Results of Proficiency Test
Liquefied Propane
October 2012

Organised by: Institute for Interlaboratory Studies
Spijkenisse, the Netherlands

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CONTENTS

1 INTRODUCTION

A first proficiency study for Liquefied Propane (composition only) was organized by iis in 2009. Afterwards the opinion of the participating laboratories was inventarized. Most participants were very positive and therefore it was decided to repeat the PT annually.

Because iis has limited gas-handling facilities in place to prepare gas samples, a co-operation with EffecTech (Uttoxeter, United Kingdom) was set up. This company is fully equipped and has experience in the preparation of synthetic natural gas samples for PT purposes. EffecTech maintains an ISO17043 accreditation for the preparation of PT samples in homogeneous and stable batches and an ISO17025 accreditation for the calibration and assignment of reference values for these samples.

This year 30 laboratories in 20 different countries have participated. See appendix 3 for the number of participants per country. In this report the results of the 2012 proficiency test on Liquefied Propane are presented and discussed. This report is also electronically available through the iis internet site http://www.iisnl.com.

2 SET UP

The Institute for Interlaboratory Studies (iis) in Spijkenisse, the Netherlands, was the organizer of this proficiency test.
To optimise the costs for the participating laboratories, it was decided to prepare one Liquefied Propane mixture. The mixture was divided over a batch of 40 cylinders.
The cylinder size is a cost-effective one-litre cylinder with dip tube device. Each cylinder, filled with approx 200 grams of liquefied propane mixture, was uniquely numbered. The limited cylinder size is chosen to optimise sample stability, cylinder costs, transport and handling costs.

Participants were requested to report rounded and unrounded results. 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/IEC 17043:2010 and ILAC-G13:2007 (R007). This ensures strict adherence to protocols for sample preparation and statistical evaluation and 100% confidentially of participant's data. Also customer's satisfaction is measured on regular basis by the distribution of questionnaires.
EffecTech is an accredited provider of proficiency testing schemes under the requirements of ISO/IEC17043:2010 by UKAS (no. 4719).

2.2 PROTOCOL

The protocol followed in the organisation of this proficiency test was the one as described for proficiency testing in the report 'iis Interlaboratory Studies: Protocol for the Organisation, Statistics and Evaluation' of 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 presented in this report must be regarded as confidential and for use by the participating companies only. Disclosure of the information in this report is only allowed by means of the entire report. Use of the contents of this report for third parties is only allowed by written permission of the Institute for Interlaboratory Studies. Disclosure of the identity of one or more of the participating companies will be done only after receipt of a written agreement of the companies involved.

2.4 SAMPLES

In this proficiency test only one sample was used. One batch of 40 one litre cylinders with artificial Liquefied Propane mixture was prepared and tested for homogeneity by EffecTech (Uttoxeter, United Kingdom) in conformance with ISO Guide 35: 2006 and ISO/IEC17043:2010 (job 12/527) starting October 1, 2012. Each cylinder was uniquely numbered. Every cylinder in the batch was analysed using 6 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 reproducibility of the reference method in agreement with the procedure of ISO 13528, Annex B2 in the next table:

Parameter	r(observed) in %mol/mol	0.3 X R(D2163) in %mol/mol
Ethane	0.079	0.077
Propane	0.071	0.273
Propylene	0.008	0.033
Iso-Butane	0.037	0.094
n-Butane	0.031	0.067
1-Butene	0.002	0.004
iso-Butylene	0.004	0.009
n-Pentane	0.015	0.028

Table 1: homogeneity test results of samples #12074

Each calculated repeatability is equal or less than 0.3 times the corresponding reproducibility of the reference method ASTM D2163:96.
Therefore, homogeneity of the subsamples #12074 was assumed.

To each of the participating laboratories one 1L cylinder was sent on October 10, 2012.

2.5 STABILITY OF THE SAMPLES

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

2.6 ANALYSES

The participants were 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 compostion: 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 as well as some of the required standards and a letter of instructions were prepared and made available for download on the iis website.
A SDS and a form to confirm receipt of the samples were added to the sample package.

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.

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 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; nos.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.

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 the fit-for-useness of the reported test result.

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 seven cylinders did reach the laboratory near or after the final reporting date and were unable to test the cylinder and to report results before the deadline of reporting. In total eleven laboratories reported the test results after the final reporting date and three other laboratories did not report any test results due to several circumstances. Not all laboratories did report all test results requested.

In total 27 participating laboratories reported 267 numerical test results. Observed were 19 outlying test results, which is 7.1% 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 were 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 n-pentane and for absolute and relative vapour pressure @100F 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 IP405 and ISO7941) for reference only. Regretfully 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.

Ethane: The determination of this component may be problematic, depending on the test method used by the laboratory. Three 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 good

agreement with the less strict reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

Propane: No analytical problems were observed. Only one statistical outlier was observed and the calculated reproducibility, after exclusion of the statistical outlier, is in good agreement with the requirements of ASTM D2163:96 and also with the reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

Propylene: No analytical problems were observed. Three statistical outliers were observed. However, the calculated reproducibility, after exclusion of the statistical outliers, is in good agreement with the requirements of ASTM D2163:96 and also with the reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

iso-Butane: No analytical problems were observed. Only one statistical outlier was observed. 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 requirements of EN27941 (identical to IP405 and ISO7941).

n-Butane: The determination of this component may be problematic, depending on the test method used by the laboratory.
Two statistical outliers were observed. 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 less strict reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

1-Butene: The determination of this component may be problematic, depending on the test method used by the laboratory. One statistical outlier was observed. The calculated reproducibility, after exclusion of the statistical outlier, is not in agreement with the requirements of ASTM D2163:96. However, the calculated reproducibility is in agreement with the less strict reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

Iso-Butene: The determination of this component may be problematic, depending on the test method used by the laboratory. One statistical outlier was observed. The calculated reproducibility, after exclusion of the statistical outlier, is not in agreement with the requirements of ASTM D2163:96. However, the calculated reproducibility is in agreement with the less strict reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

n-Pentane: The determination of this component may be problematic, depending on the test method used by the laboratory. Only one statistical outlier was 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 less strict reproducibility requirements of EN27941 (identical to IP405 and ISO7941).

Molar Mass: This calculated parameter may be problematic. The results vary over a range from 43.368 – 44.9. One statistical outlier was present. The calculated reproducibility after rejection of the statistical outlier is large in comparison with the calculated reproducibility of iis11S03P (0.22 vs. 0.14). See also the discussion in 4.3.

Rel. Density @60F: This calculated parameter may be problematic. The results vary over a range from 0.5033 – 0.5122. One statistically significant outlier was present. Possibly 6 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 fully explain for the observed spread.

Abs. Vapour Press.: 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 both test methods by using the reported contents of the components. It is noticed that the mean and spread when using the calculation method of ASTM D2598 are both small in comparison with the mean and spread when using the calculation method of ISO8973. See also the discussion in 4.3.

