Hessisches Landesamt
für Naturschutz,
Umwelt und Geologie

Hessian Agency
for Nature Conservation,
Environment and Geology

HESSEN

# Annual Report 2020

## Results of stack emission proficiency tests for substance ranges P, G, and O on the emission simulation apparatus in the year 2020

HLNUG Department I3 is accredited for performing
testing services according to DIN EN ISO/IEC 17043.
The accreditation is valid for the testing procedures listed in the certificate.

DAkkS
Deutsche
Akkreditierungsstelle
D-EP-14551-01-00

# Contents

# 0. About this Report

This report is a translation of *„Jahresbericht 2020 – Ergebnisse der Emissionsringversuche der Stoffbereiche P, G und O an der Emissionssimulationsanlage im Jahr 2020*" and was prepared with best care and attention. Nevertheless, the German version of this report shall be taken as authoritative. No guarantee can be given with respect to the English translation.

# 1. Summary

The spread of the SARS-CoV-2 virus in Europe severely affected the HLNUG proficiency test programme in 2020, with only two dust and gas proficiency tests each in February and March and four odour proficiency tests in September and October. The data basis for this annual report is accordingly much smaller than usual.

In 2020, a total of 13 §29b measuring bodies participated in HLNUG's two dust emission proficiency tests (substance range P). The success rate here was 92%.

A total of 14 §29b measuring bodies participated in 2020 in HLNUG's two gas emission proficiency tests (substance range G). Here, the success rate was 86%.

There were no voluntary participants in the dust and gas stack emission proficiency tests in 2020.

A total of 18 laboratories participated in the four odour emission proficiency tests (substance range O), 16 of which participated due to an authorization in accordance with §29b BImSchG and 2 of which participated voluntarily. Here, 63% of the authorized and none of the voluntary participants were successful.

# 2. Introduction

## 2.1 Legal Background

The stack emission proficiency tests offered at the Emission Simulation Apparatus (ESA) of Hessisches Landesamt für Naturschutz, Umwelt und Geologie (HLNUG, Hessian Agency for Nature Conservation, Environment and Geology) in Kassel were developed for the quality control of measuring bodies authorized to perform measurements in accordance with §29b Bundes-Immissionsschutzgesetz (BImSchG, Federal Immission Control Act (1)) in Germany. The proficiency tests presented in this annual report are accredited according to DIN EN ISO/IEC 17043 (2) and are recognised by all authorizing authorities in Germany within the meaning of §16 Para. 4 No. 7a of the 41. Bundes-Immissionsschutzverordnung (41. BImSchV (3), 41$^{st}$ Federal Immission Control Ordinance). Regular successful participation in these stack emission proficiency tests is therefore a prerequisite for maintaining an authorisation in accordance with §29b BImSchG.

Consequently, about 80-90% of the participants are laboratories authorized to perform measurements in accordance with §29b BImSchG (Federal Immission Control Act), or applicants for authorization in accordance with BImSchG. Nevertheless, other measuring institutes can also participate in the HLNUG stack emission proficiency tests, e.g. laboratories that do not perform measurements in the regulated sector in Germany, but still seek to check the quality of their emission measurements.

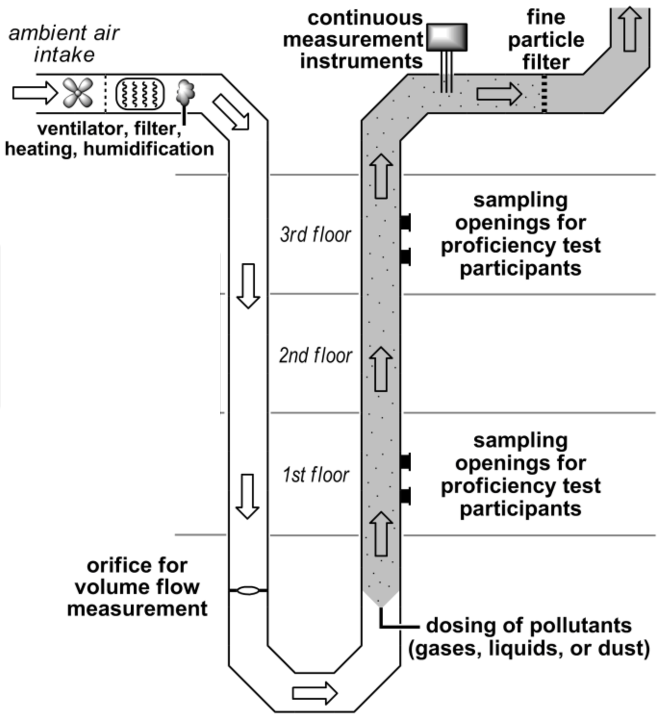
## 2.2 The Emission Simulation Apparatus

The prerequisite for carrying out stack emission proficiency tests is the ability to provide all participants at the same time with a stable and clearly defined simulated exhaust gas. For this purpose, HLNUG operates the Emission Simulation Apparatus (ESA, see scheme 1). It was designed as a model for an industrial flue gas chimney. It serves not only to carry out emission proficiency tests but also to carry out model investigations in the field of emission measurement technology.

The ESA has a total length of 110 m and extends over all seven floors of the HLNUG building in Kassel. The heart of this system is a vertical, 23 m high round stainless steel conduit with an inner diameter of 40 cm. This part of the ESA is the actual chimney substitute, equipped with sampling ports for taking samples for emission measurements.

The test atmosphere in the form of simulated exhaust gas is created by drawing in ambient air, pumping it through the system, heating it and adding precisely metered quantities of pollutants. The exhaust gas typically flows through the ESA at approx. 4 – 15 m/s, moving a volume of approx. 2000 – 6000 $m^3$/h through the system.

The air pollutants to be measured by the participants in the proficiency test are dispensed into the air flow in the dosing laboratory in the basement. For this purpose, the dosing laboratory is equipped with various Coriolis mass flow meters for dosing different gases, a calibration gas generator for dosing liquids, and a brush dosing unit for dosing dusts. The concentrations of air-polluting substances generated in the dosing laboratory are constantly monitored by continuous measurement.




**Scheme 1: Scheme of HLNUG's emission simulation apparatus (simplified and not true to scale)**

# 3. Organisational Information

In 2020, the following proficiency tests of the substance ranges P, G, and O were carried out:

**Table 1: Proficiency Tests organised by HLNUG**

| proficiency test | substance range | start | end | participants |
|---|---|---|---|---|
| 20P1 | P/dust - Staub (Stoffbereich P) | 03.02.2020 | 04.02.2020 | 7 |
| 20G1 | G/gas - Gas (Stoffbereich G) | 05.02.2020 | 07.02.2020 | 8 |
| 20P2 | P/dust - Staub (Stoffbereich P) | 17.02.2020 | 18.02.2020 | 6 |
| 20G2 | G/gas - Gas (Stoffbereich G) | 19.02.2020 | 21.02.2020 | 6 |
| 20O1 | O/odour - Geruch (Stoffbereich O) | 24.09.2020 | 24.09.2020 | 6 |
| 20O2 | O/odour - Geruch (Stoffbereich O) | 29.09.2020 | 29.09.2020 | 6 |
| 20O3 | O/odour - Geruch (Stoffbereich O) | 01.10.2020 | 01.10.2020 | 5 |
| 20O4 | O/odour - Geruch (Stoffbereich O) | 06.10.2020 | 06.10.2020 | 1 |

These proficiency tests were organised and carried out under the following conditions (see specifications for the respective substance ranges for details):

**Table 2: Characteristics of HLNUG's stack emission proficiency tests**

| | substance range P | substance range G |
|---|---|---|
| duration of each sampling | 30 min | 30 min (discontinuous samplings and TOC),<br>15 min (continuous measurements $C_3H_8$, CO, $NO_x$, $SO_2$) |
| number of samplings | for each component 10, including introductory measurement | |
| sampling | simultaneously for all participants (1st and 3rd floor) | |
| basic conditions | not detailed in specifications | 2000 … 3500 $m^3$/h<br>20 … 40 °C |
| concentrations | 1 … 12 $mg/m^3$ in the following ranges:<br>1: 1 … 4 $mg/m^3$<br>2: 4 … 7 $mg/m^3$<br>3: 7 … 12 $mg/m^3$ | $SO_2$: 20 … 150 $mg/m^3$<br>$NO_x$ as $NO_2$: 60 … 450 $mg/m^3$<br>CO: 10 … 100 $mg/m^3$<br>sum ETX: 4 … 100 $mg/m^3$<br>formaldehyde: 4 … 40 $mg/m^3$<br>TOC: 4 … 100 $mg/m^3$ (ETX/propane)<br>TOC: 5 … 100 $mg/m^3$ (propane only) |
| result submission | within six weeks after the end of the proficiency test, in $mg/m^3$ for dust concentrations and $\mu g/m^3$ for heavy metal concentrations respectively, relating to normal conditions (dry) and with one digit after decimal point. | within four weeks after the end of the proficiency test, in $mg/m^3$ relating to normal conditions (dry) and with one (components G1-3, G8, G9, see table 5) or two (G4-7 and G10, see table 5) digits after decimal point. |
| submission procedure | results are entered into an Excel-file provided by HLNUG and handed in via e-mail. | |

| | **substance range O** |
|---|---|
| duration of each sampling | 10 min |
| number of samplings | for each component 3 |
| sampling | simultaneously for all participants (1st and 3rd floor) |
| basic conditions | 2000 … 6000 $m^3$/h, flow velocity > 4 m/s, water vapour up to 50 g/$m^3$ |
| concentrations | approx. 50 … 50000 $ou_E/m^3$ |
| result submission | in $ou_E/m^3$, rounded to integers |

The proficiency tests were organised by:

Hessisches Landesamt für Naturschutz, Umwelt und Geologie
(*Hessian Agency for Nature Conservation, Environment and Geology*)

Dezernat I3 – Luftreinhaltung: Emissionen
(*Department I3 – Air Pollution Control: Emission*)

The location of the proficiency tests was:

Hessisches Landesamt für Naturschutz, Umwelt und Geologie
Ludwig-Mond-Str. 33
34121 Kassel
- GERMANY -

Tel.: +49 – 561 – 2000 137
Fax: +49 – 561 – 2000 225
E-Mail: pt@hlnug.hessen.de

Technically responsible for the execution of the proficiency tests are currently:

Dr. Jens Cordes, Benno Stoffels and Dr. Dominik Wildanger.

# 4. Execution of the Proficiency Tests

## 4.1 Description of the Test Objects

In contrast to proficiency tests by other providers, HLNUG's stack emission proficiency tests take place at a stack simulator and include the sampling procedure. The test object in our proficiency tests is therefore the exhaust gas flow in the duct during the measurement period (see section 2.2). The test objects therefore only exist during the measurement, and the usual specifications for homogeneity and stability are therefore subject to interpretation for the stack emission proficiency tests at the ESA (4). Extensive investigations have shown that the standard deviations between the samples for the sampling points or measurement cross sections assigned to the participants reach the following maximum values:

**Table 3: Maximum values of between samples standard deviations**

| variable | determined at | relative standard deviation between samples [%] |
|---|---|---|
| mass concentration of total dust and heavy metals | all available measurement planes (grid measurements) | 1.58 |
| mass concentrations of gases | lowest available measurement plane (point measurements) | 0.15 |
| mass concentrations of evaporated liquids | lowest available measurement plane (point measurements) | 0.16 |

All determined between samples standard deviations are well below the criteria for the proficiency assessment of the participants. This ensures that all participants in the proficiency test will find comparable sampling conditions. The position of the sampling, i.e. the measurement plane assigned by the organizer, has no significant influence on the mass concentrations measured by the participant. An equivalent to the stability test in conventional proficiency tests does not exist at the ESA, as the test objects are not stored after the assigned values have been determined. Instead, the assigned values are determined individually for each test object during its generation, and thus during the simultaneous measurement by the participants.

## 4.2 Preparation of the Test Objects

The exhaust gas flow sampled by the participants in the ESA is generated by adding the test substances to be measured to the air flow generated by the system. Gases are added as pure substances, evaporated liquids either also as pure substances or as solutions in other evaporable liquids. Sometimes these liquids are also dosed as a homogeneous mixture of different pure substances (5).

In contrast to the pure substances in gas and odour proficiency tests, no reference materials are available on the market in sufficient quantities for particulate substances. Therefore, for proficiency tests of the substance range P, the certified reference materials produced by HLNUG according to DIN EN ISO 17034 (6) are used. The matrix here is an industrial dust, which is optimized by specific heavy metal doping, grinding, sieving and drying steps. Finally, a complete homogenization of the dust standard is achieved by intensive mixing of the batch.

The determination of the conventionally correct value ("assigned value") of the heavy metal concentration of a doped dust batch is based on the data from interlaboratory analyses carried out by laboratories of various German state institutes. The robust mean value from the individual values of the interlaboratory comparisons is regarded as the assigned heavy metal content value of the dust standard. The dust is subject to a homogeneity and stability test and verification, which is repeated at certain intervals. Homogeneity and stability of the test dusts are verified according to DIN ISO 13528 (7).

## 4.3 Metrological Traceability

The gaseous substances CO, NO and propane are dosed using Coriolis flow sensors. The mass flows are measured and gravimetrically traced via suitable test weights and balances. During dosing, liquids are taken from a container located on a balance. The mass flow is also recorded here by recording the weight values, and the balances used are metrologically traced via suitable test weights. The mass flows for $SO_2$ and dust are determined by differential weighing of the containers used. The assigned values of the heavy metal concentrations in the dust are determined by competent laboratories using various analytical instruments within the framework of interlaboratory comparisons. Within the scope of these interlaboratory comparisons, a total digestion of the dust is carried out in accordance with DIN EN 14385 (8), as well as an analysis using calibrated measuring equipment. This calibration is carried out by means of element solutions of known traceable composition. Consequently, the heavy metal concentrations in the test dusts used are metrologically traceable. The volume flow is determined by means of an orifice plate, which is regularly checked by means of metrologically traceable measuring instruments. By calculating from metrologically traceable mass flows and metrologically traceable volume flows, all mass concentrations indicated are also metrologically traceable. The maximum values of the relative standard uncertainty of the assigned values can be found in table 5. Detailed information is given in the results communications of the individual proficiency tests.

## 4.4 Execution of the Measurements

Each participant determines the mass concentration of the emission components in accordance with (DIN) EN 15259 (9). In addition, the gas flow conditions must be recorded before the actual sampling begins. This includes exhaust gas velocity/flow rate, exhaust gas temperature and humidity as well as the air pressure in the system.

**Table 4: Sequence of the stack emission proficiency tests of substance ranges P, G, and O**

| substance range | day of the test | component | compulsory measurement procedure |
|---|---|---|---|
| P | day 1 and 2 | dust | (DIN) EN 13284-1 (10) / VDI 2066 Part 1 (11) |
| | | heavy metals | not specified |
| G | day 1 | formaldehyde | VDI 3862 part 2 (12), part 3 (13) or part 4 (14) |
| | day 2 | $SO_2$ | (DIN) EN 14791 (15) |
| | | TOC | (DIN) EN 12619 (16) |
| | | ETX | (DIN) CEN/TS 13649 (17) |
| | day 3 | TOC | (DIN) EN 12619 (16) |
| | | $NO_x$ as $NO_2$ | (DIN) EN 14792 (18) |
| | | CO | (DIN) EN 15058 (19) |
| O | day 1 | four odours | (DIN) EN 13725 (20) |

## 4.5 Evaluation of the Proficiency Tests

### 4.5.1 Calculation of z-Scores

#### Substance Ranges P and G

The evaluation of the proficiency test is carried out in accordance with the respective specifications (for substance ranges P and G) on the basis of the z-score procedure. For the measurement value $x_{ijk}$, which is the result of measurement *i* of concentration level *j* of component *k*, a z-score value $z_{ijk}$ is determined:

$$z_{ijk} = \frac{x_{ijk} - X_{ijk}}{\sigma_k \cdot X_{ijk}}$$

In this equation, $X_{ijk}$ is the assigned value of the measurement, and $\sigma_k$ is the precision criterion for component *k*. The assigned value is calculated from measurement data of the dosing devices and the volume flow.

**Substance Range O**

For odour emission proficiency tests, the evaluation is carried out on the basis of the z-score procedure, using logarithmised values:

$$z_{ik} = \frac{1}{\sigma_k} \cdot \log_{10}\left(\frac{x_{ik}}{X_{ik}}\right)$$

In this equation, $X_{ik}$ is the assigned value of the measurement, and $\sigma_k$ is the precision criterion for component $k$. The assigned value $X_{ik}$ is calculated from the mass concentration $c_{ik}$ and the odour threshold $c_{0,k}$ of the component:

$$X_{ik} = \frac{c_{ik}}{c_{0,k}}\ \mathrm{ou_E/m^3}$$

The dosed mass concentration $c_{ik}$ is determined for each measurement based on the measurement data of the dosing device and the volume flow. The odour threshold $c_{0,k}$ of $n$-butanol is $c_0 = 123\ \mathrm{\mu g/m^3}$. The thresholds of all other components are deduced from results of proficiency test participants according to the following procedure:

a) A consensus value is calculated from the measurement results reported by at least 20 participants in at least two different proficiency tests previously run by HLNUG. Here, solely results of participants are taken into account, who achieved the result 'passed' for the component $n$-butanol in the respective proficiency test. The consensus value is obtained by the robust mean of the logarithmic values according the standard DIN ISO 13528 (7) and is updated on a regular basis by including new results. This calculation is restricted to measurements of the past five years as long as the above mentioned requirements are met.

b) If not enough measurement results of former proficiency tests are available to determine the consensus value of a component by means of the procedure described under a), an alternative method is used: Here, the consensus value of a component offered during a proficiency test is subsequently calculated from the participants' measurement results. Provided that the sampling was carried out within 14 days, results of several proficiency tests can be taken into account. Solely results of those participants are considered, who achieved the result 'passed' for the component $n$-butanol in the respective proficiency test. The consensus value is obtained by the robust mean of the logarithmic values according the standard DIN ISO 13528 (7). If less than nine measurement results for a particular component are available that fulfil the above mentioned criteria, neither a z-score-based evaluation nor a performance rating are possible.

If the uncertainty of a true value $u_k$ determined in compliance with DIN ISO 13528 (7) results in a value for which with $\sigma_k = 0.10$ the following condition is not met:

$$\sigma_k \geq \frac{1}{0.3} \cdot \log_{10}(1 + u_k)$$

Then $\sigma_k$ is adjusted in accordance with DIN ISO 13528 (7). In doing so, $\sigma_k$ is recalculated precisely to two decimal places, so that the condition above is fulfilled. Participants are informed about the increase of the precision criterion at the latest when the evaluation is communicated by HLNUG.

