TEXTE
79/2015

Round Robin Test for the Implementation of Odour Measurements regarding ISO 16000-28 into the Evaluation of Building Products – Part II (Specified by VDI 4302-1)

For our Environment

Umwelt Bundesamt

TEXTE 79/2015

Project No. (FKZ) 37 185
Report No. (UBA-FB) 002199/E

Round Robin Test for the Implementation of Odour Measurements regarding ISO 16000-28 into the Evaluation of Buildings Products – Part II (Specified by VDI 4302-1)

by

Dipl.-Ing. Laura Brosig, Dr. rer. nat. Wolfgang Horn, Dr.-Ing. Oliver Jann
BAM Federal Institute for Materials Research and Testing, Berlin, Germany

On behalf of the Federal Environment Agency (Germany)

Imprint

Publisher:
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
info@umweltbundesamt.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt

Study performed by:
BAM Federal Institute for Materials Research and Testing
Unter den Eichen 87
12205 Berlin, Germany

Study completed in:
November 2014

Edited by:
Section II 1.3 Indoor Hygiene, Health-related Environmental Impacts
Dr. Ana Maria Scutaru

Publication as pdf:
http://www.umweltbundesamt.de/publikationen/round-robin-test-for-the-implementation-of-odour

ISSN 1862-4804

Dessau-Roßlau, September 2015

The Project underlying this report was supported with funding from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear safety under project number FKZ 37 185. The responsibility for the content of this publication lies with the author(s).

Zusammenfassung

Das vom Ausschuss zur gesundheitlichen Bewertung von Bauprodukten entwickelte AgBB-Schema sieht neben der Bestimmung von VOC-Emissionen aus Bauprodukten auch die Durchführung von Geruchsmessungen entsprechend der DIN ISO 16000-28 vor. Diese wurden zunächst als Platzhalter in das Schema integriert. Die Methode zur Bestimmung der empfundenen Intensität wird gegenwärtig im Rahmen der 2012 im Auftrag des Umweltbundesamtes gestarteten Pilotphase zur „Einführung der Geruchsmessungen in die Bewertung von Bauprodukten“ auf Anwendbarkeit geprüft.

Im Jahr 2012 wurde bereits ein erster Ringversuch durchgeführt, der zur Feststellung der Anwendbarkeit der DIN ISO 16000-28 in seiner Fassung vom Dezember 2012 und der Herausarbeitung von Verbesserungspotentialen diente. Basierend auf den Erkenntnissen aus diesem Ringversuch wurde 2014 ein weiterer Ringversuch durchgeführt. Um das Vorgehen der Institute zu vereinheitlichen, wurden zusätzliche Hilfsmittel wie eine Standardarbeitsanweisung für die Durchführung der Geruchsmessungen sowie eine Software zur Aufzeichnung der Messdaten zur Verfügung gestellt.

Während 2012 noch eine kommerziell erhältliche Acryldichtmasse als Probenmaterial diente, wurde 2014 ein mit speziellen Substanzen dotierter Lack an die teilnehmenden Institute zur VOC- und Geruchsmessung versendet. Die daraus resultierenden Messergebnisse der empfundenen Intensität wurden unter Berücksichtigung verschiedener Rahmenbedingungen ausgewertet, um so mögliche Einflussfaktoren auf das Verfahren zu identifizieren. Einem Vergleich beider Ringversuche wurden die jeweils qualifizierten Datensätze zugrunde gelegt.

Die bereits im Ringversuch 2012 identifizierten Verbesserungspotentiale wurden 2014 überwiegend bestätigt, so z.B. dass die gewissenhafte Durchführung der Prüfung von essentieller Bedeutung ist und die durch die DIN ISO 16000-28 vorgegebenen Rahmenbedingungen nicht eng genug gefasst sind. Weiterhin konnte die 2012 aufgestellte These, dass Messungen, die auf der Verwendung von Vergleichsmaßstäben mit nur einem Trichter basieren, größere Unsicherheiten in der Bewertung verursachen, nicht bestätigt werden.

Für beide Ringversuche ergeben sich relative Vergleichsstandardabweichungen in einem Bereich von 20-40 %, der mit dem von etablierten VOC-Ringversuchen durchaus vergleichbar ist.

Abstract

The Committee for Health-related Evaluation of Building Products developed the AgBB-Scheme that sets requirements for the product testing regarding VOC emissions from building products. Additionally a placeholder for odour measurements according to DIN ISO 16000-28 was integrated into the scheme. The therein described method for the evaluation of the perceived intensity is currently being checked in the course of a pilot phase for the “Implementation of Odour Measurements into the Evaluation of Building Products” that is conducted on behalf of the Federal Environment Agency and started in 2012.

A first interlaboratory comparison was conducted in 2012. The aim was to check the applicability of the DIN ISO 16000-28 (version from December 2012) and to identify potential for improvement. Based on the findings of 2012 another interlaboratory test was conducted in 2014. To improve the measuring process and the interlaboratory comparability a standard operation procedure as well as software to record the measurement data were provided to the participating institutes.

While in 2012 a commercially available acrylic sealant was used as sample material, in 2014 a lacquer doped with specific substances was sent to the participants for the VOC and odour measurement. The resulting measurement values for the perceived intensity were evaluated in consideration of various boundary conditions to identify parameters that could possibly influence the measurement procedure significantly. For the comparison of both interlaboratory comparisons qualified data sets were taken as a basis.

Potential for improvement identified in 2012 was mainly confirmed by the interlaboratory test 2014 as well. Besides the accurate conduction as essential part of the measurement it became obvious again that the boundary conditions of the DIN ISO 16000-28 are not defined tight enough. Moreover the thesis that measurements based on the utilisation of comparison scales with only one funnel generate results especially imprecise could not be verified.

Both interlaboratory comparisons resulted in relative standard deviations of reproducibility that lay between 20 and 40 % and such are quite comparable with those of well-established interlaboratory VOC comparisons.

Contents

List of Tables

List of Figures

List of Abbreviations

FID	flame ionisation detector
PAD	Photo acoustic detector
PID	photo-ionisation detector
C10	Decane
C16	Hexadecane
DMP	Dimethylphtalate
NMP	N-Methyl-2pyrrolidone

1 Introduction

Indoor air pollutants influence the health and comfort of buildings occupants and also affect their behaviour regarding ventilation and energy consumption. Consequently the emissions from building products can substantially reduce indoor air quality. In this context, volatile organic compounds (VOC) emitted from building products are evaluated using the AgBB (Ausschuss zur gesundheitlichen Bewertung von Bauprodukten) scheme. As VOC emissions are frequently accompanied by odours, which can also lead to health impairments, it is also important to assess the intensity and acceptability of emitted odours. Since many complaints of occupants are based on odour nuisance the human nose appears to be a suitable tool for the (sensory-based) odour measurement. To establish a procedure for the assessment of odour emissions from building products several studies have been carried out in the last years [Horn 2012, Müller 2011; AgBB 2012] and one project (FKZ 3713 95 318) financed by the Federal Environmental Agency (Umweltbundesamt, UBA) is currently being conducted. The results from these earlier projects have already been implemented in the elaboration of national and international standards like the ISO 16000-28. Based on these developments the AgBB started a pilot phase in 2012 for the introduction of sensory testing into the AgBB scheme where it is already fixed as an advanced place holder. To support and monitor the pilot phase the workgroup “AG Sensorik” was established.

The German AgBB scheme was introduced for the test and approval process of construction materials. The AgBB scheme as well as e.g. the Blue Angel Mark are based on emission tests according to the international standards ISO 16000-3 and -6 and 16000-9 to -11. Quality and trueness of results received from measurements are very important for all involved parties, producers and consumers as well; for instance, if the results were used for acceptance of a product within a labelling procedure. Therefore it is necessary to ensure that the results between the testing laboratories are comparable. The successful participation in such interlaboratory tests often is essential for the acceptance of results given by an analytical laboratory. The same assumption has to be made for the evaluation of odours. Thus for the relevant parameters (e.g. perceived intensity, hedonic tone, acceptance) round robin tests have to be conducted as well to validate the procedure and to identify suited laboratories for this task.

During the pilot phase for sensory testing in the AgBB scheme two round robin tests shall be conducted. The first round robin test was organized in 2012 [Brosig 2014]. The results of the second round robin test are presented in the project at hand.

1.1 Interlaboratory Tests at BAM

Round robin tests for the analytical step from sampling and the analysis of the thermal-desorption tubes or other sampling procedures are well established. For the complete procedure including chamber loading, sampling, identification and quantification of VOC-emissions from products BAM conducted several round robin tests from 2007 up to now. The main problem for round robin tests of the complete chamber test is the lack of a suited

reference material. Therefore in advance to such a test a material had to be chosen and tested with many complete chamber tests. This is very time consuming task so with the last round robin "RR_VOC_G_BAM_2014" we tested the first reference material we developed in an EMRP project[1]. The following Table 1 gives an overview of this round robin tests.

Table 1 VOC round robin tests organized by BAM

Round robin	Year	Number of Participants	Number of Compounds	Evaluation
Building products + odour	2006	7	7	no
ILS_DIBt_BAM-2008	2008	29	11	no (z-score test)
RR-VOC-BAM_2009	2009	38	9	z-score
RR-VOC-BAM_2012	2012	46	9	z-score
RR-VOC-G-BAM-2014	2014	54	9	z-score

1.2 Interlaboratory Tests at BAM regarding Odour Measurement

In 2006 a first cooperative test was conducted regarding the implementation of odour measurements. At the time the institutes already conducting emission chamber measurements did not operate own odour measurement devices and thus a comparison scale designed by the Herrmann-Rietschel Institute (HRI, Berlin) was sent to various institutes to test the general procedure.

In 2012 the first actual interlaboratory test was conducted. The shipped sample was a commercially available acrylic sealant that had to be filled into predetermined aluminium U-profiles by the participants and then had to be put into the emission test chambers (ISO 16000-6 and 16000-9). The odour measurement had to be conducted on the 3rd and the 7th day after the loading of the chambers. Alongside the interlaboratory comparison also the decay of odour intensity was monitored. Moreover the VOC emissions were checked on the 7th day. Therefore Tenax® tubes of the BAM were sent to the participants, loaded at the institutes and resend to BAM for analytical evaluation. The overall relative standard deviation of repeatability for all participating institutes was about 48 %. The overall minimum and maximum standard deviation determined for the institutes single measurements were 16.6 and 81.2%. The overall relative standard deviation of reproducibility was about 29.6% [Brosig 2012].

A correlation between the analytically determined substances and the perceived intensity measured by the odour panel was not detected.

In 2014 the current interlaboratory test was conducted which is described in detail in the following chapters of this report.

[1] Metrology for Chemical Pollutants in Air - MACPoll. 2014 The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

2 Preparation and Conduction of the Odour Interlaboratory Test 2014

Subsequent to the round robin test 2012 (RR12) and based on the gained experience a standard operation procedure (SOP) for the conduction of odour measurements was developed. Moreover software was provided to simplify the record and evaluation of measurement data.

Within the round robin test 2014 (RR14) doped lacquer samples were measured for VOC and odour emissions according to a prescribed schedule (see below).

2.1 Standard Operation Procedure for the Conduction of the Odour Measurements

Regarding the implementation of odour measurements into the evaluation of building products in 2012 a first round robin test was conducted. Its main aim was to test the applicability of the measurement method as it is given by ISO 16000-28. From this round robin test conclusions about potential improvements were drawn. Based on these findings a standard operation procedure (SOP) for the follow-up round robin test 2014 was generated. Supplementary more detailed requirements (in comparison to the ISO 16000-28) from the VDI 4302-1 were added to the SOP. The explicit procedure of the odour measurement as well as tolerable deviations from reference values in the acetone calibration were two focal points. The SOP is attached in Annex D.

2.2 Manual for the Handling of the LQ-Software (Record of Measurement Data)

To support the record and evaluation of measurement data the participants of the round robin test 2014 were provided with software (LQ-Software) written by an employee of the HTW (Hochschule für Technik und Wirtschaft Berlin – University of Applied Sciences). It allows the input of several parameters like perceived intensity, hedonic tone and acceptability. They can be collected separately or in various combinations. The manual is attached in Annex E.

2.3 Preparation and Shipping of Lacquer Samples

In a PhD project within the BAM division 4.2 a reference material for the measurement of VOC emissions was developed [Nohr 2014]. It is based on a clear lacquer that is certified by the Blue Angel Mark as “low emission paint”. Moreover the lacquer is advertised as being of low odour. These are essential requirements for a suitable carrier for a reference material in VOC measurements as well as in odour measurements.

Under continuous stirring the nine substances listed below were added to the lacquer in preparation to the “bottling” of the samples (see Figure 1).

- hexanal
- limonene
- ethylhexylacrylat
- styrene
- ethylhexanol
- DMP
- C10
- NMP
- C16

Figure 1 continuously stirred lacquer sample with nine added substances

Figure 2 Petri-dishes filled with fresh lacquer shortly before the drying

After the homogenous mixing of lacquer and added substances the mixture was filled into serially numbered Petri-dishes (Figure 2), capped and put into a 20 m³ emissions test chamber. When all Petri-dished had been put into the chamber to dry (Figure 3) under standardised conditions of 23 ±2°C and 50 ±5 % rH regarding to ISO 16000-9, the dishes caps were removed to start a best possible and homogeneous drying process.

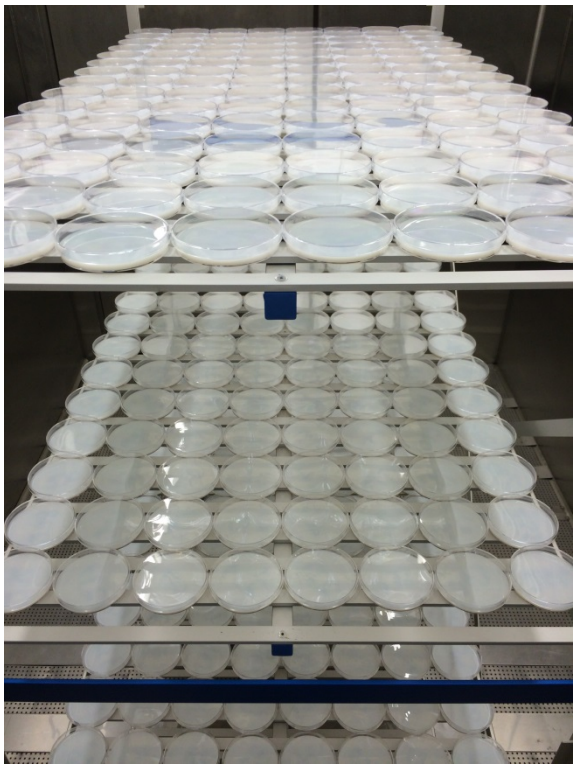


Figure 3 drying of the samples within a 20 m³ chamber at conditions complying with standard ISO 16000-9 (23°C and 50% rH)

The conditions of the 20 m³ camber are displayed in Figure 4. As expected subsequent to the loading of the chamber with the fresh lacquer samples the relative humidity increased to approximately 70% rH. Within 24 hours the relative humidity decreased to 50 ± 5% rH. The temperature remained without disruption constantly between 23 and 24°C. Thus the drying process, that lasted three days, was conducted mainly under standard conditions.

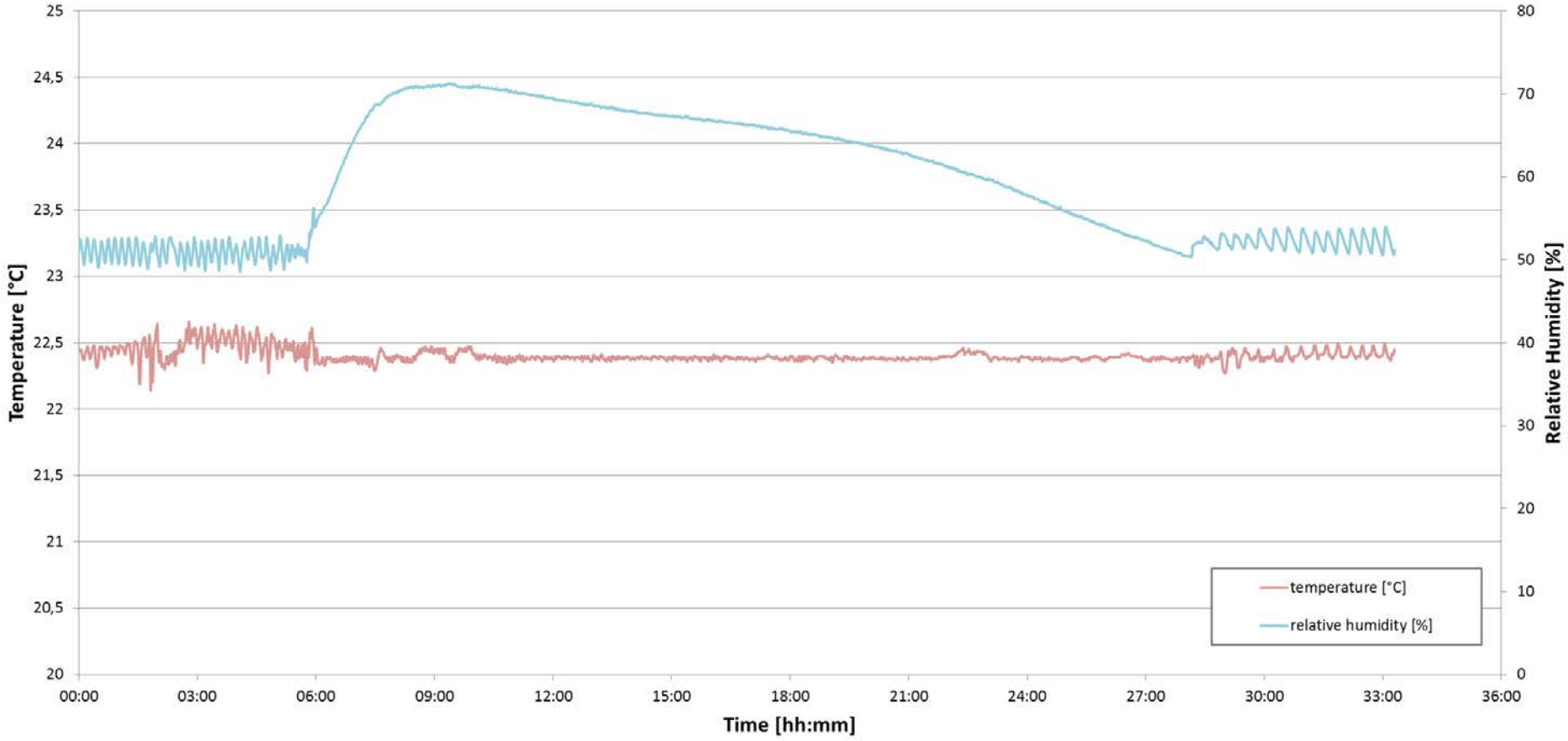


Figure 4 profiles of temperature and relative humidity in the 20m³ emission test chamber - at 6h loading of the chamber with samples, at around 30h resettling to standardised conditions

After the drying process the Petri-dishes were capped again and selected randomly from the chamber to be put into gastight aluminium-clad PE foil (Figure 5) for shipping. With this procedure potential inhomogeneity of samples depending on their position in the emission test chamber during the drying should have been evened out and a transformation of VOC and/or odour composition should have been avoided.

