Results of Proficiency Test
Benzene
February 2019
1 INTRODUCTION

Since 1999, the Institute for Interlaboratory Studies (iis) organizes a proficiency scheme for the analysis of Benzene every year. During the annual proficiency testing program 2018/2019, it was decided to continue the round robin for the analysis of Benzene in accordance with the latest applicable version of the specification for Benzene: ASTM D2359.

In the interlaboratory study 51 laboratories in 22 different countries registered for participation. See appendix 2 for the number of participants per country. In this report, the results of the 2019 proficiency test are presented and discussed. This report is also electronically available through the iis website www.iisnl.com.

2 SET UP

The Institute for Interlaboratory Studies (iis) in Spijkenisse, the Netherlands, was the organizer of this proficiency test (PT). Sample analyzes for fit-for-use and homogeneity testing were subcontracted to an ISO/IEC 17025 accredited laboratory. It was decided to send one sample of Benzene (1 liter bottle, labelled #19020). Participants were requested to report rounded and unrounded test results. The unrounded test results were preferably used for the statistical evaluation.

2.1 ACCREDITATION

The Institute for Interlaboratory Studies in Spijkenisse, the Netherlands, is accredited in agreement with ISO/IEC 17043:2010 (R007), since January 2000, by the Dutch Accreditation Council (Raad voor Accreditatie). This PT falls under the accredited scope. This ensures strict adherence to protocols for sample preparation and statistical evaluation and 100% confidentiality of participant’s data. Feedback from the participants on the reported data is encouraged and customer’s satisfaction is measured on regular basis by sending out questionnaires.

2.2 PROTOCOL

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 June 2018 (iis-protocol, version 3.5). This protocol is electronically available through the iis website www.iisnl.com, from the FAQ page.

2.3 CONFIDENTIALITY STATEMENT

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

Approximately 120 liters of Benzene was obtained from a local chemical supplier. After homogenization, 78 amber glass bottles of 1 liter were filled and labelled #19020. The homogeneity of the subsamples was checked by determination of Density at 20°C in accordance with ISO12185 on 8 stratified randomly selected samples.

<table>
<thead>
<tr>
<th>Sample #19020-1</th>
<th>Density at 20°C in kg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample #19020-2</td>
<td>0.87897</td>
</tr>
<tr>
<td>Sample #19020-3</td>
<td>0.87898</td>
</tr>
<tr>
<td>Sample #19020-4</td>
<td>0.87899</td>
</tr>
<tr>
<td>Sample #19020-5</td>
<td>0.87898</td>
</tr>
<tr>
<td>Sample #19020-6</td>
<td>0.87898</td>
</tr>
<tr>
<td>Sample #19020-7</td>
<td>0.87898</td>
</tr>
<tr>
<td>Sample #19020-8</td>
<td>0.87898</td>
</tr>
</tbody>
</table>

Table 1: homogeneity test results of subsamples #19020

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

<table>
<thead>
<tr>
<th>Density at 20°C in kg/L</th>
<th>r (observed)</th>
<th>Reference test method</th>
<th>0.3*R (reference test method)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00001</td>
<td>ISO12185:96</td>
<td>0.00015</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: evaluation of repeatability of subsamples #19020

The calculated repeatability was in agreement with 0.3 times the corresponding reproducibility of the reference test method. Therefore, homogeneity of the subsamples was assumed.

To each of the participating laboratories one 1 liter bottle of Benzene labelled #19020 was sent on February 6, 2019. An SDS was added to the sample package.

2.5 STABILITY OF THE SAMPLES

The stability of Benzene packed in amber glass bottles was checked. The material was found sufficiently stable for the period of the proficiency test.
2.6 **ANALYSES**

The participants were requested to determine on sample #19020: Acid Wash Color, Acidity, Appearance, Bromine Index, Total Chlorides, Organic Chlorides, Color Pt/Co, Density at 20°C, Distillation (IBP, 50% recovered and DP), Total Nitrogen, Purity, Methylcyclohexane, Toluene, Nonaromatics, 1,4-Dioxane, Solidification Point, Sulfur, Thiophene and Water.

It was explicitly requested to treat the sample as if it was a routine sample and to report the test results using the indicated units on the report form and not to round the test results, but report as much significant figures as possible. It was also requested not to report 'less than' test results, which are above the detection limit, because such test results cannot be used for meaningful statistical evaluations.

To get comparable test results, a detailed report form and a letter of instructions are prepared. On the report form the reporting units are given as well as the appropriate reference test methods that will be used during the evaluation. The detailed report form and the letter of instructions are both made available on the data entry portal www.kpmd.co.uk/sgs-iis/. The participating laboratories are also requested to confirm the sample receipt on this data entry portal. The letter of instructions can also be downloaded from the iis website www.iisnl.com.

