso-Butane	%mol/mol	26	1.089	0.145	0.126	0.385	0.5
n-Pentane	%mol/mol	24	0.538	0.122	0.062	0.115	0.5
Molar Mass	g/mol	15	44.67	0.14	n/a	n/a	n/a
Rel. Density @60F		19	0.5106	0.0008	n/a	n/a	n/a
Abs. Vapour press.	psi	14	see §4.3		n/a	n/a	n/a
Rel. Vapour press.	psi	15	see §4.3		n/a	n/a	n/a

Table 2: Performance of the group in comparison with the target reproducibilities

Without further statistical calculations it can be concluded that for most components/tests there is a good compliance of the group of participating laboratories with the relevant standard. The problematic components/tests have been discussed in paragraph 4.1.

4.3 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 Scott Specialty Gases in the following table.

Parameter	Average values by Scott Specialty Gases in %mol/mol	Consensus values from participants results in %mol/mol	Absolute differences in %mol/mol	z-score
Ethane	0.118	0.120	+0.002	+0.37
Propane	95.449	95.368	-0.081	-0.24
Propylene	0.778	0.788	+0.009	+0.29
n-Butane	2.057	2.065	+0.007	+0.09
iso-Butane	1.049	1.089	+0.040	+0.90
n-Pentane	0.548	0.538	-0.010	-0.46

Table 3: comparison of consensus values with values determined by Scott Specialty Gases

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

In total seven laboratories reported the presence of one or more additional components (iso-pentane (0.0003-0.02 %mol/mol, cyclopropane 0.03%M/M). Probably these components were present as impurity in one or more of the pure components that were used to prepare the propane mixture.

In principle no additional spread should be introduced when applying a calculation on the reported component concentrations. However, in practice a significant additional uncertainty is added. This cannot be caused only by rounding of test results before use in the calculations. See the striking differences between the test results as reported by the participating laboratories for absolute and relative vapour pressure.

For the calculation of the Vapour Pressure two different methods were used. Nine participants used ISO8973/IP432 and also nine participants used ASTM D2598. In ISO 8973 (identical to IP432) the Absolute Vapour Pressure is calculated from the mole fraction per component and a Vapour Pressure factor of that component (given for all components). From the Absolute Vapour Pressure the Relative Vapour Pressure is calculated.

In ASTM D2598 the Gage pressure (identical to the Relative Vapour Pressure) is calculated from the liquid volume percentage per component and a Vapour Pressure factor of that component (not given for n-pentane). From the Relative Vapour Pressure the Absolute Vapour Pressure is calculated.

As one would expect to find identical values from both calculation methods, it is remarkable to see that the results from the ASTM D2598 calculation are approx 3.3 psi lower than the results from the ISO8973/IP432 calculation. The reason is yet unknown.

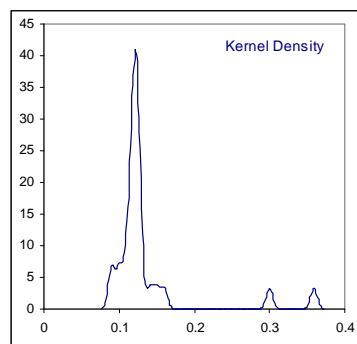
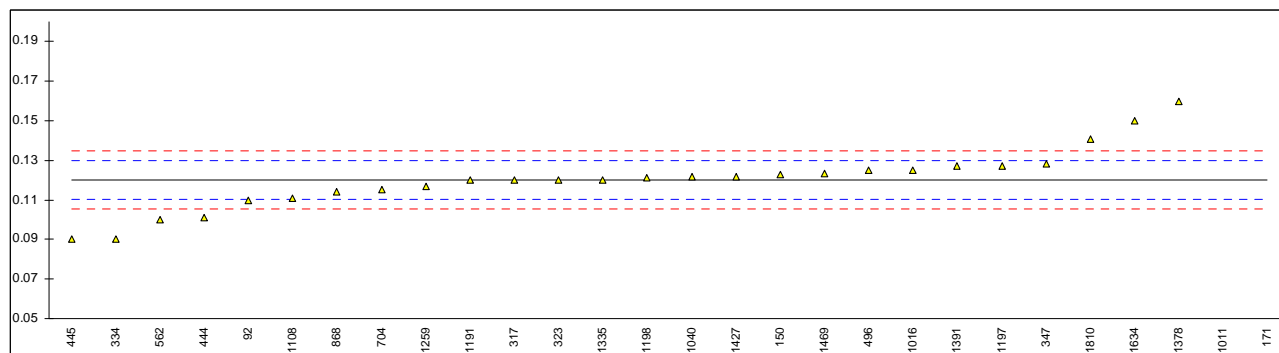
APPENDIX 1