Figure 5 shrink-wrapping of the samples in gastight aluminium-clad PE-foil

For further quality management a data logger was added (together with a short questionnaire to monitor the date of arrival and unpacking – see Annex C) to every package to record temperature profiles during the transport and until the unpacking of the samples.

The profiles are attached in Annex A.

Figure 6 data logger (Co. VTT Expert Services Ltd.) for the record of temperature profiles within the packages starting by packing at BAM and ending by unpacking at the test laboratories or upon receipt at BAM

Figure 7 sample package for shipment

2.4 Schedule

For the interlaboratory test 2014 the time offset between sample production and the actual measurement had to be as short as possible in order to avoid alteration of the samples (decrease of substance concentration and change of odour perception in the course of time). Therefore the schedule was very tight (Figure 8). Thus the time offset between the "lacquer production" and loading of chambers varied between 1.5 and 2.5 weeks. Only one institute conducted the measurement later than the 16th of May (RR14_29 conducted the measurement on the 19th of May).

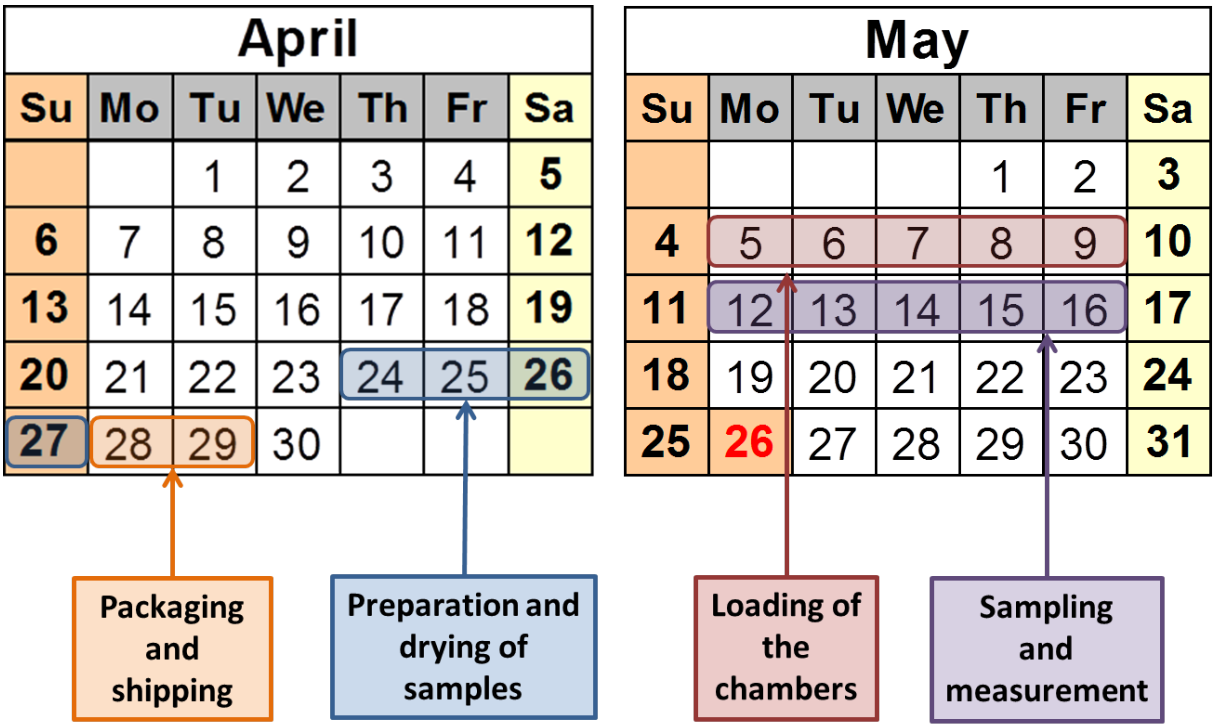


Figure 8 schedule for the odour interlaboratory test 2014

3 Evaluation of the Institutes of the Interlaboratory Test 2014

In the current odour interlaboratory test 21 institutes reported odour measurement results. Most are based on ISO 16000-28, VDI 4302-1 and the SOP (see Annex D) but other methods were used as well.

While the interlaboratory test was mainly focused on the assessment of the perceived intensity other parameters (also established in ISO 16000-28) like hedonic tone and acceptance were also measured. Among the participating institutes some determined each of these parameters while others measured only certain ones. The perceived intensity was not measured by every institute. Due to those differences and also the above mentioned various measurement methods some results cannot or only partially be considered in the main evaluation of this report. The hedonic tone is treated only superficially in the evaluation and the data of the acceptance measurement is at least mentioned for completeness.

Before the actual evaluation of measurement data the boundary conditions for each institute are listed below. Based on this individual analysis and with possible improvements of the odour measurement method in mind the odour results are evaluated under a certain selection of aspects like the qualification and experience of institutes, various boundary conditions like funnels, type of measurement etc. (see chapter 4).

For each institute (potentially) significant parameters are listed below to allow for a direct comparison of institutes and detection of correlations between measurement results and those parameters.

The temperature profiles recorded during the sample transport (see Annex A) are described in the following chapters and used to check whether variations in temperature after the drying process might have an (significant) influence. For most institutes that participated in the odour interlaboratory test the profiles did not show major deviations.

For being within or below the standardised temperatures (see ISO 16000-9), temperatures below 25°C were considered uncritical for the samples. Samples that were exposed to temperatures above 30°C were monitored closely.

The participating institutes had the chance to receive samples for up to two emission test chambers. Therefore some institutes submitted data for more than one sample. That is why measurement values of institutes that used more than one emission test chamber or that assessed samples directly and indirectly in parallel the odour values (provided that they were assessed according to ISO 16000-28) were (mostly) averaged before further evaluation. The values for the perceived intensity given in the tables that summarise the measurement results of the hedonic tone and acceptability as well, are averaged values for qualified data sets (definition see chapter 4.2 and Table 49).

3.1 RR14_02

In the temperature profile no abnormalities during the transport could be detected. The minimum temperature was about 14.1°C while the maximum and overall mean values were 28.8 and 22.4°C. Profiles of the temperature and humidity in the emission test chambers were not transmitted to BAM.

Alongside the transport temperature data further measurement specifications are given in Table 2.

Table 2 temperature data during samples transport and measurement specifications of RR14_02

Sample transport		Measurement specifications			
T_{min} [°C]	14.1	No. of funnels	5	Type of meas.	Indirect
T_{max} [°C]	28.8	Flow rate [L/s] at funnel(s)	0.8	Bag material	Nalophan ®
$T_{average}$ [°C]	22.4	Size of funnel(s) H x Ø in [cm]	18 x 8	Measurement device	PID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 25	Substance for calibration of meas. device	"external & internal (TD)"

Averaged measurement for the perceived intensity as well as the acceptability assessment and hedonic tone are given in Table 3.

Table 3 perceived intensity, acceptability and hedonic tone of RR14_02

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	7/10	6.11	1.82	2.83	6.48
Acceptability	10	1.43	3.46	5.67	0.33
Hedonic tone	10	-0.20	0.80	1.40	-0.51

Institute RR14_02 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.2 RR14_05

During the samples transport the minimum temperature was about 7.4°C while the maximum and average values were 27.5 and 23.6°C. The temperature in the emission test chamber mainly varied between 23 ±2°C slightly undercutting 21°C several times. The humidity lay mainly within the limits of 50 ±5% rH (see Figure 24 in Annex A and Figure 42 in Annex B).

Alongside the transport temperature data further measurement specifications are given in Table 4.

Table 4 temperature data during samples transport and measurement specifications of RR14_05

Sample transport		Measurement specifications			
T_{min} [°C]	7.4	No. of funnels	5	Type of meas.	Indirect
T_{max} [°C]	27.5	Flow rate [L/s] at funnel(s)	0.7	Bag material	Tedlar®
$T_{average}$ [°C]	23.6	Size of funnel(s) H x Ø in [cm]	16x9	Measurement device	"other"
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 10	Substance for calibration of meas. device	-

The measurement of the perceived intensity was conducted according to ISO 16000-28 for the first time by institute RR14_05. Data for the acetone calibration was not submitted and measurement specifications were incomplete. Thus no traceability of the conducted measurement is given and assessment values will not be included in the calculation of the overall mean values.

The data of the perceived intensity and hedonic tone are given in Table 5.

Table 5 perceived intensity, acceptability and hedonic tone of RR14_05

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity*	8	13	2	1.3	6.48
Acceptability	-	-	-	-	-
Hedonic tone	15	0.31	0.54	1.18	-0.51

* results of RR14_05 are no part of the overall evaluation

3.3 RR14_07

In the temperature profile no abnormalities during the transport could be detected. The minimum temperature was about 13.1 while the maximum and the overall mean value were 28.5 and 21.9°C. The temperature in the emission test chamber lay within 23 ±2°C. The humidity also was within the standardised limit of 50 ±5% rH (see Table 6, Figure 25 in Annex A and Figure 43 in Annex B).

Table 6 temperature data during samples transport and measurement specifications of RR14_07

Sample transport		Measurement specifications			
T_{min} [°C]	13.1	No. of funnels	-	Type of meas.	-
T_{max} [°C]	28.5	Flow rate [L/s] at funnel(s)	-	Bag material	-
$T_{average}$ [°C]	21.9	Size of funnel(s) H x Ø in [cm]	-	Measurement device	-
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	-	Substance for calibration of meas. device	-

The assessment of the perceived intensity was not conducted according to ISO 16000-28 and thus the values are not included in the overall evaluation. Due to a measurement scale that deviated clearly from the 15- pi -Scale not even a rough comparison can be drawn. The values are given in Table 7 nonetheless.

The acceptability however was conducted according to ISO 16000-28 and is given in Table 7.

Table 7 perceived intensity, acceptability and hedonic tone of RR14_07

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity*	22	1.70	0.28	0.76	6.48
Acceptability	22	0.28	0.15	0.41	0.33
Hedonic tone	-	-	-	-	-

* results of RR14_07 are no part of the overall evaluation

3.4 RR14_09

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 12.8 and 26.9°C. The overall mean value was 21.7°C (see Table 8 and Figure 26).

The temperature and humidity lay in both emission test chambers within 23 ±2°C and 50 ±5% rH (see Figure 44 in Annex B) and thus meet the requirements of ISO 16000-9.

Table 8 temperature data during samples transport and measurement specifications of RR14_09

Sample transport		Measurement specifications			
T_{min} [°C]	12.8	No. of funnels	1	Type of meas.	Direct
T_{max} [°C]	26.9	Flow rate [L/s] at funnel(s)	0.7	Bag material	-
$T_{average}$ [°C]	21.7	Size of funnel(s)	18 x 8	Measurement	PID

		H x Ø in [cm]		device	
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 10	Substance for calibration of meas. device	Acetone test gas

The assessment of the perceived intensity was conducted according to ISO 16000-28. The evaluation results of the qualified data sets for the perceived intensity are given in Table 9 alongside the hedonic tone.

Table 9 perceived intensity, acceptability and hedonic tone of RR14_09

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	9	4.94	1.34	2.17	6.48
Acceptability	-	-	-		-
Hedonic tone	24	-0.29	0.41	1.17	-0.51

Institute RR14_09 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.5 RR14_10

The temperature profile showed exceptional low temperatures that were attributed to cold storage for seven days before the measurement. The minimum and the maximum temperature were about 9 and 26°C. Due to cold storage the overall mean value was 9.9°C. Alongside the transport data further measurement specifications are given in Table 10 (also see Figure 27 in Annex A).
In the emission test chamber the temperature as well as the humidity lay within the standardised conditions 23 ±2°C and 50 ±5% rH (see Figure 45 in Annex B).

Table 10 temperature data during samples transport and measurement specifications of RR14_10

Sample transport		Measurement specifications			
T_{min} [°C]	9.0	No. of funnels	7	Type of meas.	Indirect
T_{max} [°C]	26.0	Flow rate [L/s] at funnel(s)	0.6	Bag material	Tedlar®
$T_{average}$ [°C]	9.9	Size of funnel(s) H x Ø in [cm]	18 x 8	Measurement device	Micro balance
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 1	Substance for calibration of meas. device	Reference weight

According to the institutes questionnaire the measurement of the perceived intensity was conducted following ISO 16000-28 but the comparison scale ranged from 0 pi to 6 pi only. Resulting measurement values lay between 0 and 1.8 pi. Considering that the comparison scale is made of several 3 L Tedlar® bags with various acetone concentrations, possible causes for those relatively low values come to mind. On the one hand the flow rate might deviate strongly and the inhalation of additional ambient air seems to be most likely. On the other hand only a limited volume of acetone gas is available for each measurement and thus sets a fixed limit for comparability. Assuming that a panellist inhales between 0.5 to 1.5 L per sniff, one bag would be sufficient for two to six sniffs. Adequate sniffing requires at least two sniffs to affirm an assessment. This does not even contain the option to check between different concentrations for the assessment of an air sample.

Moreover no acetone calibration data of the panellists are available.

As a result of these aspects the measurement results of institute RR14_10 are no part of the overall evaluation of the perceived intensity. Nonetheless the measurement results of the institute are summarised in the following Table 11.

Table 11 perceived intensity, acceptability and hedonic tone of RR14_10

	No. of participants	**Mean value**	**90% confidence interval**	**Standard deviation**	**Overall mean value [pi]**
Perceived intensity*	8	0.85	0.42	0.63	6.48
Acceptability	-	-	-		-
Hedonic tone	24	-0.29	0.41	1.17	-0.51
* results of RR14_10 are no part of the overall evaluation					

3.6 RR14_16

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 14.8 and 30°C. The overall mean value averaged to 22.6°C. Alongside the transport temperature data further measurement specifications are given in Table 12.

The temperature as well as the humidity in the emission test chambers lay within the standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 46 in Annex B).

Table 12 temperature data during samples transport and measurement specifications of RR14_16

Sample transport		**Measurement specifications**			
T_{min} [°C]	14.8	No. of funnels	1	Type of meas.	(In)direct
T_{max} [°C]	30.0	Flow rate [L/s] at funnel(s)	1.0	Bag material	Nalophan ®
$T_{average}$ [°C]	22.6	Size of funnel(s)	31 x	Measurement	FID

		H x Ø in [cm]	7.5	device	
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 100	Substance for calibration of meas. device	Acetone test gas

The institute RR14_16 conducted the assessment of the perceived intensity directly at the emission test chambers as well as in parallel indirectly both according to ISO 16000-28. The averaged measurement results of the qualified data set for the perceived intensity as well as the hedonic tones assessment are given in Table 13.

Table 13 perceived intensity, acceptability and hedonic tone of RR14_16

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	12	4.64	1.03	1.98	6.48
Acceptability	-	-	-		-
Hedonic tone	12	-0.47	0.64	1.24	-0.51

Institute RR14_016 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.7 RR14_17

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 12.9 and 29.1°C. The overall mean value was 22.4°C.

The temperature in the emission test chamber as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 47 in Annex B).

Alongside the transport data further measurement specifications are given in Table 14.

Table 14 temperature data during samples transport and measurement specifications of RR14_17

Sample transport		Measurement specifications			
T_{min} [°C]	12.9	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	29.1	Flow rate [L/s] at funnel(s)	0.7	Bag material	Nalophan ®
$T_{average}$ [°C]	22.4	Size of funnel(s) H x Ø in [cm]	10 x 5.5	Measurement device	GC-MS
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 5	Substance for calibration of meas. device	Acetone test gas

The measurement was conducted according to ISO 16000-28. The data of the perceived intensity, acceptability assessment and the hedonic tone are given in Table 15.

Table 15 perceived intensity, acceptability and hedonic tone of RR14_17

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	12	10.08	0.71	1.38	6.48
Acceptability	13	-3.00	0.81	1.65	0.33
Hedonic tone	13	-0.58	0.41	0.84	-0.51

3.8 RR14_21

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 12.4 and 26.4°C. The overall mean value was 22.9°C (see Figure 30 in Annex A).

The temperature in the emission test chamber as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 48 in Annex B).

Alongside the transport temperature data further measurement specifications are given in Table 16.

Table 16 temperature data during samples transport and measurement specifications of RR14_21

Sample transport		Measurement specifications			
T_{min} [°C]	12.4	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	26.4	Flow rate [L/s] at funnel(s)	0.8	Bag material	Nalophan ®
$T_{average}$ [°C]	22.9	Size of funnel(s) H x Ø in [cm]	20 x 6	Measurement device	PAD
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 10	Substance for calibration of meas. device	Acetone test gas

The measurement was conducted according to ISO 16000-28 but no panel acetone calibration data was submitted. Thus the results are no part of the calculation of the overall mean value. The data of the perceived intensity and the hedonic tone are summarised in the following Table 17.

Table 17 perceived intensity, acceptability and hedonic tone of RR14_21

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity*	11	6.27	0.98	1.79	6.48
Acceptability	-	-	-	-	-
Hedonic tone	11	-2.41	0.44	0.80	-0.51

* results of RR14_21 are no part of the overall evaluation

3.9 RR14_23

The minimum and the maximum temperature during the transport were at about 7.5 and 28.8°C. The average temperature was 21.9°C. The data for the sample transport is given in Table 18 alongside further measurement specifications. The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 31 in Annex A and Figure 49 in Annex B).

The measurement of the perceived intensity was not conducted according to ISO 16000-28 exactly (glass jars) and thus the results are no part of the calculation of the overall mean value and the overall evaluation of qualified data sets. Nonetheless further measurement specifications are given in Table 18.

Table 18 temperature data during samples transport and measurement specifications of RR14_23

Sample transport		Measurement specifications			
T_{min} [°C]	7.5	No. of funnels	5	Type of meas.	Indirect
T_{max} [°C]	28.8	Flow rate [L/s] at funnel(s)	-	Bag material	Tedlar®
$T_{average}$ [°C]	21.9	Size of funnel(s) H x Ø in [cm]	-	Measurement device	-
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 1	Substance for calibration of meas. device	-

The data of the perceived intensity and acceptability assessment are given in Table 19.

Table 19 perceived intensity, acceptability and hedonic tone of RR14_23

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity*	12	9.29	1.05	2.03	6.48
Acceptability	12	2.25	1.55	2.99	0.33
Hedonic tone	-	-	-		-

* results of RR14_23 are no part of the overall evaluation

3.10 RR14_24

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 13.6 and 28.8°C. The overall mean temperature was 22.7°C. (see Figure 32 in Annex A)

The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 50 in Annex B).

Alongside the transport temperature data further measurement specifications are given in Table 20.

Table 20 temperature data during samples transport and measurement specifications of RR14_24

Sample transport		Measurement specifications			
T_{min} [°C]	13.6	No. of funnels	6	Type of meas.	(In)direct
T_{max} [°C]	28.8	Flow rate [L/s] at funnel(s)	1	Bag material	Nalophan ®

$T_{average}$ [°C]	22.7	Size of funnel(s) H x Ø in [cm]	31 x 7.8	Measurement device	FID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 15	Substance for calibration of meas. device	Propane

Averaged measurement results of the institute are summarised in the following Table 21. For the direct measurement the 90% confidence interval is slightly exceeded and thus this measurement does not count as qualified and is excluded from the "qualified" evaluation.