3 **RESULTS**

During five weeks after sample dispatch, the test results of the individual laboratories were gathered via the data entry portal www.kpmd.co.uk/sgs-iis/. The reported test results are tabulated per determination in appendix 1 of this report. The laboratories are presented by their code numbers.

Directly after the deadline, a reminder was sent to those laboratories that had not reported test results at that moment. Shortly after the deadline, the available test results were screened for suspect data. A test result was called suspect in case the Huber Elimination Rule (a robust outlier test) found it to be an outlier. The laboratories that produced these suspect data were asked to check the reported test results (no reanalyses). Additional or corrected test results are used for data analysis and original test results are placed under 'Remarks' in the test result tables in appendix 1. Test results that came in after the deadline were not taken into account in this screening for suspect data and thus these participants were not requested for checks.

3.1 **STATISTICS**

The protocol followed in the organization of this proficiency test was the one as described for proficiency testing in the report ‘iis Interlaboratory Studies: Protocol for the Organisation, Statistics and Evaluation’ of June 2018 (iis-protocol, version 3.5).

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. In this PT, the criterion of ISO13528, paragraph 9.2.1 was met for all evaluated tests, therefore, the uncertainty of all assigned values may be negligible and need not be included in the PT report.

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

3.2 GRAPHICS

In order to visualize the data against the reproducibilities from literature, Gauss plots were made, using the sorted data for one determination (see appendix 1). On the Y-axis the reported 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, EN or ISO reproducibilities, the z-scores were calculated using a target standard deviation. This results in an evaluation independent of the variation of this interlaboratory study.

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

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

The z-scores were calculated according to:

\[ z_{\text{target}} = \frac{\text{test result} - \text{average of PT}}{\text{target standard deviation}} \]

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 dispatch of the samples. Participants in Brazil, China and India received the samples late due to problems at customs. Four participants reported the test results after the final reporting date and one laboratory did not report any test results. Not all laboratories were able to perform all analyses requested. Finally, in total 50 participants reported 532 numerical test results. Observed were 17 outlying results, which is 3.2% of the total of numerical test results. In proficiency studies, outlier percentages of 3% - 7.5% are quite normal.

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

In this section, the reported test results are discussed 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.

Unfortunately, a suitable reference test method, providing the precision data, is not available for all determinations. For the tests, that have no available precision data, the calculated reproducibility was compared against the reproducibility estimated from the Horwitz equation.

**Acid Wash Color:** This determination was not problematic. No statistical outliers were observed. The calculated reproducibility is in good agreement with the requirements of ASTM D848:14.

**Acidity:** This determination was not problematic. The majority of laboratories report “no free acid” (NFA) or “Pass” in accordance with ASTM D847:15.

**Appearance:** No analytical problems were observed. All labs agreed about the appearance of the sample, which was bright, clear and free of suspended matter (Pass).

**Bromine Index:** This determination was not problematic. No statistical outliers were observed. The calculated reproducibility is in agreement with the requirements of ASTM D5776:14a.

**Chlorides, Total:** This determination was not problematic. No statistical outliers were observed, but one test result was excluded. The calculated reproducibility after rejection of the suspect data is in full agreement with the requirements of ASTM D5194:18.

**Chlorides, Organic:** This determination was not problematic. No statistical outliers were observed. The calculated reproducibility is in good agreement with the requirements of ASTM D5808:18.

**Color Pt/Co:** This determination was not problematic. No statistical outliers were observed. The calculated reproducibility is in full agreement with the requirements of ASTM D5386:16 and ASTM D1209:05(2011).

**Density at 20°C:** This determination was not problematic. No statistical outliers were observed. The calculated reproducibility is in good agreement with the requirements of ISO12185:96.

**Distillation:** This determination was problematic for a number of laboratories. In total nine statistical outliers were observed and four test results were excluded. However, all calculated reproducibilities after rejection of the suspect data are in agreement with the requirements of ASTM D850-A:18.
From the reported results of the 50% recovered, it appears that four participants possibly did not correct the results for barometric pressure and thermometer inaccuracy as described in ASTM D850 (paragraph 11).

**Total Nitrogen:** This determination was problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is not in agreement with the requirements of ASTM D7184:15.

**GC General:** ASTM D4492 was withdrawn in 2018 and replaced by ASTM D7504:18. Test method ASTM D7504 was used to evaluate the GC parameters.