Rel. Vapour Press.: 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 both test methods by using the reported contents of the components. It is noticed that the mean and spread when using the calculation method of ASTM D2598 are both small in comparison with the mean and spread when using the calculation method of ISO8973. 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**
Ethane	%mol/mol	23	1.963	0.421	0.226	0.739
Propane	%mol/mol	25	91.013	0.693	0.910	1.015
Propylene	%mol/mol	23	0.952	0.068	0.110	0.213
iso-Butane	%mol/mol	25	2.823	0.344	0.325	0.384
n-Butane	%mol/mol	24	2.053	0.309	0.236	0.386
1-Butene	%mol/mol	24	0.116	0.022	0.013	0.168
Iso-Butene	%mol/mol	24	0.254	0.049	0.029	0.167
n-Pentane	%mol/mol	25	0.832	0.219	0.096	0.305
Molar Mass	g/mol	12	44.746	0.221	n/a	n/a
Rel. Density @60F		17	0.5100	0.0029	n/a	n/a
Abs. Vapour press.	psi		see §4.3		n/a	n/a
Rel. Vapour press.	psi		see §4.3		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 some 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 EffecTech, United Kingdom in the following table.

Parameter	Average values by EffecTech in %mol/mol	Consensus values from participants results in %mol/mol	Absolute differences in %mol/mol	z-score
Ethane	2.230	1.963	+0.267	+3.30
Propane	90.980	91.013	-0.033	-0.10
Propylene	0.964	0.952	+0.012	+0.32
iso-Butane	2.722	2.823	-0.101	-0.87
n-Butane	1.945	2.053	-0.108	-1.28
1-Butene	0.111	0.116	-0.005	-0.96
Iso-Butene	0.250	0.254	-0.004	-0.37
n-Pentane	0.798	0.832	-0.034	-0.99

Table 3: comparison of consensus values with values determined by EffecTech

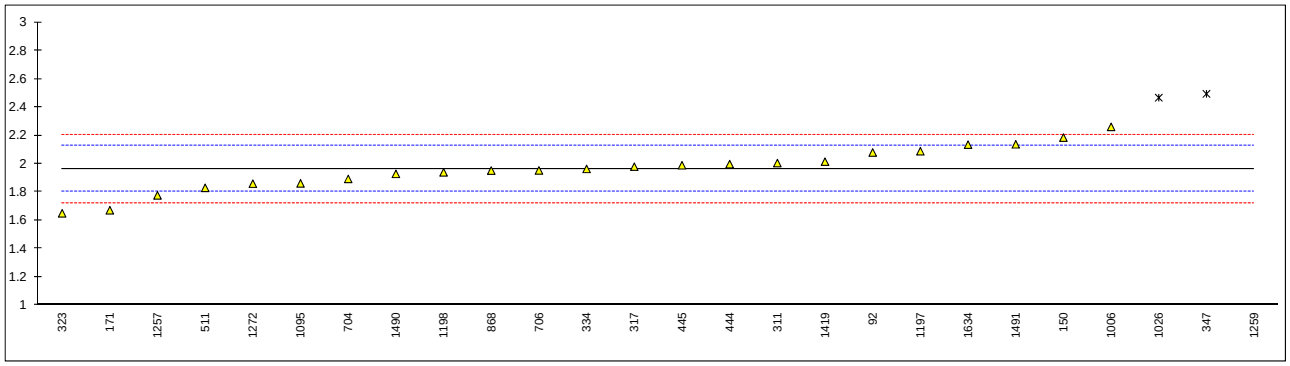
From this comparison it is clear that not all consensus values as determined in this PT are in line with the values as determined by EffecTech during the preparation of the cylinders.

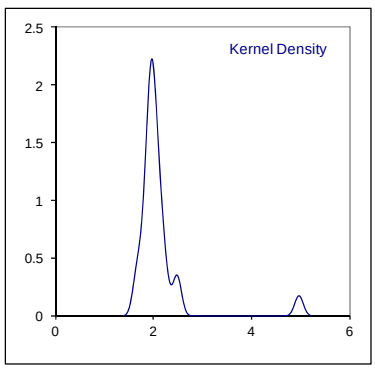
For the calculation of the Vapour Pressure (VP), ten participants used ISO8973/IP432 and four participants used ASTM D2598. In ISO 8973 (identical to IP432) the Absolute VP is calculated from the mole fraction per component and a VP factor of that component (given for all components). From the Absolute VP, the Relative VP is calculated.
In ASTM D2598 the Gage pressure (identical to the Relative VP) is calculated from the liquid volume percentage per component and a VP factor of that component. Regretfully in the 2002 (2007) version of D2598 no factors are given for n-butene, 1-butene and n-pentane. However, in the draft 2012 version, factors are mentioned for these and other components. 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 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:
"*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 #12074; results in %mol/mol

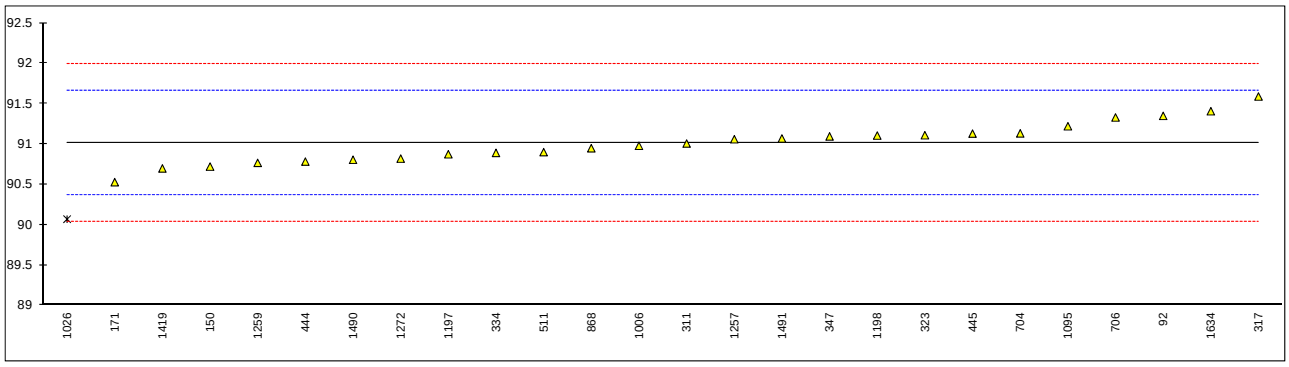
lab	method	value	mark	z(targ)	remarks
92	D2163	2.08		1.44	
150	D2163	2.185		2.75	
171	D2163	1.672		-3.61	
311	D2163	2.005		0.52	
317	D2163	1.98		0.21	
323	D2163	1.65		-3.88	
334	EN27941	1.964		0.01	
347	D2163	2.494	DG(0.05)	6.57	
444	IP405	1.998		0.43	
445	D2163	1.99		0.33	
511	D2163	1.830		-1.65	
704	D2163	1.893		-0.87	
706	D2163	1.953		-0.13	
868	D2163	1.952		-0.14	
912		-----		-----	
1006	D2163	2.261		3.69	
1026	ISO7941	2.467	DG(0.05)	6.24	
1095	EN27941	1.862		-1.26	
1197	D2163	2.089		1.56	
1198	D2163	1.940		-0.29	
1200		-----		-----	
1257	D2163	1.777		-2.31	
1259	EN27941	4.968	C,G(0.01)	37.22	First reported 5.704
1272	EN27941	1.86		-1.28	
1419	EN27941	2.015		0.64	
1490	EN27941	1.929		-0.43	
1491	ISO7941	2.138		2.16	
1497		-----		-----	
1634	ISO7941	2.135		2.13	
	normality	OK			
	n	23			
	outliers	3			
	mean (n)	1.963			
	st.dev. (n)	0.1503			
	R(calc.)	0.421			
	R(D2163:96)	0.226			Compare R(EN27941(liq)) = 0.739