The data of the perceived intensity and hedonic tone are given in Table 21.

Table 21 perceived intensity, acceptability and hedonic tone of RR14_24

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	10	8.91	1.79	3.14	6.48
Acceptability	-	-	-	-	-
Hedonic tone	10	-1.34	0.63	1.12	-0.51

Institute RR14_24 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.11 RR14_25

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 13.3 and 28.8°C. The overall mean value was 21°C. (see Figure 33 in Annex A)

The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH. (see Figure 51 in Annex B)

Alongside the transport temperature data further measurement specifications are given in Table 22.

Table 22 temperature data during samples transport and measurement specifications of RR14_25

Sample transport		Measurement specifications			
T_{min} [°C]	13.3	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	28.8	Flow rate [L/s] at funnel(s)	0.6	Bag material	Nalophan ®

$T_{average}$ [°C]	21.0	Size of funnel(s) H x Ø in [cm]	9.5 x 4.6	Measurement device	PID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 5	Substance for calibration of meas. device	Acetone test gas

The data of the perceived intensity and the hedonic tone are given in Table 23.

Table 23 perceived intensity, acceptability and hedonic tone of RR14_25

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity*	11	6.00	4.68	2.56	6.48
Acceptability	-	-	-	-	-
Hedonic tone	11	-0.75	0.82	1.49	-0.51

* results of RR14_25 are no part of the overall evaluation

Institute RR14_25 already participated in the earlier round robin test in 2012 but due to the 90% confidence interval of the perceived intensities measurement exceeding 2.00 pi the institute is not classified as experienced institute and is not part of the overall evaluation of the perceived intensity.

3.12 RR14_26

The maximum temperature exceeded 30°C with 30.8°C for less than 6 hours. The minimum temperature was about 15.6°C and the overall mean value was 22.8°C (see Figure 34 in Annex A).

Data for the temperature and humidity in the emission test chambers are not available.

Alongside the transport temperature data further measurement specifications are given in Table 24.

Table 24 temperature data during samples transport and measurement specifications of RR14_26

Sample transport		Measurement specifications			
T_{min} [°C]	15.6	No. of funnels	7	Type of meas.	Indirect
T_{max} [°C]	30.8	Flow rate [L/s] at funnel(s)	0.8	Bag material	Nalophan ®
$T_{average}$ [°C]	22.8	Size of funnel(s) H x Ø in [cm]	18 x 8.5	Measurement device	PID

time [h] with T>30°C	< 6	Experience (number of total odour measurements reported)	≥ 70	Substance for calibration of meas. device	DNPH / HPLC

The data of the perceived intensity and hedonic tone are given in Table 25.

Table 25 perceived intensity, acceptability and hedonic tone of RR14_26

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	10	3.70	1.26	2.18	6.48
Acceptability	-	-	-	-	-
Hedonic tone	10	-0.50	0.58	1.00	-0.51

Institute RR14_26 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.13 RR14_29

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 13.7 and 27.8°C. The overall mean value was 22.3°C (see Figure 35 in Annex A).

The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 52 in Annex B).

Alongside the transport temperature data further measurement specifications are given in Table 26.

Table 26 temperature data during samples transport and measurement specifications of RR14_29

Sample transport		Measurement specifications			
T_{min} [°C]	13.7	No. of funnels	8	Type of meas.	Indirect
T_{max} [°C]	27.8	Flow rate [L/s] at funnel(s)	0.8	Bag material	Nalophan ®
$T_{average}$ [°C]	22.3	Size of funnel(s) H x Ø in [cm]	20 x 7	Measurement device	FID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≤ 10	Substance for calibration of meas. device	Propane

The institute RR14_29 did not transmit the panel acetone calibration data to BAM and thus the data is no part of the calculation of the overall mean value. Averaged measurement results of the institute are summarised in the following Table 27.

Table 27 perceived intensity, acceptability and hedonic tone of RR14_29

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity*	11	7.48	1.06	1.94	6.48
Acceptability	-	-	-	-	-
Hedonic tone	11	-1.11	0.36	0.66	-0.51

* results of RR14_29 are no part of the overall values calculation

Due to the unavailable acetone calibration data of institute RR14_29 it is not possible to classify it as experienced institute even though it took part in the earlier round robin test 2012. The measurement results are still displayed in the evaluation diagrams but they are not included in the overall values calculation.

3.14 RR14_32

In the temperature profile one minor abnormality was detected at the beginning of the shipment. There the maximum temperature reached 30.6°C. The minimum and the overall mean temperature were about 17 and 21.4°C (see Table 28 and Figure 36 in Annex A).

The temperature in the emission test chamber varied between 23 ±2°C while the humidity lay mainly within the limits of 50 ±5% rH but undercut 45% by 1-3 % twice (see Figure 53 in Annex B).

The institute RR14_32 did not measure the perceived intensity but the hedonic tone of the lacquer sample. According to the institutes questionnaire the measurement was not conducted as required by ISO 16000-28 and thus the values are no part of the calculation of overall values.

Table 28 temperature data during samples transport and measurement specifications of - RR14_32

Sample transport		Measurement specifications			
T_{min} [°C]	17.0	No. of funnels	-	Type of meas.	direct
T_{max} [°C]	30.6	Flow rate [L/s] at funnel(s)	-	Bag material	-
$T_{average}$ [°C]	21.4	Size of funnel(s)	-	Measurement	-

		H x Ø in [cm]		device	
time [h] with T>30°C	< 6	Experience (number of total odour measurements reported)	-	Substance for calibration of meas. device	-

The data of the hedonic tone are given in Table 29.

Table 29 perceived intensity, acceptability and hedonic tone of RR14_32

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	-	-	-	-	-
Acceptability	-	-	-	-	-
Hedonic tone	15	2.17	0,38		-0.37

3.15 RR14_33

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 15.4 and 27.6°C. The overall mean value was 22.3°C (see Figure 37 in Annex A).

The temperature in both emission test chambers as well as the humidity lay mainly within standardised conditions of 23 ±2°C and 50 ±5% rH. For the second chamber the temperature undercut 21°C several times by about 1°C (see Figure 54 in Annex B).

Alongside the transport data further measurement specifications are given in Table 30.

Table 30 temperature data during samples transport and measurement specifications of RR14_33

Sample transport		Measurement specifications			
T_{min} [°C]	15.4	No. of funnels	7	Type of meas.	Indirect
T_{max} [°C]	27.6	Flow rate [L/s] at funnel(s)	1.0	Bag material	Tedlar®
$T_{average}$ [°C]	22.3	Size of funnel(s) H x Ø in [cm]	31 x 7.5	Measurement device	UV- and IR-photometry
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≥ 20	Substance for calibration of meas. device	Acetone test gas

The data of the perceived intensity and hedonic tone are given in Table 31.

Table 31 perceived intensity, acceptability and hedonic tone of RR14_33

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	11	5.58	1.56	2.86	6.48
Acceptability	-	-	-	-	-
Hedonic tone	11	-0.23	0.51	0.93	-0.51

Institute RR14_33 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.16 RR14_34

The temperature data that was recorded during the transport was not transmitted to BAM by institute RR14_34. The temperature in the emission test chamber as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH. (see Figure 55 in Annex B).

Measurement specifications regarding the direct odour assessment are given in Table 32.

Table 32 temperature data during samples transport and measurement specifications of RR14_34

Sample transport		Measurement specifications			
T_{min} [°C]	-	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	-	Flow rate [L/s] at funnel(s)	0.7	Bag material	Nalophan ®
$T_{average}$ [°C]	-	Size of funnel(s) H x Ø in [cm]	25 x 6	Measurement device	FID
time [h] with T>30°C	-	Experience (number of total odour measurements reported)	≤ 50	Substance for calibration of meas. device	Propane

The data of the perceived intensity and hedonic tone are given in Table 33.

Table 33 perceived intensity, acceptability and hedonic tone of RR14_34

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	11	7.18	0.84	1.54	6.48
Acceptability	-	-	-	-	-

Hedonic tone	11	-1.05	0.63	1.15	-0.51

Institute RR14_34 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.17 RR14_35

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 13.7 and 29.5°C. The overall mean value was 21.2°C (see Figure 38 in Annex A).

The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 56 and Figure 57 in Annex B).

Alongside the transport temperature data further measurement specifications are given in Table 34.

Table 34 temperature data during samples transport and measurement specifications of RR14_35

Sample transport		Measurement specifications			
T_{min} [°C]	13.7	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	29.5	Flow rate [L/s] at funnel(s)	0.4	Bag material	Tedlar®
$T_{average}$ [°C]	21.2	Size of funnel(s) H x Ø in [cm]	10 x 5	Measurement device	FID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≥ 20	Substance for calibration of meas. device	propane

The comparison scale was operated with butanol. No pi-butanol-values or verification of those concentration relating to the standardised acetone concentrations were submitted. Also the flow rated provided at the funnels are too low (0.4 L/a instead of 0.6-1.0 L/s).

Moreover the institute did not transmit the panel calibration data to BAM and thus the data is no part of the overall evaluation of the RR14. It is not included in the calculation of the overall mean value but summarised in Table 35 nonetheless.

The measurement for the acceptability and hedonic tone were conducted according to ISO 16000-28 and the data are given in Table 35 as well.

Table 35 perceived intensity, acceptability and hedonic tone of RR14_35

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived	9	4.67	0.95	1.53	6.48

intensity*					
Acceptability	16	0.67	0.13	0.29	0.33
Hedonic tone	16	-0.22	0.59	1.34	-0.51
* results of RR14_35 are no part of the overall evaluation					

3.18 RR14_39

In the temperature profile no abnormalities during the transport could be detected. The minimum temperature was about 13°C while the maximum was 28°C. The overall mean value was 22.7°C (see Figure 39 Annex A).

The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 58 in Annex B).

Alongside the transport temperature data further measurement specifications are given in Table 36.

Table 36 temperature data during samples transport and measurement specifications of RR14_39

Sample transport		**Measurement specifications**			
T_{min} [°C]	13.0	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	28.0	Flow rate [L/s] at funnel(s)	0.7	Bag material	Nalophan ®
$T_{average}$ [°C]	22.7	Size of funnel(s) H x Ø in [cm]	10 x 5	Measurement device	FID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≥ 10	Substance for calibration of meas. device	Propane

The data of the hedonic tone are given in Table 37. The measurement results for the perceived intensity are based on a measurement panel that was almost entirely (12 out of 13 members) not able to assess the acetone concentrations of the calibration within a deviation of 2 pi. Furthermore one of the two measurements resulted in a 90% confidence interval above 2.00 pi. Thus the submitted and averaged raw data of RR14_39 is given in the following Table 37.

Table 37 perceived intensity, acceptability and hedonic tone of RR14_39

	No. of participants	**Mean value**	**90% confidence interval**	**Standard deviation**	**Overall mean value [pi]**
Perceived intensity	13	5.62	1.79	3.62	6.48
Acceptability	-	-	-	-	-
Hedonic tone	13	0.74	0.75	1.51	-0.51

* results of RR14_39 are no part of the overall evaluation

3.19 RR14_41

The temperature data that was recorded during the transport was not transmitted to BAM by institute RR14_41.

The temperature in both emission test chambers as well as the humidity lay within standardised conditions of 23 ±2°C and 50 ±5% rH (see Figure 59 in Annex B).

Due to unavailable transport temperature data only the measurement specifications are given in Table 38.

Table 38 temperature data during samples transport and measurement specifications of RR14_41

Sample transport		Measurement specifications			
T_{min} [°C]	-	No. of funnels	7	Type of meas.	Indirect
T_{max} [°C]	-	Flow rate [L/s] at funnel(s)	0.9	Bag material	Tedlar®
$T_{average}$ [°C]	-	Size of funnel(s) H x Ø in [cm]	31 x 8	Measurement device	PAD
time [h] with T>30°C	-	Experience (number of total odour measurements reported)	≥ 100	Substance for calibration of meas. device	Acetone test gas

The data of the perceived intensity and hedonic tone are given in Table 39.

Table 39 perceived intensity, acceptability and hedonic tone of RR14_41

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	11	6.23	1.46	2.68	6.48
Acceptability	-	-	-	-	-
Hedonic tone	11	-0.23	0.54	0.98	-0.51

Institute RR14_41 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.20 RR14_43

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 15.6 and 27.2°C. The overall mean value was 22.6°C (see Figure 40 in Annex A).

Profiles of the temperature and humidity in the emission test chambers were not generated. Due to well regulated air supply system it was assumed the values lay within the standardised limits of 23 ±2°C and 50 ±5% rH.

Alongside the transport temperature data further measurement specifications are given in Table 40.

Table 40 temperature data during samples transport and measurement specifications of RR14_43

Sample transport		Measurement specifications			
T_{min} [°C]	15.6	No. of funnels	7	Type of meas.	Direct
T_{max} [°C]	27.2	Flow rate [L/s] at funnel(s)	0.9	Bag material	-
$T_{average}$ [°C]	22.6	Size of funnel(s) H x Ø in [cm]	31 x 8	Measurement device	PAD
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≥ 100	Substance for calibration of meas. device	Acetone test gas

The data of the perceived intensity and the hedonic tone are given in Table 41.

Table 41 perceived intensity, acceptability and hedonic tone of RR14_43

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	12	5.75	1.61	3.10	6.48
Acceptability	-	-	-	-	-
Hedonic tone	12	-0.08	0.66	1.28	-0.51

Institute RR14_43 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

3.21 RR14_50

In the temperature profile no abnormalities during the transport could be detected. The minimum and the maximum temperature were about 11.7 and 27.4°C. The overall mean value was 22.1°C (see Figure 41 in Annex A).

Unfortunately the computer controlled monitoring of temperature and humidity was not started correctly and hence the data is not available. That is why temperature and humidity were controlled on a daily base by a technician and were always within the requirements of 50±5% and 23°C±2°C.

Alongside the transport temperature data further measurement specifications are given in Table 42.

Table 42 temperature data during samples transport and measurement specifications of RR14_50

Sample transport		Measurement specifications			
T_{min} [°C]	11.7	No. of funnels	1	Type of meas.	Indirect
T_{max} [°C]	27.4	Flow rate [L/s] at funnel(s)	0.7	Bag material	Tedlar®
$T_{average}$ [°C]	22.1	Size of funnel(s) H x Ø in [cm]	10 x 5	Measurement device	FID
time [h] with T>30°C	0	Experience (number of total odour measurements reported)	≥ 20	Substance for calibration of meas. device	Acetone test gas

The data of the perceived intensity and the hedonic tone are given in Table 43.

Table 43 perceived intensity, acceptability and hedonic tone of RR14_50

	No. of participants	Mean value	90% confidence interval	Standard deviation	Overall mean value [pi]
Perceived intensity	8	8.63	1.01	1.51	6.48
Acceptability	-	-	-	-	-
Hedonic tone	8	-0.31	0.64	0.96	-0.51

Institute RR14_50 already participated in the earlier round robin test in 2012 and thus is classified as experienced institute.

4 Evaluation of the Perceived Intensity

Based on the boundary conditions listed in chapter 3 a detailed evaluation for the perceived intensity was conducted. For example the influence of different comparison scales (number of funnels, size of funnels etc.), type of measurement (direct or indirect assessment) and experience were checked and analysed as various "evaluation models".

Generally the institutes submitted their raw data to BAM. Thus data of not qualified panel members[2] as well as of insufficient measurement cycles[3] was to be evaluated. For each evaluation model overall values were calculated (mean, minimum and maximum value, standard deviation and 90% confidence interval) from institutes single or averaged values. In some cases the overall mean values are not calculated from all displayed measurements but from results of institutes classified as qualified. Those values are given below as "revised" values. In such cases the number of institutes included in the calculation and those not qualified are given in the following tables in parallel like in the following example were only 13 institutes out of 17 were included in the overall values calculation: e.g. 13(17) (see also Table 44).

The diagrams are generated in the style of VDI 4302-1. Green (or partial coloured differently) columns represent the mean values of the perceived intensity. White semi-transparent boxes are the 90% confidence interval and vertical lines represent the standard deviation. The horizontal green framed and semi-transparent green bars mark the 2 pi tolerance zone around the overall mean value that should not be exceeded by the institutes. Institutes that are marked with a (*) did not submit data of the acetone calibration (but it is assumed that their measurement values are based on qualified panel members) and thus were not included in the calculation of the overall mean values that provide the 2 pi tolerance zone. Institutes that are bracketed showed mayor deviations from the standardised method and are also no part of the overall calculation.

Diagrams are displayed in two ways. On the one hand the measurement results are sorted by the institutes ID and on the other hand they are sorted by their mean values as commonly used in interlaboratory tests.

The values calculated for the perceived intensity are summarised and described in the following Table 44.

For the consideration of outliers robust statistics can be used. In the current study outliers of the panel members are identified by the results achieved within the acetone calibration. Outliers of whole institutes measurements however are identified by 90% confidence intervals exceeding 2.00 pi.

[2] Panel member that evaluate at least two thirds of the acetone concentrations in the acetone calibration within a deviation of 2 pi from the set value are considered qualified.

[3] Measurement results with a 90% confidence interval below 2.00 pi are considered qualified.

Table 44 overall values for averaged measurements based on qualified panel members and measurement cycles for experienced institutes conducting indirect measurement | Institutes of RR12 only

			Description of Parameter
	No. of Institutes		No. of qualified institutes (No. of displayed inst.)
Repeatability	Overall Mean Value	[pi]	Mean of institutes mean values
	Overall Minimum Value	[pi]	Minimum mean value within the institutes mean values
	Overall Maximum Value	[pi]	Maximum mean value within the institutes mean values
	Overall Standard Deviation	[pi]	Averaged standard deviations of the evaluated institutes
	Overall 90% Confidence Interval	[pi]	Averaged 90% confidence intervals of the evaluated institutes
	Overall Relative Standard Deviation	[%]	Quotient of the overall standard deviation and the overall mean value
	Minimum rel. standard deviation	[%]	Maximum relative standard deviation within the single institutes
	Maximum rel. standard deviation	[%]	Minimum relative standard deviation within the single institutes
Reproducibility	Standard Deviation	[pi]	Standard deviation calculated from the institutes mean values
	Relative Standard Deviation	[%]	Quotient of the standard deviation of reproducibility and the overall mean value
	90 % Confidence Interval	[pi]	90% confidence interval calculated from the institutes overall mean values

4.1 Overall Evaluation of raw Data and averaged raw Data

4.1.1 Raw Data of each measured Sample

In this evaluation all transmitted data that was allegedly determined according to the requirements of ISO 16000-28 are considered (RR14_5, RR14_10 were completely excluded from the evaluation of the perceived intensity – see chapters 3.2and 3.5). Thus 30 measurements done by 17 institutes that conducted between one and three measurements each are taken into account for this evaluation model.