**Purity:** This determination 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 D7504:18.

**Methylcyclohexane:** This determination may be problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is not agreement with the estimated reproducibility calculated using the Horwitz equation.

**Nonaromatics:** This determination was not problematic. One statistical outlier was observed. However, the calculated reproducibility after rejection of the statistical outlier is in agreement with the requirements of ASTM D7504:18.

**Toluene:** All reporting participants agreed that the sample was not positive for Toluene (<10 mg/kg).

**1,4-Dioxane:** All reporting participants agreed that the sample was not positive for 1,4-Dioxane (<10 mg/kg).

**Solidification Point:** This determination was not problematic. Two statistical outliers were observed. However, the calculated reproducibility after rejection of the statistical outliers is in full agreement with the requirements of ASTM D852:16.

**Sulfur:** This determination was not problematic. One statistical outlier was observed. However, the calculated reproducibility after rejection of the statistical outlier is in agreement with the requirements of ASTM D5453:16e1.

**Thiophene:** All reporting participants agreed that the sample was not positive for Thiophene (<1 mg/kg).

**Water:** This determination was problematic. One statistical outlier was observed. The calculated reproducibility after rejection of the statistical outlier is not in agreement with the requirements of ASTM E1064:16.
4.2 PERFORMANCE EVALUATION FOR THE GROUP OF LABORATORIES

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>unit</th>
<th>n</th>
<th>average</th>
<th>2.8 * sd</th>
<th>R (lit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Wash Color</td>
<td></td>
<td>34</td>
<td>0.7 (1-)</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Acidity</td>
<td>mg NaOH/100mL</td>
<td>35</td>
<td>No free acid</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td>45</td>
<td>Pass (C&amp;B)</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Bromine Index</td>
<td>mg Br/100g</td>
<td>30</td>
<td>1.4</td>
<td>2.3</td>
<td>4.6</td>
</tr>
<tr>
<td>Chlorides, Total</td>
<td>mg/kg</td>
<td>12</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Chlorides, Organic</td>
<td>mg/kg</td>
<td>16</td>
<td>1.0</td>
<td>0.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Color Pt/Co</td>
<td></td>
<td>36</td>
<td>7.6</td>
<td>5.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Density at 20°C</td>
<td>kg/L</td>
<td>46</td>
<td>0.8790</td>
<td>0.0002</td>
<td>0.0005</td>
</tr>
<tr>
<td>Distillation, IBP</td>
<td>°C</td>
<td>28</td>
<td>79.8</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Distillation, 50% rec.</td>
<td>°C</td>
<td>29</td>
<td>80.1</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Distillation, DP</td>
<td>°C</td>
<td>29</td>
<td>80.2</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/kg</td>
<td>21</td>
<td>0.25</td>
<td>0.27</td>
<td>0.23</td>
</tr>
<tr>
<td>Purity</td>
<td>%M/M</td>
<td>45</td>
<td>99.991</td>
<td>0.005</td>
<td>0.025</td>
</tr>
<tr>
<td>Methylcyclohexane</td>
<td>mg/kg</td>
<td>27</td>
<td>9.0</td>
<td>3.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Nonaromatics</td>
<td>mg/kg</td>
<td>44</td>
<td>73.9</td>
<td>29.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Toluene</td>
<td>mg/kg</td>
<td>46</td>
<td>&lt;10</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>1,4-Dioxane</td>
<td>mg/kg</td>
<td>24</td>
<td>&lt;10</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Solidification Point</td>
<td>°C</td>
<td>22</td>
<td>5.49</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Sulfur</td>
<td>mg/kg</td>
<td>25</td>
<td>0.29</td>
<td>0.25</td>
<td>0.23</td>
</tr>
<tr>
<td>Thiophene</td>
<td>mg/kg</td>
<td>10</td>
<td>&lt;1</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Water</td>
<td>mg/kg</td>
<td>35</td>
<td>151</td>
<td>30</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 3: reproducibilities of tests on sample #19020

Without further statistical calculations, it can be concluded that for most of the tests there is a good compliance of the group of participating laboratories with the relevant reference test methods. The tests that are problematic have been discussed in paragraph 4.1.
4.3 **Comparison of the Proficiency Test of February 2019 with Previous PTS**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of reporting labs</td>
<td>50</td>
<td>51</td>
<td>67</td>
<td>59</td>
<td>51</td>
</tr>
<tr>
<td>Number of test results</td>
<td>532</td>
<td>545</td>
<td>743</td>
<td>793</td>
<td>729</td>
</tr>
<tr>
<td>Number of statistical outliers</td>
<td>17</td>
<td>24</td>
<td>32</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Percentage outliers</td>
<td>3.2%</td>
<td>4.4%</td>
<td>4.3%</td>
<td>2.4%</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

Table 4: Comparison with previous proficiency tests.