## 4.5.2 Criteria for Proficiency Assessment

The criteria for the proficiency assessment of the participants (precision criteria) $\sigma_k$ were defined as values from findings in accordance with section 6.3 of DIN ISO 13528 (7) by the German Federation/Federal States Working Group on Immission Control (LAI) and published within the framework of the specifications for stack emission proficiency tests. For components that are not part of these specifications, criteria were established by the HLNUG using a comparable procedure. The values are for the individual components:

**Table 5: Precision criteria**

| No. | component | measurement mode | short designation | precision criterion $\sigma_k$ in % of true value | maximum for standard uncertainty of assigned values [%] |
|---|---|---|---|---|---|
| | | | **substance range P** | | |
| P1 | dust | discontinuous | St | 7.0 | 1.55 |
| P2 | Cadmium | discontinuous | Cd | 8.0 | 1.71 |
| P3 | Cobalt | discontinuous | Co | 8.0 | 1.80 |
| P4 | Chromium | discontinuous | Cr | 12.0 | 1.76 |
| P5 | Copper | discontinuous | Cu | 8.0 | 1.90 |
| P6 | Manganese | discontinuous | Mn | 10.0 | 1.85 |
| P7 | Nickel | discontinuous | Ni | 8.0 | 1.81 |
| P8 | Lead | discontinuous | Pb | 8.0 | 1.81 |
| P9 | Vanadium | discontinuous | V | 10.0 | 2.11 |
| | | | **substance range G** | | |
| G1 | $SO_2$ | discontinuous | Sd | 3.1 | 1.01 |
| G2 | $SO_2$ | continuous | Sk | 3.9 | 1.01 |
| G3 | $NO_x$ as $NO_2$ | continuous | Nk | 3.1 | 1.01 |
| G4 | toluene | discontinuous | Td | 5.6 | 1.01 |
| G5 | ethylbenzene | discontinuous | Ed | 5.8 | 1.01 |
| G6 | sum of *o*-, *m*-, *p*-xylene | discontinuous | Xd | 5.3 | 1.01 |
| G7 | formaldehyde | discontinuous | Fd | 3.5 | 1.17 |
| G8 | TOC (propane, ETX) | continuous | Ck | 3.3 | 1.08 |
| G9 | TOC (propane) | continuous | Pk | 3.3 | 1.08 |
| G10 | CO | continuous | Kk | 3.6 | 1.07 |
| | | | **substance range O** | | |
| O1 | *n*-butanol | discontinuous | NBU | 0.10† | 1.01 |
| O2 | solvent mixture | discontinuous | ETX | 0.10 † | 6.86 |
| O3 | tetrahydrothiophene | discontinuous | THT | 0.14 † | 9.50 |
| O4 | artificial pigsty odour | discontinuous | PIG | 0.17 † | 12.2 |

† In proficiency test O the precision criterion is not expressed in % of true value (see section 4.5.1)

## 4.5.3 Interpretation of z-Scores

The z-scores can be interpreted using the following scheme:

$|z_{ijk}| \leq 2$ satisfactory

$2 < |z_{ijk}| < 3$ questionable

$|z_{ijk}| \geq 3$ unsatisfactory

Generally, for each measurement resulting in a z-score of more than two, a causal research is advised.

The assessment of the individual component proceeds differently for the three substance ranges.

## 4.5.4 Assessment of Components and Overall Result

### Substance Ranges P and G

For the components in the dust and gas proficiency test, the mean value $z_{jk}$ of the absolute values of the *n* z-scores of one concentration level (usually *n* = 3) is calculated:

$$z_{jk} = \sum_{i=1}^{n} \frac{|z_{ijk}|}{n}$$

Based on $z_{jk}$, to each concentration level a class number $K_{jk}$ is assigned according to the following scheme:

$z_{jk} \leq 2$ results in $K_{jk} = 1$

$2 < z_{jk} < 3$ results in $K_{jk} = 2$

$z_{jk} \geq 3$ results in $K_{jk} = 3$

For each component at least 6 measurement results must be submitted, otherwise the respective component is automatically evaluated as „failed".

The evaluation of single components as well as the overall assessment differs between substance ranges P and G.

### Dust Emission Proficiency Test

A component was determined successfully, if the respective sum of class numbers does not exceed 5. If in justified single cases only values for two concentration levels were submitted, the component was determined successfully if the sum of class numbers does not exceed 4 and the sum of absolute z-scores does not exceed 5.2. Successful determinations are labelled "passed", unsuccessful determinations are labelled "failed".

The overall result of the proficiency test is "passed", if the component total dust (no. P1) and at least 5 of the 6 mandatory heavy metal components (no. P2 to P5, no. P7, and no. P8) are rated "passed", otherwise the overall result is "failed".

### Gas Emission Proficiency Test

A component was determined successfully, if the respective sum of class numbers does not exceed 6. If in justified single cases only values for two concentration levels were submitted, the component was determined successfully if the sum of class numbers does not exceed 4. Successful determinations are labelled "passed", unsuccessful determinations are labelled "failed".

With the publication of the new version of the guideline VDI 4220 (21), the component G2 ($SO_2$ continuous) became a voluntary component in November 2018. From this point on, the proficiency test was successfully passed if the components no. G1 and G3 to G8 were successfully determined.

The analytical part of the proficiency test, the analysis of a solution of ethylbenzene, toluene and xylene in carbon disulphide, could not be performed since the beginning of 2019 due to quality problems at the supplier for the standards used. An alternative supplier that meets the quality requirements of HLNUG was not available.

**Odour Emission Proficiency Test**

For the evaluation of odour measurements, the mean value $z_k$ of the absolute values of the $n$ z-scores (usually $n$ = 3) of one component is calculated:

$$z_k = \sum_{i=1}^{n} \frac{|z_{ik}|}{n}$$

A component was determined successfully, if

$$z_k < 3$$

is fulfilled. In this case, the component is rated “passed“. If this criterion is not met or if no measurement result was submitted in due time, the component is rated “failed“. The overall result of the proficiency test is “passed”, if all components were determined successfully. If one or more components are rated “failed”, the overall result is “failed”.

### 4.5.5 Communication of the Assessment Result

Communication of the evaluation of the participants’ results by HLNUG was done within six weeks after the last day for submission of results for the respective proficiency test. This evaluation is given to the participants in form of a general survey, including tables and diagrams, and quoting their unique ID-code.

# 5. Results

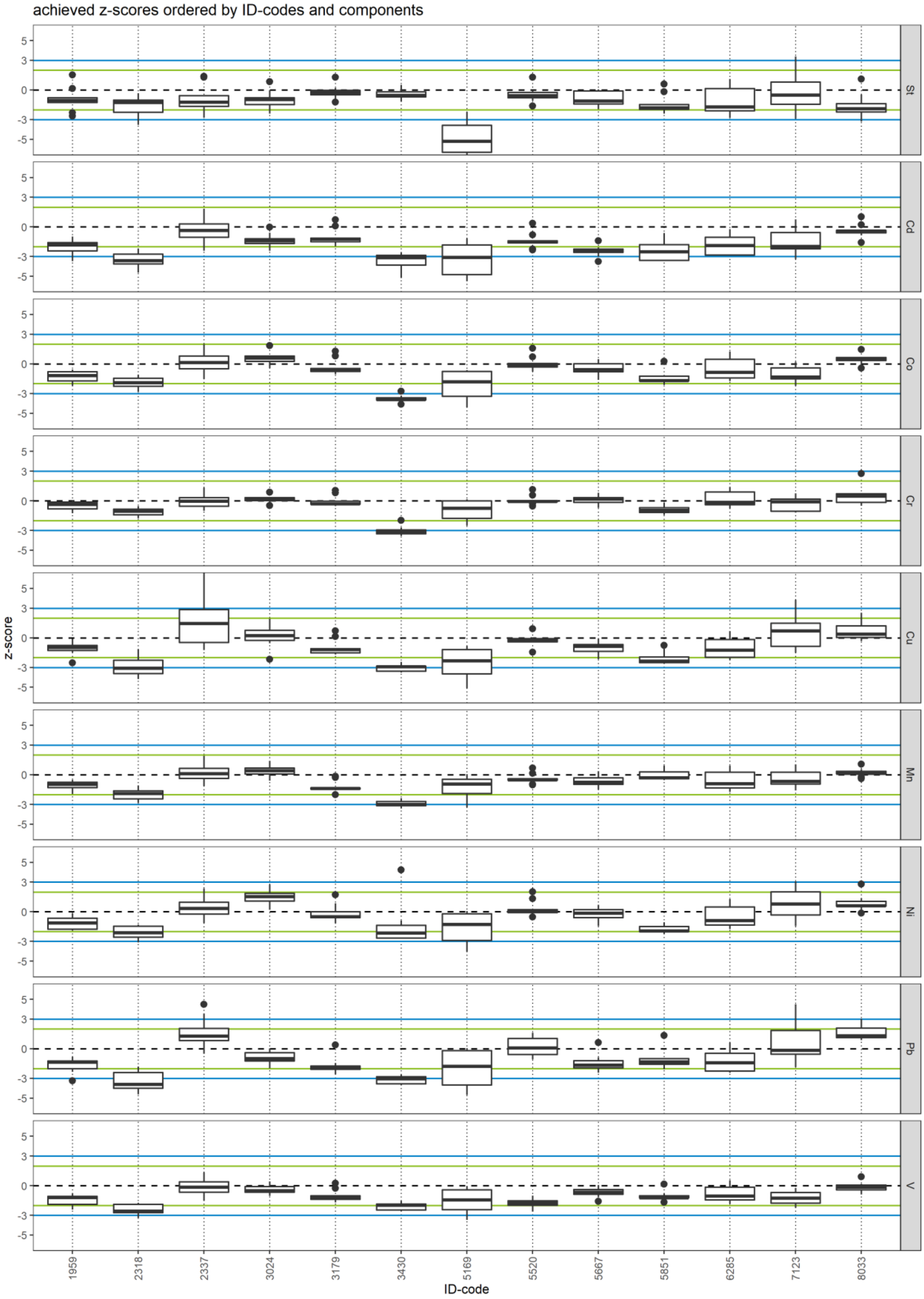
## 5.1 z-Scores

A compact overview of the z-scores achieved by the participants can be found in the following box whisker plots. The rectangle indicates values between the 25th and 75th percentile (interquartile distance), the continuous line in the rectangle indicates the median of the values. The "antennas" reach from the upper edge of the rectangle to the highest and from the lower edge to the lowest value, which is still within 1.5 times the interquartile distance. Values outside this range are entered separately as points in the diagram.

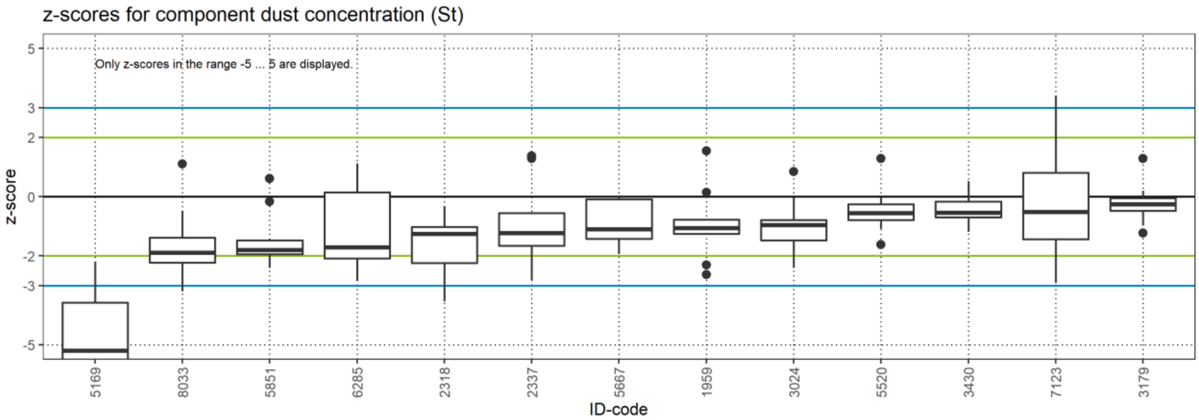
In order to be able to assess the performance of individual participants across all components and to get an impression of the quality of measurements for individual components, the diagrams are available in two different sorts; on the one hand as an overview on one page, on the other hand sorted according to the respective median of the achieved z-scores.

A list of the individual measurements of all participants can be found in a separate document (appendix to the annual report).

## 5.1.1 Substance Range P




**Scheme 2: Achieved z-scores dust proficiency test (only values in the range -5 ... 5 are shown)**


z-scores for component dust concentration (St)
Only z-scores in the range -5 ... 5 are displayed.
z-score
5
3
2
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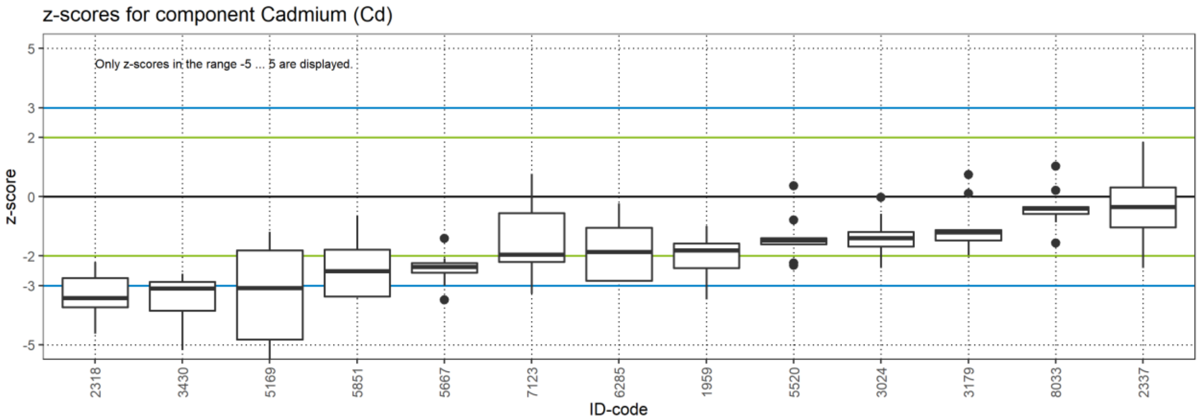
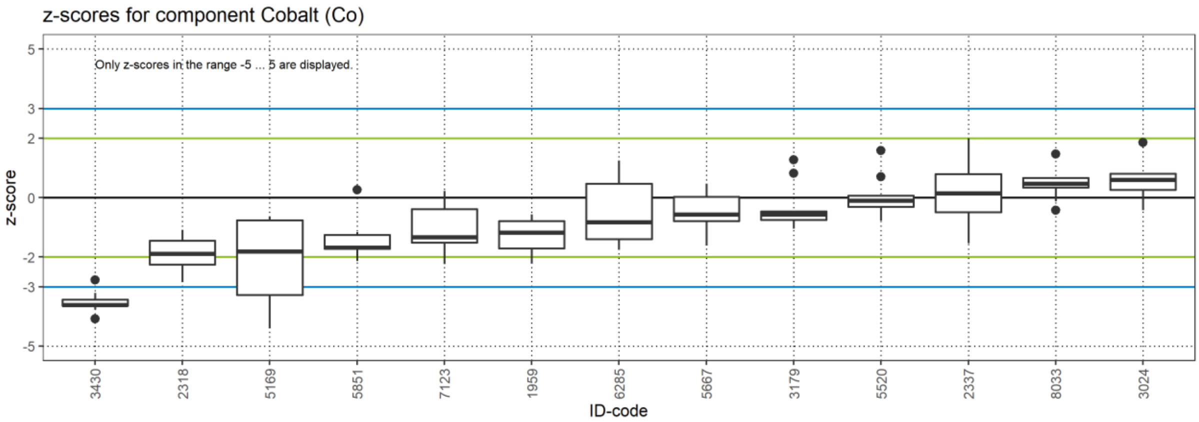
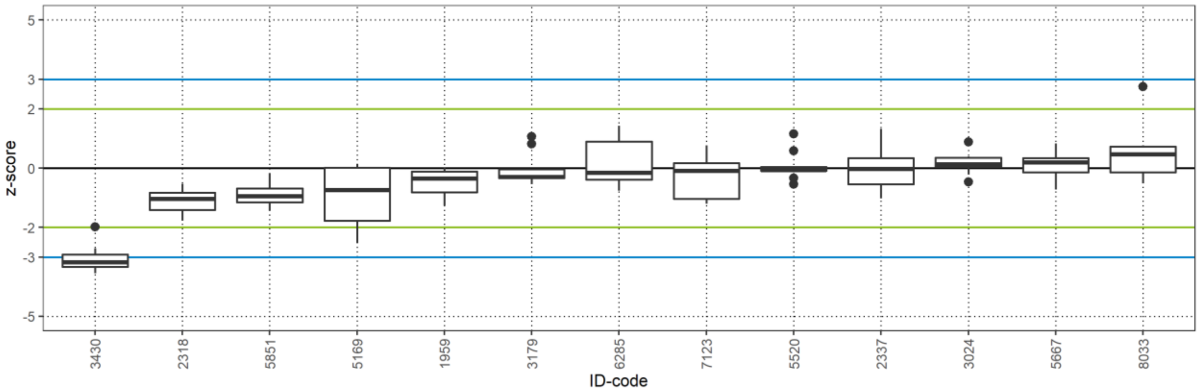
-2
-3
-5
5169
8033
5851
6285
2318
2337
5667
1959
3024
5520
3430
7123
3179
ID-code

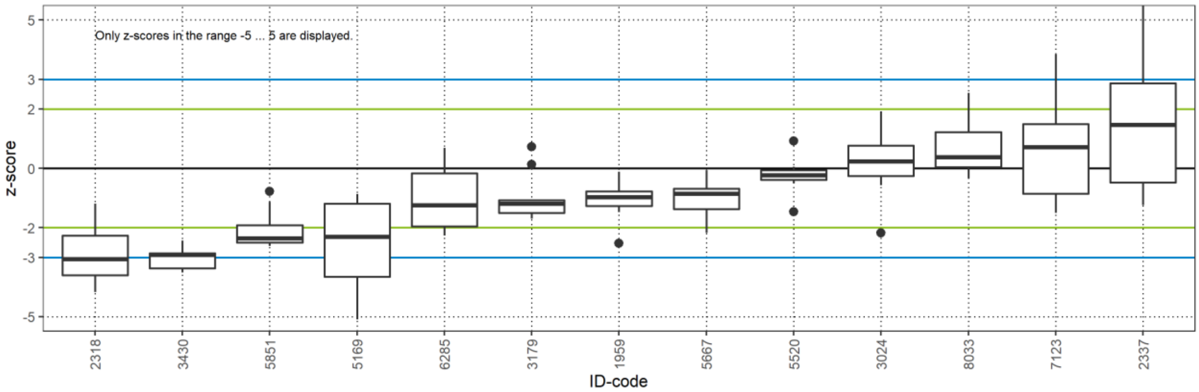

z-scores for component Cadmium (Cd)
Only z-scores in the range -5 ... 5 are displayed.
z-score
5
3
2
0
-2
-3
-5
2318
3430
5169
5851
5667
7123
6285
1959
5520
3024
3179
8033
2337
ID-code


z-scores for component Cobalt (Co)
Only z-scores in the range -5 ... 5 are displayed.
z-score
5
3
2
0
-2
-3
-5
3430
2318
5169
5851
7123
1959
6285
5667
3179
5520
2337
8033
3024
ID-code