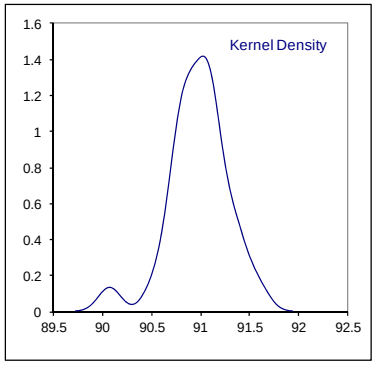




Determination of Propane on sample #12074 ; results in %mol/mol

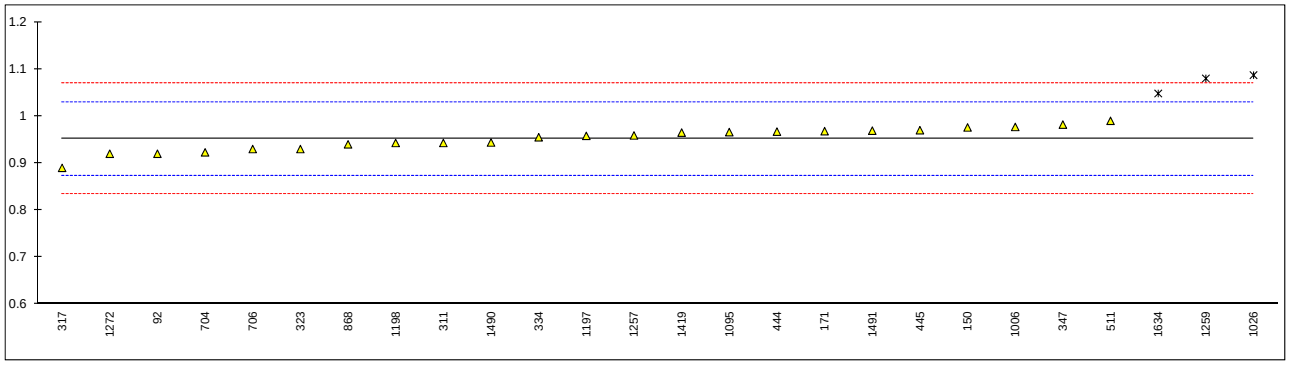
lab	method	value	mark	z(targ)	remarks
92	D2163	91.35		1.04	
150	D2163	90.721		-0.90	
171	D2163	90.528		-1.49	
311	D2163	91.007		-0.02	
317	D2163	91.59	C	1.78	First reported 91.41
323	D2163	91.11		0.30	
334	EN27941	90.891		-0.38	
347	D2163	91.095		0.25	
444	IP405	90.783		-0.71	
445	D2163	91.13		0.36	
511	D2163	90.900		-0.35	
704	D2163	91.133		0.37	
706	D2163	91.330		0.98	
868	D2163	90.948		-0.20	
912		-----		-----	
1006	D2163	90.979		-0.10	
1026	ISO7941	90.069	G(0.05)	-2.90	
1095	EN27941	91.221		0.64	
1197	D2163	90.874		-0.43	
1198	D2163	91.106		0.29	
1200		-----		-----	
1257	D2163	91.060		0.14	
1259	EN27941	90.767	C	-0.76	First reported 87.061
1272	EN27941	90.82		-0.59	
1419	EN27941	90.698		-0.97	
1490	EN27941	90.806		-0.64	
1491	ISO7941	91.069		0.17	
1497		-----		-----	
1634	ISO7941	91.407		1.21	
	normality	OK			
	n	25			
	outliers	1			
	mean (n)	91.013			
	st.dev. (n)	0.2474			
	R(calc.)	0.693			
	R(D2163:96)	0.910			Compare R(EN27941(liq)) = 1.015