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

The performance of the determinations of the proficiency tests was compared against the requirements of the respective reference test methods. The conclusions are given in the following tables:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Wash Color</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Bromine Index</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Chlorides, Total</td>
<td>+/-</td>
<td>-</td>
<td>+/-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chlorides, Organic</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Color Pt/Co</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Density at 20°C</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Distillation</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>-</td>
<td>+</td>
<td>+/-</td>
<td>--</td>
<td>-</td>
</tr>
<tr>
<td>Purity</td>
<td>++</td>
<td>-</td>
<td>+/-</td>
<td>-</td>
<td>+/-</td>
</tr>
<tr>
<td>Methylcyclohexane</td>
<td>-</td>
<td>--</td>
<td>+/-</td>
<td>+/-</td>
<td>n.e.</td>
</tr>
<tr>
<td>Nonaromatics</td>
<td>++</td>
<td>-</td>
<td>+/-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Toluene</td>
<td>n.e.</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>1,4-Dioxane</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
</tr>
<tr>
<td>Solidification Point</td>
<td>+</td>
<td>+/-</td>
<td>+</td>
<td>+/-</td>
<td>+/-</td>
</tr>
<tr>
<td>Sulfur</td>
<td>+/-</td>
<td>+/-</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
</tr>
<tr>
<td>Thiophene</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
</tr>
<tr>
<td>Water</td>
<td>-</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
<td>n.e.</td>
</tr>
</tbody>
</table>

Table 5: Comparison determinations against the reference test methods

The performance of the determinations against the requirements of the respective reference test methods is listed in the above table. 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
- **n.e.**: not evaluated
## APPENDIX 1

**Determination of Acid Wash Color (acid layer) on sample #19020**

<table>
<thead>
<tr>
<th>lab</th>
<th>method</th>
<th>value</th>
<th>mark</th>
<th>z(targ)</th>
<th>remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>D848</td>
<td>0+</td>
<td></td>
<td>-0.66</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>D848</td>
<td>1-</td>
<td></td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>311</td>
<td>D848</td>
<td>0+</td>
<td></td>
<td>-0.66</td>
<td></td>
</tr>
<tr>
<td>317</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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- normality not OK
- n = 34
- outliers = 0
- mean (n) = 0.73 (1-)
- st.dev. (n) = 0.163
- R(calc.) = 0.46
- st.dev.(D848:14) = 0.728
- R(D848:14) = 2.04

*) In the calculation of the mean, standard deviation, reproducibility and in the graphs, a reported value of ’y-’, ’-y’ or ’<y’ is changed into y-0.25 (for example 1- into 0.75) and ’y+’ is changed into y+0.25 (for example 0+ into 0.25).
Determination of Acidity on sample #19020; results in mg NaOH/100mL

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Abbreviation
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Mean (n)  Pass (Clear & Bright)

**Abbreviation**

C&B = Clear and Bright
CFSM/CFFSM = Clear and Free from suspended matter
## Determination of Bromine Index on sample #19020; results in mg Br/100g

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- **normality:** suspect
- **n:** 12
- **outliers:** 0 (+1 excl)
- **mean (n):** 0.870
- **st.dev. (n):** 0.3287
- **R(calc.):** 0.920
- **st.dev.(D5194:18):** 0.3214
- **R(D5194:18):** 0.9
## Determination of Chlorides, Organic on sample #19020; results in mg/kg

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- **normality**: OK
- **n**: 16
- **outliers**: 0
- **mean (n)**: 0.985
- **st.dev. (n)**: 0.1270
- **st.dev. (D5808:18)**: 0.4643
- **R(calc.)**: 0.356
- **R(D5808:18)**: 1.3
## Determination of Color Pt/Co on sample #19020;

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Normality: OK  
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Number of outliers: 0  
Mean (n): 7.56  
Standard deviation (n): 1.81  
R(calc.): 5.07  
Standard deviation (D5386:16): 2.061  
R(D5386:16): 5.77

Compare:  
R(D1209:05) = 7
## Determination of Density at 20°C on sample #19020; results in kg/L

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- **St.dev. (n)** 0.00062
- **R(calc.)** 0.00017
- **St.dev.(ISO12185:96)** 0.000179
- **R(ISO12185:96)** 0.0005
**Determination of Distillation on sample #19020; results in °C**

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- **n** 28
- **outliers** 3 (+2 excl)
- **mean** (n) 79.75
- **st.dev. (n)** 0.039
- **R(calc.)** 0.19
- **st.dev.(D850-A:18)** 0.208
- **R(D850-A:18)**) 0.58
- **Compare** R(D850-M:18) 0.41

**Lab 334: first reported 79.1, 79.7 and 79.7 respectively**

ex = test result excluded as the other reported test results are statistical outliers.