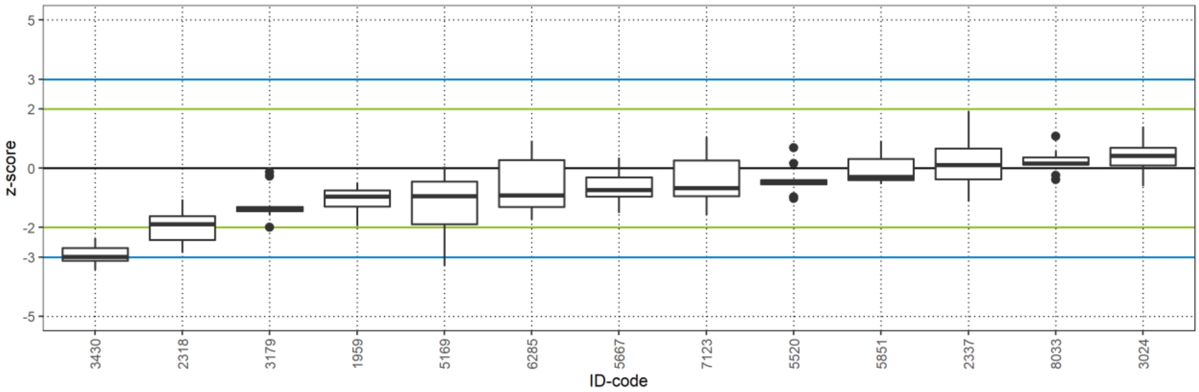
z-scores for component Chromium (Cr)

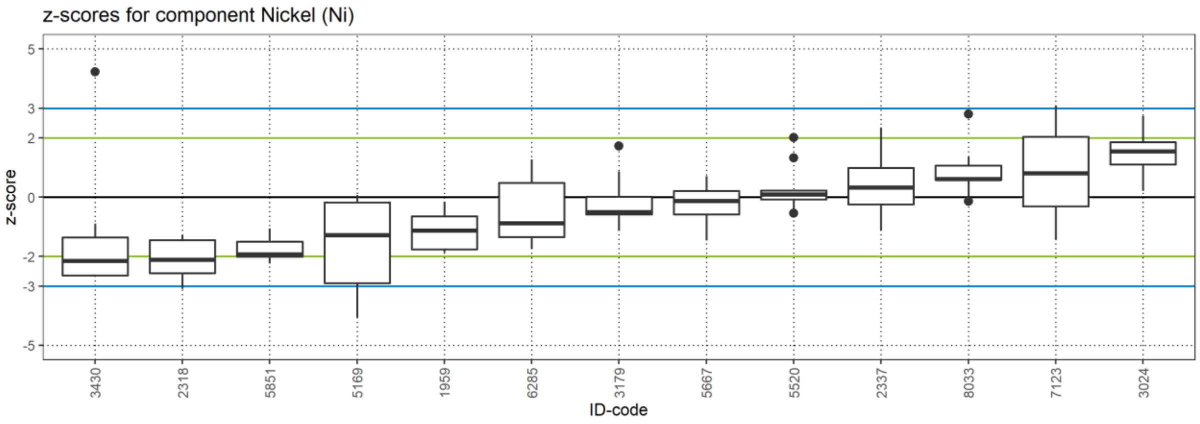



z-scores for component Copper (Cu)




z-scores for component Manganese (Mn)




z-scores for component Nickel (Ni)
z-score
5
3
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-3
-5
3430
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5169
1959
6285
3179
5667
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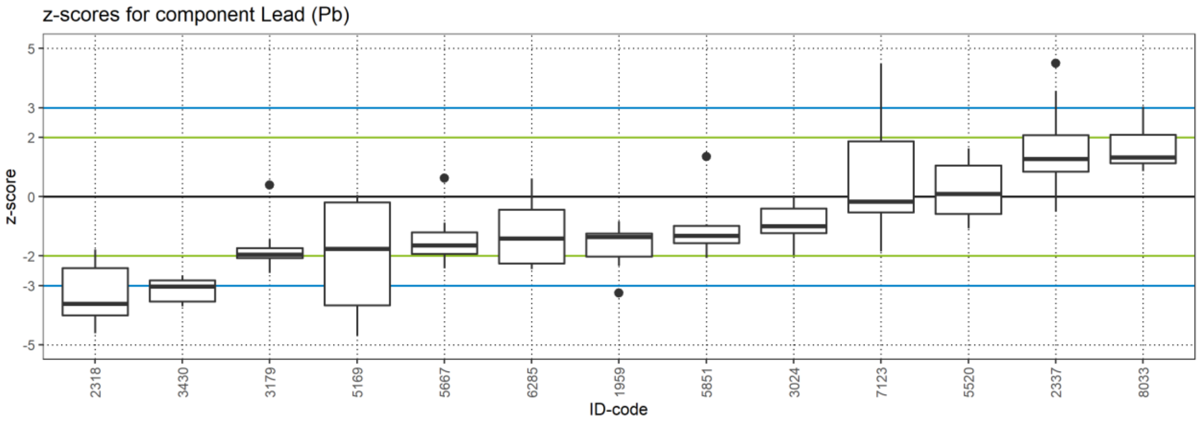
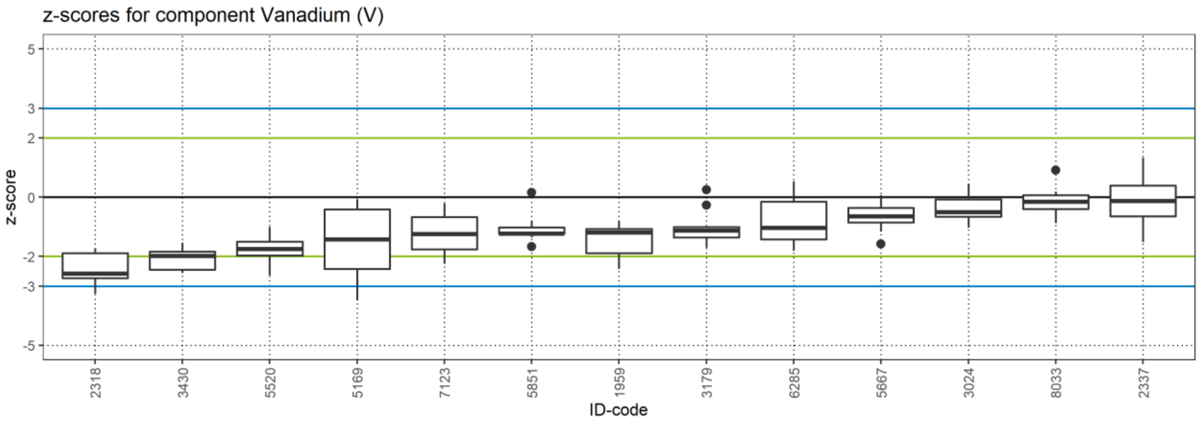
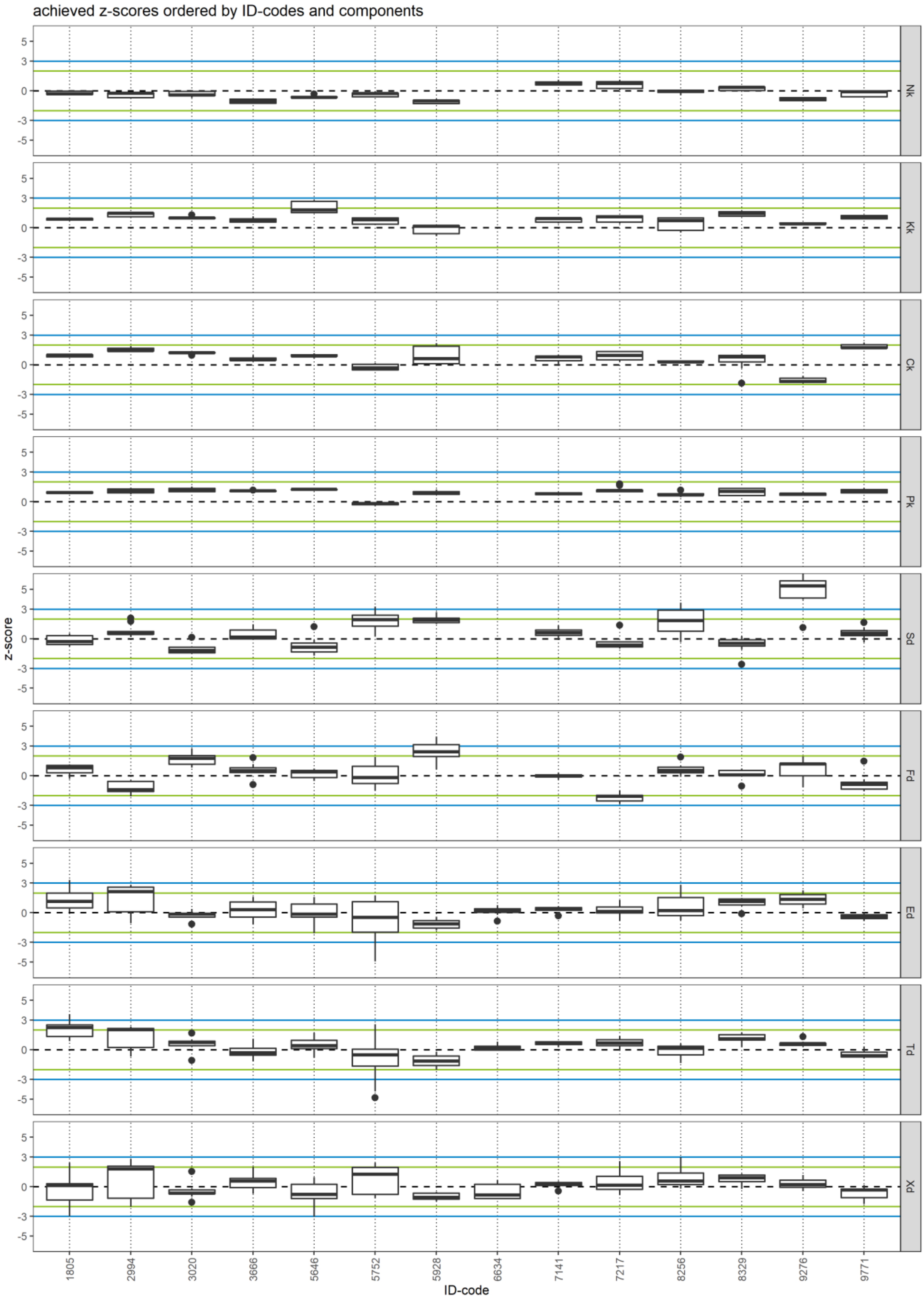
8033
7123
3024
ID-code

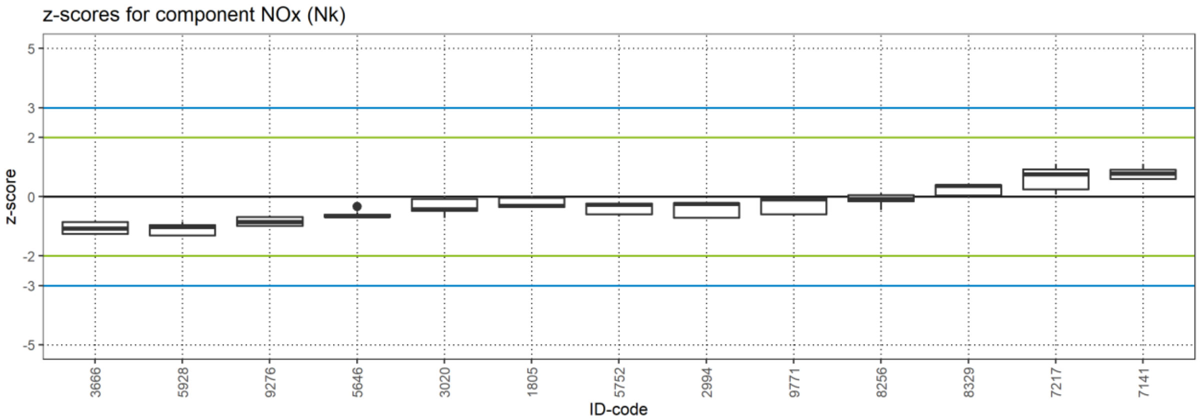

z-scores for component Lead (Pb)
z-score
5
3
2
0
-2
-3
-5
2318
3430
3179
5169
5667
6285
1959
5851
3024
7123
5520
2337
8033
ID-code

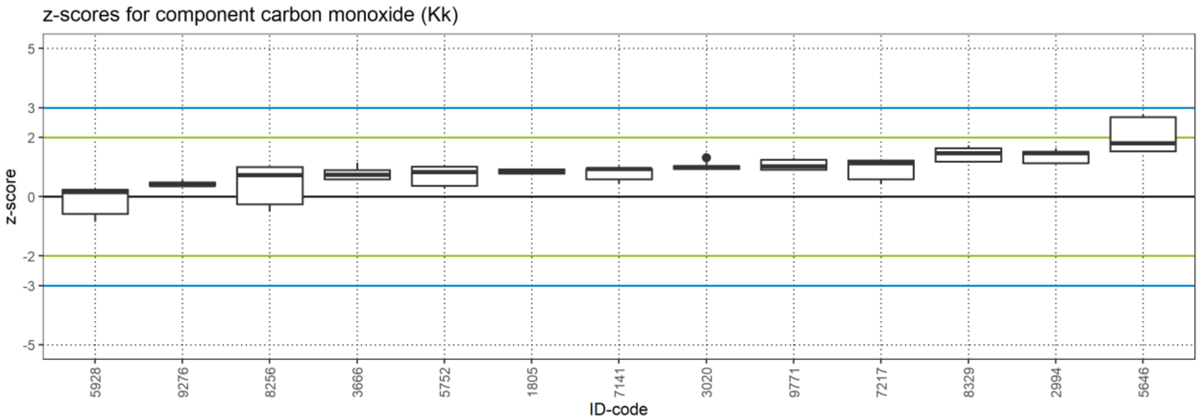

z-scores for component Vanadium (V)
z-score
5
3
2
0
-2
-3
-5
2318
3430
5520
5169
7123
5851
1959
3179
6285
5667
3024
8033
2337
ID-code