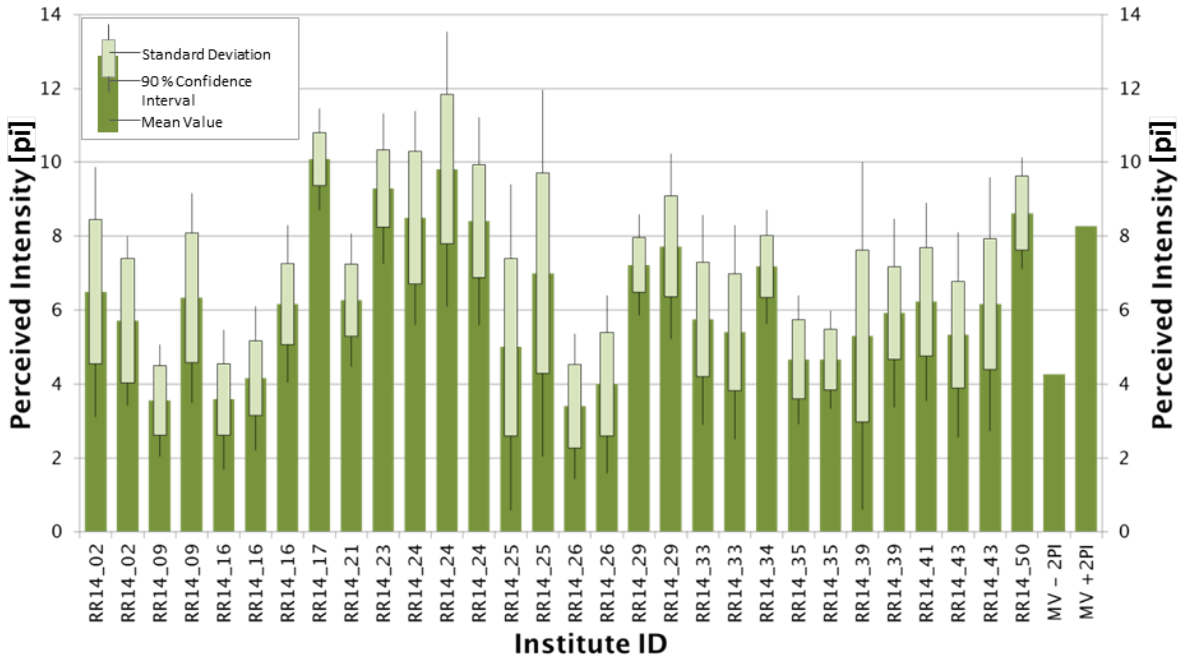
The calculation of overall values is displayed in Table 45.

Table 45 calculated overall values based on the raw data of each conducted measurement

		RR14
No. of Institutes	[-]	17
Overall Mean Value	[pi]	6.27
Overall Minimum Value	[pi]	3.40
Overall Maximum Value	[pi]	10.08
Overall Standard Deviation	[pi]	1.78
Overall 90% Confidence Interval	[pi]	0.67
Overall relative Standard Deviation	[%]	28.4

Figure 9 shows all 30 measurement values. Five measurements undercut the 2 pi tolerance zone and six exceed it. The overall relative standard deviation is 28.4%.

A)



B)

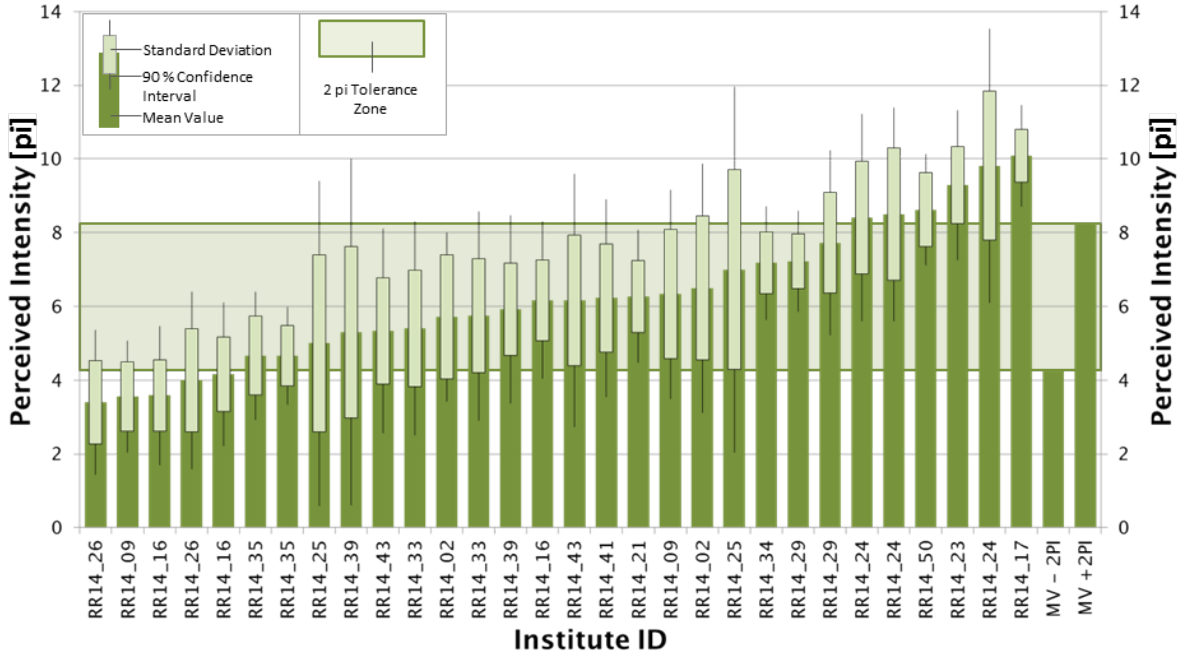


Figure 9 perceived intensity for all conducted measurements | A) sorted by institutes ID B) sorted by mean values

4.1.2 Each measured Sample with revised overall Values

Institutes that did not measure adequately according to ISO 16000-28 (RR14_23, RR14_35) and institutes without panel acetone calibration (RR14_21, RR14_29, RR14_35) were excluded from the calculation of the overall values (see Table 46) but are still displayed in Figure 10.

Table 46 calculated overall values based on the raw data of each conducted measurement - revised

No. of Institutes		13 (17)
Overall Mean Value	[pi]	6.17
Overall Minimum Value	[pi]	3.40
Overall Maximum Value	[pi]	10.08
Overall Standard Deviation	[pi]	1.87
Overall 90% Confidence Interval	[pi]	0.66
Overall relative Standard Deviation	[%]	30.3

Excluding the above mentioned institutes and their measurements from the calculation of overall values the overall mean averages to 6.17. Referring the 30 individual measurement values to this overall mean only four measurements undercut the 2 pi tolerance zone and six exceed it. The overall relative standard deviation however is 30.3%.

A)

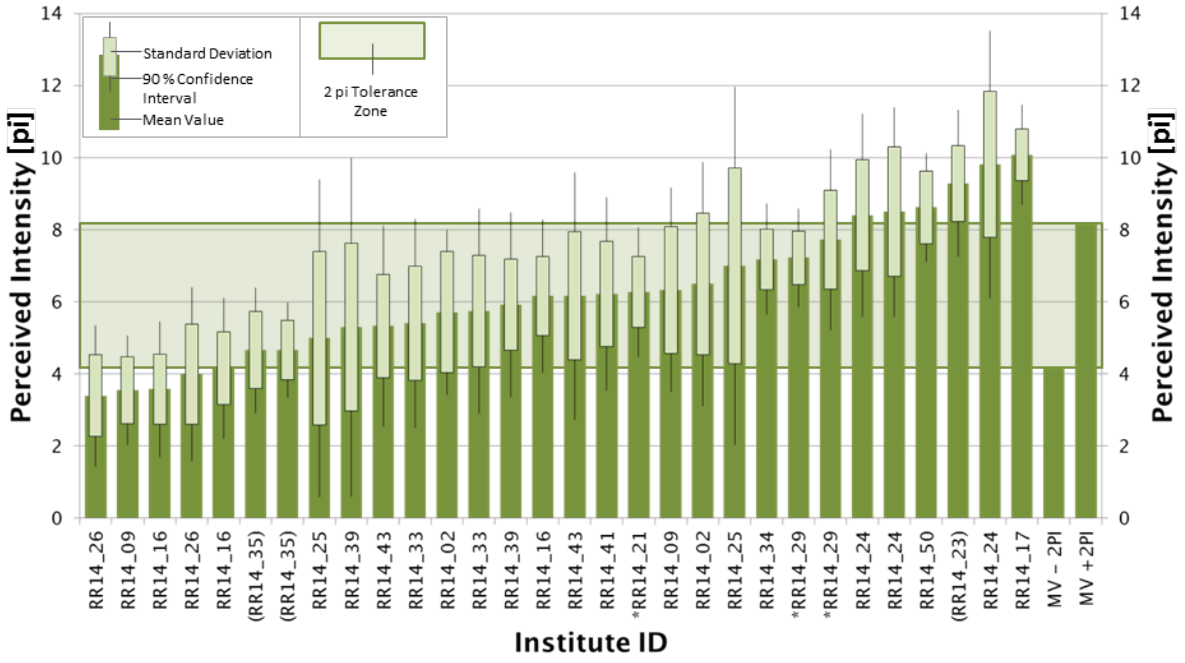


Figure 10 perceived intensity for all conducted measurements (revised overall mean)| values of institutes in brackets are not included in the calculation of the overall mean value (MV) | sorted by mean values

4.1.3 Values averaged for each Institute

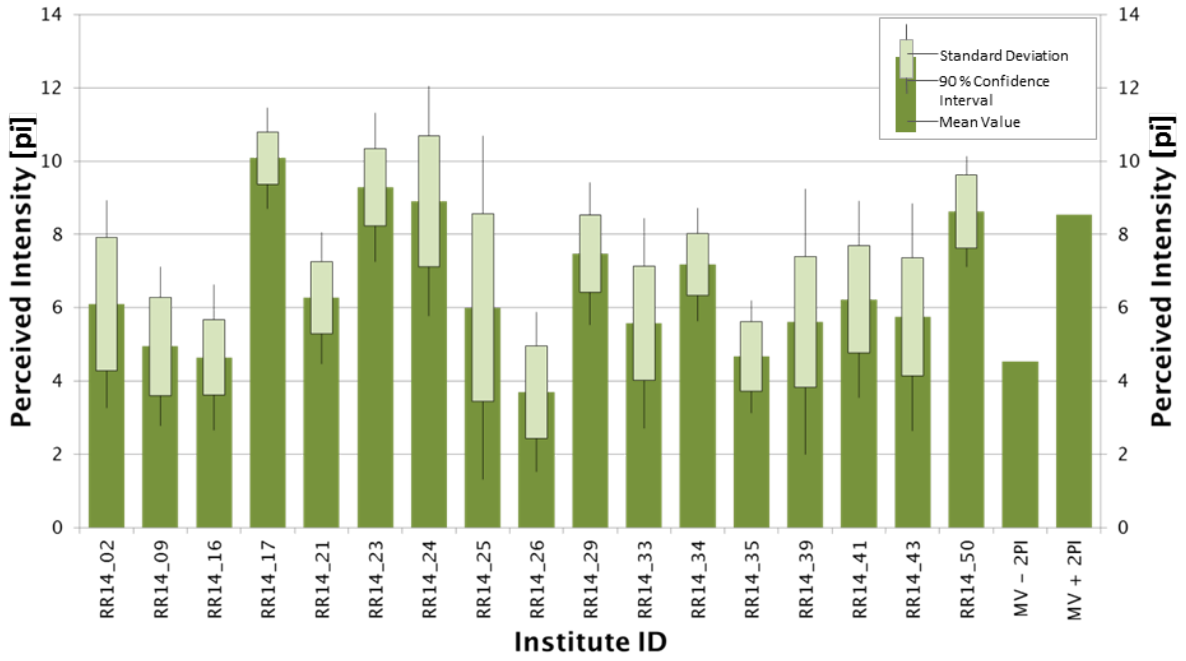
The measurement values of institutes that conducted more than one assessment were averaged and the overall mean value was calculated from all mean values. Values based on measurements that e.g. exceeded the 90% confidence interval were excluded from the calculation (Table 47).

Table 47 calculated overall values based on averaged measurement results

No. of Institutes		17
Overall Mean Value	[pi]	6.53
Overall Minimum Value	[pi]	3.70
Overall Maximum Value	[pi]	10.08
Overall Standard Deviation	[pi]	1.81
Overall 90% Confidence Interval	[pi]	0.76
Overall relative Standard Deviation	[%]	27.7

In this evaluation model there are 17 parallel measurement results. One institute undercuts the 2 pi tolerance zone and four exceed it. The overall relative standard deviation is 27.7%. The data for the perceived intensity is displayed in Figure 11.

A)



B)

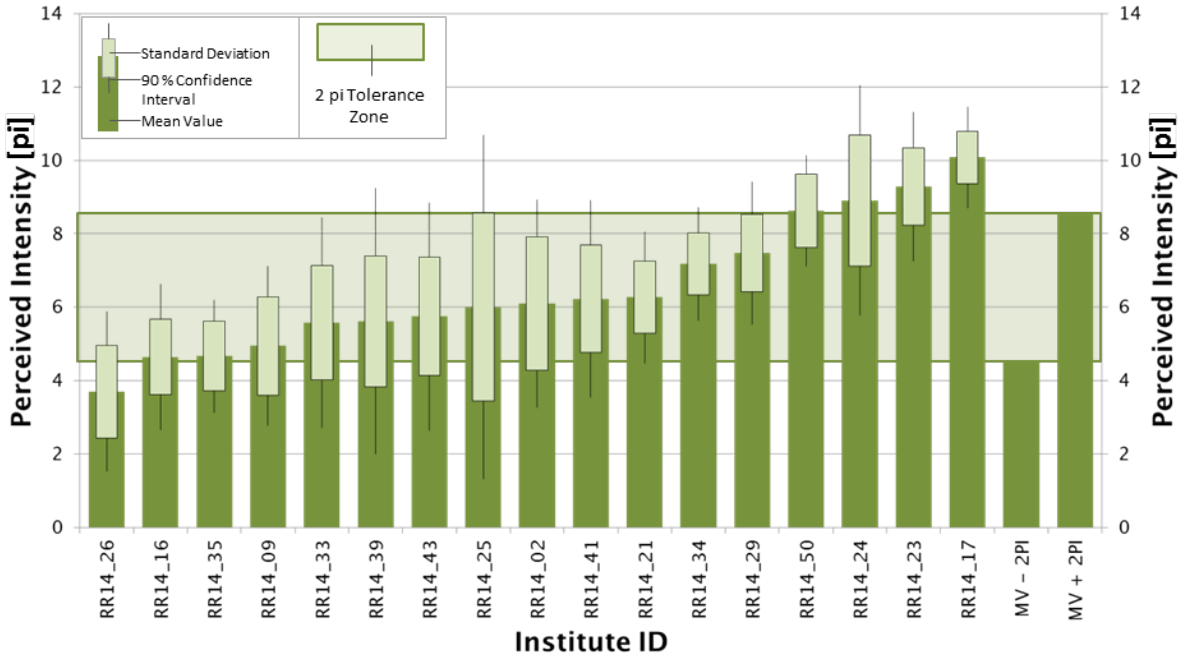


Figure 11 perceived intensity for all conducted measurements averaged for each institute | A) sorted by institutes ID and B) sorted by mean values

4.1.4 Values averaged for each Institute with revised overall Values

The evaluation is based on chapter 4.1.3 but the overall mean value was calculated without the results of institutes identified as unsufficient according to ISO 16000-28 (see chapter 4.1.2). The statistic values and the revised overall mean value are given in Table 48.

Table 48 calculated overall values based on averaged measurement results – revised

No. of Institutes		17
Overall Mean Value	[pi]	6.41
Overall Minimum Value	[pi]	3.70
Overall Maximum Value	[pi]	10.08
Overall Standard Deviation	[pi]	1.82
Overall 90% Confidence Interval	[pi]	0.90
Overall relative Standard Deviation	[%]	28.4

As in chapter 4.1.3 two measurement values undercut the 2 pi tolerance zone and four exceed it. The overall relative standard deviation is 28.4% and the results of the perceived intensity are summarised in Figure 12.

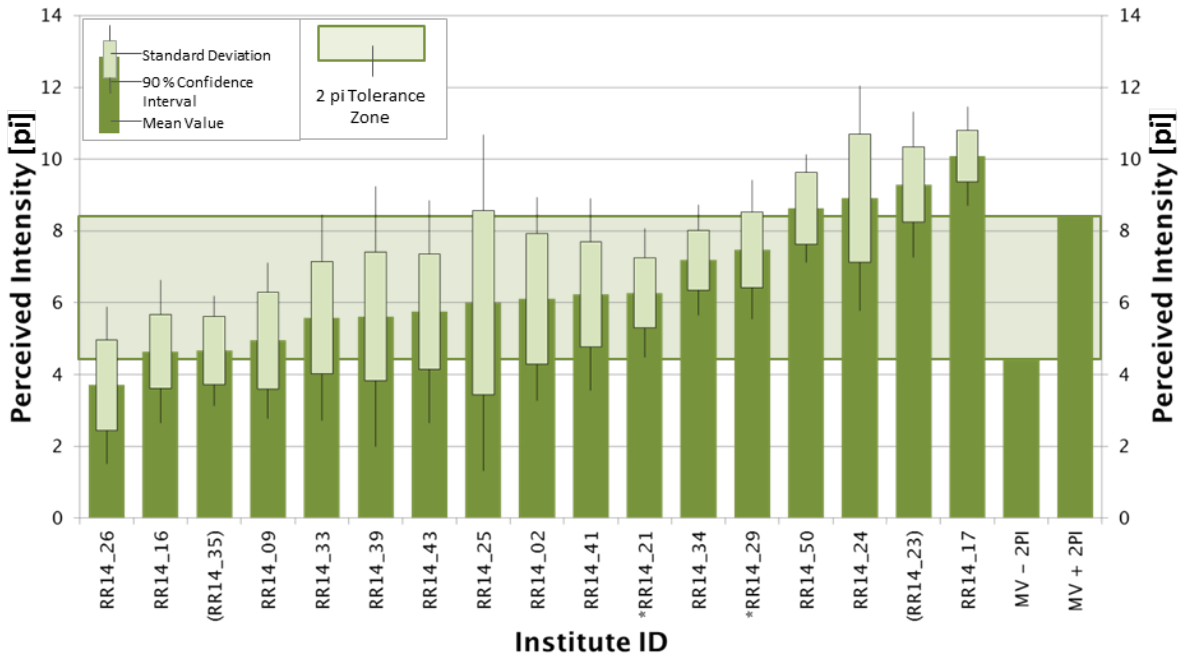


Figure 12 perceived intensity for all conducted measurements averaged for each institute | values of institutes marked with *(did not submit calibration data) or in brackets (measurement method differed from ISO 16000-28) are not included in the calculation of the overall mean value (MV) | sorted by mean values

4.2 Overall Evaluation of "qualified" Data

Data is considered "qualified" when the panel members and the measurement cycles themselves prove sufficiently accurate.

A panel member is approved qualified when they are able to assess at least two thirds (66%) of the perceived intensities during the acetone calibration within a variance of ±2 pi based on the given values. Thus a value set to 6 pi has to be assessed between 4 and 8 pi by the panellists.