Determination of Ethane; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.11		-2.04	
150	D2598	0.123		0.59	
171	D2163	0.359	G(0.01)	48.30	
317	D2163	0.12		-0.02	
323	D2163	0.12		-0.02	
334	EN27941	0.09		-6.09	
347	D2163	0.128		1.60	
444	IP405	0.101		-3.86	
445	IP405	0.09		-6.09	
447		-----		-----	
496	EN27941	0.125		0.99	
562	D2163	0.10		-4.06	
704	D2163	0.115		-1.03	
868	D2163	0.114		-1.23	
1011	EN27941	0.30	G(0.01)	36.37	
1016	ISO7941	0.125		0.99	
1040	DIN51619	0.122		0.38	
1095		-----	W	-----	results withdrawn
1108	D2163	0.111		-1.84	
1191	IP473	0.120		-0.02	
1197	D2163	0.127		1.40	
1198	D2163	0.121		0.18	
1259	EN27941	0.117		-0.63	
1284		-----		-----	
1335	D2163	0.1202		0.02	
1378	ISO7941	0.16		8.07	
1391	D2163	0.127		1.40	
1427	ISO7941	0.122		0.38	
1469	D2163	0.1234		0.67	
1634	ISO7941	0.15		6.05	
1810	EN27941	0.141	C	4.23	reported 0.095 %V/V

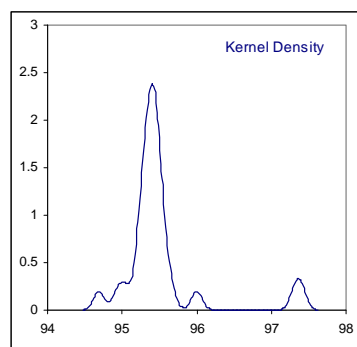
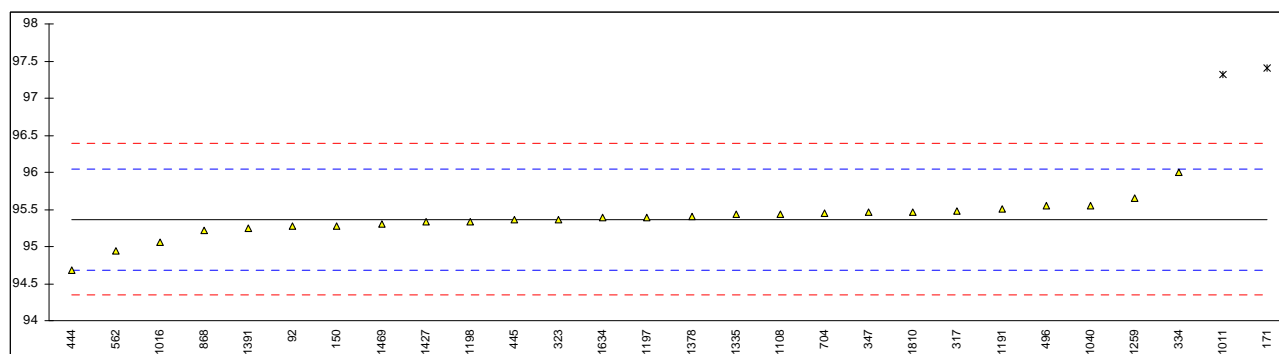
normality not OK
n 26
outliers 2
mean (n) 0.120
st.dev. (n) 0.0155
R(calc.) 0.043
R(D2163:96) 0.014

Compare R(EN27941(liq))=0.296



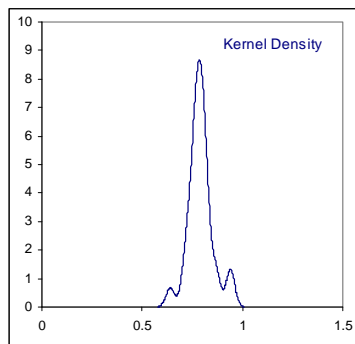
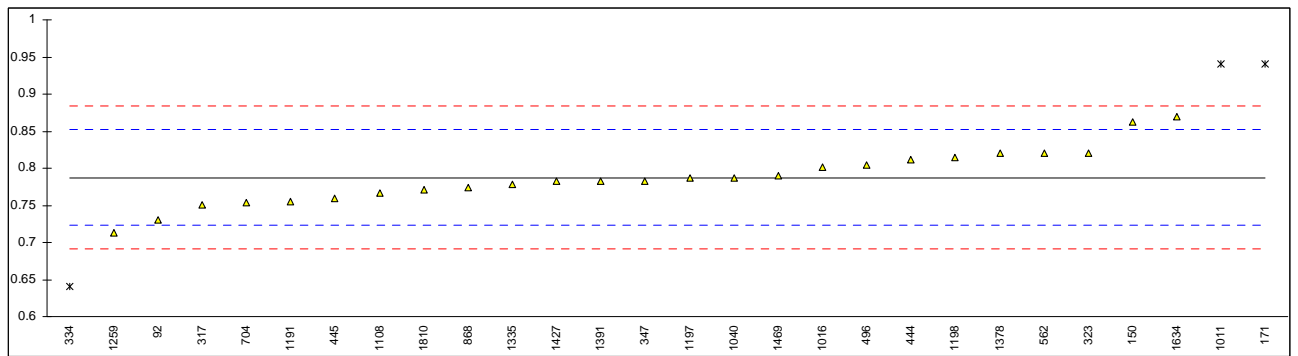
Determination of Propane; results in %mol/mol