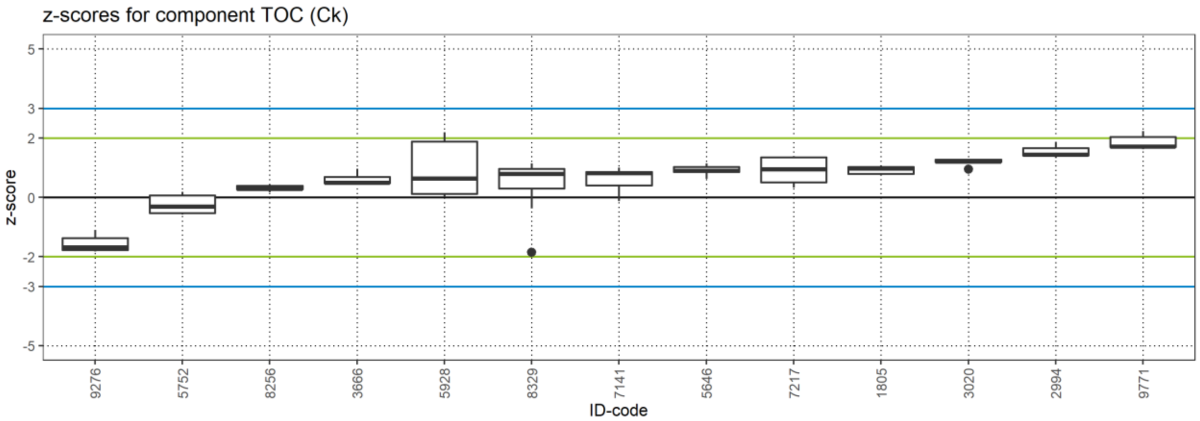
# 5.1.2 Substance Range G

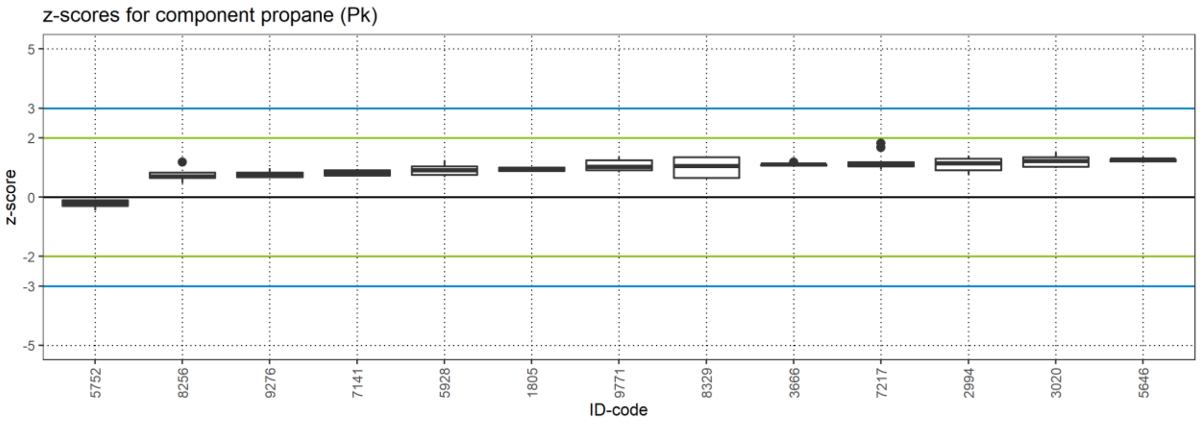


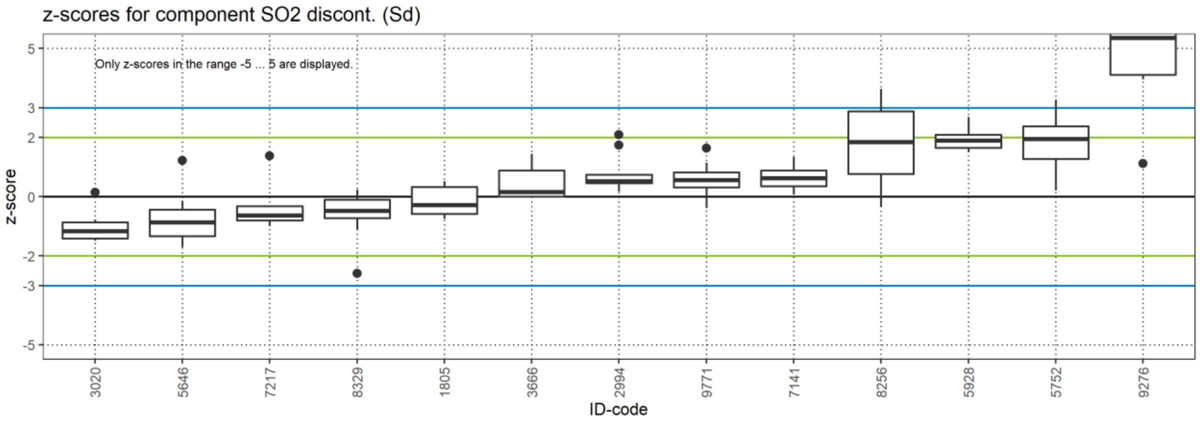

**Scheme 3: Achieved z-scores gas proficiency test (only values in the range -5 … 5 are shown)**

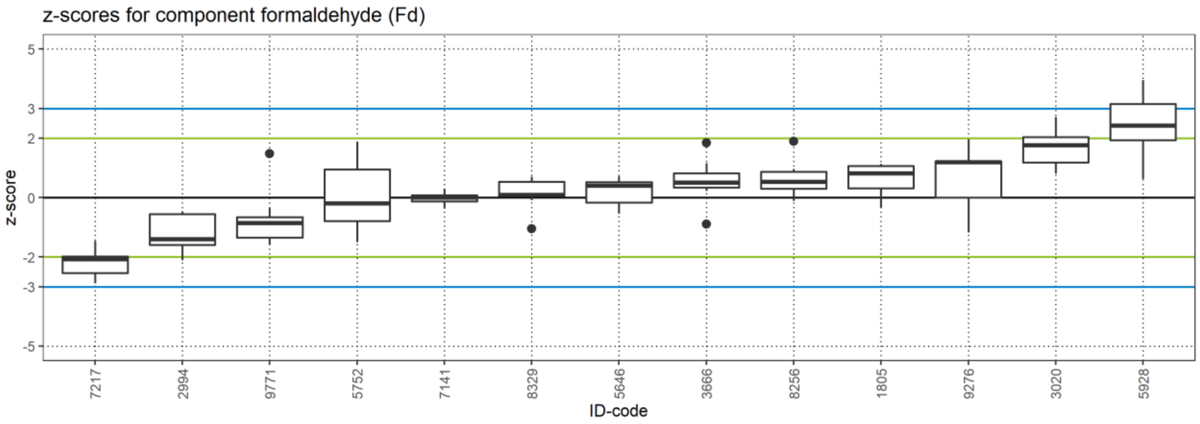

z-scores for component NOx (Nk)
z-score
ID-code
3666
5928
9276
5646
3020
1805
5752
2994
9771
8256
8329
7217
7141

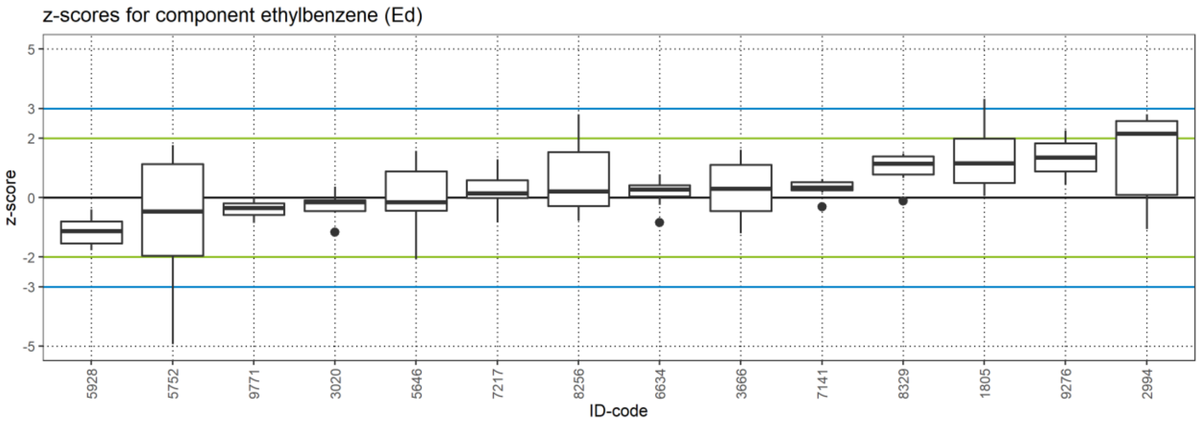

z-scores for component carbon monoxide (Kk)
z-score
ID-code
5928
9276
8256
3666
5752
1805
7141
3020
9771
7217
8329
2994
5646

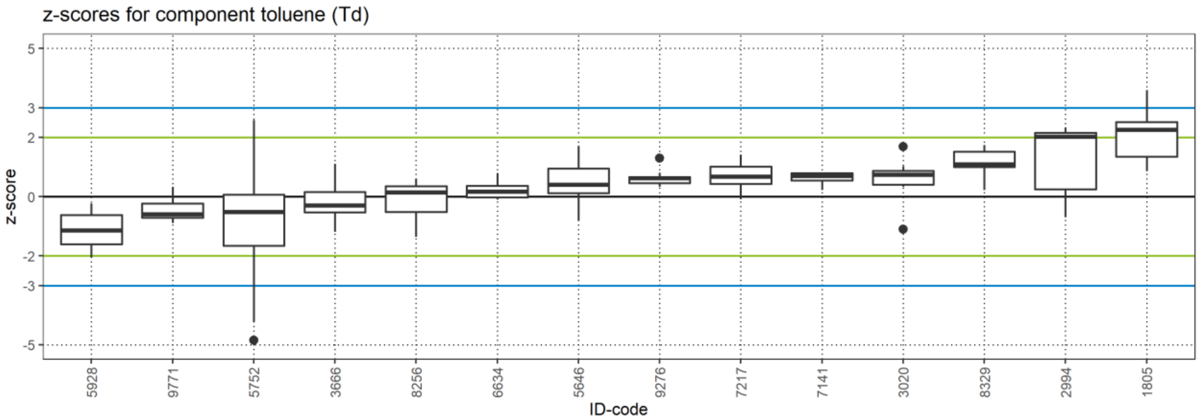

z-scores for component TOC (Ck)
z-score
ID-code
9276
5752
8256
3666
5928
8329
7141
5646
7217
1805
3020
2994
9771

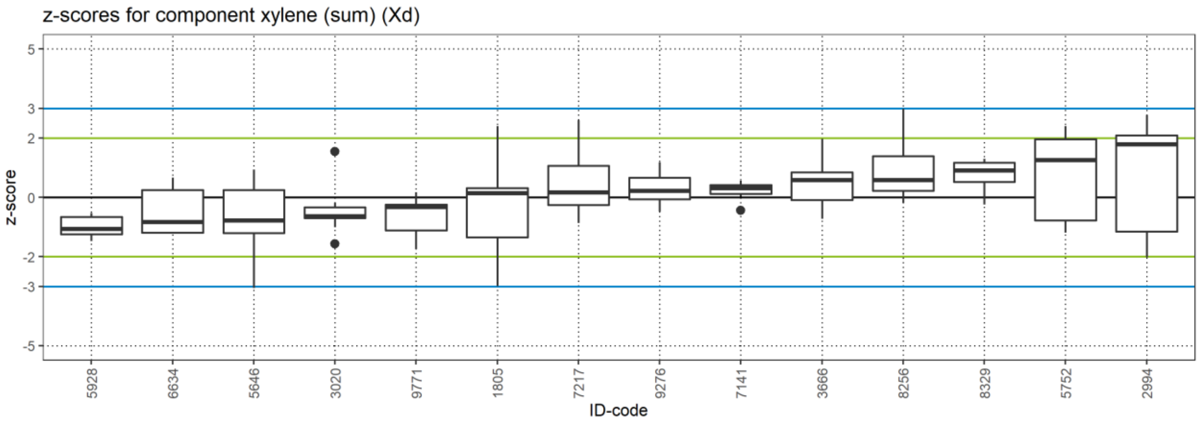

z-scores for component propane (Pk)
z-score
ID-code
5752
8256
9276
7141
5928
1805
9771
8329
3666
7217
2994
3020
5646


z-scores for component SO2 discont. (Sd)
Only z-scores in the range -5 ... 5 are displayed.
z-score
ID-code
3020
5646
7217
8329
1805
3666
2994
9771
7141
8256
5928
5752
9276

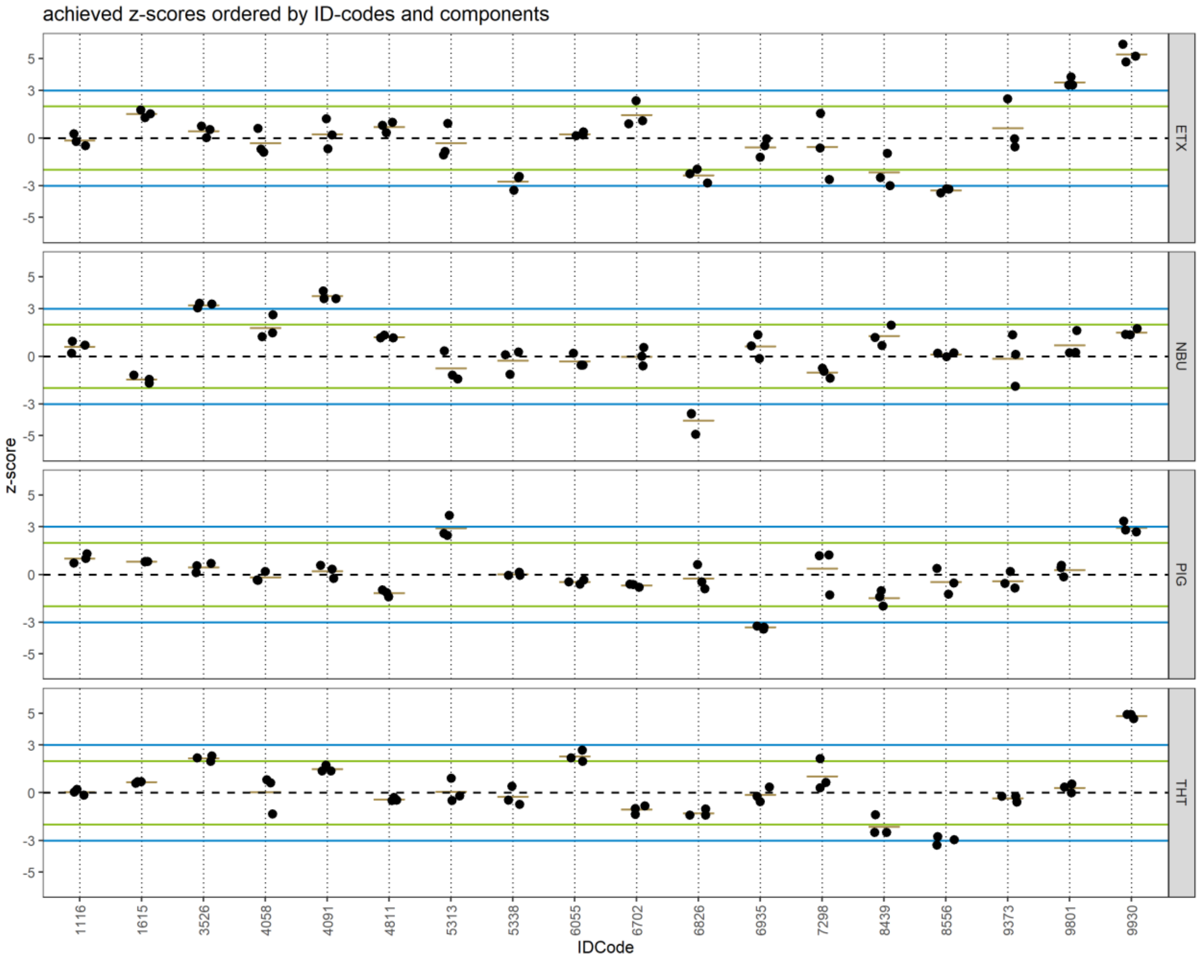

z-scores for component formaldehyde (Fd)
z-score
ID-code
7217
2994
9771
5752
7141
8329
5646
3666
8256
1805
9276
3020
5928


z-scores for component ethylbenzene (Ed)
z-score
5
3
2
0
-2
-3
-5
5928
5752
9771
3020
5646
7217
8256
6634
3666
7141
8329
1805
9276
2994
ID-code

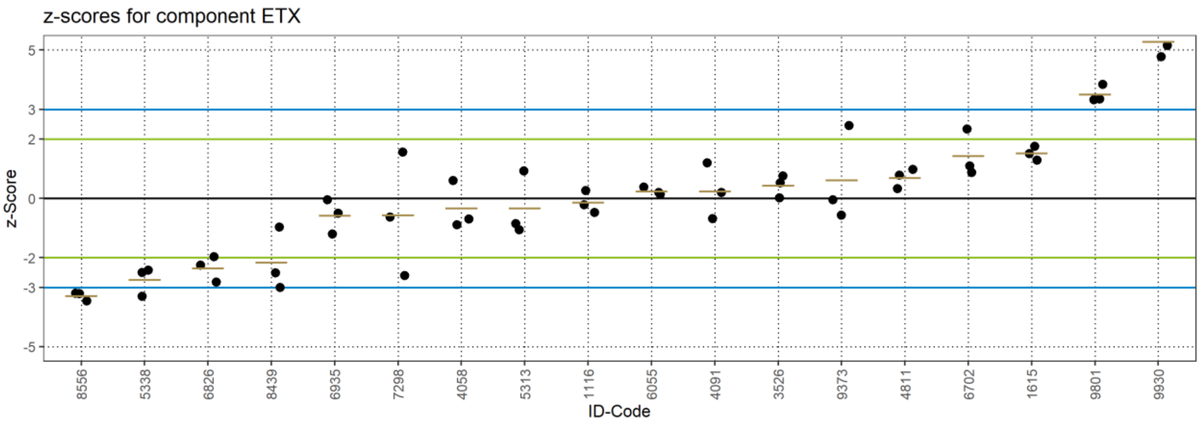

z-scores for component toluene (Td)
z-score
5
3
2
0
-2
-3
-5
5928
9771
5752
3666
8256
6634
5646
9276
7217
7141
3020
8329
2994
1805
ID-code

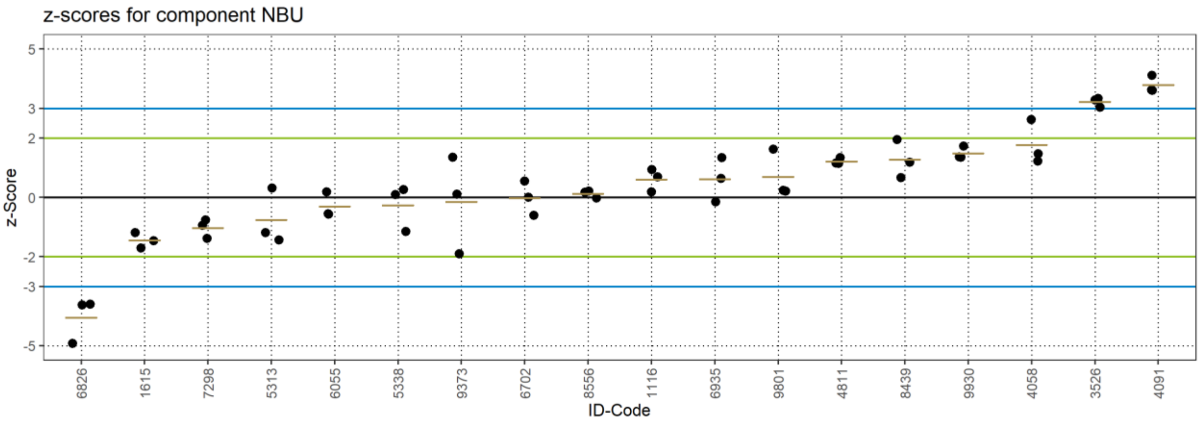

z-scores for component xylene (sum) (Xd)
z-score
5
3
2
0
-2
-3
-5
5928
6634
5646
3020
9771
1805
7217
9276
7141
3666
8256
8329
5752
2994
ID-code