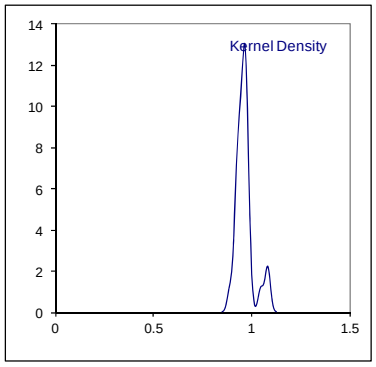




Determination of Propylene on sample #12074; results in %mol/mol

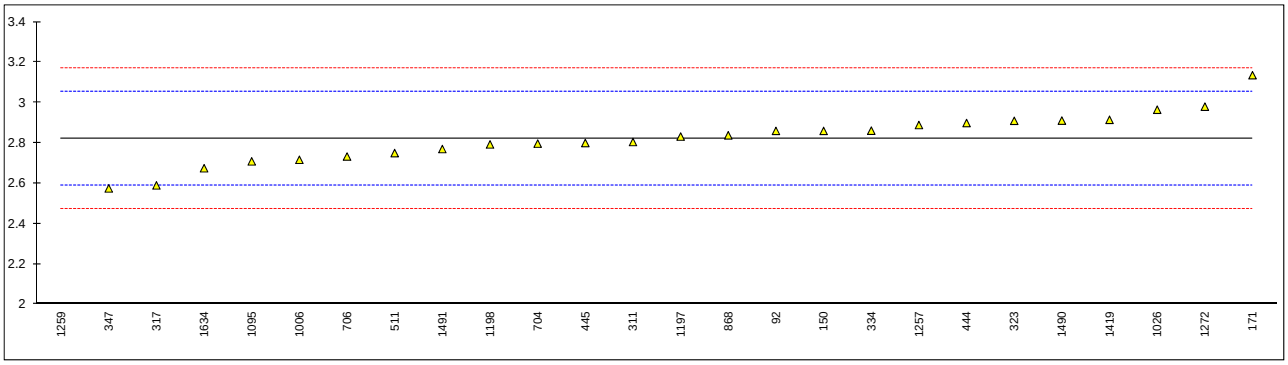
lab	method	value	mark	z(targ)	remarks
92	D2163	0.92		-0.81	
150	D2163	0.976		0.63	
171	D2163	0.968		0.42	
311	D2163	0.943		-0.22	
317	D2163	0.89	C	-1.57	First reported 0.86
323	D2163	0.93		-0.55	
334	EN27941	0.955		0.09	
347	D2163	0.982		0.78	
444	IP405	0.967		0.40	
445	D2163	0.97		0.47	
511	D2163	0.990		0.98	
704	D2163	0.923		-0.73	
706	D2163	0.930		-0.55	
868	D2163	0.940		-0.29	
912		-----		-----	
1006	D2163	0.977		0.65	
1026	ISO7941	1.087	DG(0.01)	3.46	
1095	EN27941	0.966		0.37	
1197	D2163	0.958		0.17	
1198	D2163	0.943		-0.22	
1200		-----		-----	
1257	D2163	0.959		0.19	
1259	EN27941	1.080	C,DG(0.01)	3.28	First reported 1.037
1272	EN27941	0.92		-0.81	
1419	EN27941	0.965		0.34	
1490	EN27941	0.944		-0.19	
1491	ISO7941	0.969		0.45	
1497		-----		-----	
1634	ISO7941	1.048	G(0.05)	2.47	
	normality	OK			
	n	23			
	outliers	3			
	mean (n)	0.952			
	st.dev. (n)	0.0245			
	R(calc.)	0.068			
	R(D2163:96)	0.110			Compare R(EN27941(liq)) = 0.213

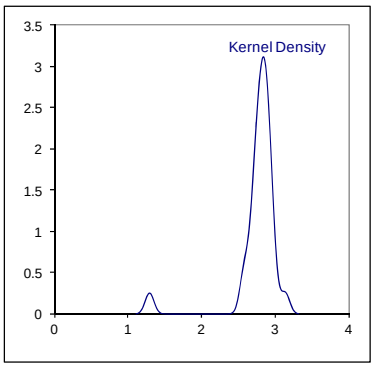




Determination of iso-Butane on sample #12074; results in %mol/mol

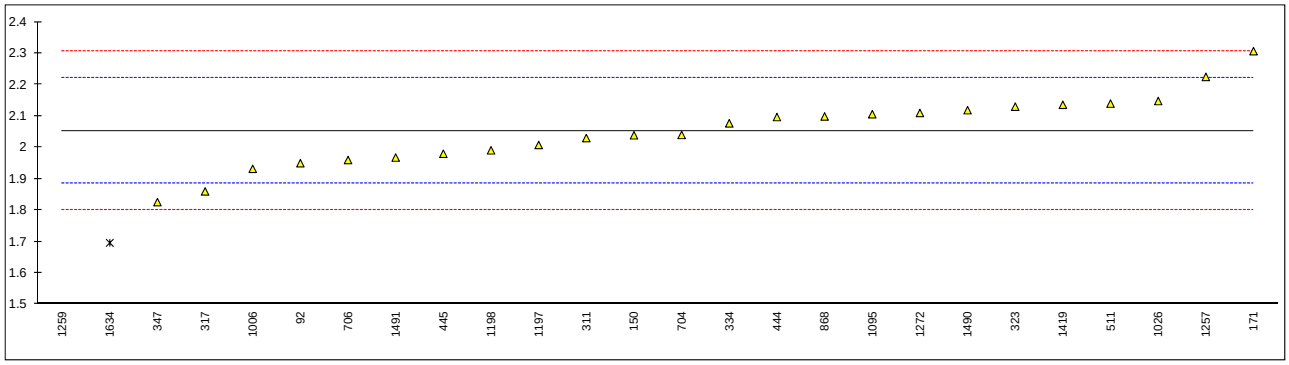
lab	method	value	mark	z(targ)	remarks
92	D2163	2.86		0.32	
150	D2163	2.860		0.32	
171	D2163	3.136		2.70	
311	D2163	2.805		-0.15	
317	D2163	2.59		-2.01	
323	D2163	2.91		0.75	
334	EN27941	2.861		0.33	
347	D2163	2.575		-2.14	
444	IP405	2.899		0.66	
445	D2163	2.80		-0.20	
511	D2163	2.750		-0.63	
704	D2163	2.797		-0.22	
706	D2163	2.733		-0.77	
868	D2163	2.838		0.13	
912		-----		-----	
1006	D2163	2.717		-0.91	
1026	ISO7941	2.965		1.23	
1095	EN27941	2.709		-0.98	
1197	D2163	2.832		0.08	
1198	D2163	2.793		-0.26	
1200		-----		-----	
1257	D2163	2.889		0.57	
1259	EN27941	1.301	C,G(0.01)	-13.11	First reported 1.137
1272	EN27941	2.98		1.35	
1419	EN27941	2.915		0.79	
1490	EN27941	2.911		0.76	
1491	ISO7941	2.770		-0.45	
1497		-----		-----	
1634	ISO7941	2.675		-1.27	
	normality	OK			
	n	25			
	outliers	1			
	mean (n)	2.823			
	st.dev. (n)	0.1228			
	R(calc.)	0.344			
	R(D2163:96)	0.325			Compare R(EN27941(liq)) = 0.384