lab	method	value	mark	z(target)	remarks
92	D2163	95.28		-0.26	
150	D2598	95.281		-0.26	
171	D2163	97.406	G(0.05)	5.98	
317	D2163	95.48		0.33	
323	D2163	95.36		-0.02	
334	EN27941	96.00		1.86	
347	D2163	95.457		0.26	
444	IP405	94.688		-2.00	
445	IP405	95.36		-0.02	
447		-----		-----	
496	EN27941	95.555		0.55	
562	D2163	94.94		-1.26	
704	D2163	95.456		0.26	
868	D2163	95.212		-0.46	
1011	EN27941	97.32	G(0.01)	5.73	
1016	ISO7941	95.055		-0.92	
1040	DIN51619	95.556		0.55	
1095		-----	W	-----	results withdrawn
1108	D2163	95.437		0.20	
1191	IP473	95.501		0.39	
1197	D2163	95.392		0.07	
1198	D2163	95.340		-0.08	
1259	EN27941	95.650		0.83	
1284		-----		-----	
1335	D2163	95.4355		0.20	
1378	ISO7941	95.41		0.12	
1391	D2163	95.244		-0.36	
1427	ISO7941	95.328		-0.12	
1469	D2163	95.2989		-0.20	
1634	ISO7941	95.39		0.06	
1810	EN27941	95.460	C	0.27	reported 94.289 %V/V
normality		OK			
n		26			
outliers		2			
mean (n)		95.368			
st.dev. (n)		0.238			
R(calc.)		0.668			
R(D2163:96)		0.954			Compare R(EN27941(liq))=1.013



Determination of Propylene; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.73		-1.78	
150	D2598	0.863		2.34	
171	D2163	0.941	DG(0.05)	4.75	
317	D2163	0.75		-1.16	
323	D2163	0.82		1.01	
334	EN27941	0.64	G(0.05)	-4.57	
347	D2163	0.783		-0.14	
444	IP405	0.812		0.76	
445	IP405	0.76		-0.85	
447		-----		-----	
496	EN27941	0.804		0.51	
562	D2163	0.82		1.01	
704	D2163	0.754		-1.04	
868	D2163	0.774		-0.42	
1011	EN27941	0.94	DG(0.05)	4.72	
1016	ISO7941	0.801		0.42	
1040	DIN51619	0.787		-0.02	
1095		-----	W	-----	results withdrawn
1108	D2163	0.767		-0.64	
1191	IP473	0.755		-1.01	
1197	D2163	0.787		-0.02	
1198	D2163	0.815		0.85	
1259	EN27941	0.713		-2.31	
1284		-----		-----	
1335	D2163	0.7782		-0.29	
1378	ISO7941	0.82		1.01	
1391	D2163	0.782		-0.17	
1427	ISO7941	0.782		-0.17	
1469	D2163	0.7902		0.08	
1634	ISO7941	0.87		2.55	
1810	EN27941	0.771	C	-0.51	reported 0.727 %V/V
normality		OK			
n		25			
outliers		3			
mean (n)		0.788			
st.dev. (n)		0.0364			
R(calc.)		0.102			
R(D2163:96)		0.090			Compare R(EN27941(liq))=0.213

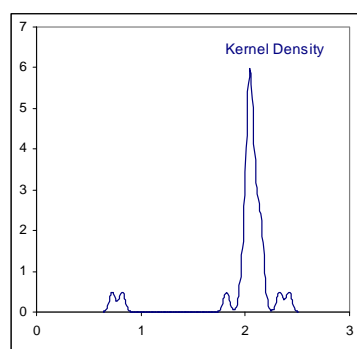
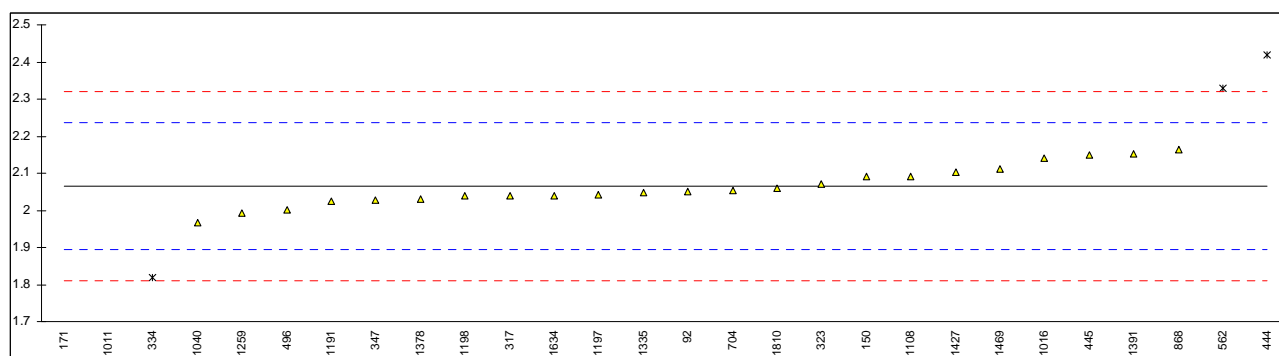