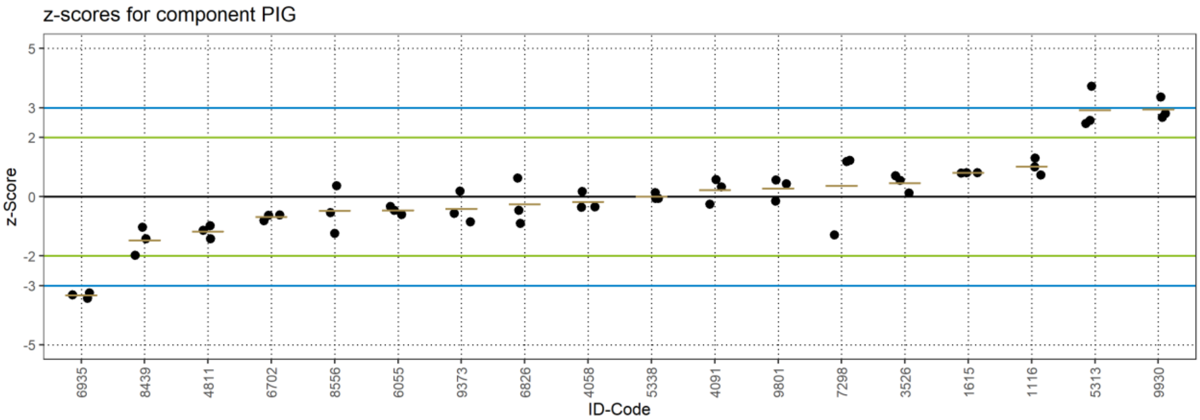
## 5.1.3 Substance Range O

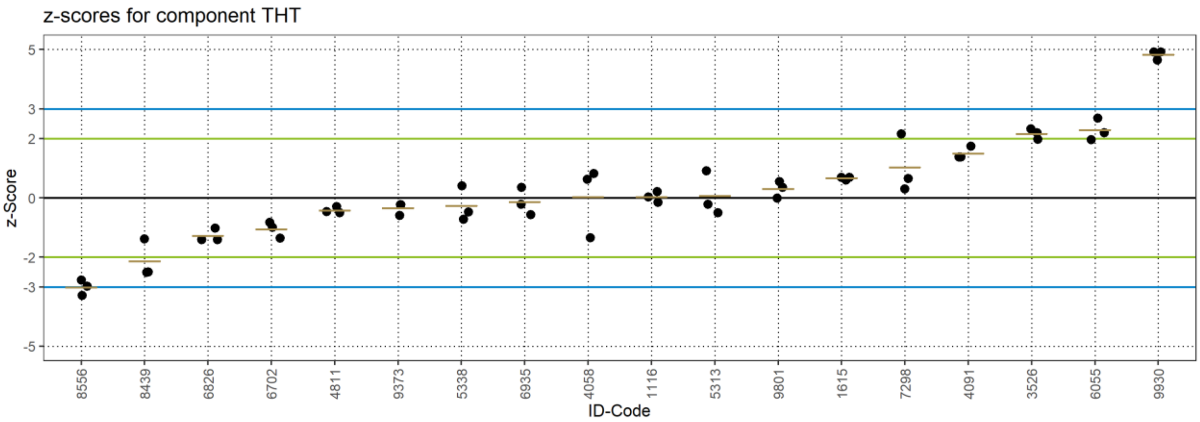



**Scheme 4: Achieved z-scores odour proficiency test (only values in the range -5 ... 5 are shown)**




z-scores for component NBU
z-Score
5
3
2
0
-2
-3
-5
6826 1615 7298 5313 6055 5338 9373 6702 8556 1116 6935 9801 4811 8439 9930 4058 3526 4091
ID-Code

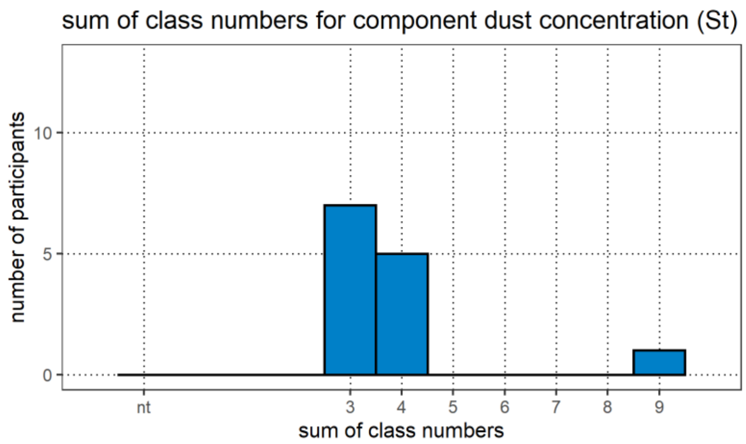

z-scores for component PIG
z-Score
5
3
2
0
-2
-3
-5
6935 8439 4811 6702 8556 6055 9373 6826 4058 5338 4091 9801 7298 3526 1615 1116 5313 9930
ID-Code

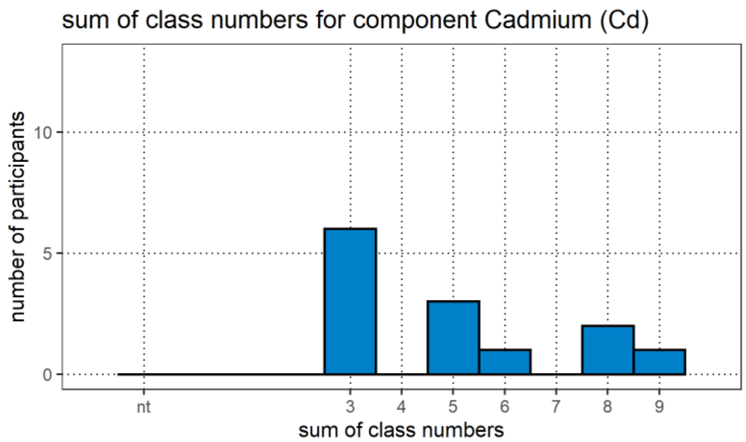

z-scores for component THT
z-Score
5
3
2
0
-2
-3
-5
8556 8439 6826 6702 4811 9373 5338 6935 4058 1116 5313 9801 1615 7298 4091 3526 6055 9930
ID-Code

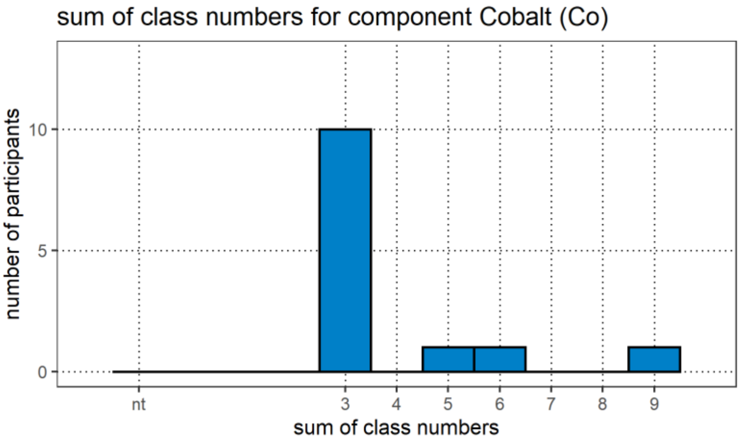
## 5.2 Sums of Class Numbers

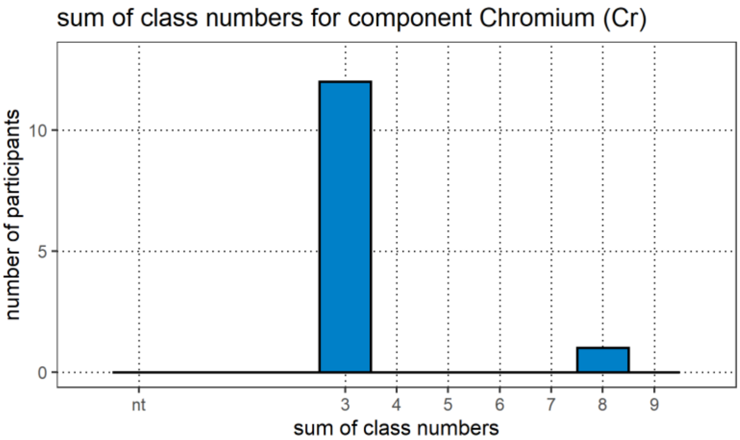
The following schemes show the sum of class numbers that the participants achieved for the different components in form of histogram charts. For the interpretation of the sums of class numbers, please see section 4.5.3. Participants that did not hand in results for a component are listed as "nt".

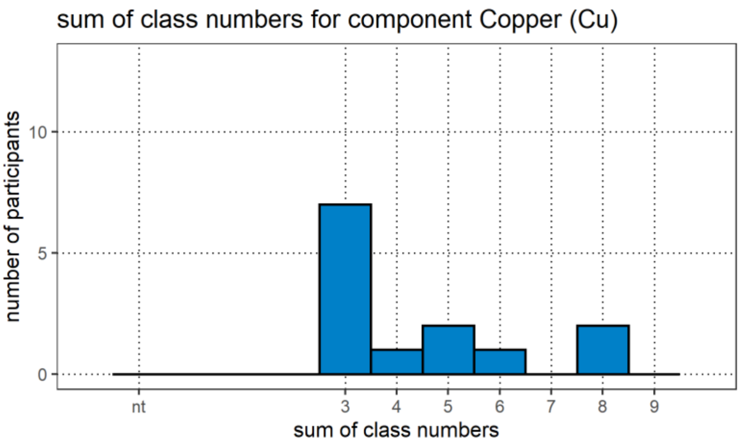
### 5.2.1 Substance Range P

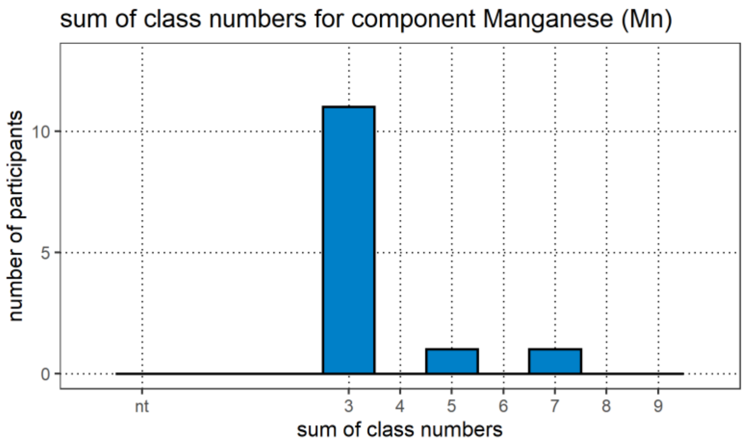


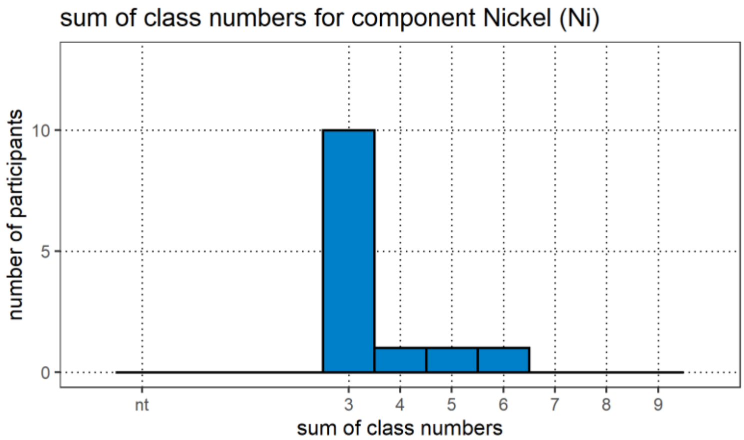



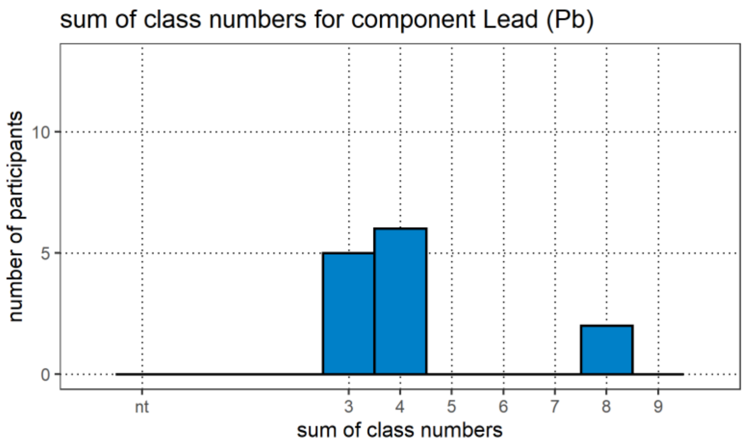

sum of class numbers for component Cobalt (Co)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

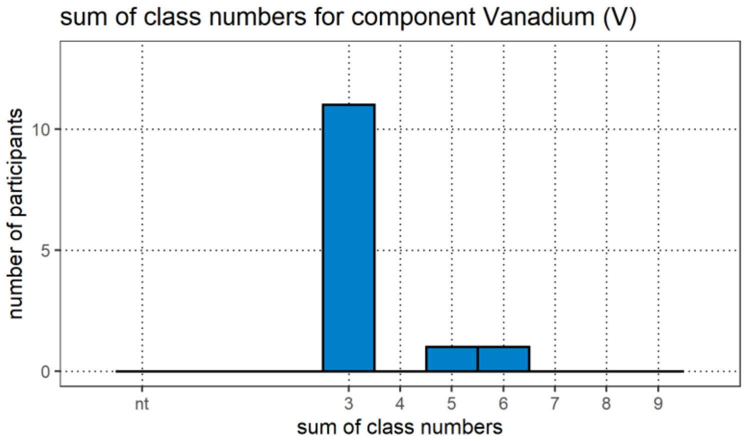

sum of class numbers for component Chromium (Cr)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers


sum of class numbers for component Copper (Cu)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

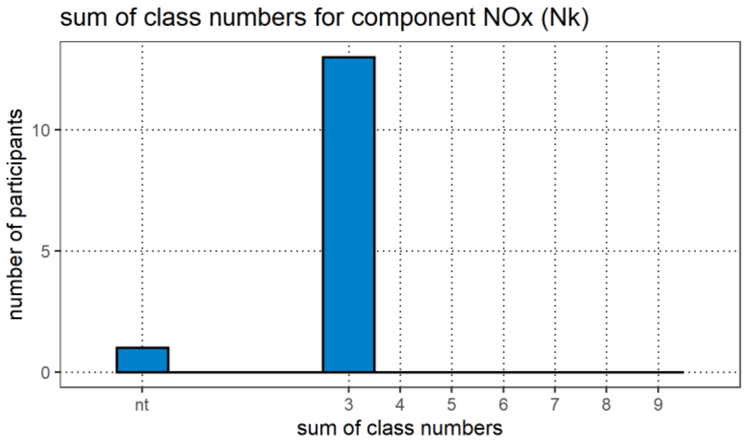

sum of class numbers for component Manganese (Mn)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

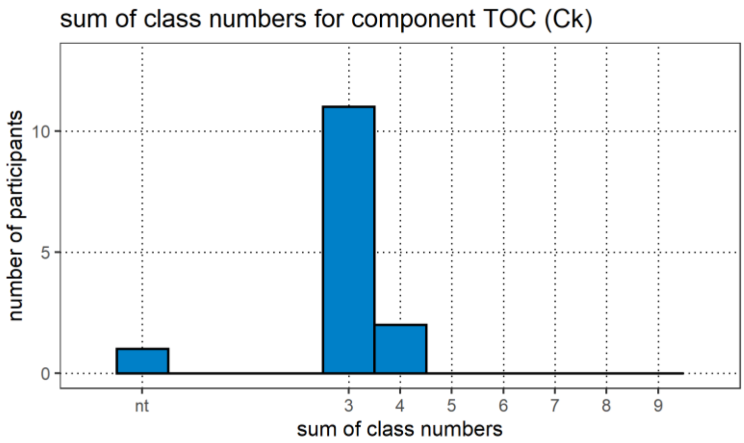

sum of class numbers for component Nickel (Ni)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

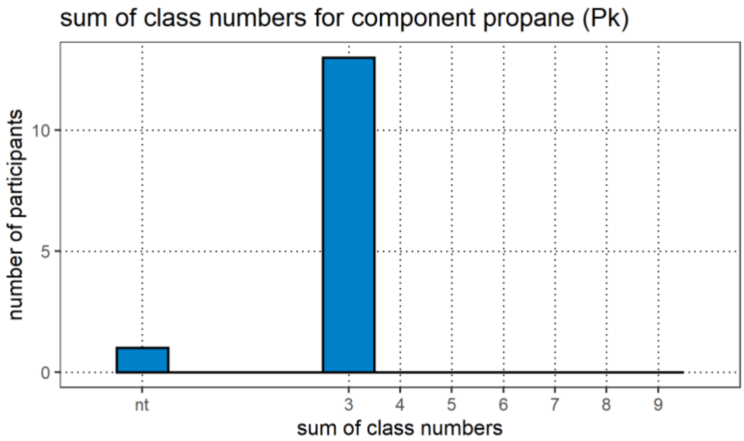

sum of class numbers for component Lead (Pb)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

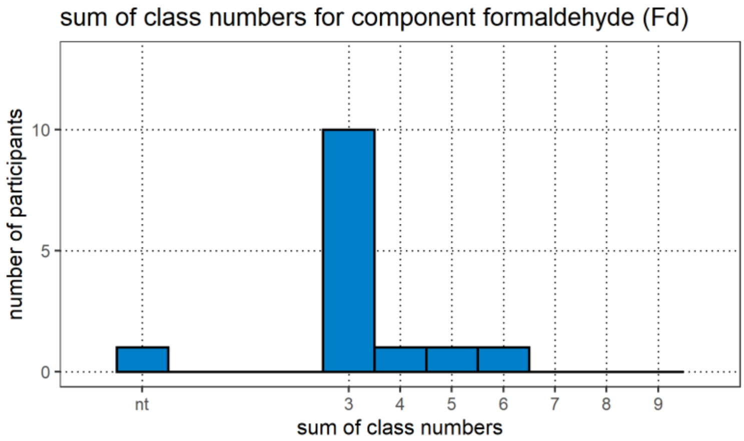


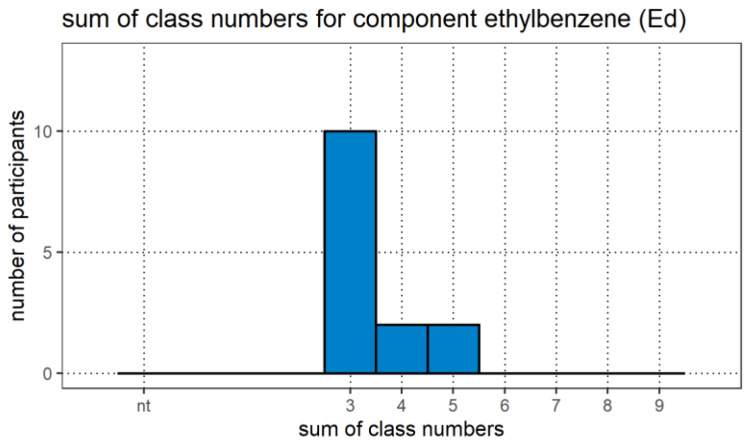

## 5.2.2 Substance range G

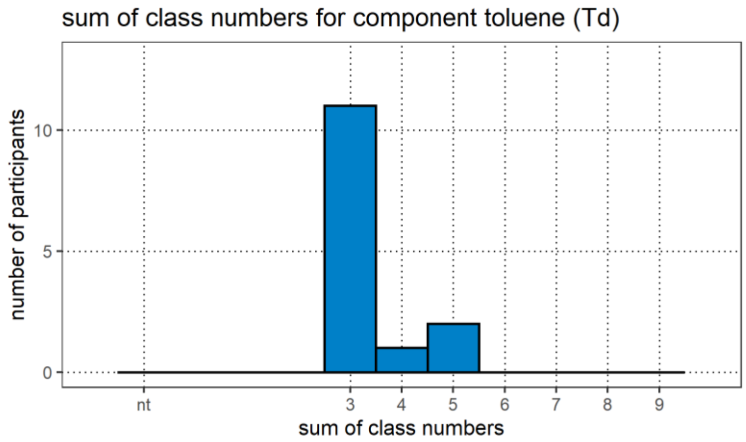


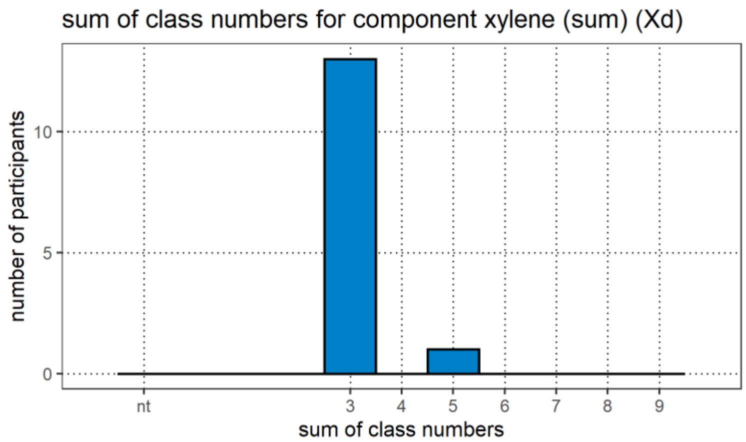


sum of class numbers for component TOC (Ck)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers


sum of class numbers for component propane (Pk)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers


sum of class numbers for component formaldehyde (Fd)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