A measurement cycle is considered sufficiently precise when the 90 % confidence interval is below 2.00 pi.

The size of the panel (which should consist of at least 8 panel members) is no part of the evaluation at hand.

Institutes RR14_05, RR14_07, RR14_10 and RR14_32 are no part of the evaluation of the perceived intensity because they either evaluated the intensity with a method significantly deviating from the ISO 16000-28 or did not measure the intensity at all.

The measurement results of the institutes RR14_23, RR14_25, RR14_35, and RR14_39 were excluded from further evaluation due to the following reasons:

- Instead of a comparison scale with a well-defined flow rate between 0.6 and 1.0 L/s the institute RR14_23 used some kind of glass jars that do not meet the requirements of ISO 16000-28.
- Both measurements conducted by RR14_25 show 90% confidence intervals above 2,00 pi.
- Contrary to the other participating institutes RR14_35 did not use acetone as reference substance but operated with iso-butanol. Yet neither the iso-butanol concentrations were submitted nor were they validated with the required acetone concentrations.
- RR14_39 tolerated deviations of 3 pi in the panel acetone calibration which does not comply with ISO 16000-28, VDI 4302-1 or the SOP. Only one assessor of the institute measured the acetone concentrations within the required 2 pi deviation.

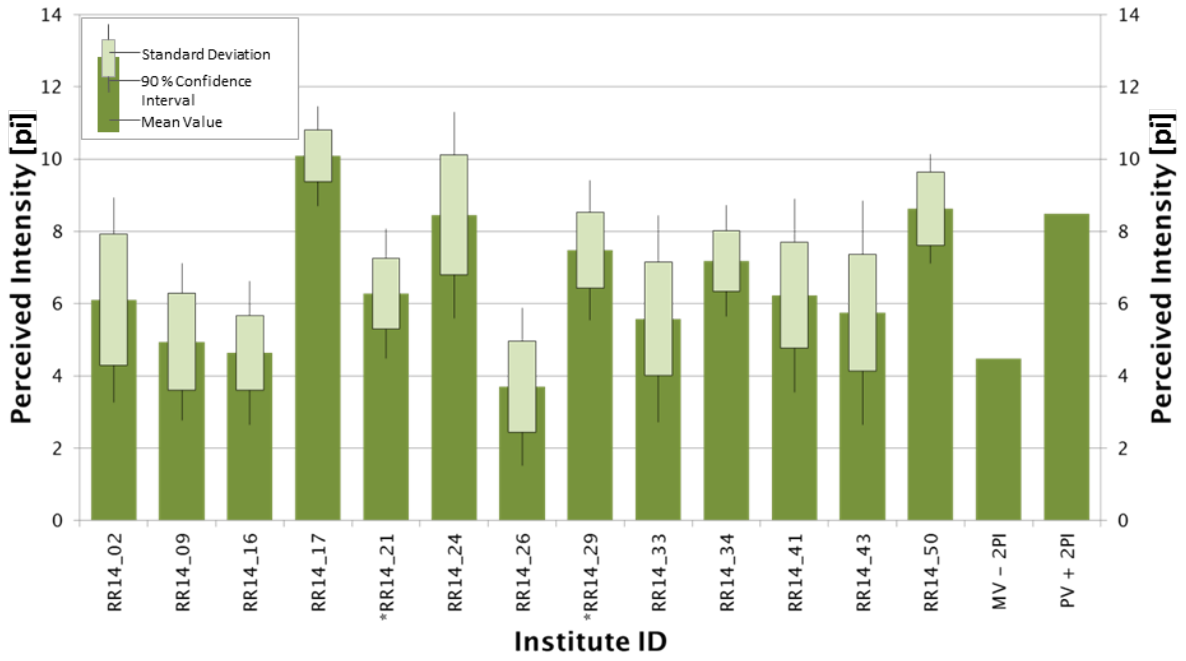
The institutes RR14_21 and RR14_29 submitted measurement data for the perceived intensity but did not send the data for the acetone calibration of the panel members. Therefore their results are no part of the calculation of the overall values but are still viewed in the following diagrams.

Table 49 calculated overall values for averaged measurement results based on qualified panel members and measurement cycles

		RR14
No. of Institutes		11 (13)
Overall Mean Value	[pi]	6.48
Overall Minimum Value	[pi]	3.70
Overall Maximum Value	[pi]	10.08
Overall Standard Deviation	[pi]	1.92
Overall 90% Confidence Interval	[pi]	1.05
Overall relative Standard Deviation	[%]	29.6

One measurement undercuts the 2 pi tolerance zone and two exceed it. The overall relative standard deviation is 29.6%. The results for the perceived intensity are displayed in Figure 13.

A)



B)

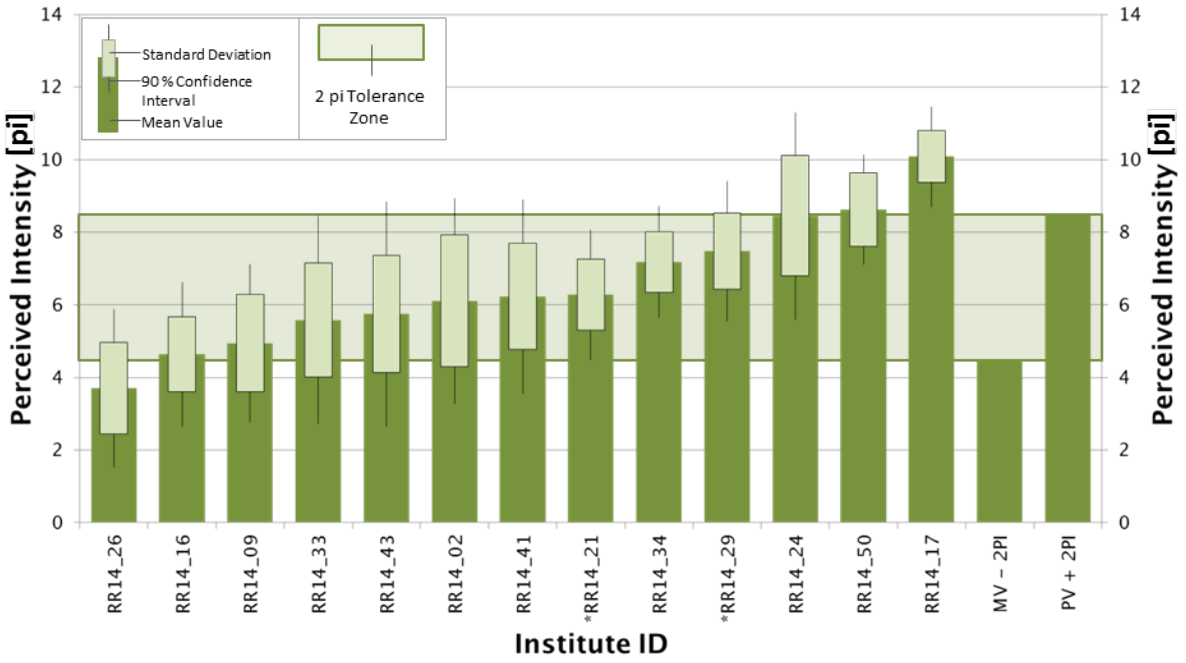


Figure 13 perceived intensity for all (averaged) measurements based on qualified panel members and measurement cycles | values of institutes marked with *(did not submit calibration data) are not included in the calculation of the overall mean value (MV) | A) sorted by institutes ID and B) sorted by mean values

4.2.1 Participants who already took Part in the Interlaboratory Test 2012

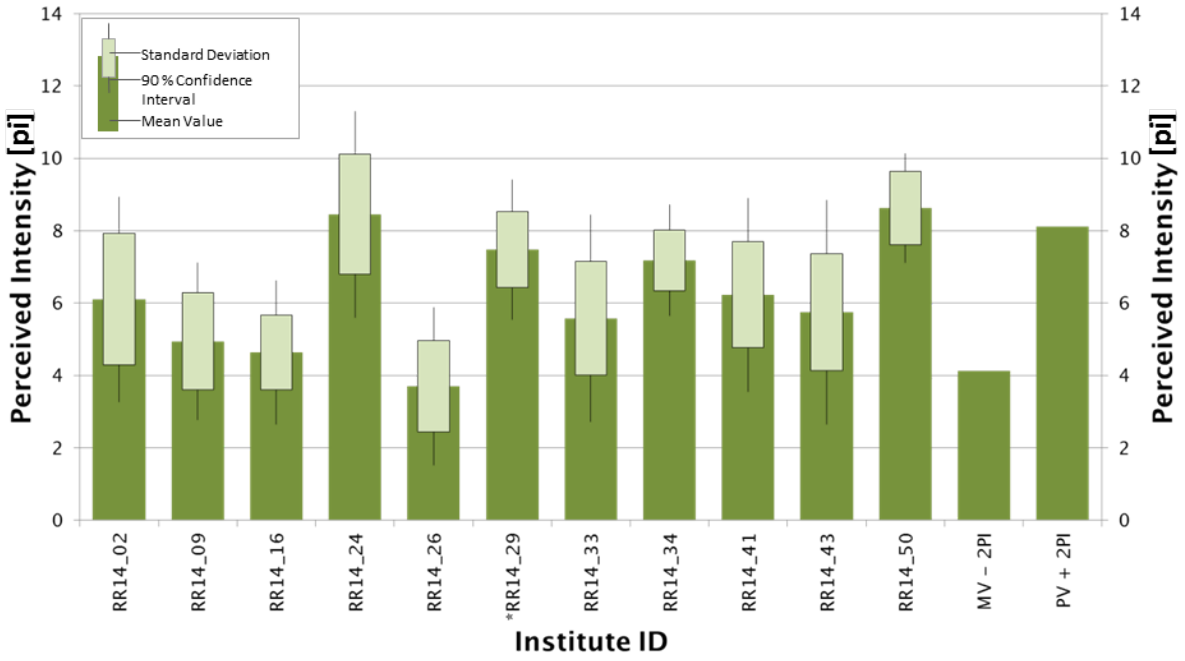
In this evaluation measurement results of qualified institutes that already participated in the interlaboratory test 2012 are included. Due to the missing acetone calibration data the measurement results of institute RR14_29 are not taken into account for the overall calculation (Table 50).

Table 50 calculated overall values for averaged measurement results based on qualified panel members and measurement cycles for experienced institutes (institutes that already took part in the RR12)

No. of Institutes		10 (11)
Overall Mean Value	[pi]	6.12
Overall Minimum Value	[pi]	3.70
Overall Maximum Value	[pi]	8.63
Overall Standard Deviation	[pi]	1.59
Overall 90% Confidence Interval	[pi]	0.92
Overall relative Standard Deviation	[%]	26.0

One measurement value undercuts the 2 pi tolerance zone and two exceed it. The overall relative standard deviation is 26.0%. The results for the perceived intensity are summarised in Figure 14.

A)



B)

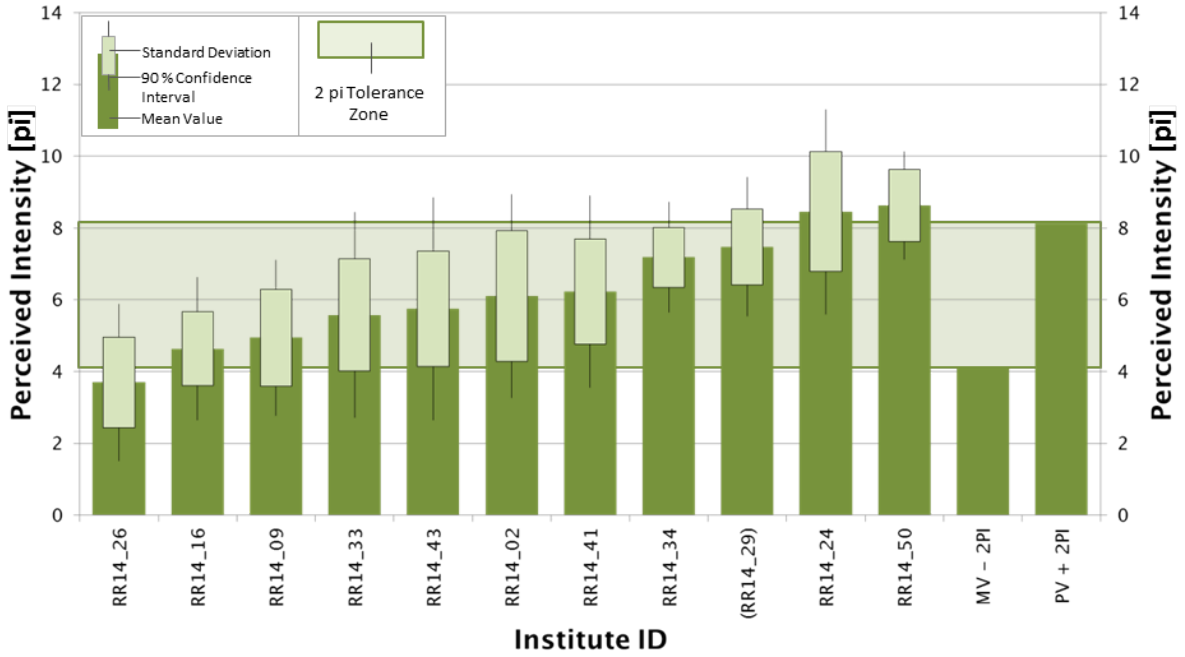


Figure 14 perceived intensity of institutes that already participated in RR12 | all (averaged) measurements based on qualified panel members and measurement cycles | values of institutes marked with *(did not submit calibration data) are not included in the calculation of the overall mean value (MV) | A) sorted by institutes ID and B) sorted by mean values

4.3 Further Variations of Evaluation regarding boundary Conditions of the Measurements

In chapter 4.2 “qualified” measurement results of the institutes were averaged and evaluated regardless of their boundary conditions of measurement (type of measurement (direct / indirect), number of acetone funnels (one / more than one) and size of the used funnel (short / long)) to guarantee an equal weighting of each institute.

In this chapter the single measurements of each institute are taken into account to divide out direct and indirect measurements. If several single measurements with the same considered boundary conditions were conducted not the single values but the institutes mean values were included in the calculation of the overall values.

4.3.1 Institutes conducting direct Measurement

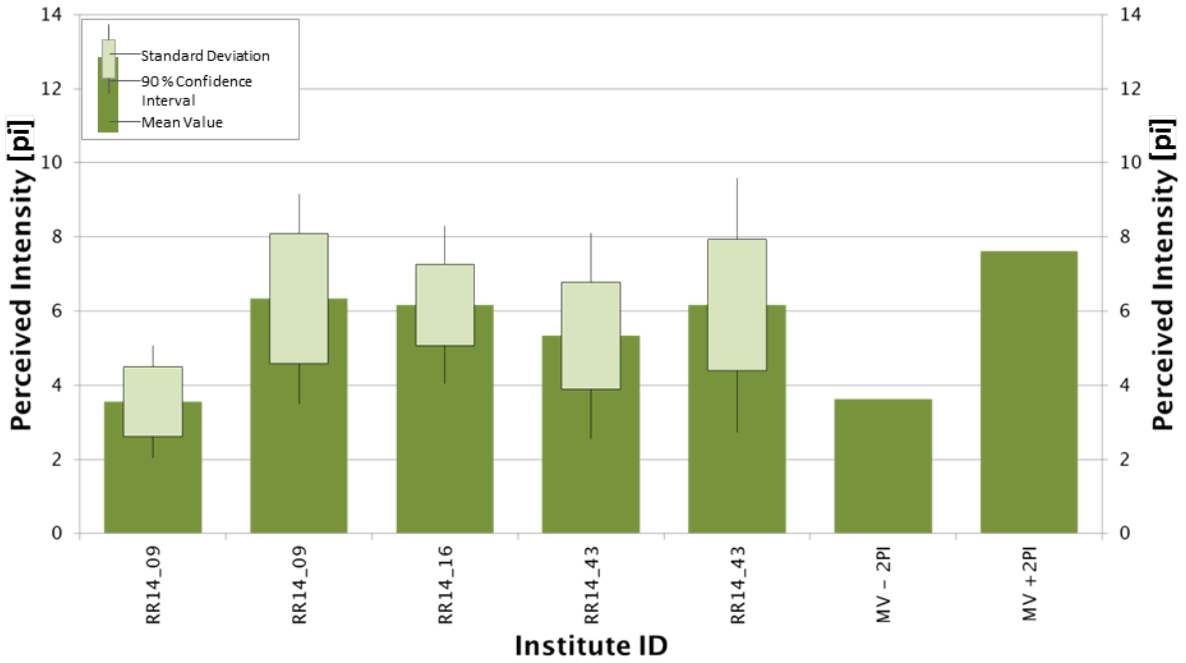
The three institutes that conducted the odour measurement directly at the emission test chamber were selected for this evaluation. Altogether they conducted five independent odour measurements that make for the following overall values (Table 51). The overall values are nonetheless based on the averaged values of each institute. Hence the overall values are generated out of three values and actually are statistically not evaluable. Thus the results in Table 51 cannot be considered reliable.

Table 51 calculated overall values for measurement results based on qualified panel members and measurement cycles - direct measurement

No. of Institutes		3
Overall Mean Value	[pi]	5.62
Overall Minimum Value	[pi]	4.94
Overall Maximum Value	[pi]	6.17
Overall Standard Deviation	[pi]	0.62
Overall 90% Confidence Interval	[pi]	1.05
Overall relative Standard Deviation	[%]	11.0

The lower measurement result of RR14_09 is 3.56 pi and undercuts the 2 pi tolerance zone by 0.06 pi. The average value for institute RR14_09 is 4.94 and is within the 2 pi tolerance zone. All results are shown in Figure 15.

A)



B)

Figure 15 perceived intensity based on qualified data for direct measurement | A) sorted by institutes ID and B) sorted by mean values

4.3.2 Institutes conducting indirect Measurement

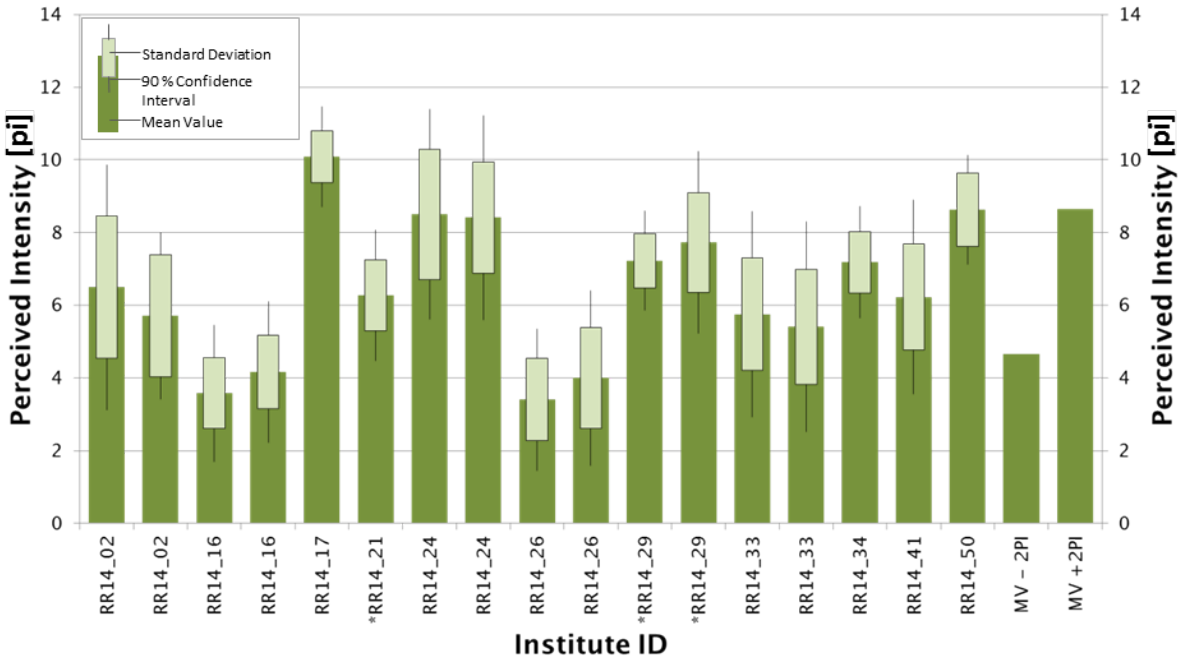
Eleven institutes conducted the indirect measurement but two did not submit acetone calibration data (RR14_21, RR14_29) and therefore are no part of the overall values calculation (Table 52).