Determination of n-Butane; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	2.05		-0.17	
150	D2598	2.090		0.30	
171	D2163	0.725	G(0.01)	-15.72	
317	D2163	2.04		-0.29	
323	D2163	2.07		0.06	
334	EN27941	1.82	D(0.05)	-2.87	
347	D2163	2.028		-0.43	
444	IP405	2.419	G(0.05)	4.16	
445	IP405	2.15		1.00	
447		-----		-----	
496	EN27941	2.000		-0.76	
562	D2163	2.33	D(0.05)	3.11	
704	D2163	2.053		-0.14	
868	D2163	2.164		1.16	
1011	EN27941	0.82	G(0.01)	-14.61	
1016	ISO7941	2.142		0.91	
1040	DIN51619	1.966		-1.16	
1095		-----	W	-----	results withdrawn
1108	D2163	2.091		0.31	
1191	IP473	2.024		-0.48	
1197	D2163	2.042		-0.27	
1198	D2163	2.040		-0.29	
1259	EN27941	1.994		-0.83	
1284		-----		-----	
1335	D2163	2.0482	C	-0.20	first reported 1.0690, result mixed up with i-butane
1378	ISO7941	2.03		-0.41	
1391	D2163	2.153		1.03	
1427	ISO7941	2.104		0.46	
1469	D2163	2.1125		0.56	
1634	ISO7941	2.04		-0.29	
1810	EN27941	2.060	C	-0.06	reported 2.681 %V/V

normality OK
n 23
outliers 5
mean (n) 2.0649
st.dev. (n) 0.05318
R(calc.) 0.1489
R(D2163:96) 0.2386

Compare R(EN27941(liq))=0.3815

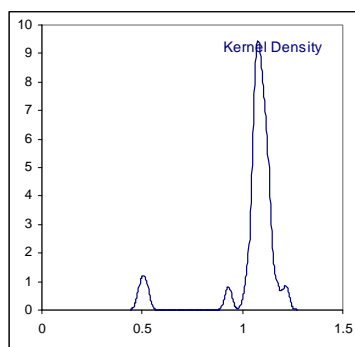
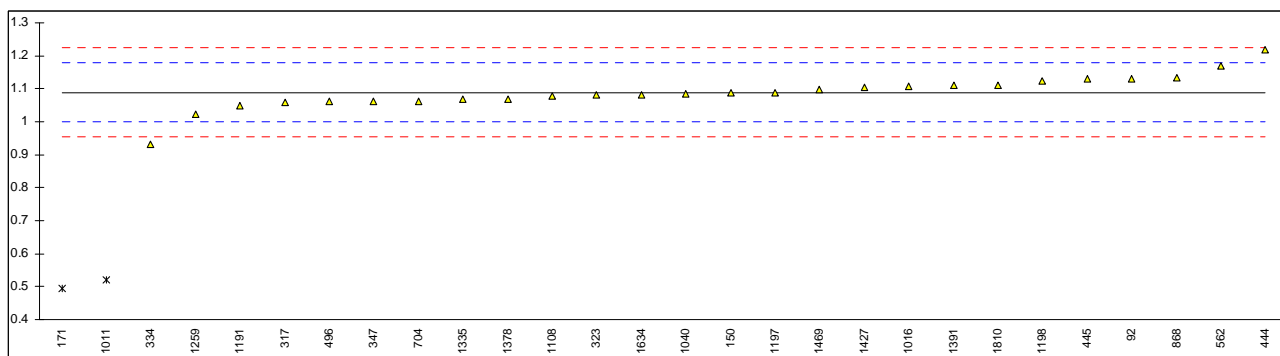


Determination of iso-Butane; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	1.13		0.91	
150	D2598	1.087		-0.05	
171	D2163	0.493	G(0.01)	-13.30	
317	D2163	1.06		-0.65	
323	D2163	1.08		-0.21	
334	EN27941	0.93		-3.55	
347	D2163	1.062		-0.61	
444	IP405	1.217		2.85	
445	IP405	1.13		0.91	
447		-----		-----	
496	EN27941	1.061		-0.63	
562	D2163	1.17		1.80	
704	D2163	1.063		-0.59	
868	D2163	1.133		0.97	
1011	EN27941	0.52	G(0.01)	-12.70	
1016	ISO7941	1.109		0.44	
1040	DIN51619	1.084		-0.12	
1095		-----	W	-----	results withdrawn
1108	D2163	1.078		-0.25	
1191	IP473	1.048		-0.92	
1197	D2163	1.088		-0.03	
1198	D2163	1.123		0.75	
1259	EN27941	1.022		-1.50	
1284		-----		-----	
1335	D2163	1.0690	C	-0.45	first reported 2.0482, result mixed up with n-butane
1378	ISO7941	1.07		-0.43	
1391	D2163	1.112		0.51	
1427	ISO7941	1.104		0.33	
1469	D2163	1.0993		0.22	
1634	ISO7941	1.08		-0.21	
1810	EN27941	1.112	C	0.51	reported 1.448 %V/V

normality OK
n 26
outliers 2
mean (n) 1.0893
st.dev. (n) 0.05167
R(calc.) 0.1447
R(D2163:96) 0.1256