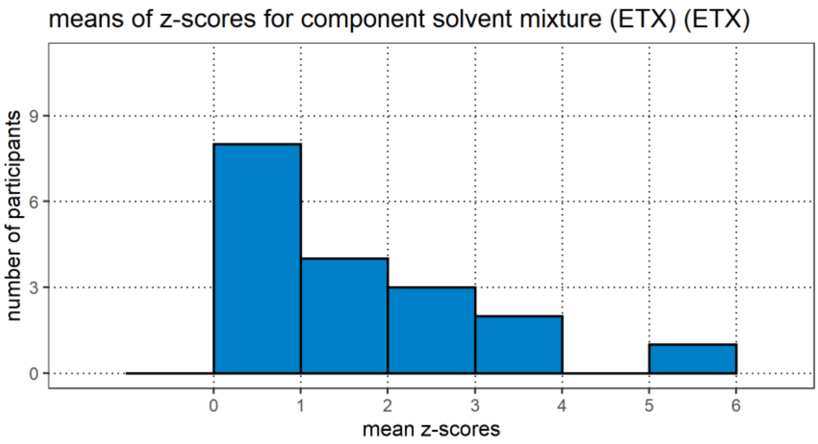

sum of class numbers for component ethylbenzene (Ed)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

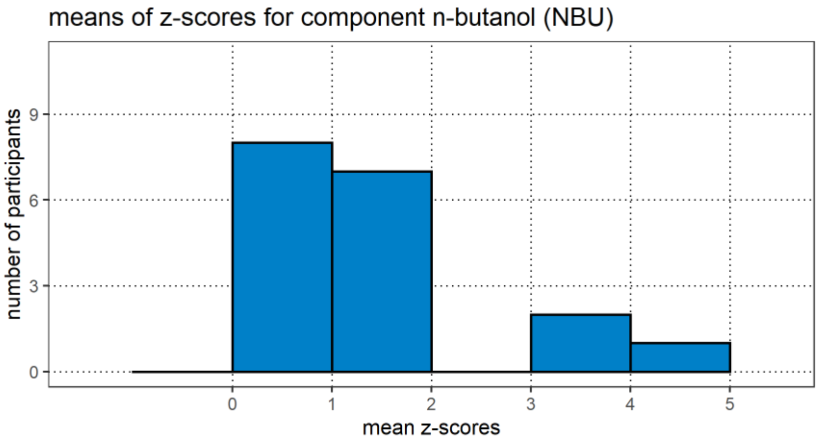

sum of class numbers for component toluene (Td)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

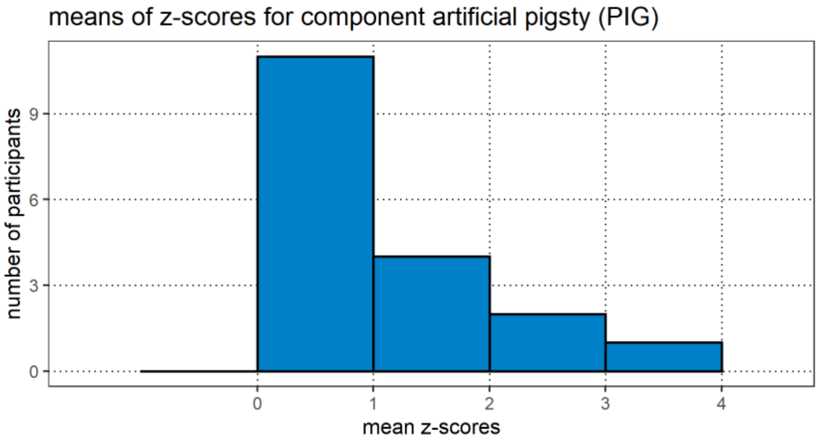

sum of class numbers for component xylene (sum) (Xd)
number of participants
0
5
10
nt
3
4
5
6
7
8
9
sum of class numbers

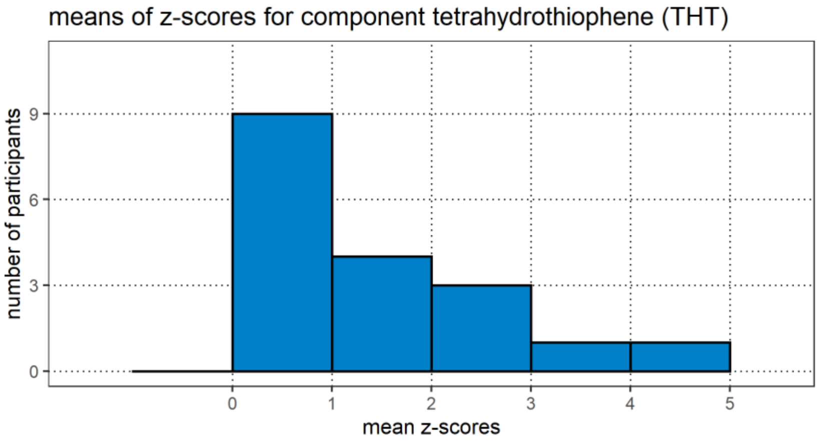
## 5.2.3 Substance Range O

In odour emission proficiency tests, instead of sums of class numbers a mean value of z-scores is calculated. In the following histograms, the participants are allocated to a group by rounding down their mean z-score to the next lower integer.

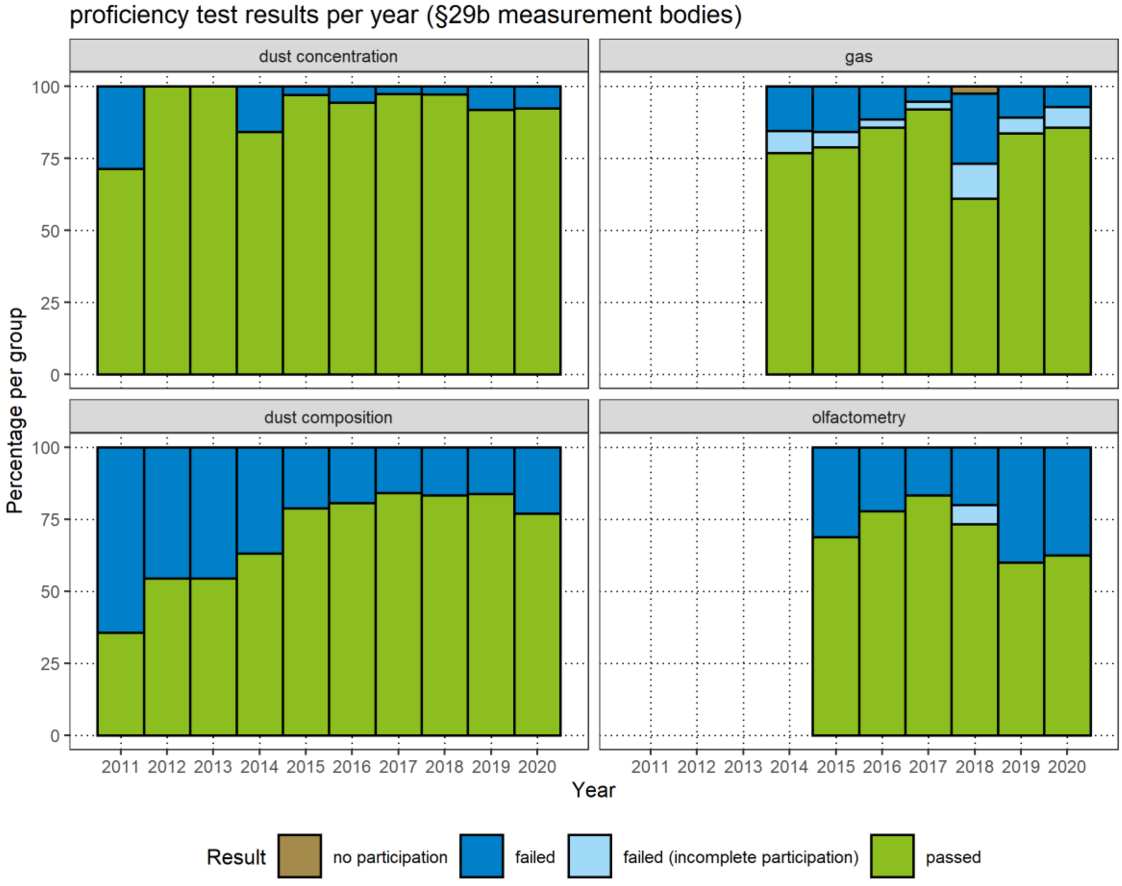


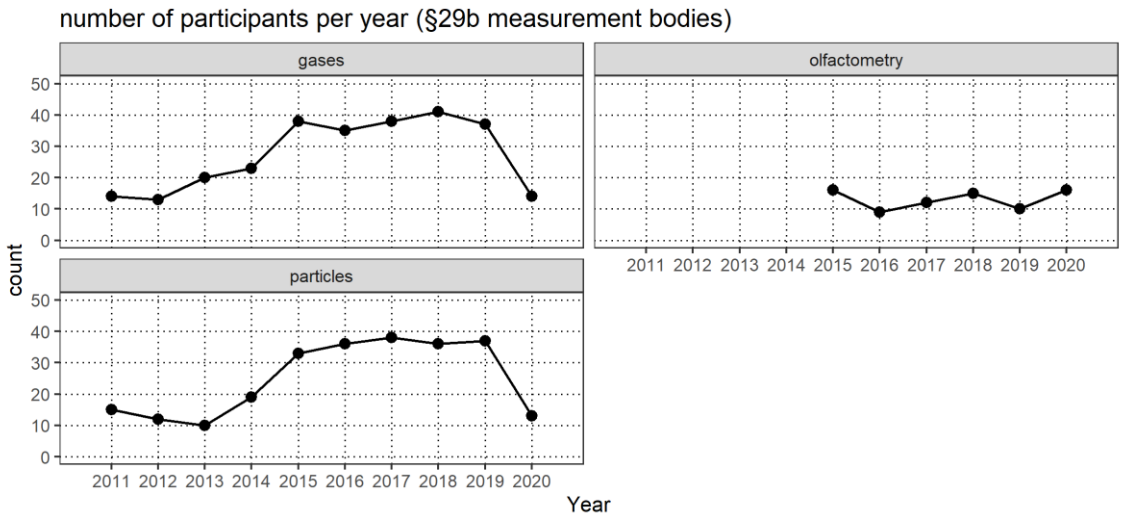



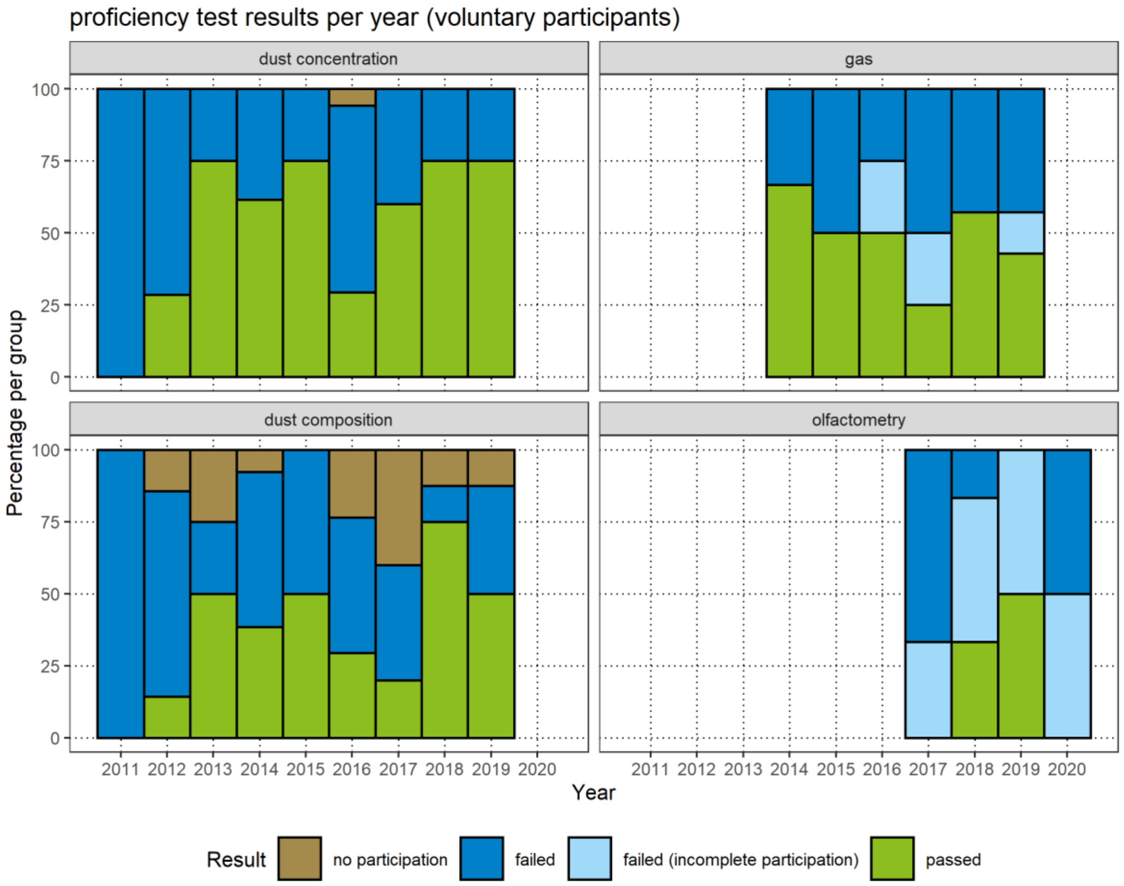




means of z-scores for component tetrahydrothiophene (THT)
number of participants
0
3
6
9
0
1
2
3
4
5
mean z-scores

# 6. Interpretation of Results




proficiency test results per year (voluntary participants)
dust concentration
gas
dust composition
olfactometry
Percentage per group
0
25
50
75
100
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Year
Result
no participation
failed
failed (incomplete participation)
passed

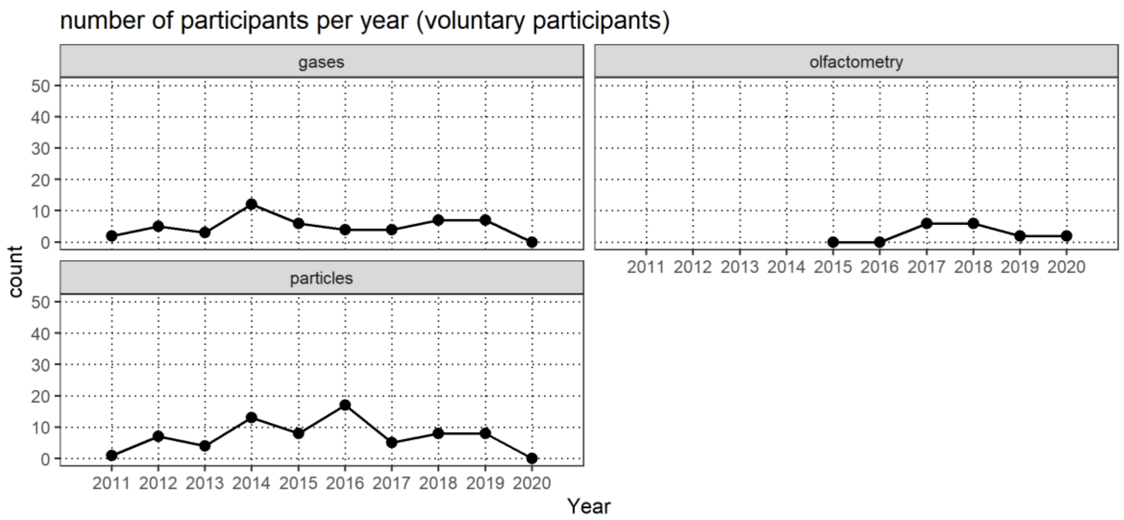

number of participants per year (voluntary participants)
gases
olfactometry
particles
count
0
10
20
30
40
50
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Year

**Table 6: Overview of results since 2016 (§29b-bodies)**

| year | components group | passed | failed | failed (incompl. participation) | no participation |
|---|---|---|---|---|---|
| 2016 | gas | 30 | 4 | 1 | - |
| | odour | 7 | 2 | - | - |
| | dust (total) | 34 | 2 | - | - |
| | dust composition | 29 | 7 | - | - |
| | dust composition (post-analysis) | 4 | 1 | - | - |
| 2017 | gas | 35 | 2 | 1 | - |
| | odour | 10 | 2 | - | - |
| | dust (total) | 37 | 1 | - | - |
| | dust composition | 32 | 6 | - | - |
| | dust composition (post-analysis) | 3 | 2 | - | - |
| 2018 | gas | 25 | 10 | 5 | 1* |
| | odour | 11 | 3 | 1 | - |
| | dust (total) | 35 | 1 | - | - |
| | dust composition | 30 | 6 | - | - |
| | dust composition (post-analysis) | 4 | 1 | - | - |
| 2019 | gas | 31 | 4 | 2 | - |
| | odour | 6 | 4 | - | - |
| | dust (total) | 34 | 3 | - | - |
| | dust composition | 31 | 6 | - | - |
| | dust composition (post-analysis) | 3 | - | - | - |
| 2020 | gas | 12 | 1 | 1 | - |
| | odour | 10 | 6 | - | - |
| | dust (total) | 12 | 1 | - | - |
| | dust composition | 10 | 3 | - | - |
| | dust composition (post-analysis) | 2 | - | - | - |

* One participant was absent without excuse at his proficiency test date.