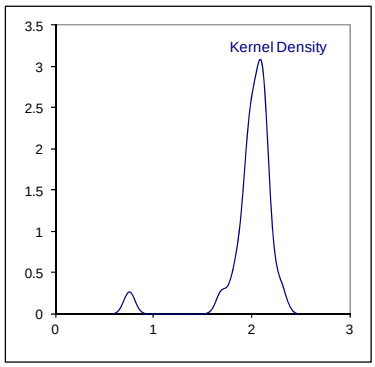




Determination of n-Butane on sample #12074; results in %mol/mol

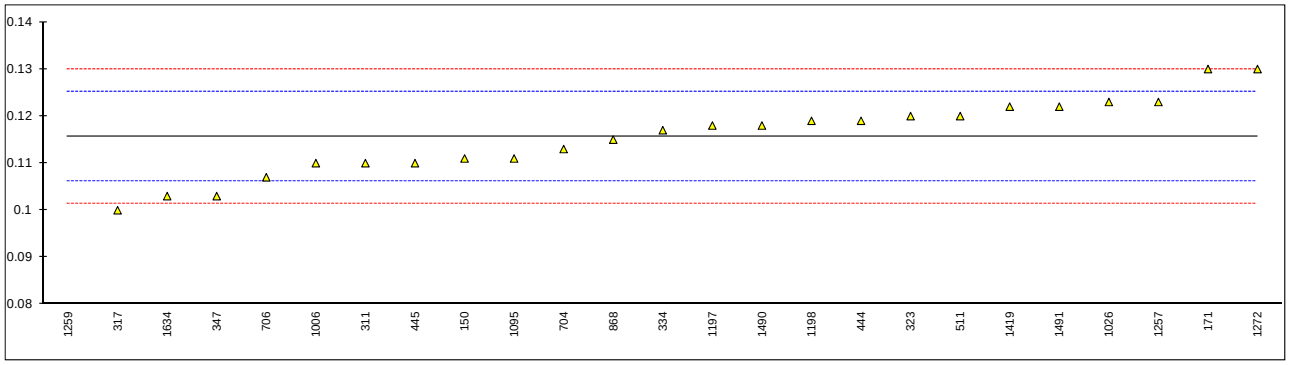
lab	method	value	mark	z(targ)	remarks
92	D2163	1.95		-1.22	
150	D2163	2.039		-0.17	
171	D2163	2.307		3.01	
311	D2163	2.030		-0.28	
317	D2163	1.86		-2.29	
323	D2163	2.13		0.91	
334	EN27941	2.077		0.28	
347	D2163	1.826		-2.69	
444	IP405	2.097		0.52	
445	D2163	1.98		-0.87	
511	D2163	2.140		1.03	
704	D2163	2.040		-0.16	
706	D2163	1.960		-1.10	
868	D2163	2.099		0.54	
912		-----		-----	
1006	D2163	1.932		-1.44	
1026	ISO7941	2.148		1.12	
1095	EN27941	2.106		0.62	
1197	D2163	2.008		-0.54	
1198	D2163	1.991		-0.74	
1200		-----		-----	
1257	D2163	2.225		2.03	
1259	EN27941	0.753	C,G(0.01)	-15.40	First reported 0.629
1272	EN27941	2.11		0.67	
1419	EN27941	2.136		0.98	
1490	EN27941	2.119		0.78	
1491	ISO7941	1.968		-1.01	
1497		-----		-----	
1634	ISO7941	1.696	G(0.05)	-4.23	
	normality	OK			
	n	24			
	outliers	2			
	mean (n)	2.053			
	st.dev. (n)	0.1104			
	R(calc.)	0.309			
	R(D2163:96)	0.236			Compare R(EN27941(liq)) = 0.386

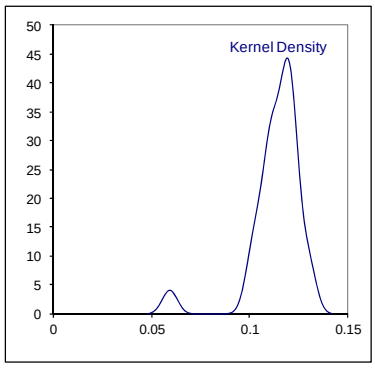




Determination of 1-Butene on sample #12074; results in %mol/mol

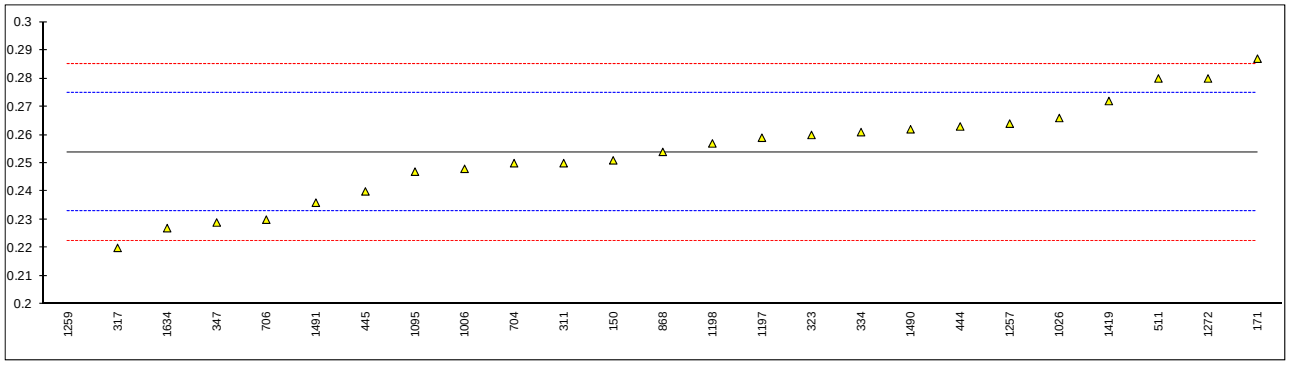
lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150	D2163	0.111		-0.96	
171	D2163	0.130		3.03	
311	D2163	0.110		-1.17	
317	D2163	0.10		-3.28	
323	D2163	0.12		0.93	
334	EN27941	0.117		0.30	
347	D2163	0.103		-2.65	
444	IP405	0.119		0.72	
445	D2163	0.11		-1.17	
511	D2163	0.120		0.93	
704	D2163	0.113		-0.54	
706	D2163	0.107		-1.81	
868	D2163	0.115		-0.12	
912		-----		-----	
1006	D2163	0.110		-1.17	
1026	ISO7941	0.123		1.56	
1095	EN27941	0.111		-0.96	
1197	D2163	0.118		0.51	
1198	D2163	0.119		0.72	
1200		-----		-----	
1257	D2163	0.123		1.56	
1259	EN27941	0.059	C,G(0.01)	-11.91	First reported 0.039
1272	EN27941	0.13		3.03	
1419	EN27941	0.122		1.35	
1490	EN27941	0.118		0.51	
1491	ISO7941	0.122		1.35	
1497		-----		-----	
1634	ISO7941	0.103		-2.65	
	normality	OK			
	n	24			
	outliers	1			
	mean (n)	0.116			
	st.dev. (n)	0.0080			
	R(calc.)	0.022			
	R(D2163:96)	0.013			Compare R(EN27941(liq)) = 0.168