Compare R(EN27941(liq))=0.3849

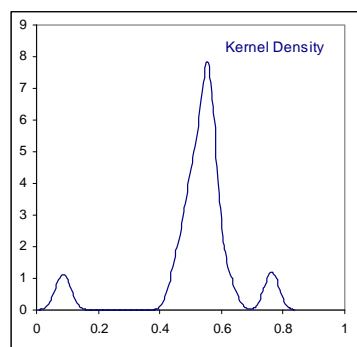
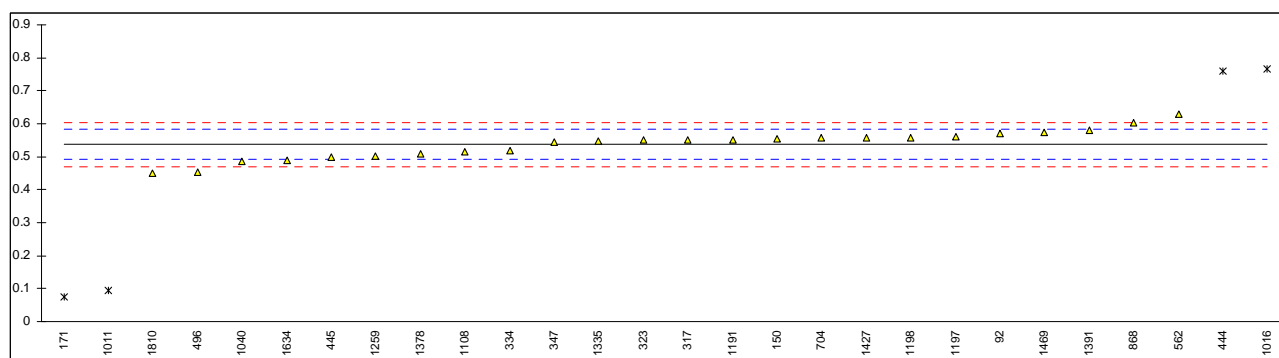


Determination of n-Pentane; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92	D2163	0.57		1.44	
150	D2598	0.555		0.76	
171	D2163	0.076	G(0.05)	-20.74	
317	D2163	0.55		0.54	
323	D2163	0.55		0.54	
334	EN27941	0.52		-0.81	
347	D2163	0.543		0.22	
444	IP405	0.759	G(0.01)	9.92	
445	IP405	0.50		-1.71	
447		-----		-----	
496	EN27941	0.453		-3.82	
562	D2163	0.63		4.13	
704	D2163	0.556		0.81	
868	D2163	0.602		2.87	
1011	EN27941	0.096	G(0.01)	-19.84	
1016	ISO7941	0.767	G(0.05)	10.28	
1040	DIN51619	0.485		-2.38	
1095		-----	W	-----	results withdrawn
1108	D2163	0.514		-1.08	
1191	IP473	0.551		0.58	
1197	D2163	0.561		1.03	
1198	D2163	0.558		0.90	
1259	EN27941	0.502		-1.62	
1284		-----		-----	
1335	D2163	0.5485		0.47	
1378	ISO7941	0.51		-1.26	
1391	D2163	0.582		1.97	
1427	ISO7941	0.558		0.90	
1469	D2163	0.5738		1.61	
1634	ISO7941	0.49		-2.16	
1810	EN27941	0.450	C	-3.95	reported 0.757 %V/V

normality OK
n 24
outliers 4
mean (n) 0.5380
st.dev. (n) 0.04366
R(calc.) 0.1222
R(D2163:96) 0.0624

Compare R(EN27941(liq))=0.1153



Determination of 1-Butene; results in %mol/mol

lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
171	D2163	<0.01		----	
317	D2163	<0.01		----	
323	D2163	<0.01		----	
334	EN27941	<0.1		----	
347		----		----	
444	IP405	<0.01		----	
445	IP405	<0.01		----	
447		----		----	
496	EN27941	<0.001		----	
562	D2163	0.00		----	
704	D2163	<0.01		----	
868	D2163	<0.01		----	
1011	EN27941	<0.1		----	
1016	ISO7941	<0.01		----	
1040	DIN51619	0		----	
1095		----	W	----	results withdrawn
1108	D2163	n.d.		----	
1191	IP473	0.000		----	
1197		----		----	
1198		----		----	
1259	EN27941	0.0		----	
1284		----		----	
1335		----		----	
1378		----		----	
1391	D2163	<0.01		----	
1427		----		----	
1469	D2163	0.0000		----	
1634	ISO7941	0.00		----	
1810	EN27941	0.0001	C	----	reported 0.0002 %V/V
	normality	n.a.			
	n	7			
	outliers	0			
	mean (n)	0.00001			
	st.dev. (n)	0.00004			
	R(calc.)	0.00011			
	R(D2163:96)	n.a.			