**Table 7: Overview since 2016 (voluntary paricipants)**

| year | components group | passed | failed | failed (incompl. participation) | no participation |
|---|---|---|---|---|---|
| 2016 | gas | 2 | 1 | 1 | - |
| | dust (total) | 5 | 11 | - | 1 |
| | dust composition | 5 | 8 | - | 4 |
| | dust composition (post-analysis) | 2 | - | - | - |
| 2017 | gas | 1 | 2 | 1 | - |
| | odour | - | 4 | 2 | - |
| | dust (total) | 3 | 2 | - | - |
| | dust composition | 1 | 2 | - | 2 |
| | dust composition (post-analysis) | - | 1 | - | - |
| 2018 | gas | 4 | 3 | - | - |
| | odour | 2 | 1 | 3 | - |
| | dust (total) | 6 | 2 | - | - |
| | dust composition | 6 | 1 | - | 1 |

| year | components group | passed | failed | failed (incompl. participation) | no participation |
|---|---|---|---|---|---|
| 2019 | gas | 3 | 3 | 1 | - |
| | odour | 1 | - | 1 | - |
| | dust (total) | 6 | 2 | - | - |
| | dust composition | 4 | 3 | - | - |
| | dust composition (post-analysis) | 1 | - | - | - |
| 2020 | gas | - | - | - | - |
| | odour | - | 1 | 1 | - |
| | dust (total) | - | - | - | - |
| | dust composition | - | - | - | - |
| | dust composition (post-analysis) | - | - | - | - |

## 6.1 §29b Measuring Bodies

Due to the number of authorized measuring bodies or sites and the requirements of the 41st BImSchV, the number of proficiency test participations by §29b measuring bodies is usually about 30-40 participations for gas and dust per year. Due to the restrictions caused by the SARS-CoV-2 pandemic, however, only parts of the planned proficiency test programme were carried out in 2020. As a result, only about a dozen measuring bodies were able to participate in the dust and gas proficiency tests this year.

The results of the §29b measuring bodies in the dust proficiency test are still at a high level, 12 of 13 participants (92%) were successful in the dust (total) part of the proficiency test. With regard to dust composition, the results seem to continue to stabilise at a high level, 10 out of 13 participants (77%) passed this part of the proficiency test on a regular basis, a further 2 participants (15%) only passed this part of the proficiency test via post-analysis. In total, 92% of the participants in the dust proficiency test were successful.

In the gas proficiency test 12 of 14 (86%) of the §29b measuring bodies passed. After the unusually low pass rate in 2018, the pass rate has thus stabilised again at the level observed previously.

10 of 16 participants (63%) passed the odour proficiency test. The pass rate was the same as last year, although the total number of participants is comparatively low. It is noticeable that 4 of the 6 participants who were not successful in 2020 had already achieved insufficient results in previous proficiency tests. The reason for the poor performance of the unsuccessful participants cannot be finally clarified. However, it can be assumed that, in view of the uncertainty of individual test person results, the statistically too small number of usually 4 test persons used for odour measurements plays a crucial role here.

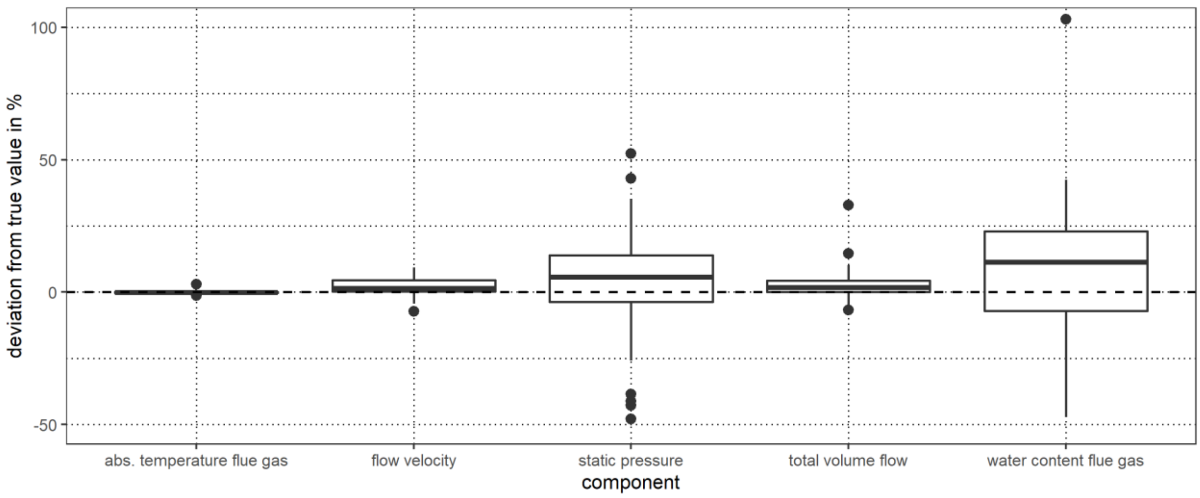
## 6.2 Voluntary Participants

The number of voluntary participations in the proficiency tests varies from year to year, usually there are about 4 participations in the gas proficiency test and about 8 participations in the dust proficiency test. In 2020, there were no voluntary participants in the dust and gas proficiency tests due to the cancellation of several rounds because of the SARS-CoV-2 pandemic.

In the odour proficiency tests, none of the two voluntary participants passed. One participant (50%) delivered correct measured values, but these were not determined within 6 hours according to VDI 3880. The results were therefore classified as "failed (incomplete participation)".

## 6.3 Basic Flow Conditions

For each proficiency test, the participants must also determine and specify the basic flow conditions. The measured values of the participants are compared in the result communications with the target values determined by the HLNUG. The data basis for the evaluation in this report are the measured values received from proficiency test participants in 2020. A list of individual results is not given here, in the following scheme only a summary representation of the values is shown. The display is limited to relative deviations of the participant measured values from the respective setpoint value in order to be able to compare different proficiency tests with different flow conditions. Obviously incorrect measured values that deviate from the setpoint by orders of magnitude were removed from the data collective. This applies in particular to information on static pressure. Here, numerical values were often submitted that would be reasonably correct, e.g. in the unit Pa or as total pressure, but not as static pressure in the unit hPa, as asked for in the results submission.




As can be seen, the measured values for the exhaust gas temperature are always very close to the setpoint. In comparison, the measured values for the flow velocity and the volume flow show a significantly higher dispersion and many individual values that are far from the setpoint value. Even more extremely, the measured values of the participants scatter for the static pressure and the water vapour concentration.

An evaluation of the absolute values of the relative deviations (positive and negative deviations do not cancel each other out here) can be found in the following table. The median of the absolute values of the respective deviations as well as the 25th and 75th percentile are listed there. This information should be understood as follows: Only a quarter of the readings showed a deviation below the 25th percentile. Half of the measurements showed a deviation below or above the median. One quarter of the measured values had a deviation (positive or negative) greater than the 75th percentile.

**Table 8: Absolute relative deviations from true values for basic conditions (2020)**

| | absolute temperature [%] | flow velocity [%] | static pressure [%] | volume flow [%] | water vapour concentration [%] |
|---|---|---|---|---|---|
| 75th percentile | 0.32 | 5.43 | 23.4 | 4.73 | 28.5 |
| median | 0.17 | 3.24 | 13.2 | 2.76 | 17.5 |
| 25th percentile | 0.05 | 1.13 | 5.6 | 1.06 | 4.0 |
| number of values | 84 | 84 | 82 | 84 | 84 |

The deviations from the assigned values were thus relatively close to the results from previous years.

# 7. Optional Information from Participants

All participants were asked to provide additional information on their measurements on a voluntary basis together with the measurement results. The data received are summarised in the following tables and presented graphically. The database is based on feedback from participants from the years 2016 to 2020.

For some components, the participants in the proficiency test have a certain freedom in the choice of various process parameters. Based on the participants' voluntary data, an attempt was made to determine correlations between the methods, equipment, etc. used and the results obtained. Since 9 measurements are always carried out at different concentrations for each component, it is difficult to make a clear statement about the quality of a procedure. For a simple and clear presentation, correlations to the mean z-scores of the participants were therefore established, with negative values also being included in the mean value. In addition, similar components such as heavy metals or organic solvents were combined to form a common mean value. This type of evaluation certainly represents a simplification of the problem and cannot show all the details. Thus, for example, different influences in different concentration ranges or high fluctuations between the individual results of a participant are completely ignored in this evaluation. However, the limitation to the mean values of the participants' z-scores allows a simple estimation of the effects of different methods on the mean deviation of the measured values from the assigned value.

For most evaluations, a certain stabilisation of the values can be observed. This is ultimately due to the fact that the data basis for the 2018 Annual Report has only increased by about one third, while the values for most evaluations hardly differ from the values of previous years. As a result, most of the findings become more and more reliable and meaningful over time.

For all correlations presented in this report, it should be kept in mind that a correlation is merely an indication of a connection, but by no means proves causality. For example, it is quite conceivable that participants who use a certain device or procedure may happen to have other similarities that actually affect the measurement results, while the identified similarity actually plays no role at all.

## 7.1 Measurement Uncertainties

The participants' data on the absolute extended measurement uncertainties of their methods used in the dust proficiency test are shown in the following scheme. The median of the respective data as well as the 25th and 75th percentile are listed in the following table. This information should be understood as follows: Only a quarter of the participants indicated an uncertainty of measurement below the 25th percentile. Half of the participants indicated an uncertainty of measurement below or above the median. A quarter of the participants indicated an uncertainty of measurement greater than the 75th percentile.

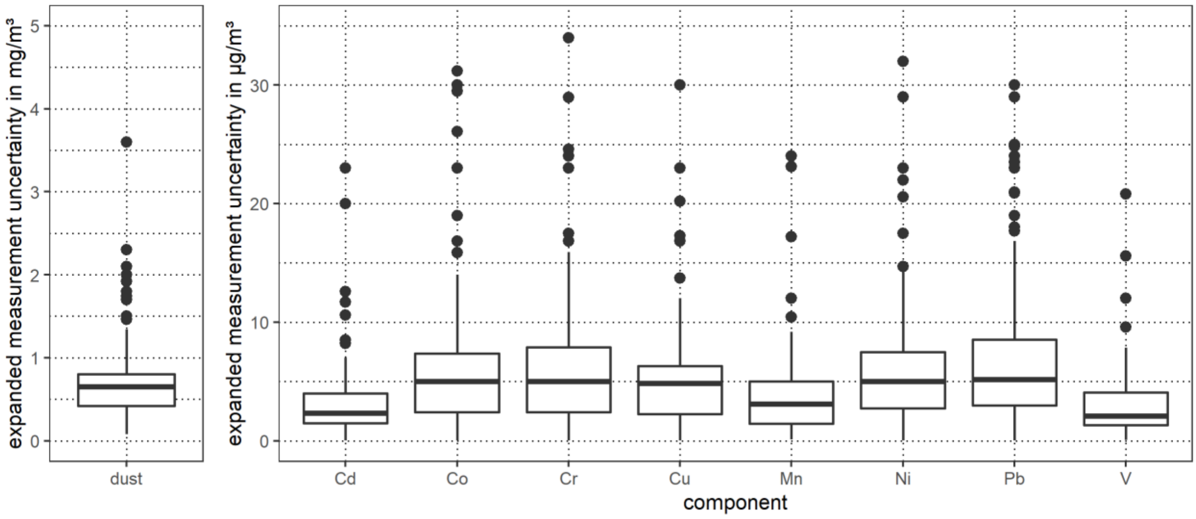



**Table 9: Expanded measurement uncertainties reported by participants of the dust proficiency test**

| | **dust** [mg/m³] | **Cd** [µg/m³] | **Co** [µg/m³] | **Cr** [µg/m³] | **Cu** [µg/m³] | **Mn** [µg/m³] | **Ni** [µg/m³] | **Pb** [µg/m³] | **V** [µg/m³] |
|---|---|---|---|---|---|---|---|---|---|
| 75th percentile | 0.90 | 4.03 | 7.50 | 8.00 | 6.30 | 5.15 | 7.50 | 8.61 | 4.35 |
| median | 0.66 | 2.32 | 5.00 | 5.00 | 4.84 | 3.10 | 5.00 | 5.21 | 2.12 |
| 25th percentile | 0.42 | 1.46 | 2.40 | 2.40 | 2.20 | 1.42 | 2.70 | 2.86 | 1.32 |
| number of values | 139 | 122 | 123 | 123 | 123 | 85 | 123 | 122 | 82 |

For all information on absolute expanded measurement uncertainties, it should be noted that for reasons of comparability, participants were asked to give only one value for each method. The information may therefore refer to the highest concentration measured in the proficiency test and would be lower for lower concentrations. Nevertheless, these values should enable all participants to make an approximate assessment of how their own uncertainty of measurement relates to the uncertainty of measurement of other laboratories.

For the gas emission proficiency test, the following uncertainties were reported.

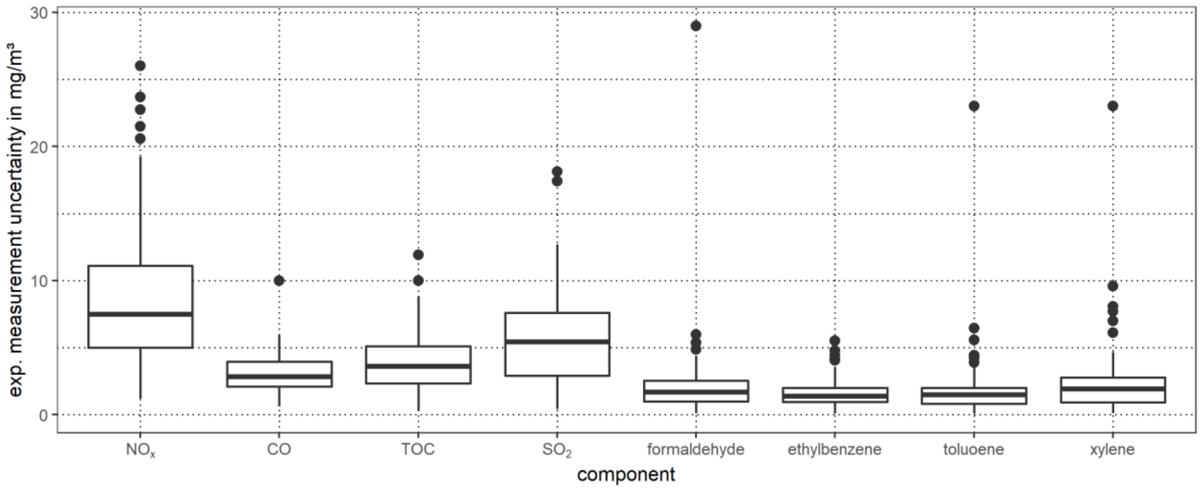


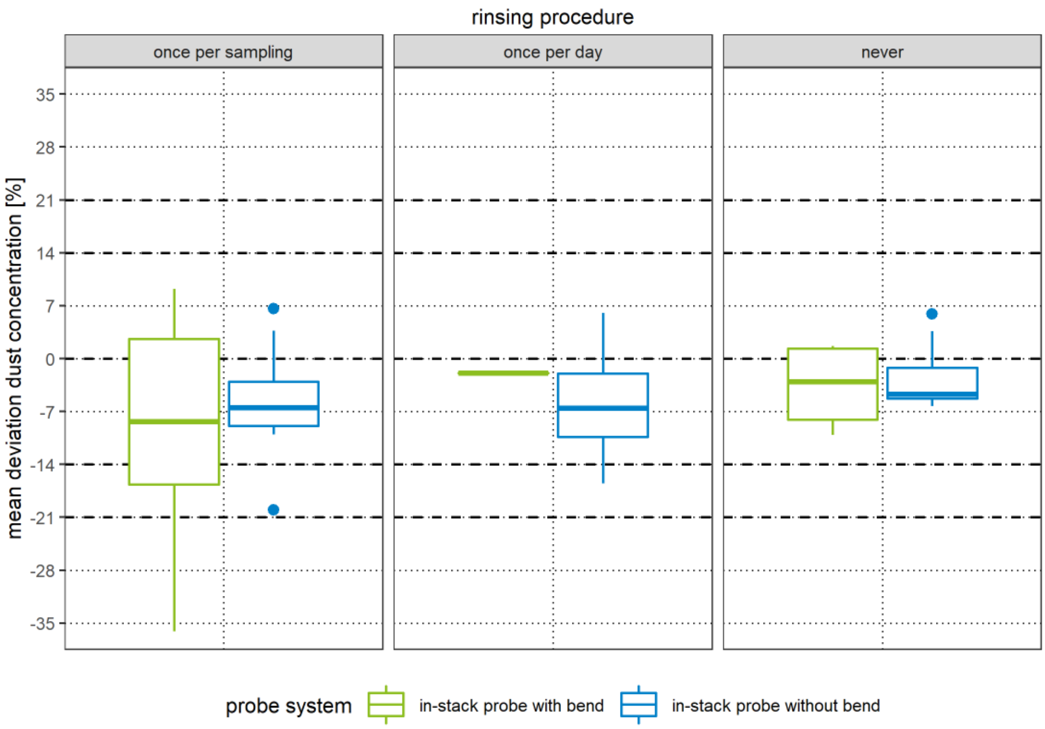

**Table 10: Expanded measurement uncertainties reported by participants of the gas proficiency test**

| | $NO_x$ as $NO_2$ [mg/m³] | CO [mg/m³] | TOC [mg/m³] | $SO_2$ [mg/m³] | form-aldehyde [mg/m³] | ethyl-benzene [mg/m³] | toluene [mg/m³] | sum of xylenes [mg/m³] |
|---|---|---|---|---|---|---|---|---|
| 75th percentile | 11.1 | 3.95 | 5.10 | 7.60 | 2.52 | 2.00 | 2.00 | 2.78 |
| median | 7.50 | 2.85 | 3.63 | 5.42 | 1.69 | 1.40 | 1.50 | 1.94 |
| 25th percentile | 5.00 | 2.10 | 2.33 | 2.90 | 0.97 | 0.96 | 0.80 | 0.90 |
| number of values | 129 | 52 | 124 | 128 | 125 | 125 | 126 | 126 |

## 7.2 Probes and Rinsing Procedures in Dust Sampling

For the correlation of probe systems and rinsing procedures, the field of participants in the dust proficiency tests is divided into 6 groups, depending on whether an in-stack probe with or without gooseneck is used, and whether this probe is rinsed after each sampling, every working day, or never. Four participants who stated that they rinse once at the end of the proficiency test were considered to rinse once at the end of each working day.