Table 52 calculated overall values for measurement results based on qualified panel members and measurement cycles - indirect measurement

No. of Institutes		9 (11)
Overall Mean Value	[pi]	6.65
Overall Minimum Value	[pi]	3.70
Overall Maximum Value	[pi]	10.08
Overall Standard Deviation	[pi]	2.16
Overall 90% Confidence Interval	[pi]	1.34
Overall relative Standard Deviation	[%]	32.5

In Figure 16 measurement results of all eleven institutes are shown. Four institutes undercut the 2 pi tolerance zone and one institute exceeds the limits. The overall relative standard deviation is 32.5%.

A)



B)

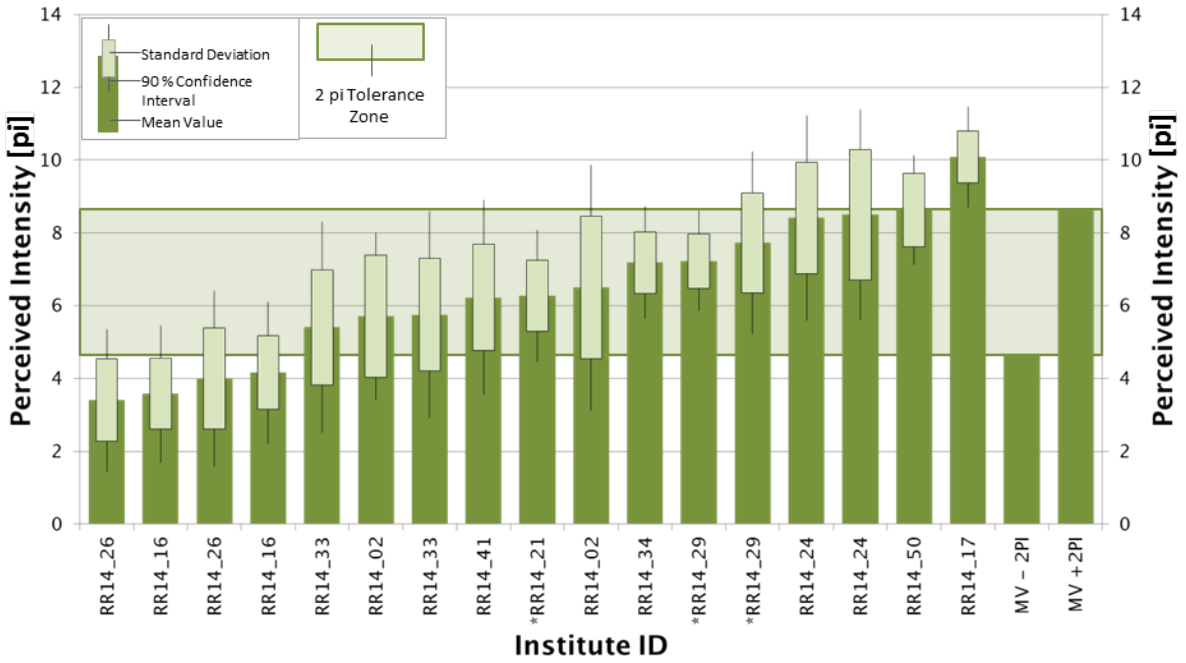


Figure 16 perceived intensity based on qualified data for indirect measurement | values of institutes marked with *(did not submit calibration data) are not included in the calculation of the overall mean value (MV) | A) sorted by institutes ID and B) sorted by mean values

4.3.2.1 Tedlar® / Nalophan®

The evaluation of chapter 4.3.2 is specified and the measurement results are divided into the used bag materials Tedlar® and Nalophan®.

The overall values for Tedlar® are based on the measurements of two institutes and hence they are actually statistically not evaluable and results cannot be considered reliable.

Table 53 calculated overall values for measurement results based on qualified panel members and measurement cycles - direct measurement divided into Tedlar® and Nalophan® usage

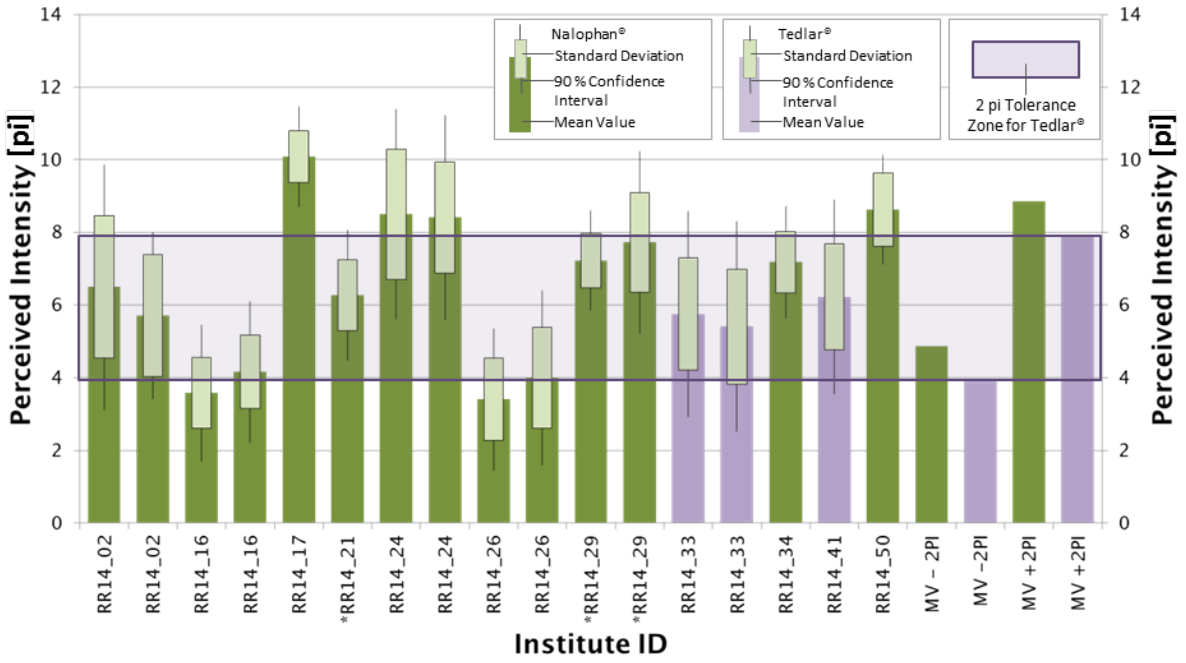
		Nalophan®	Tedlar®
No. of Institutes		7 (9)	2
Overall Mean Value	[pi]	6.86	5.90*
Overall Minimum Value	[pi]	3.70	5.58*
Overall Maximum Value	[pi]	10.08	6.23*
Overall Standard Deviation	[pi]	2.44	0.07*
Overall 90% Confidence Interval	[pi]	1.79	0.32*
Overall relative Standard Deviation	[%]	35.6	1.2*

* results based on only two values and thus not statistically evaluable

Only institutes RR14_33 and RR14_41 of the 11 institutes that conducted indirect measurements used bags made of Tedlar®. Institute RR14_33 did two parallel measurements while institute RR14_41 measured only one sample. In Figure 17 violet marked values belong to institutes that used Tedlar® bags while the green ones refer to Nalophan® bags.

Four institutes using Nalophan® undercut the 2 pi tolerance zone (green horizontal bar) while one exceeded it. Institutes using Tedlar® without exception lay within the tolerance zone (violet horizontal bar).

A)



B)

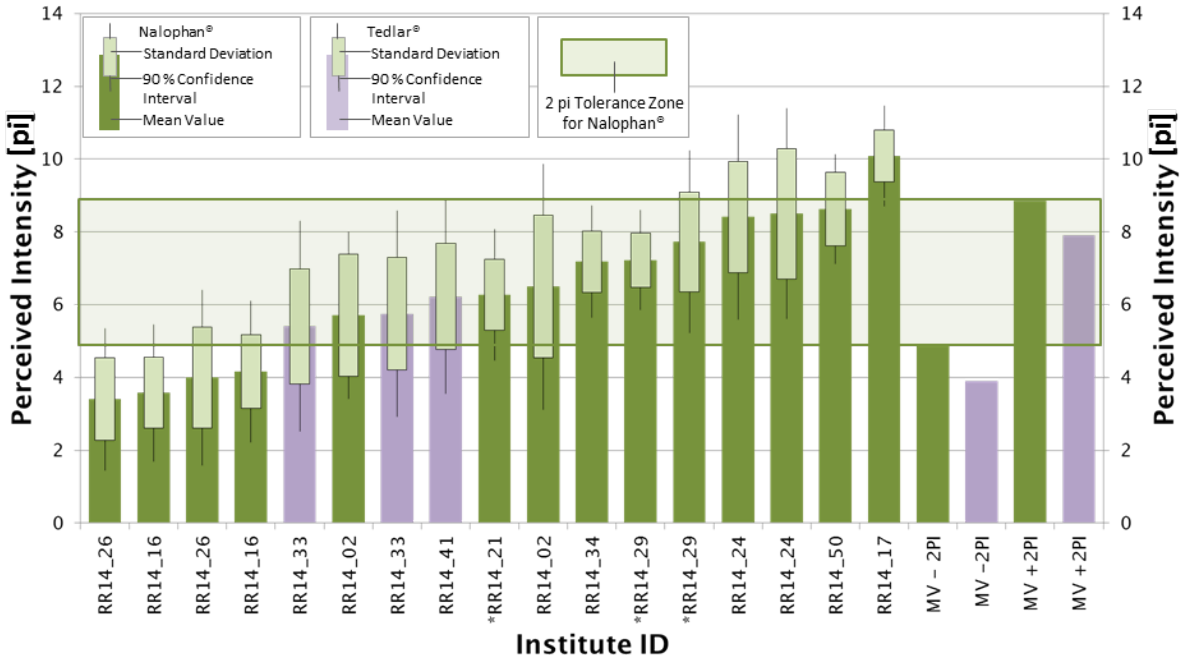


Figure 17 perceived intensity based on qualified data for indirect measurement| green columns represent the use of Nalophan® bags and violet columns belong to institutes using Tedlar® bags | values of institutes marked with *(did not submit calibration data) are not included in the calculation of the overall values | A) sorted by institutes ID and B) sorted by mean values

Even though the number of measurements is limited the repeatedly discussed statement, that bags made of Tedlar® automatically cause higher perceived intensities (e.g. due to an alleged individual smell of the bags) does not prove true.

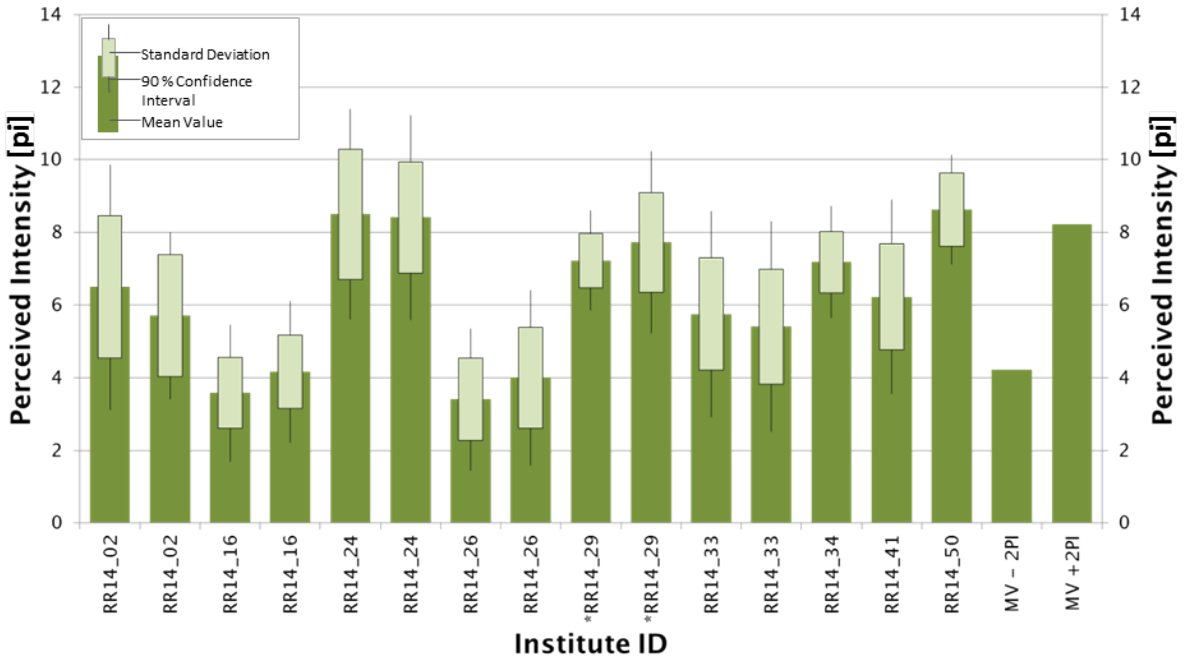
4.3.3 Participants (qualified, only RR12) conducting indirect Measurement

In this chapter only institutes with qualified panel members and measurement cycles that already took part in the round robin test 2012 were taken into account. The overall values are given in the following Table 54.

Table 54 calculated overall values for measurement results based on qualified panel members and measurement cycles - indirect measurement | Institutes of RR12 only

No. of Institutes		8 (9)
Overall Mean Value	[pi]	6.22
Overall Minimum Value	[pi]	3.70
Overall Maximum Value	[pi]	8.63
Overall Standard Deviation	[pi]	1.85
Overall 90% Confidence Interval	[pi]	1.24
Overall relative Standard Deviation	[%]	29.7

A)



B)

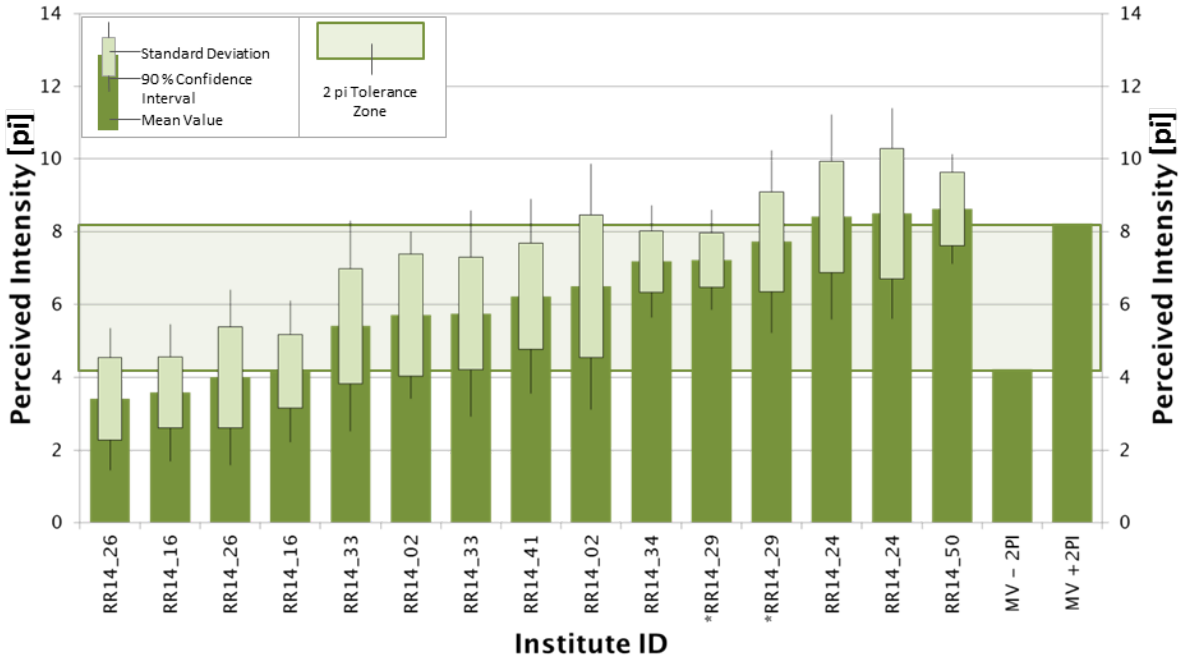
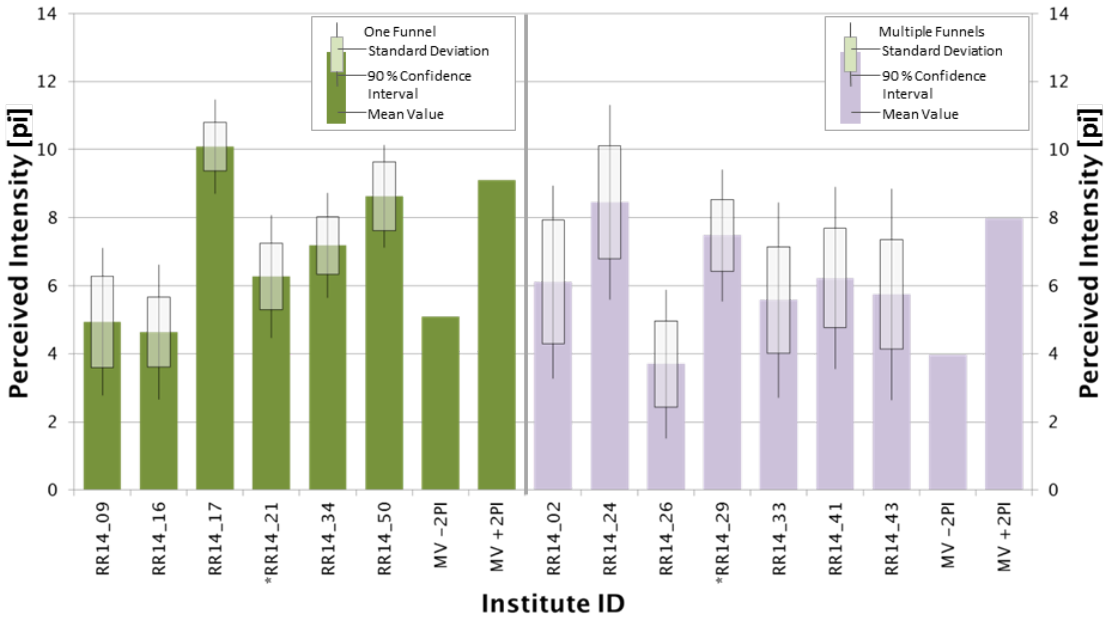


Figure 18 perceived intensity based on qualified data for indirect measurement limited to institutes that already took part in the RR12 | values of institutes marked with *(did not submit calibration data) are not included in the calculation of the overall values | A) sorted by institutes ID and B) sorted by mean values

4.3.4 Participants with Comparison Scales with only one Funnel vs. multiple-Funnel Systems

Within the qualified measurements there are seven institutes using comparison scales with more than five acetone funnels and six institutes with one acetone funnel. In Figure 19 measurement results for both variations of funnel numbers are compared. The perceived intensity measured by comparison scales with more than five acetone funnel on average is 1.12 pi lower than measurement results determined by using comparison scales with one funnel.