Determination of iso-Butene; results in %mol/mol

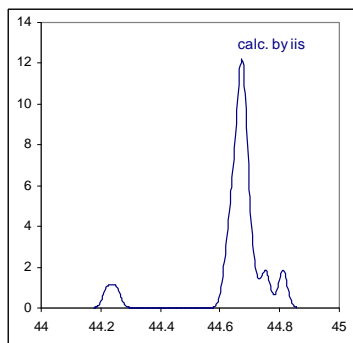
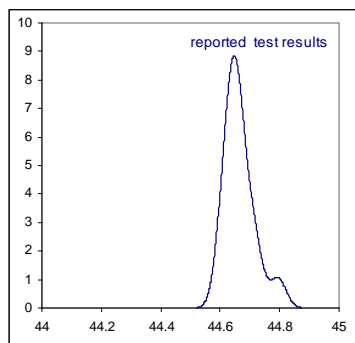
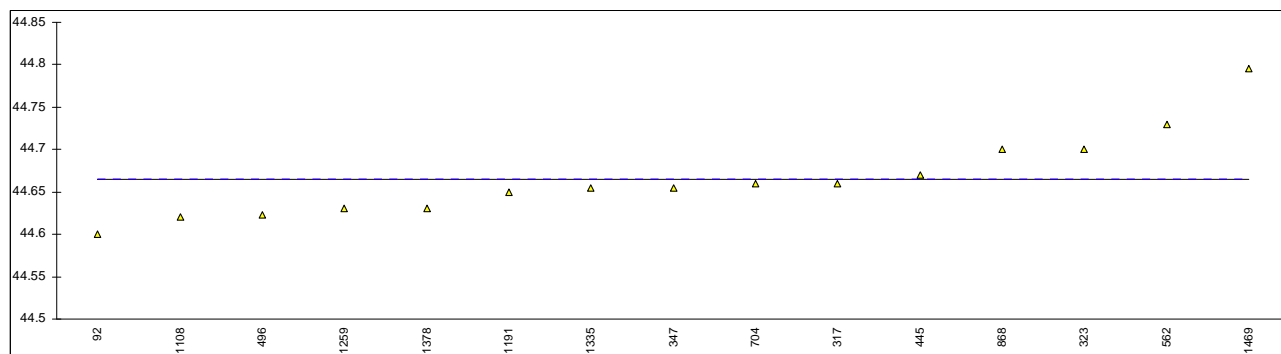
lab	method	value	mark	z(targ)	remarks
92		----		----	
150		----		----	
171	D2163	<0.01		----	
317	D2163	<0.01		----	
323	D2163	<0.01		----	
334	EN27941	<0.1		----	
347		----		----	
444	IP405	<0.01		----	
445	IP405	<0.01		----	
447		----		----	
496	EN27941	<0.001		----	
562	D2163	0.00		----	
704	D2163	<0.01		----	
868	D2163	<0.01		----	
1011	EN27941	<0.1		----	
1016	ISO7941	<0.01		----	
1040	DIN51619	0		----	
1095		----	W	----	results withdrawn
1108	D2163	n.d.		----	
1191	IP473	0.000		----	
1197		----		----	
1198		----		----	
1259	EN27941	0.0		----	
1284		----		----	
1335		----		----	
1378		----		----	
1391	D2163	<0.01		----	
1427		----		----	
1469	D2163	0.0000		----	
1634	ISO7941	0.00		----	
1810	EN27941	0.0001	C	----	reported 0.0001 %V/V
	normality	n.a.			
	n	7			
	outliers	0			
	mean (n)	0.00001			
	st.dev. (n)	0.00004			
	R(calc.)	0.00011			
	R(D2163:96)	n.a.			

Determination of Molar Mass; results in g/mol

lab	method	value	mark	z(targ)	remarks
92	GPA2145	44.6		----	
150		----		----	
171		----		----	
317	D2598	44.66		----	
323	D3588	44.7		----	
334		----		----	
347	D2421	44.655		----	
444		----		----	
445	IP432	44.670		----	
447		----		----	
496	D2421	44.623		----	
562		44.73		----	
704		44.6593		----	
868	calc.	44.70		----	
1011		----		----	
1016		----		----	
1040		----		----	
1095		----	W	----	result withdrawn
1108	D2421	44.62		----	
1191	ISO6976	44.65	C	----	first reported 36.52
1197		----		----	
1198		----		----	
1259	ISO8973	44.630		----	
1284		----		----	
1335	D2598	44.655		----	
1378	ISO8973	44.63		----	
1391		----		----	
1427		----		----	
1469	D2421	44.796		----	
1634		----		----	
1810		----		----	

Calculated by iis from all reported test results:

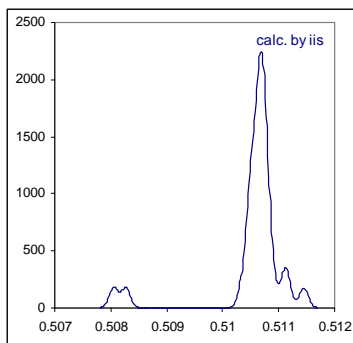
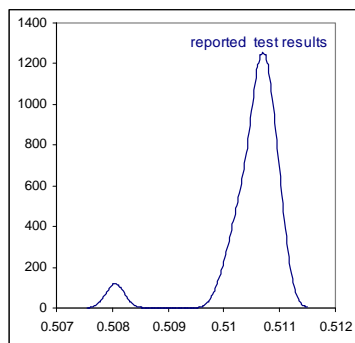
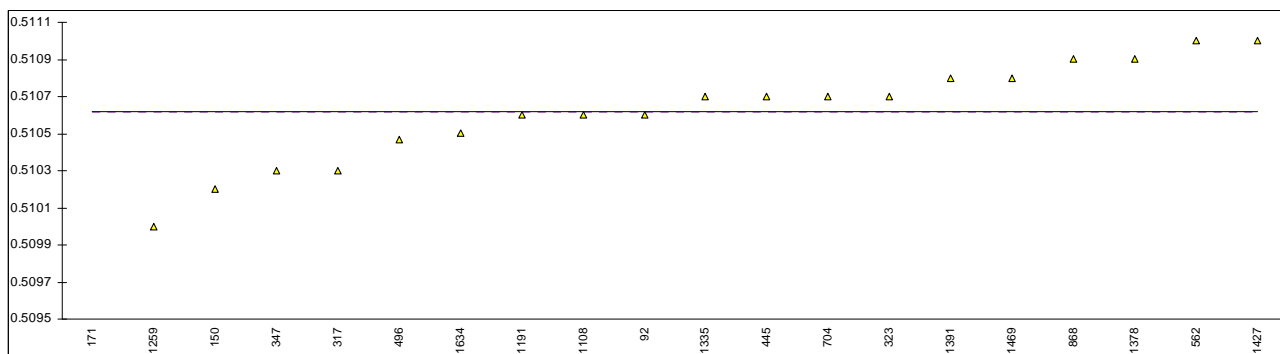
normality	OK	OK
n	15	23
outliers	0	5
mean (n)	44.665	44.666
st.dev. (n)	0.0499	0.0233
R(calc.)	0.140	0.065
R(iit)	unknown	unknown
R(iis10S03P)	0.329	0.096 (for comparison)