*) precision data of Toluene is used
Determination of Total Nitrogen on sample #19020; results in mg/kg

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mean (n) 0.254
st.dev. (n) 0.0949
R(calc.) 0.266
st.dev.(D7184:15) 0.0826
R(D7184:15) *) 0.231

Application range D7184:15: 0.1 – 1.2 mg/kg

Precision data of all aromatics are used to create a linear fit over range of 0.1 – 1.2 mg/kg
Determination of Purity by GC on sample #19020; results in %M/M

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R(calc.) 0.00463
st.dev.(D7504:18) 0.008836
R(D7504:18) 0.02474

Compare R(D4492:10) 0.00071

ASTM D4492 is withdrawn in 2018 and replaced by ASTM D7504
Determination of Methylcyclohexane on sample #19020 in mg/kg

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outliers 1
mean (n) 8.99
st.dev. (n) 1.333
R(calc.) 3.73
st.dev.(Horwitz) 1.033
R(Horwitz) 2.89
### Determination of Nonaromatics on sample #19020; results in mg/kg

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- **normality OK**
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- **mean (n) 73.94**
- **st.dev. (n) 10.362**
- **R(calc.) 29.01**
- **st.dev.(D7504:18) 21.425**
- **R(D7504:18) 59.99**

**Compare**

- **R(D4492:10) 31.92**

ASTM D4492 is withdrawn in 2018 and replaced by ASTM D7504
Determination of Toluene on sample #19020; results in mg/kg

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- outliers 2
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- st.dev. (n) 0.0147
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- R(D852:16) 0.05
### Determination of Sulfur on sample #19020; results in mg/kg

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- **st.dev. (n)**: 0.0877
- **R(calc.)**: 0.246
- **st.dev.(D5453:16e1)**: 0.0808
- **R(D5453:16e1)**: 0.226

Application range: ASTM D5453 = 1 - 8000 mg/kg
### Determination of Thiophene on sample #19020; results in mg/kg

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## Determination of Water on sample #19020; results in mg/kg

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- normality: suspect
- n: 35
- outliers: 1
- mean (n): 150.5
- st.dev. (n): 10.52
- R(calc.): 29.5
- st.dev.(E1064:16): 9.19
- R(E1064:16): 25.7
APPENDIX 2

Number of participants

1 lab in BELGIUM
2 labs in BRAZIL
1 lab in CANADA
9 labs in CHINA, People's Republic
2 labs in FINLAND
1 lab in FRANCE
4 labs in GERMANY
4 labs in INDIA
1 lab in ISRAEL
2 labs in KUWAIT
4 labs in NETHERLANDS
1 lab in PORTUGAL
2 labs in ROMANIA
6 labs in SAUDI ARABIA
1 lab in SLOVAKIA
1 lab in SOUTH KOREA
2 labs in SPAIN
1 lab in THAILAND
1 lab in UKRAINE
1 lab in UNITED ARAB EMIRATES
3 labs in UNITED KINGDOM
1 lab in UNITED STATES OF AMERICA
APPENDIX 3

Abbreviations

C = final test result after checking of first reported suspect test result
D(0.01) = outlier in Dixon’s outlier test
D(0.05) = straggler in Dixon’s outlier test
G(0.01) = outlier in Grubbs’ outlier test
G(0.05) = straggler in Grubbs’ outlier test
DG(0.01) = outlier in Double Grubbs’ outlier test
DG(0.05) = straggler in Double Grubbs’ outlier test
R(0.01) = outlier in Rosner’s outlier test
R(0.05) = straggler in Rosner’s outlier test
W = test result withdrawn on request of participant
ex = test result excluded from statistical evaluation
n.a. = not applicable
n.e. = not evaluated
n.d. = not detected
fr. = first reported
SDS = Safety Data Sheet

Literature

1 iis Interlaboratory Studies, Protocol for the Organisation, Statistics & Evaluation, June 2018
2 ASTM E178:02
3 ASTM E1301:03
4 ISO13528:15
5 ISO 5725:86
6 ISO 5725, parts 1-6, 1994
9 IP 367:84
10 DIN 38402 T41/42
12 J.N. Miller, Analyst, 118, 455, (1993)
13 Analytical Methods Committee Technical brief, No 4, January 2001
16 Honwitz, R. Albert, J. AOAC Int. 79-3, 589 (1996)