A)



B)

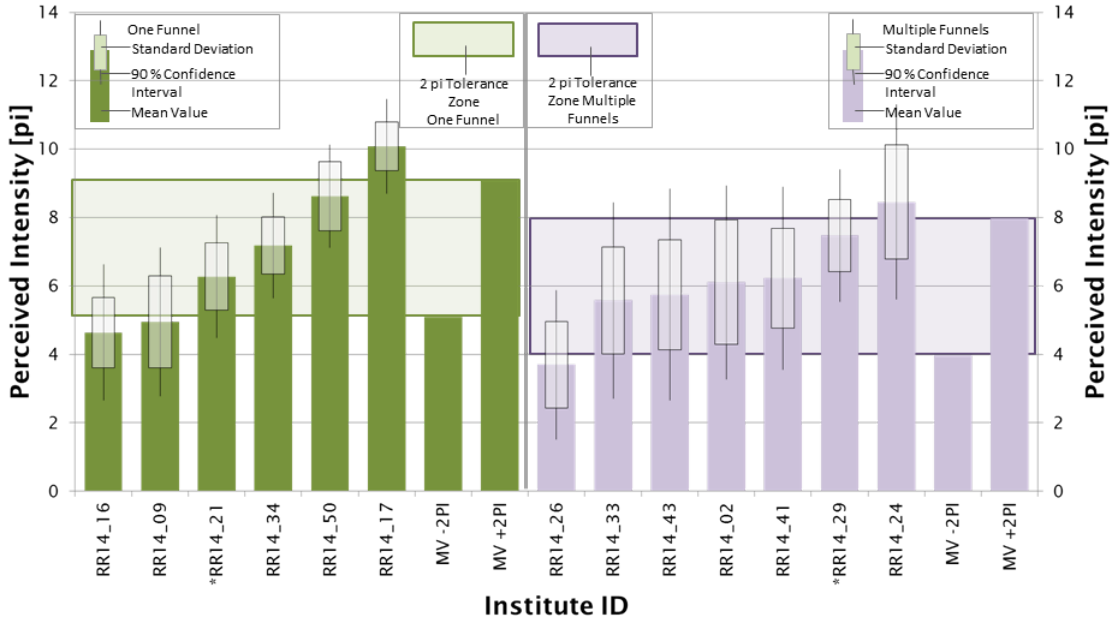


Figure 19 perceived intensity based on qualified data | green columns represent the use of comparison scales with one acetone funnel and violet columns belong to institutes using comparison scales with multiple acetone funnels | values of institutes marked with *(did not

submit calibration data) are not included in the calculation of the overall values | A) sorted by institutes ID and B) sorted by mean values

What can be observed in Figure 19 is that the standard deviations and 90% confidence intervals are noticeable higher for measurements based on multiple funnel systems.

4.3.5 Evaluation regarding the Size of Funnels

The institutes comparison scales were operated with differently sized funnels. For the evaluation they were divided into three size ranges / classes (see Table 55).

Table 55 division of institutes into size ranges of their acetone funnels | crossed out and bracketed institutes are no part of the overall evaluation (see below)

Class	Description	Size height x opening diameter in [cm]	Institutes ID
I	Small	9.5 – 10 x 4.6 – 5.5	17, (25), ~~35~~, (39), 50
II	Medium	16 – 20 x 6 – 9	2, ~~5~~, 9, ~~10~~, 21, 26, 29
III	Large	25 – 31 x 6 – 8	16, 24, 33, 34, 41, 43

Institutes which are crossed out are not included in the evaluation because of significantly deviation measurement methods from the ISO 16000-28. Bracketed institutes did not fulfil the requirements of the ISO 16000-28 regarding the measurement accuracy and therefore the results are only of secondary importance but viewed in the diagram (Figure 20) nonetheless.

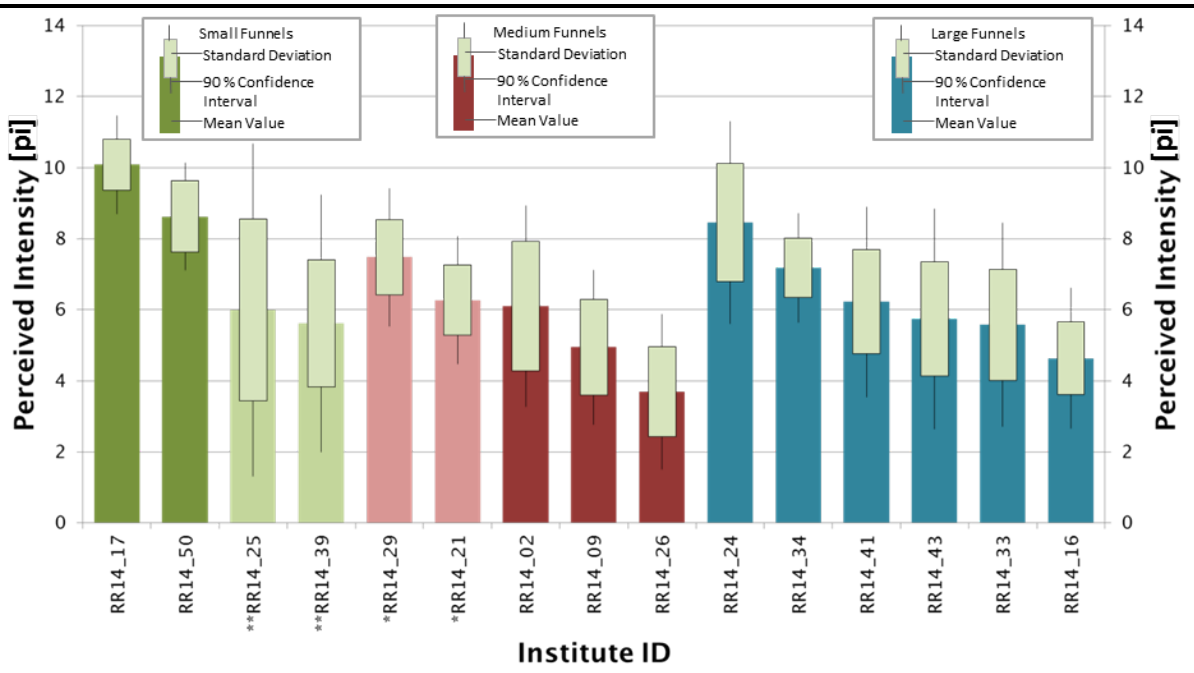


Figure 20 perceived intensity with respect to the size of acetone funnels | values of institutes marked with *(did not submit calibration data) and marked with **(panel members did not pass the acetone calibration) are not included in the calculation of the overall values | dark green (class I), red (class II) and blue (class III) columns are representative measurements; light columns are less qualified measurements and of secondary interest

4.4 Summary of Evaluation Model Results

The following Table 56 summarises the overall mean values, the overall 90% confidence intervals as well as the overall standard deviation of reproducibility for each of the different evaluation models that were applied in chapters 4.1, 4.2 and 4.3.

Naturally the standard deviations as well as the confidence intervals increase the more measurement results are excluded from the evaluation. With a 90% confidence interval of 0.92 pi and a standard deviation of 1.59 pi the evaluation of the qualified data sets for the institutes that already took part in the RR12 - round robin test 2012 - shows the best results.

Table 56 overall results for the perceived intensity depending on the evaluation model

	Overall mean value [pi]	**Overall 90% confidence interval [pi]**	**Overall standard deviation [pi]**
Qualified data sets	6.48	1.05	1.92
Only RR12-institutes	6.12	0.92	1.59
Direct	5.62*	1.05*	0.62*
Indirect	6.65	1.34	2.16
Indirect and only RR12-institutes	6.22	1.24	1.85
Indirect Tedlar®	5.90*	0.32*	0.07*
Indirect Nalophan®	6.86	1.79	2.44
Raw data of each sample	6.27	0.67	1.78
Revised	6.17	0.66	1.87
Raw data averaged	6.53	0.76	1.81
Revised mean	6.41	0.90	1.82
* results based on only two to three values and thus not statistically evaluable			

5 Evaluation of the Hedonic Tone

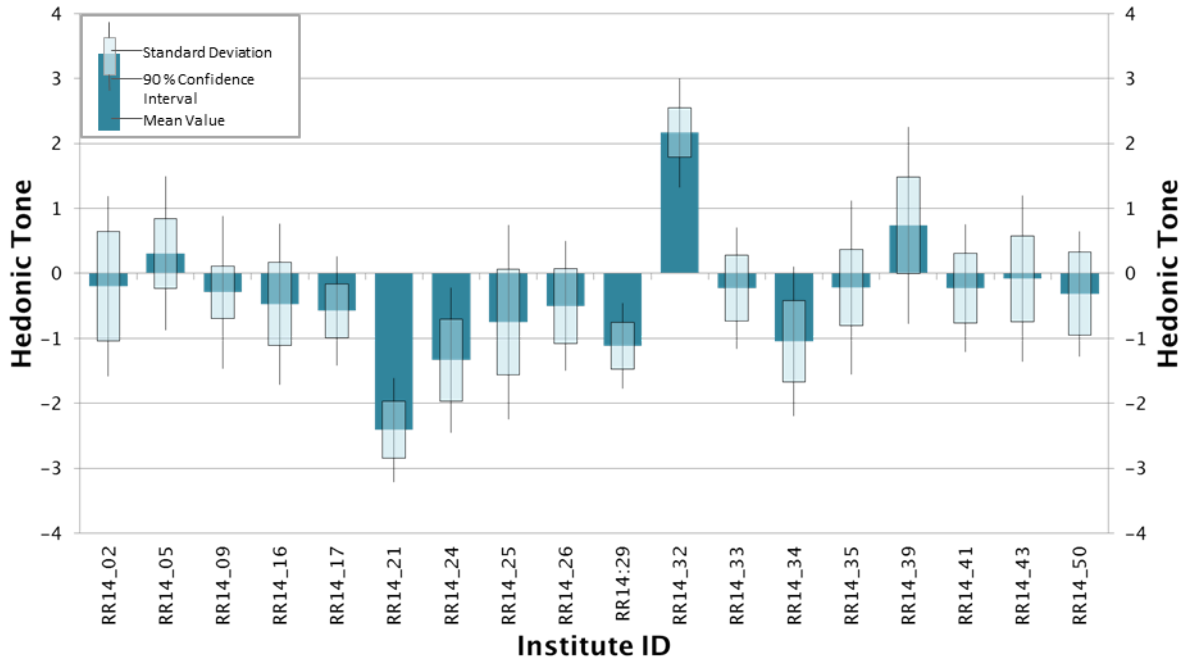
The (overall) hedonic tones results of RR14 are given in Table 57 and Figure 21. Mean values of institutes range from -2.41 to 0.74 and altogether average to -0.51. The overall standard deviation equals the standard deviation of reproducibility and all institutes conducted the measurement within the required 90 % confidence interval of ± 1 [ISO 16000-28].

Table 57 results for the hedonic tone RR14

	Mean value	90% confidence interval	Standard deviation
RR14_02	-0.20	0.80	1.40
RR14_05	0.31	0.54	1.18
RR14_09	-0.29	0.41	1.17
RR14_16	-0.47	0.64	1.24
RR14_17	-0.58	0.41	0.84
RR14_21	-2.41	0.44	0.80
RR14_24	-1.34	0.63	1.12
RR14_25	-0.75	0.82	1.49
RR14_26	-0.50	0.58	1.00
RR14_29	-1.11	0.36	0.66
RR14_32	2.17	0.38	0.84
RR14_33	-0.23	0.51	0.93
RR14_34	-1.05	0.63	1.15
RR14_35	-0.22	0.59	1.34
RR14_39	0.74	0.75	1.51
RR14_41	-0.23	0.54	0.98
RR14_43	-0.08	0.66	1.28
RR14_50	-0.31	0.64	0.96
Overall values	-0.51	0.30	0.70

The measurement results of RR14_32 are not included in the calculation of overall values because it was not conducted according to ISO 16000-28.

A)



B)

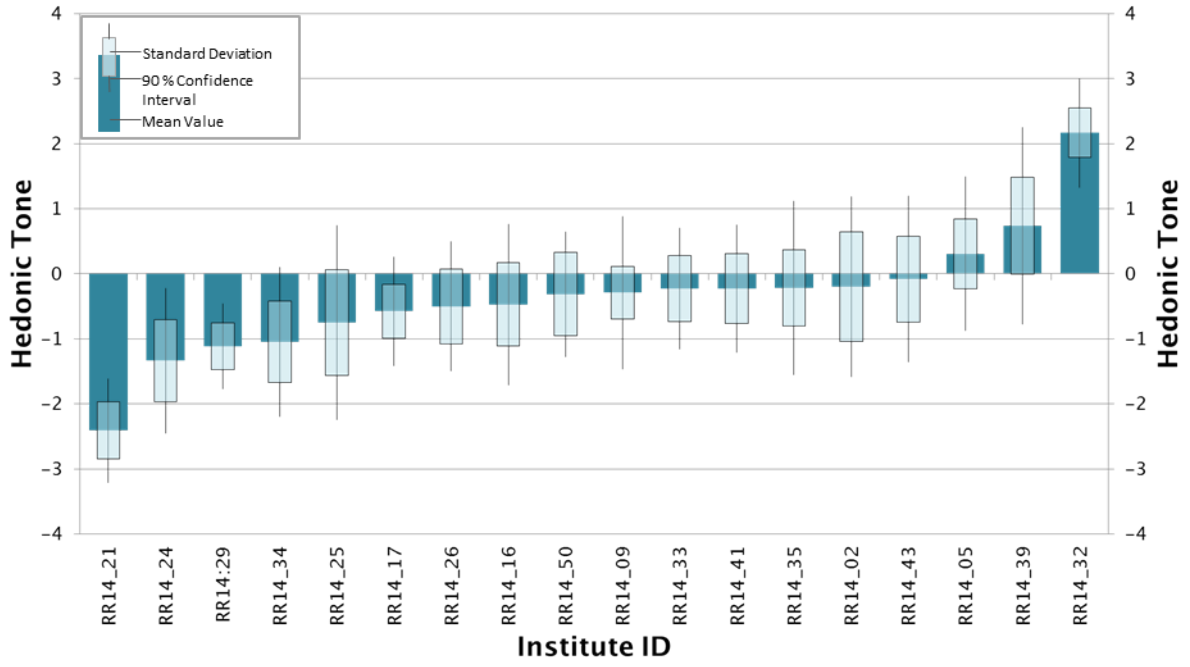


Figure 21 hedonic tone RR14 |A) sorted by Institute ID and B) sorted by mean value

6 Evaluation of the Acceptability

The acceptability assessment was conducted by the five institutes RR14_02, RR14_07, RR14_17, RR14_23 and RR14_35. Measurement values of RR14_02 range between -7.5 and +10 and for RR14_21 and RR14_23 from -6 to -1.5 and -2 to +7. For institute RR14_02 the values range between -0.5 and +1.0 and for RR14_35 between 0 and 1.

Those results suggest that different scales were taken as a basis for those measurements and thus the comparability as well as the overall results are questionable without revision of the submitted values. The results of the institutes are given in Table 58. In case more than one sample was assessed, the mean values for the sample specific mean, the confidence interval and the standard deviation were averaged. For the overall values the standard deviation of reproducibility was calculated.

Table 58 results for the acceptability RR14

	Mean value	90% confidence interval	Standard deviation
RR14_02	1.43	3.46	5.67
RR14_07	0.28	0.15	0.41
RR14_17	-3.00	0.81	1.65
RR14_23	2.25	1.55	2.99
RR14_35	0.67	0.13	0.29
Overall values	0.33	1.91	2.01

7 Comparison to the past Odour Interlaboratory Test 2012

The objective for the second interlaboratory test in 2014 was to improve the measurement method with support of the VDI 4302-1 and the SOP (Annex D). In the following chapters the measurement results for the perceived intensity and the hedonic tone are compared.

The round robin tests of 2012 and 2014 had with 4.54 pi and 6.48 pi significantly different overall mean values. Thus a comparison scaled to 100% would distort the values and the conclusion drawn would not represent the actual facts. Therefore the measurement values of the perceived intensity are correlated to the overall mean value of the associated round robin test.

The overall mean values are set to 0 pi each and institutes mean values are displayed as deviation from the original mean values (see Figure 22). For the evaluation and comparison of the perceived intensity data sets of qualified panel members and measurement cycles were chosen.

For the hedonic tone only the overall values are displayed in chapter 7.2.

7.1 Perceived Intensity

For the round robin test 2012 the measurements of 12 institutes were evaluated and besides the overall mean value of 4.54 pi, relative standard deviations of repeatability between 16.6 and 81.2% were calculated. The overall mean of those standard deviations was 47.8%. [UBA 2012]

Due to the round robin test 2014 being conducted based on the experience gained in 2012, not only the frame conditions were adjusted but also the evaluation of measurement data. Hence the evaluation done for the RR12 [UBA 2012] deviates from the one conducted for RR14. Therefore the data of 2012 was re-evaluated according to the requirements also met by the evaluation of RR14. In a first step only the qualified data sets (qualified panel members and measurement cycles only) were selected. Thus only eight out of the 12 institutes are considered qualified for the evaluation. The overall mean decreases to 3.66 pi while standard deviations of repeatability are unaffected from this selection. By comparison the standard deviation of reproducibility changes noticeable from 1.77 pi to 0.87 pi. The same applies to the relative standard deviation and the 90 % confidence interval with the values 39.2% decreasing to 23.8% and 0.92 pi decreasing to 0.58 pi. In this context it has to be considered that the overall mean of RR12 is 3.66 pi and thus lies near the limit of quantification[4]. Therefore the interpretability of the re-evaluated values of RR12 is restricted and it is refrained from a more detailed interpretation.

[4] If neutral air of emission test chambers is evaluated normally values between 2 and 3 pi result from those measurements.