Determination of Relative Density @60F; unitless results

lab	method	value	mark	z(targ)	remarks
92	D2598	0.5106		----	
150	D2598	0.51020		----	
171	D2421	0.50805	G(0.01)	----	
317	D2421	0.5103		----	
323	D2598	0.5107		----	
334		----		----	
347	D2598	0.5103		----	
444		----		----	
445	IP432	0.5107	C	----	
447		----		----	
496	D2598	0.51047		----	
562	D2598	0.511		----	
704	D2598	0.5107		----	
868	D2598	0.5109		----	
1011		----		----	
1016		----		----	
1040		----		----	
1095		----		----	
1108	D2598	0.5106		----	
1191	D2598	0.5106		----	
1197		----		----	
1198		----		----	
1259	ISO8973	0.510	C	----	
1284		----		----	
1335	D2598	0.5107		----	
1378	ISO8973	0.5109		----	
1391	D2598	0.5108		----	
1427	ISO8973	0.511		----	
1469	D2598	0.5108		----	
1634	ISO8973	0.5105		----	
1810		----		----	

		<u>Calculated by iis from all reported test results:</u>	<u>Idem for 15°C</u>
normality	OK	OK	OK
n	19	23	23
outliers	1	5	5
mean (n)	0.51062	0.51065	0.51059
st.dev. (n)	0.000273	0.000129	0.000129
R(calc.)	0.00076	0.00036	0.00036
R(lit)	unknown	unknown	unknown
R(iis10S03P)	0.00150	0.00070 (for comparison)	0.00070

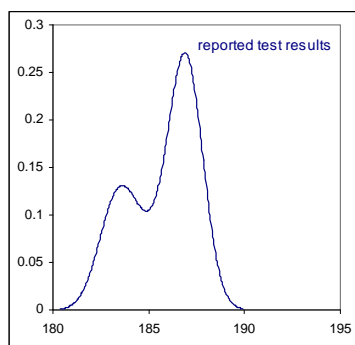
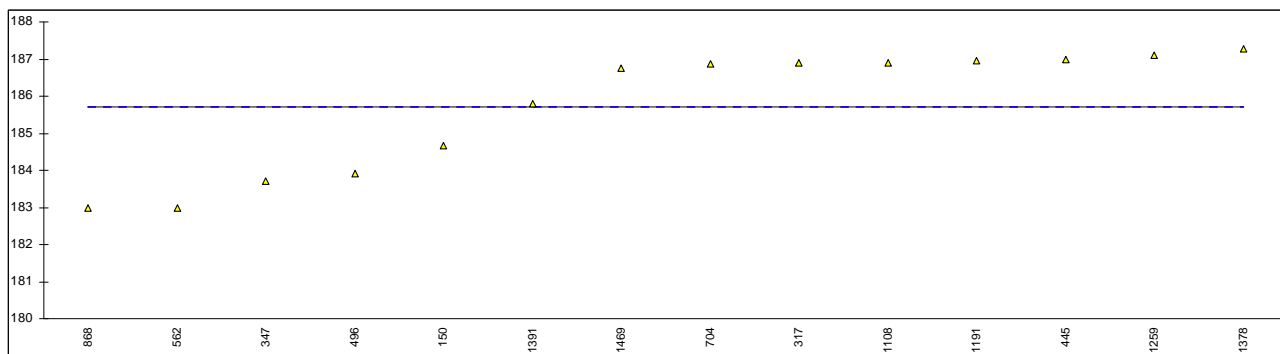


Determination of Absolute Vapour Pressure @ 100F; results in psi

lab	method	value	mark	z(targ)	remarks
92		----		----	
150	D2598	184.68	E	----	calculation by iis gave 183.52
171		----		----	
317	ISO8973	186.9		----	
323		----		----	
334		----		----	
347	D2598	183.7		----	
444		----		----	
445	IP432	187		----	
447		----		----	
496	D2598	183.9		----	
562	D2598	183		----	
704	ISO8973	186.86		----	
868	D2598	183		----	
1011		----		----	
1016		----		----	
1040		----		----	
1095		----	W	----	result withdrawn
1108	D2598	186.9		----	
1191	ISO8973	186.955		----	
1197		----		----	
1198		----		----	
1259	ISO8973	187.09		----	
1284		----		----	
1335		----	C	----	first reported 169, result mixed up with relative vapour pressure
1378	ISO8973	187.27		----	
1391	ISO8973	185.8	E	----	calculation by iis gave 186.7
1427		----		----	
1469	D2598	186.762		----	
1634		----		----	
1810		----		----	

Calculated by iis from all reported test results, see §4.3:

	ISO8973 / IP432:	ASTM D2598:
normality	not OK	not OK
n	14	26
outliers	0	2
mean (n)	185.701	183.493
st.dev. (n)	1.6615	0.3853
R(calc.)	4.652	1.079
R(lit)	unknown	unknown

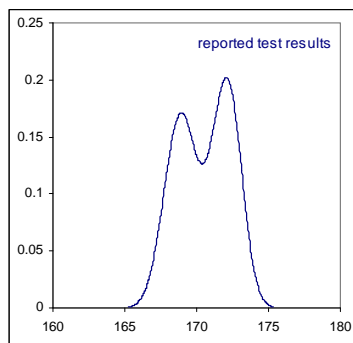
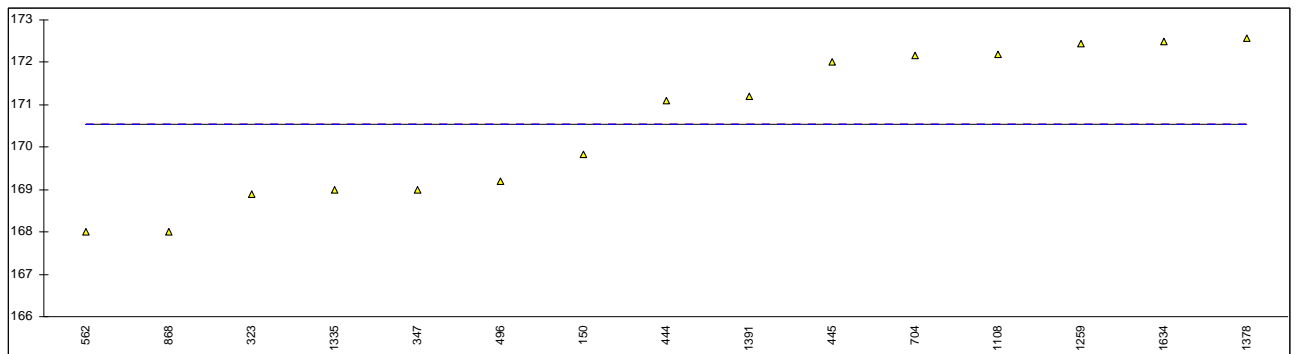


Determination of Relative Vapour Pressure @100F (Gage pressure); results in psi

lab	method	value	mark	z(targ)	remarks
92		----		----	
150	D2598	169.84	E	----	calculation by iis gave 172.17
171		----		----	
317		----		----	
323	D2598	168.9		----	
334		----		----	
347	D2598	169		----	
444	IP432	171.1		----	
445	IP432	172		----	
447		----		----	
496	D2598	169.2		----	
562	D2598	168		----	
704	ISO8973	172.16		----	
868	D2598	168		----	
1011		----		----	
1016		----		----	
1040		----		----	
1095		----	W	----	result withdrawn
1108	D2598	172.2		----	
1191		----		----	
1197		----		----	
1198		----		----	
1259		172.45		----	
1284		----		----	
1335	D2598	169		----	
1378	ISO8973	172.57	C	----	first reported n.a., result mixed up with absolute vapour pressure
1391	ISO8973	171.2	E	----	calculation by iis gave 172.00
1427		----		----	
1469		----		----	
1634	ISO8973	172.497		----	
1810		----		----	

Calculated by iis from all reported test results, see §4.3:

	ISO8973 / IP432:	ASTM D2598:
normality	OK	not OK
n	15	26
outliers	0	2
mean (n)	170.541	168.797
st.dev. (n)	1.74195	0.3853
R(calc.)	4.8774	1.079
R(lit)	unknown	unknown



APPENDIX 2

Number of participants per country

1 lab in BELGIUM
1 lab in CANADA
1 lab in CHILE
1 lab in CROATIA
1 lab in CZECH REPUBLIC
1 lab in EGYPT
1 lab in FINLAND
1 lab in FRANCE
2 labs in GERMANY
2 labs in GREECE
2 labs in MALAYSIA
2 labs in P.R. of CHINA
4 labs in PORTUGAL
1 lab in QATAR
1 lab in SPAIN
1 lab in TAIWAN R.O.C.
1 lab in THE NETHERLANDS
2 labs in U.S.A.
1 lab in UKRAINE
3 labs in UNITED KINGDOM

APPENDIX 3

Abbreviations:

C	= final result after checking of first reported suspect 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
ex	= excluded from calculations
n/a	= not applicable
W	= withdrawn on request participant
U	= reported in wrong unit
E	= error in calculations
SDS	= Safety Data Sheet

Literature:

- 1 iis Interlaboratory Studies, Protocol for the Organisation, Statistics and Evaluation, January 2010
- 2 prNEN 12766-2:2000.
- 3 ASTM E178-89
- 4 ASTM E1301-89
- 5 ISO 5725-86
- 6 ISO 5725, parts 1-6, 1994
- 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, First reported Z. Anal. Chem, 331, 513, (1988)
- 12 J.N. Miller, Analyst, 118, 455, (1993)
- 13 Analytical Methods Committee Technical Brief, No4 January 2001
- 14 The Royal Society of Chemistry 2002, Analyst 2002, 127 page1359-1364, P.J. Lowthian and M. Thompson. (see <http://www.rsc.org/suppdata/an/b2/b205600n/>)
- 15 ISO 17043
- 16 EN 27941
- 17 ASTM D2163
- 18 ASTM D2421