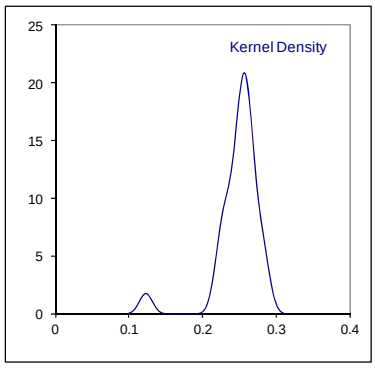




Determination of iso-Butene on sample #12074; results in %mol/mol

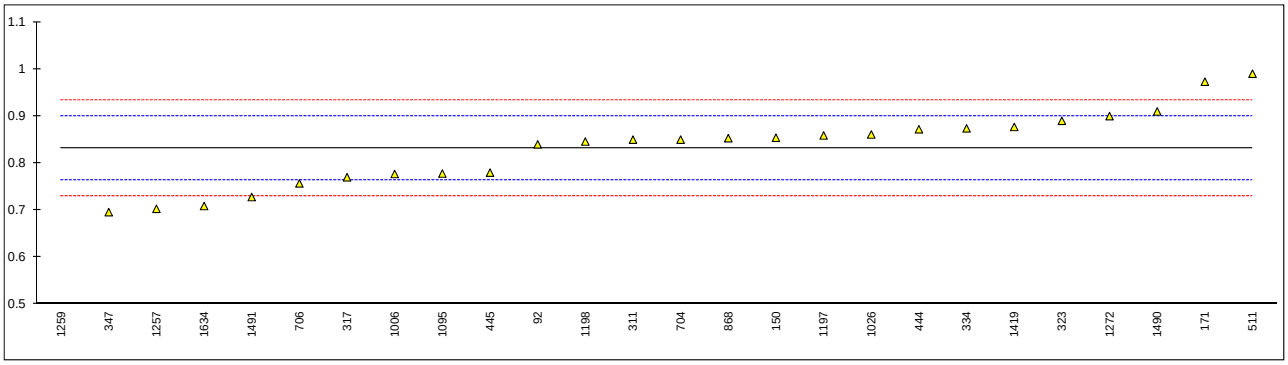
lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150	D2163	0.251		-0.28	
171	D2163	0.287		3.17	
311	D2163	0.250		-0.37	
317	D2163	0.22		-3.25	
323	D2163	0.26		0.59	
334	EN27941	0.261		0.68	
347	D2163	0.229		-2.38	
444	IP405	0.263		0.87	
445	D2163	0.24		-1.33	
511	D2163	0.280		2.50	
704	D2163	0.250		-0.37	
706	D2163	0.230		-2.29	
868	D2163	0.254		0.01	
912		-----		-----	
1006	D2163	0.248		-0.56	
1026	ISO7941	0.266		1.16	
1095	EN27941	0.247		-0.66	
1197	D2163	0.259		0.49	
1198	D2163	0.257		0.30	
1200		-----		-----	
1257	D2163	0.264		0.97	
1259	EN27941	0.123	C,G(0.01)	-12.54	First reported 0.102
1272	EN27941	0.28		2.50	
1419	EN27941	0.272		1.74	
1490	EN27941	0.262		0.78	
1491	ISO7941	0.236		-1.71	
1497		-----		-----	
1634	ISO7941	0.227		-2.57	
	normality	OK			
	n	24			
	outliers	1			
	mean (n)	0.254			
	st.dev. (n)	0.0175			
	R(calc.)	0.049			
	R(D2163:96)	0.029			Compare R(EN27941(liq)) = 0.167

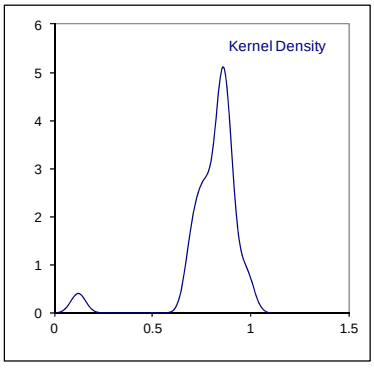




Determination of n-Pentane on sample #12074; results in %mol/mol

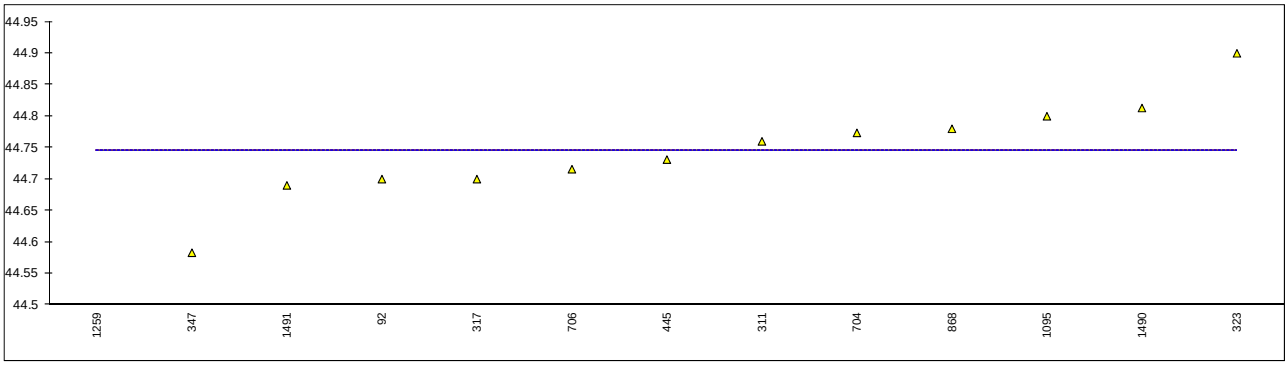
lab	method	value	mark	z(targ)	remarks
92	D2163	0.84		0.24	
150	D2163	0.854		0.65	
171	D2163	0.973		4.13	
311	D2163	0.850		0.53	
317	D2163	0.77	C	-1.81	First reported 0.99
323	D2163	0.89		1.70	
334	EN27941	0.874		1.23	
347	D2163	0.696		-3.97	
444	IP405	0.872		1.17	
445	D2163	0.78		-1.52	
511	D2163	0.990		4.62	
704	D2163	0.850		0.53	
706	D2163	0.757		-2.19	
868	D2163	0.853		0.62	
912		-----		-----	
1006	D2163	0.777		-1.60	
1026	ISO7941	0.861		0.85	
1095	EN27941	0.778		-1.58	
1197	D2163	0.859		0.79	
1198	D2163	0.846		0.41	
1200		-----		-----	
1257	D2163	0.703		-3.77	
1259	EN27941	0.121	C,G(0.01)	-20.78	First reported 0.092
1272	EN27941	0.90		1.99	
1419	EN27941	0.877		1.32	
1490	EN27941	0.910		2.28	
1491	ISO7941	0.728		-3.04	
1497		-----		-----	
1634	ISO7941	0.709		-3.59	
	normality	not OK			
	n	25			
	outliers	1			
	mean (n)	0.832			
	st.dev. (n)	0.0782			
	R(calc.)	0.219			
	R(D2163:96)	0.096			Compare R(EN27941(liq)) = 0.305