The data basis in this report is limited to the results between autumn 2018 and summer 2020. In summer 2018, the query about the rinsing procedure was concretised with regard to frequency; a total of 50 participants gave corresponding information about their rinsing procedure. In previous years, only the basic rinsing procedure (yes/no) was queried, the data are therefore unfortunately not comparable.


rinsing procedure
once per sampling
once per day
never
mean deviation dust concentration [%]
35
28
21
14
7
0
-7
-14
-21
-28
-35
probe system
in-stack probe with bend
in-stack probe without bend

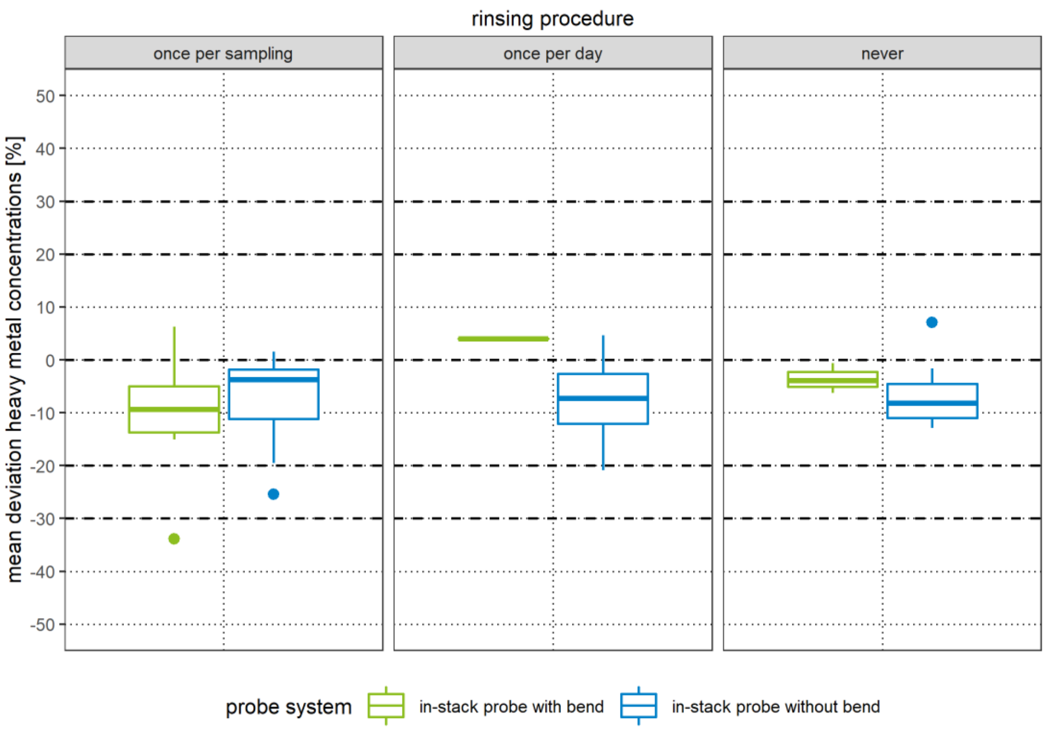

rinsing procedure
once per sampling
once per day
never
mean deviation heavy metal concentrations [%]
50
40
30
20
10
0
-10
-20
-30
-40
-50
probe system
in-stack probe with bend
in-stack probe without bend

**Table 11: Correlation of dust measurement results with probe systems and rinsing procedures (2018-2020)**

| combi-nation | probe system | rinsing proce-dure | median of mean devia-tions total dust results | number of participants | median of mean devia-tions heavy metal results | number of participants |
|---|---|---|---|---|---|---|
| 1 **(left)** | in-stack probe **with** bend(s) | after each sam-pling | -8.3% | 9 | -9.3% | 9 |
| 2 **(centre)** | | once per day | -1.9% | 1 | +4.0% | 1 |
| 3 **(right)** | | no rinsing | -3.1% | 4 | -3.9% | 3 |
| 4 **(left)** | in-stack probe **without** bend | after each sam-pling | -6.5% | 13 | -3.7% | 13 |
| 5 **(centre)** | | once per day | -6.7% | 15 | -7.1% | 15 |
| 6 **(right)** | | no rinsing | -4.7% | 8 | -8.2% | 8 |

Due to the very small number of cases, the results presented are considerably influenced by various influences of the respective laboratories. For example, the above-average results for combination 3 (probe with gooseneck that is not rinsed: right figures, green) are hardly representative for this type of sampling. Combination 3 explicitly does not conform to the standard, since with this probe geometry, dust deposits on the inner surface of the probe are to be expected in any case, which can lead to significantly lower results if no rinsing is performed.

## 7.3 Diameter of the Nozzle Opening in Dust Samplings

The information provided by the participants on the diameter of the probe's nozzle opening does not indicate a clear trend. Regardless of the diameter, the measured values always seem to scatter over a wide range. Overall, however, the size of the nozzle opening does not seem to be a determining factor for the measurement results. Probe diameters that were mentioned by less than 5% of all participants are not listed here.

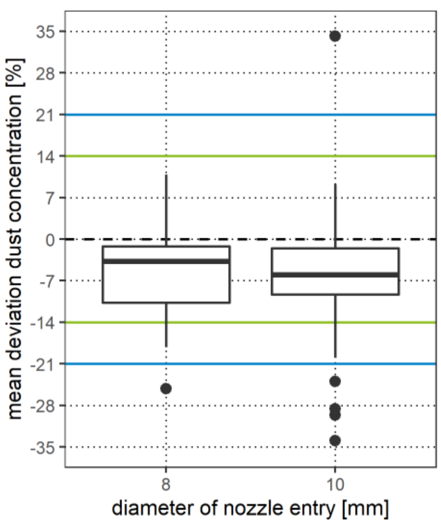


**Table 12: Correlation of absolute means of z-scores for total dust with nozzle opening diameters**

| diameter of nozzle opening | 8 mm | 10 mm |
|---|---|---|
| 75th percentile (z-score) | −1.22% | −1.52% |
| median (z-score) | −3.70% | −6.03% |
| 25th percentile (z-score) | −10.7% | −9.32% |
| number of values | 32 | 124 |

## 7.4 Analytical Instruments for Heavy Metals

The information provided by the participants on the analytical instrument used for heavy metal analysis shows little difference between AAS and ICP users. A total of 22 participants stated that heavy metal analysis was performed using AAS equipment, while 145 participants stated that they used an ICP instrument. On average, all participants achieved comparable z scores for the heavy metals, regardless of the analytical instrument used. However, the measured values of the ICP users scatter significantly more than those of the AAS users. In addition, ICP users seem to be more prone to massive underreporting than users of AAS devices.

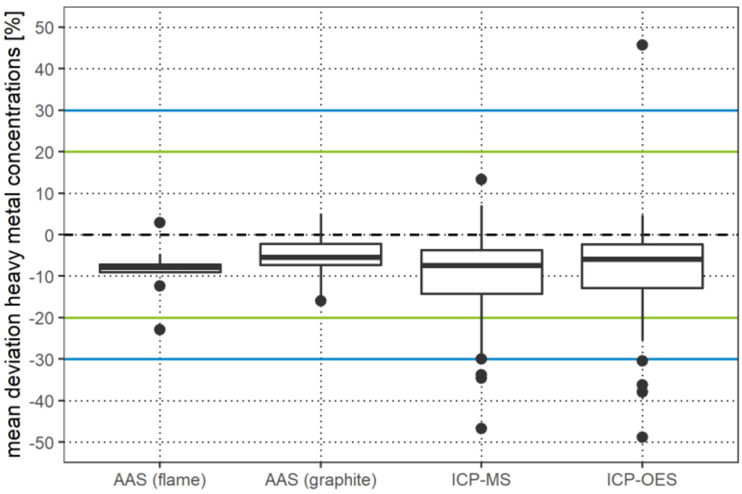



**Table 13: Correlation of heavy metal results and analysis devices**

| analysis device | flame-AAS | graphite furnace AAS | ICP-MS | ICP-OES |
|---|---|---|---|---|
| 75th percentile | −7.17% | −2.20% | −3.67% | −2.34% |
| median | −7.91% | −5.42% | −7.44% | −5.89% |
| 25th percentile | −9.08% | −7.34% | −14.2% | −12.8% |
| number of values | 9 | 13 | 87 | 58 |

## 7.5 Formaldehyde

For the measurement of formaldehyde concentrations, participants can choose from the guidelines VDI 3862 Parts 2 (12), 3 (13) and 4 (14). Only the procedures according to Part 2 and Part 4 were used by more than 5% of the participants and are therefore shown in the following diagram. The following picture emerges from the information provided by the participants:

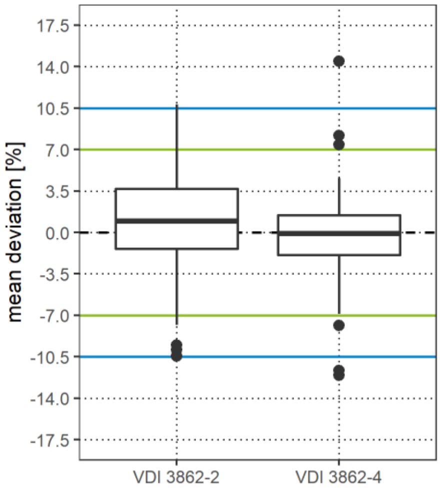



**Table 14: Correlation of formaldehyde measurement results with the guidelines used**

| guideline (method) | VDI 3862 Part 2 (DNPH wash bottles) | VDI 3862 Part 4 (AHMT-procedure) |
|---|---|---|
| 75th percentile | +3.70% | +1.47% |
| median | +0.95% | −0.07% |
| 25th percentile | −1.39% | −1.91% |
| number of values | 92 | 56 |

The DNPH wash bottle procedure apparently delivers on average comparable good values as the AHMT procedure, but spreads over a larger area.

## 7.6 Sulphur Dioxide

For the discontinuous determination of sulphur dioxide concentrations, participants can choose between analysis of the samples using ion chromatography or the Thorin method as part of the standard reference method. The following picture emerges from the information provided by the participants:

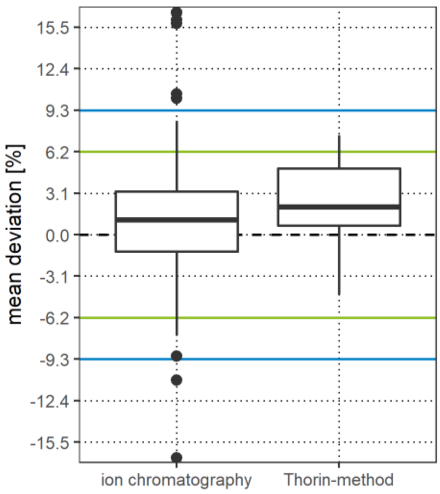



**Table 15: Correlation of sulphur dioxide measurement results with the analytical method used**

| method | ion chromatography | Thorin-method |
|---|---|---|
| 75th percentile | 3.23% | 4.94% |
| median | 1.12% | 2.09% |
| 25th percentile | −1.26% | 0.67% |
| number of values | 149 | 14 |

The available results indicate a tendency towards better average accuracy in the IC procedure, but the number of participants using the Thorin method is comparatively small. The higher dispersion of the IC method with various "outliers" may be due solely to the almost 10 times higher number of participants.

## 7.7 Solvents for Desorption of ETX

For the desorption of the solvents ethylbenzene, toluene and xylene (ETX) the participants can choose between other solvents or solvent mixtures besides the usual solvent carbon disulphide ($CS_2$). The majority of the participants reported that they had worked with $CS_2$. The average results of all participants were close to the target value.

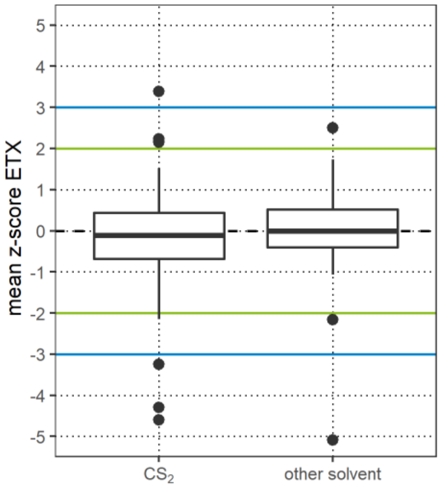



**Table 16: Correlation of ETX measurement results with the desorption solvent**

| solvent used in desorption | $CS_2$ | other solvent |
|---|---|---|
| 75th percentile (z-score) | +0.43 | +0.52 |
| median (z-score) | −0.11 | −0.01 |
| 25th percentile (z-score) | −0.68 | −0.40 |
| number of values | 138 | 19 |

## 7.8 Gas Chromatography Detectors

Gas chromatographs with either an FID detector or a mass spectrometer are usually used for the analysis of ETX samples. The information provided by the participants results in the following picture:

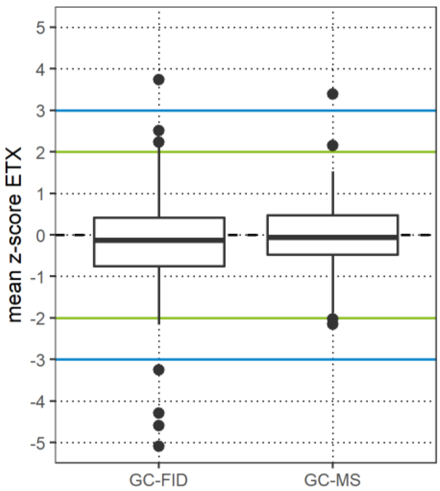


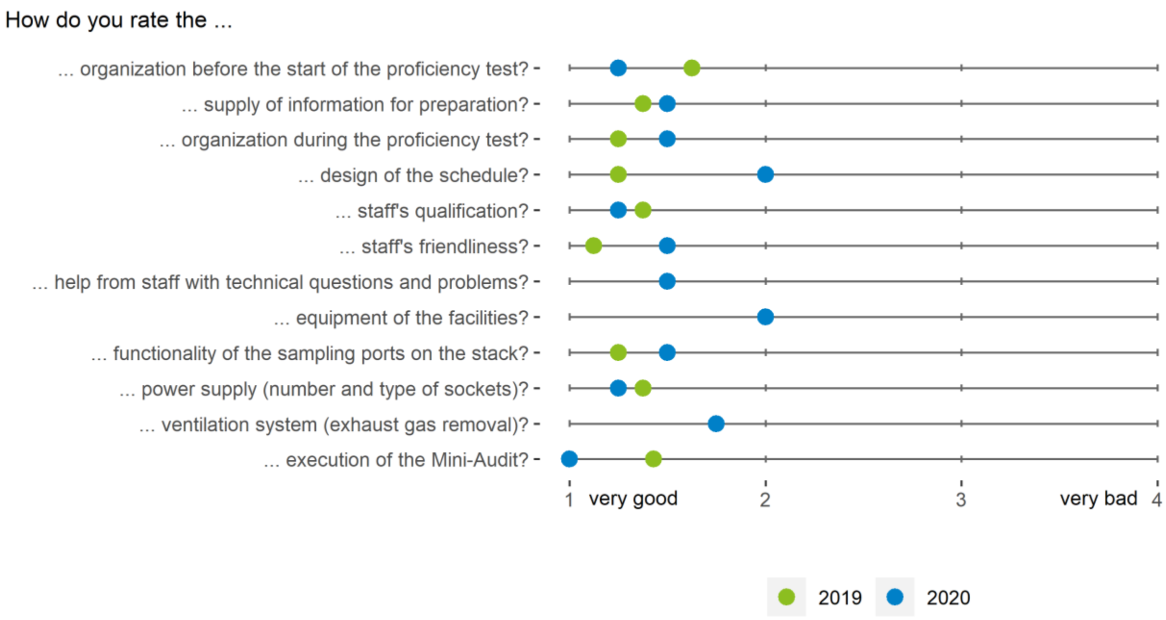
**Table 17: Correlation of ETX measurement results with analytical instruments**

| analytical instrument | GC-FID | GC-MS |
|---|---|---|
| 75th percentile (z-score) | +0.42 | +0.48 |
| median (z-score) | −0.12 | −0.06 |
| 25th percentile (z-score) | −0.75 | −0.48 |
| number of values | 67 | 91 |

For the overall procedure of sampling and analysis, the participants achieved comparable results close to the target value with both detector variants.

## 7.9 Feedback from Participants

Since 2019 HLNUG provides an online feedback questionnaire for its proficiency test participants. The possible ratings for the questions range from 1 (very good), over 2 (rather good), 3 (rather bad) to 4 (very bad). The mean value for the answers to the respective question is shown in the following scheme.




Overall, the feedback received showed a high level of satisfaction of the participants with the current proficiency tests. Due to the low number of participants, however, the number of feedback received in 2020 was also very low.

# 8. Concluding Remark

The spread of the SARS-CoV-2-virus in Europe has severely affected the HLNUG proficiency testing programme in 2020. Large parts of the programme planned for this year for the substance ranges P and G could not be carried out as planned. The data basis for this annual report is accordingly much smaller than usual for dust and gas. Only the odour emission proficiency tests could be carried out to the usual extent.

The available results are at the same level as in previous years. The results show again this year that the majority of the authorized measuring bodies are capable of reliably obtaining correct measured values. At the same time, however, it is still apparent that some participants do not show the reliability required for measurements in the legally regulated area.

On 1st July 2020, new specifications for the substance ranges P and G became effective. Both the spectrum of components and the criteria for assessing the performance of the participants have changed as a result. Due to the cancellation of the proficiency tests as of March 2020, this new set of rules has not yet been applied, contrary to the plan. However, the first experience with the new dust and gas proficiency tests should be available in the 2021 annual report.

Kassel, 3rd December 2020

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| --- | --- | --- |
| Dr. Jens Cordes | Benno Stoffels | Dr. Dominik Wildanger |
| Technical Supervisor<br>Proficiency Testing | Deputy Technical Supervisor<br>Proficiency Testing | Head of Department |
| (Fachlich Verantwortlicher Ringversuche) | (Stellvertretender Fachlich Verantwortlicher Ringversuche) | (Dezernatsleiter) |

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