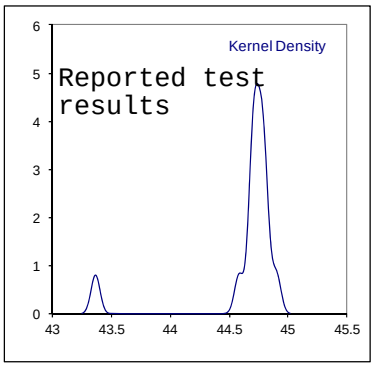


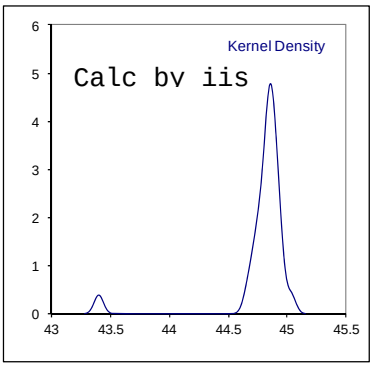


Determination of Molar Mass on sample #12074; results in g/mol

lab	method	value	mark	z(targ)	remarks
92	inh-2145	44.7		-----	
150		-----		-----	
171		-----		-----	
311	INH-407	44.760		-----	
317	D2598	44.7		-----	
323	D3588	44.9		-----	
334		-----		-----	
347	D2421	44.583		-----	
444		-----		-----	
445	IP432	44.731		-----	
511		-----		-----	
704	D2163	44.7735		-----	
706	D2163	44.7157		-----	
868	CALC	44.78		-----	
912		-----		-----	
1006		-----		-----	
1026		-----		-----	
1095		44.8		-----	
1197		-----		-----	
1198		-----		-----	
1200		-----		-----	
1257		-----		-----	
1259	ISO8973	43.3680036	C,G(0.01)	-----	First reported 41.7155
1272		-----		-----	
1419		-----		-----	
1490	CALC	44.813		-----	
1491	ISO8973	44.69		-----	
1497		-----		-----	
1634		-----		-----	
					Calculated by iis from all reported test results:
	normality	OK			OK
	n	12			25
	outliers	1			1
	mean (n)	44.746			44.754
	st.dev. (n)	0.0788			0.0738
	R(calc.)	0.221			0.207
	R(lit)	unknown			unknown
	R(iis11S03P)	0.140			0.065 (for comparison)

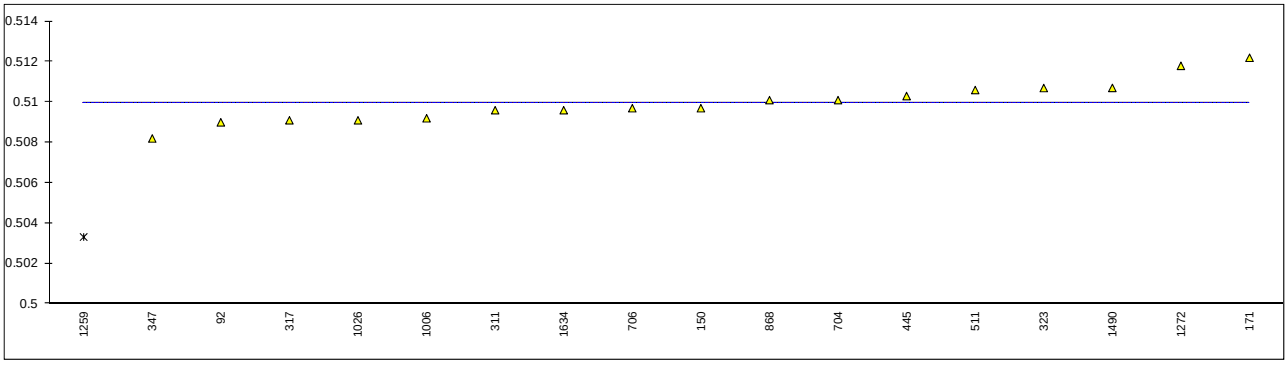


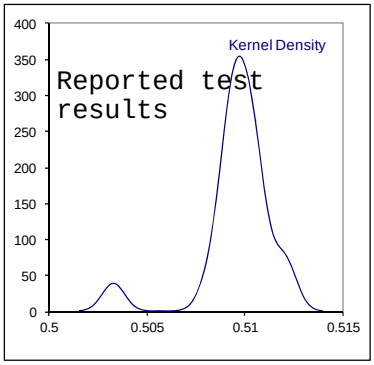


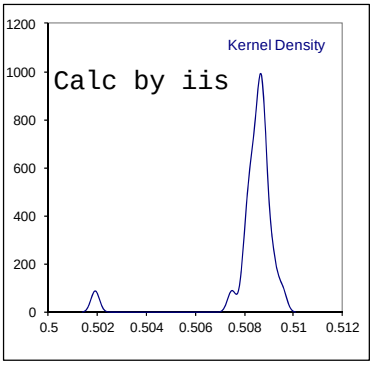


Determination of Relative Density @60F; unitless results

lab	method	value	mark	z(targ)	remarks	
92	D2598	0.509		-----		
150	D2598	0.5097		-----		
171	D2598	0.5122		-----		
311	INH-407	0.5096		-----		
317	ISO8973	0.5091		-----		
323	D2598	0.5107		-----		
334		-----		-----		
347	D2598	0.5082		-----		
444		-----		-----		
445	IP432	0.5103		-----		
511	D2598	0.5106		-----		
704	D2598	0.5101		-----		
706	D2598	0.5097		-----		
868	D2598	0.5101		-----		
912		-----		-----		
1006	D2598	0.5092		-----		
1026	ISO8973	0.5091		-----		
1095		-----	W	-----		
1197		-----		-----		
1198		-----		-----		
1200		-----		-----		
1257		-----		-----		
1259		0.5033143	C,G(0.01)	-----	First reported 0.50189	
1272	ISO8973	0.5118	C	-----		
1419		-----		-----		
1490	ISO8973	0.510704		-----		
1491		-----		-----		
1497		-----		-----		
1634	ISO8973	0.5096		-----		
					Calculated by iis from all reported test results:	Idem for 15ºC:
	normality	OK			OK	OK
	n	17			25	25
	outliers	1			1	1
	mean (n)	0.50998			0.50990	0.51020
	st.dev. (n)	0.001016			0.000530	0.000498
	R(calc.)	0.00285			0.00148	0.00139
	R(lit)	unknown			unknown	unknown
	R(iis11S03P)	0.00076			0.00036	0.00036





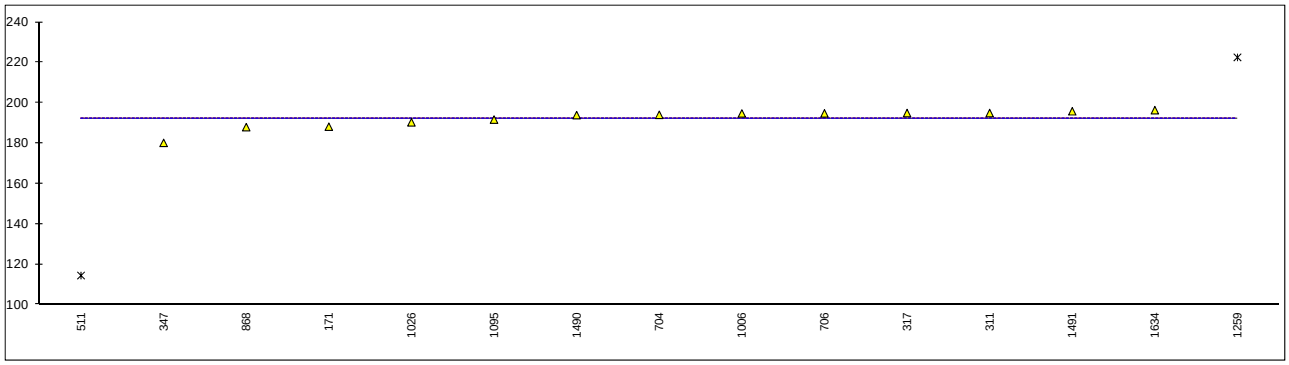


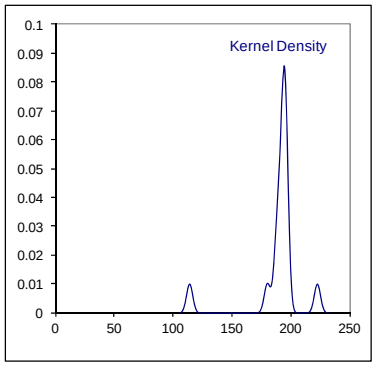
Determination of Absolute Vapour Pressure @100F; results in psi

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
171	D2598	188.22	C	-----	First reported 164.57
311	ISO8973	195		-----	
317	ISO8973	195		-----	
323		-----		-----	
334		-----		-----	
347	D2598	180.2		-----	
444		-----		-----	
445		-----		-----	
511	D2598	114.4316	G(0.01)	-----	
704	ISO8973	194.10		-----	
706	ISO8973	194.84		-----	
868	D2598	188		-----	
912		-----		-----	
1006	ISO8973	194.8		-----	
1026	ISO8973	190.4		-----	
1095		191.74		-----	
1197		-----		-----	
1198		-----		-----	
1200		-----		-----	
1257		-----		-----	
1259		222.5829	C,G(0.01)	-----	First reported 213.5106
1272		-----		-----	
1419		-----		-----	
1490	ISO8973	193.95		-----	
1491	ISO8973	195.89		-----	
1497		-----		-----	
1634	ISO8973	196.435		-----	

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

	ISO8973 / IP432	ASTM D2598
normality	OK	OK
n	25	25
outliers	1	1
mean (n)	194.273	188.300
st.dev. (n)	1.4745	1.2060
R(calc.)	4.129	3.377
R(lit)	unknown	unknown



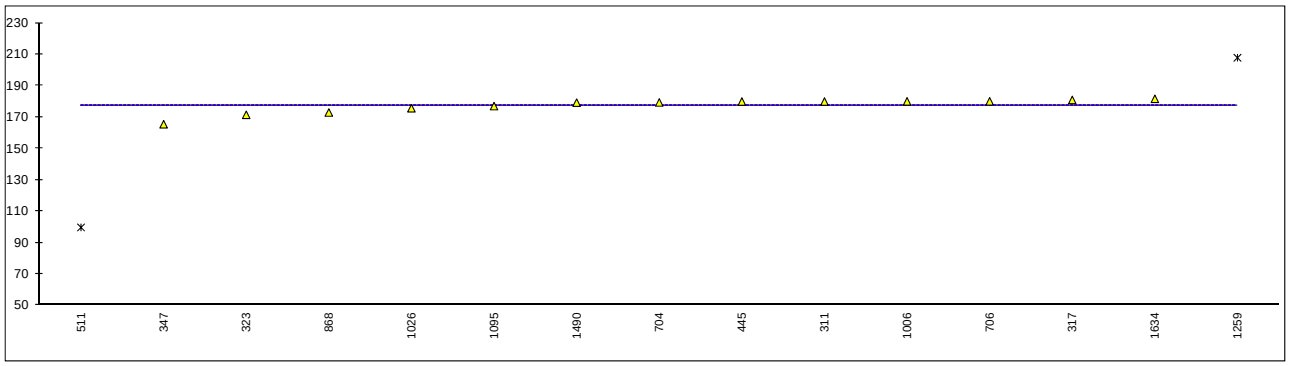


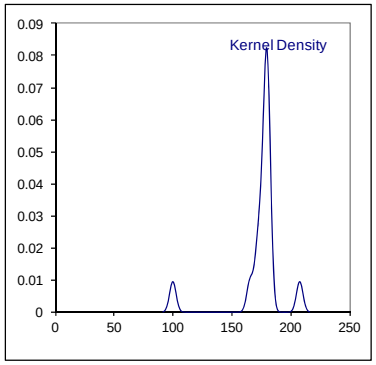
Determination of Relative Vapour Pressure @100F (Gage pressure); results in psi

lab	method	value	mark	z(targ)	remarks
92		-----		-----	
150		-----		-----	
171		-----		-----	
311	ISO8973	180		-----	
317	ISO8973	181	C	-----	First reported 180
323	D2598	171.5		-----	
334		-----		-----	
347	D2598	165.5		-----	
444		-----		-----	
445	IP432	180		-----	
511	D2598	99.7316	G(0.01)	-----	
704	ISO8973	179.40		-----	
706	ISO8973	180.14		-----	
868	D2598	173		-----	
912		-----		-----	
1006	ISO8973	180.1		-----	
1026	ISO8973	175.7		-----	
1095		177.05		-----	
1197		-----		-----	
1198		-----		-----	
1200		-----		-----	
1257		-----		-----	
1259		207.887	C,G(0.01)	-----	First reported 198.8105
1272		-----		-----	
1419		-----		-----	
1490	ISO8973	179.26		-----	
1491		-----		-----	
1497		-----		-----	
1634	ISO8973	181.739		-----	

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

	ISO8973 / IP432	ASTM D2598
normality	OK	OK
n	25	25
outliers	1	1
mean (n)	179.577	173.604
st.dev. (n)	1.4745	1.2060
R(calc.)	4.129	3.377
R(lit)	unknown	unknown





APPENDIX 2

Number of participants per country

1 lab in	BELGIUM
1 lab in	CANADA
1 lab in	CROATIA
1 lab in	EGYPT
1 lab in	FRANCE
1 lab in	INDIA
2 labs in	MALAYSIA
1 lab in	P.R. of CHINA
1 lab in	PERU
4 labs in	PORTUGAL
1 lab in	SAUDI ARABIA
2 labs in	SERBIA
1 lab in	SLOVAKIA
1 lab in	SPAIN
1 lab in	TAIWAN R.O.C.
3 labs in	THE NETHERLANDS
1 lab in	U.A.E.
2 labs in	U.S.A.
2 labs in	UKRAINE
2 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

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