The results for the perceived intensity of RR12 (evaluation as conducted in the report 2012[5] [UBA 2012] and the re-evaluated results) and RR14 are summarised in the following Table 59. The first column "RR12 original" contains the calculated values as they are published in the report [UBA 2012]. Within the report of 2012 also institutes that did not meet all requirements given by ISO 16000-28 were included in the calculation of the overall values. The resulting values for RR12 are given in the second column "RR12 re-evaluated" of the table below and are taken as basis for the comparison of both round robin tests.

The evaluable number of institutes for RR12 was eight while for RR14 eleven institutes met the fundamental requirements[6] of ISO 16000-28. The overall relative standard deviation decreased from 45.3 in RR12 to 36.9 % in RR14 while the relative standard deviation of reproducibility increased from 23.8 to 29.6 %.

Table 59 overall values for averaged measurements based on qualified panel members and measurement cycles for experienced institutes conducting indirect measurement | Institutes of RR12 only

			RR12 original	RR12 re-evaluated	RR14
	No. of Institutes		12	8	11 (13)
Repeatability	Overall Mean Value	[pi]	4.54	3.66	6.48
	Overall Minimum Value	[pi]	2.29	2.29	3.70
	Overall Maximum Value	[pi]	9.00	5.11	10.08
	Overall Standard Deviation	[pi]	1.85	1.66	2.28
	Overall 90% Confidence Interval	[pi]	1.28	1.01	1.30
	Overall Relative Standard Deviation	[%]	40.7*	45.3	36.9
	Minimum rel. Standard deviation	[%]	22.5*	22.5	13.7
	Maximum rel. Standard deviation	[%]	81.0*	81.0	58.9
du cib	Standard Deviation	[pi]	1.77	0.87	1.92

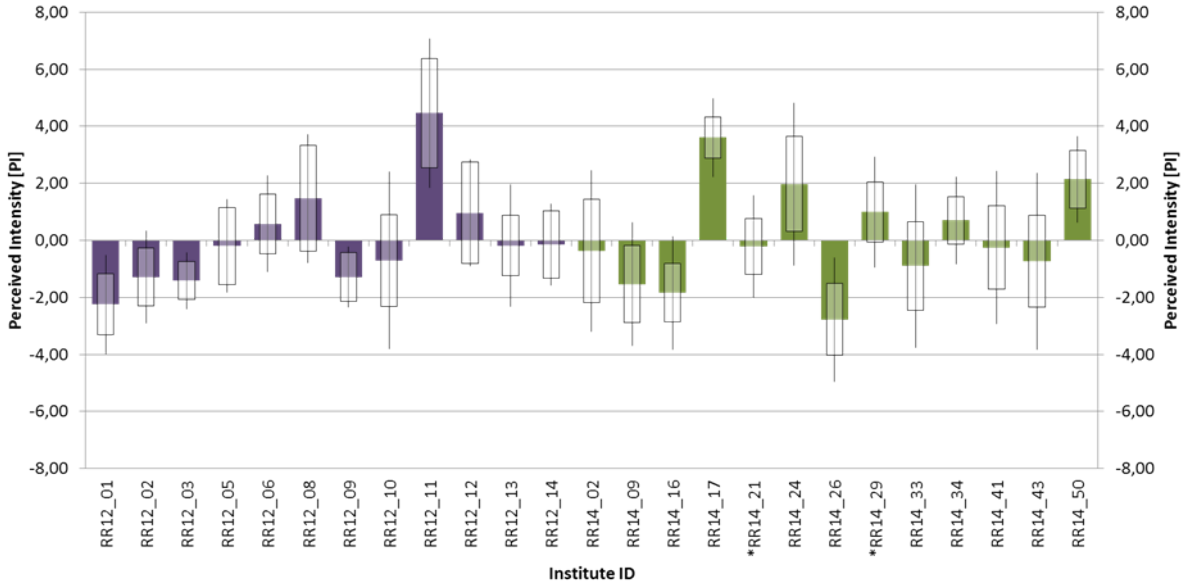
[5] Values for the relative standard deviation are slightly deviating from the published values in [UBA 2012] due to different calculations. In 2012 the relative standard deviation was calculated as mean of all single relative standard deviations. In 2014 it was calculated from the overall mean value and the (overall) standard deviation.

[6] E.g. sufficient acetone calibration and 90% confidence intervals below 2.00 pi

Relative Standard Deviation	[%]	38.9	23.8	29.6
90 % Confidence Interval	[pi]	0.92	0.58	1.05

* values slightly deviating from values given in [UBA 2012]

A)



B)

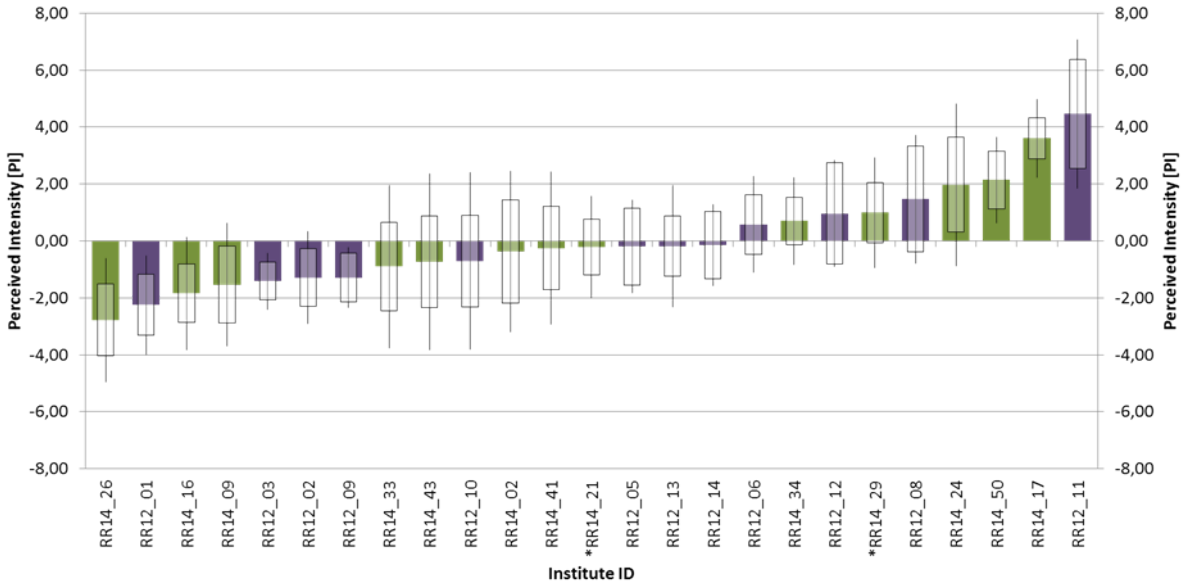


Figure 22 comparison of the perceived intensity of RR12 (violet) and RR14 (green) in relation to the individual mean value of each of the two round robin tests | A) sorted by institute ID and B) sorted by deviation from the mean value(s)

7.2 Hedonic Tone

The overall results of the hedonic tone of RR12 and RR14 are given in Table 60.

Table 60 overall results for the hedonic tone RR12 and RR14

	Overall mean value	Overall 90% confidence interval	Overall standard deviation
RR12	-0.41	0.27	0.52
RR14	-0.51	0.30	0.70

7.3 Acceptability

The acceptability was no part of the round robin test 2012 and thus no comparison can be drawn.

8 Conclusion

In the interlaboratory odour test 2014 21 institutes took part and submitted odour measurement data to BAM. 17 of those institutes conducted between one and three measurements of the perceived intensity each and altogether submitted 30 data sets for the round robin tests evaluation. The residual four institutes submitted either data for the hedonic tone and/or the acceptability which were no focal point of this interlaboratory test.

All in all 207 panellists took part in the measurement of the lacquer sample of whom 25 were not qualified according to the acetone calibration. For further 22 panellists no calibration data was submitted. Thus the number of qualified assessors lies between 182 and 170 panellists or rather 77 to 88% of them were qualified.

The interlaboratory test 2014 showed that the odour measurement method basically is applicable but that there is still considerably potential for improvement and thus confirms the findings that were already elaborated regarding the interlaboratory test 2012.

One mayor issue is that the implementation of the pre-set parameters of the ISO 16000-28 and VDI 4302-1 is still inadequate in many cases. Even though the SOP (see Annex D) that was provided for the round robin test 2014 should have had a positive effect on the measurement results it is evident that the pre-set parameters are still not as detailed as obviously would be necessary. Due to the frame conditions of the standards still being not defined tight enough a revision of the ISO 16000-28 (and VDI 4302-1) is strongly required.

This is even more pointed up by the assessment of perceived intensity, hedonic tone as well as the acceptability that are amongst other things based on different underlying scales / reference systems (e.g. different scales used for the acceptability (chapter 6)) and thus makes a comparison of results arbitrary complicated or even impossible. Furthermore the careless application shows also in the usage of glass jars or 3 L bags as comparison scales that could never guarantee for the required flow rate of 0.6 to 1.0 L/s at the outlet. Another directly attached aspect is the size and type of the funnels used for the provision of acetone air as well as of sample air. According to ISO 16000-28 the opening angle has to be at least 12° to allow for a homogeneous dilution of the provided acetone samples. Some institutes for examples used very short funnels that are directly connected to a 6 mm outlet and thus there is no possibility for the air to spread through the whole funnel but will come out as condensed stream. Hence the smelling position at the funnel becomes essential for the assessment because the concentration in the funnels middle ought to be much higher than at the edge. The same holds for the air velocity at the funnels. That is why it is assumed that the type of funnel might significantly influence the measurement results. Moreover it has to be ensured that no ambient air can be inhaled additional to the sample air.

The thesis that the number of acetone funnels might have a significant impact on the evaluation of odour samples could neither be confirmed nor rebuted. Nonetheless the results of RR14 imply that the provision of acetone via a single funnel might lead to adequate results as

long as the training of panel members matches the requirements and prepares the assessors sufficiently for the comparatively long waiting time between acetone concentrations.

Other influencing parameters are certainly still the panel member and panel leader themselves and the conscientiousness they take as a basis for their measurements. To which extend e.g. the humidification of the acetone air influences the results could not yet be resolved definitively.

Another aspect that has to be mentioned is that scarcely any institute filled in the questionnaire send to them completely. Thus there is a lot of vagueness regarding the actual air flow rate (air flow rates of 0.2 to 0.4 L/s were reported to BAM) and acetone concentration at the funnels (partially concentrations 2 pi below the should-be value were reported).

Furthermore the lacquer sample sent to the participants for measurement was a freshly developed candidate for a VOC referencing material that was supplemented by some odorous substances to be applicable for the odour measurement as well. To what extend the odour of the chosen substances in the lacquer is well or poorly measurable by panellists was not tested and could be another cause for the deviations that were determined within the RR14.

Summing up the informational value of this round robin test is limited under the current conditions and the maximum utilisation of variances allowed by the ISO 16000-28.

Nonetheless the relative standard deviations of reproducibility for the RR12 (38.9% for the original evaluation and 23.8% for the re-evaluated results) and RR14 with 29.6% are quite comparable to average VOC interlaboratory tests that normally produce relative standard deviations between 20 and 30 %. But even for VOC interlaboratory comparisons for some substances relative standard deviations significantly above 30% are possible [e.g. BAM 2009; DiBt 2007; ECA 21].

9 Outlook

The interlaboratory odour test 2014 does not allow for a coherent statement regarding the pilot phase for the implementation of odour measurements into the evaluation of building products but is a step in the right direction to establish the odour measurement method for the evaluation of products e.g. for the Blue Angel or the AgBB-scheme.

As most important tool to improve the odour measurement method the ISO 16000-28 has to be revised and plain but strict requirements have to be determined. Moreover the detailed record of frame conditions of the odour measurement should be obligatory. The implementation of a checklist or questionnaire, that has to be filled in for each measurement, could be a valuable tool for the quality management and also could improve the comparability between institutes. Moreover it would simplify quality audits and the uncovering of deficits that might be missed e.g. by the panel members or the panel leader.

The development of a comprehensive quality management tool for the odour measurements especially regarding the perceived intensity should be aimed at to guarantee for a consistently

standardised measurement method and to allow for independent and significant audits and accreditation based on a measurable basis.

Moreover the impact of temperature variation on (gastight wrapped) samples for example during storage or during the transport to the measurement institutes should be tested and ideally be correlated to VOC measurements as well previously to further comprehensive measurements.

10 Acknowledgement

We thank the following institutes for the participation in the odour round robin test in 2014:

Institute	**Contact person**	**Location**
BAM Bundesanstalt für Materialforschung und -prüfung	Olaf Wilke / Wolfgang Horn	Berlin; Germany
Berner Fachhochschule; Architektur, Holz und Bau	Ingo Mayer	Biel; Switzerland
Bremer Umweltinstitut GmbH	Jutta Mertens	Bremen; Germany
Certech	Tiphaine Pacary / Catherine Henneuse	Seneffe; Belgium
Danish Technological Institute; Wood Technology - Indoor Environment	Helene B. Klinke	Taastrup; Denmark
Eco Institute	Alexandra Kühn	Köln, Germany
Entwicklungs- und Prüflabor Holztechnologie GmbH; Chemische Prüfung	Anne Kuban	Dresden; Germany
Eurofins Product Testing A/S	Charlotte Greve Tolbøl	Galten; Denmark
Eurofins Testing Technology (Shenzhen) Co Ltd; Chemical	Jack Lu	Shenzhen; China
Finnish Institute of Occupational Health; Laboratory of Chemistry	Katri Härkönen	Helsinki; Finland
Fraunhofer WKI; Fachbereich MAIC	Erik Uhde / Nicole Schulz	Braunschweig; Germany
Fraunhofer-Institut für Bauphysik; IBP	Florian Mayer	Valley, Germany
Fraunhofer-Institut für Chemische Technologie ICT; Umwelt-Engineering	(René Bison), Beatrice Tuebke, Sonja Lauinger	Pfinztal, Germany
HTW-Berlin	Alexander Mertes / Birgit Müller	Berlin, Germany
MPA Eberswalde Materialprüfanstalt Brandenburg GmbH	Robby Wegner	Eberswalde; Germany
Odournet GmbH; P&M	Björn Maxeiner	Kiel; Germany
SCAS Chiba	Masashi Murakami	Chiba, Japan
TFI Aachen	Gerd Bittner	Aachen, Germany
TÜV Rheinland LGA	Volker Mendrok	Nürnberg, Germany
TÜV Süd	Holger Struwe	München, Germany
Wessling GmbH	Christopher Teichmann	Altenberge, Germany

Moreover we would like to thank the German Environmental Agency (UBA) for the financial support.

11 Reference List

[AgBB 2012] Committee for Health-related Evaluation of Building Products (AgBB) (2012) A contribution to the Construction Products Directive: Health-related Evaluation Procedure for Volatile Organic Compounds Emissions (VOC and SVOC) from Building Products. http://www.umweltbundesamt.de/sites/default/files/medien/355/dokumente/agbb_evaluation_scheme_2012.pdf (checked 30.10.2014)

[BAM 2009] Wilke, O., Horn, W., Wiegner, K., Jann, O., Bremser, W., Brödner, D., Kalus, S., Juritsch, E., Till, C.: Investigations for the improvement of the measurement of volatile organic compounds from floor coverings within the healthrelated evaluation of building products, BAM Bundesanstalt für Materialforschung und -prüfung, Final Report, 2009. Berlin

(http://www.bam.de/en/service/publikationen/publikationen_medien/abschlussbericht_engl_ils_dibt_2009.pdf)

[Brosig 2013] Brosig L., Horn W., Pyza L., Jann O., Plehn W. (2013) Gefahrstoffe – Reinhaltung der Luft "Round Robin Test for the Implementation of Odour Measurement according to DIN ISO 16000-28 into the Assessment of Emissions from Building Products", Berlin

[Brosig 2014] Brosig, L., Horn, W., Pyza, L., Jann, O., Ringversuch zur Einführung der Geruchsmessungen nach DIN ISO 16000-28 in die Bewertung von Bauprodukten. Umweltbundesamt Texte, Dessau, 2014 (in press)

[DiBt 2007] Kirchner, D., Emissionsmessungen auf dem Prüfstand. DIBt Mitteilungen, 2007: p. 77-85.

[ECA 21] European Commission - Joint Research Centre - Environment Institute, ECA Report No 21 - European Inter-laboratory Comparison on VOC emitted from building materials and products, 1999. Office for Official Publications of the European Communities, Luxembourg

[Horn 2007] W. Horn; O. Jann; J. Kasche; F. Bitter; D. Müller; B. Müller (2007) Environmental and Health Provisions for Building Products - Identification and evaluation of VOC emissions and odour exposure UBA-Texte 21/2007. Umweltbundesamt, Dessau http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3247.pdf (checked 30.10.2014)

[ISO 16000-3] ISO 16000-3 (2011) International Organization for Standardization (ISO) Indoor Air - Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air - Active sampling method (ISO 16000-3:2011)

[ISO 16000-4] ISO 16000-4 (2004) International Organization for Standardization (ISO) Indoor Air - Part 4: Determination of formaldehyde - Diffusive sampling method. (ISO 16000-4:2004)

[ISO 16000-5] ISO 16000-5 (2007) International Organization for Standardization (ISO) Indoor Air - Part 5: Sampling strategy for volatile organic compounds (VOCs) (ISO16000-5:2007)

[ISO 16000-6] ISO 16000-6 (2011) International Organization for Standardization (ISO) Indoor Air - Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA® sorbent, thermal desorption and gaschromatography using MS or MS-FID (ISO 16000-6:2011)

[ISO 16000-9] ISO 16000-9 (2006) International Organization for Standardization (ISO) Indoor Air - Part 9: Determination of the emission of volatile organic compounds from building products and furnishing — Emission test chamber method, Beuth Verlag, Berlin

[ISO 16000-10] ISO 16000-10 (2006) International Organization for Standardization (ISO) Indoor Air - Part 10: Determination of the emission of volatile organic compounds from building products and furnishing - Emission test cell method (ISO 16000-10:2006)

[ISO 16000-11] ISO 16000-11 (2006) International Organization for Standardization (ISO) Indoor Air - Part 11: Determination of the emission of volatile organic compounds from building products and furnishing - Sampling, storage of samples and preparation of test specimens (ISO 16000-11:2006)

[ISO 16000-28] ISO 16000-28 (2012) International Organization for Standardization (ISO) Indoor Air - Part 28: Determination of odour emissions from building products using test chambers (ISO 16000-28:2012)

[Müller 2011] B. Müller; J. Panašková; M. Danielak; W. Horn; O. Jann; D. Müller (2011) Sensory-based evaluation of building product emissions Integration into the Blue Angel award criteria and assessment scheme of the Committee for Health Evaluation of Building Products http://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4186.pdf (checked 30.10.2014)

[Nohr 2014] Nohr, Michael, PhD thesis: “Development of a material with reproducible emission of selected volatile organic compounds“ Berlin, submitted 2014

[VDI 4302-1] VDI 4302 Blatt 1 (Entwurf): Geruchsprüfung von Innenraumluft und Emissionen aus Innenraummaterialien; Grundlagen; Beuth Verlag; Berlin Mai 2012

Annex A. Temperature Data during the Samples Transport

Annex A.1 RR14_02

Keylog: 14.1 to 28.8°C; mean: 22.43°C

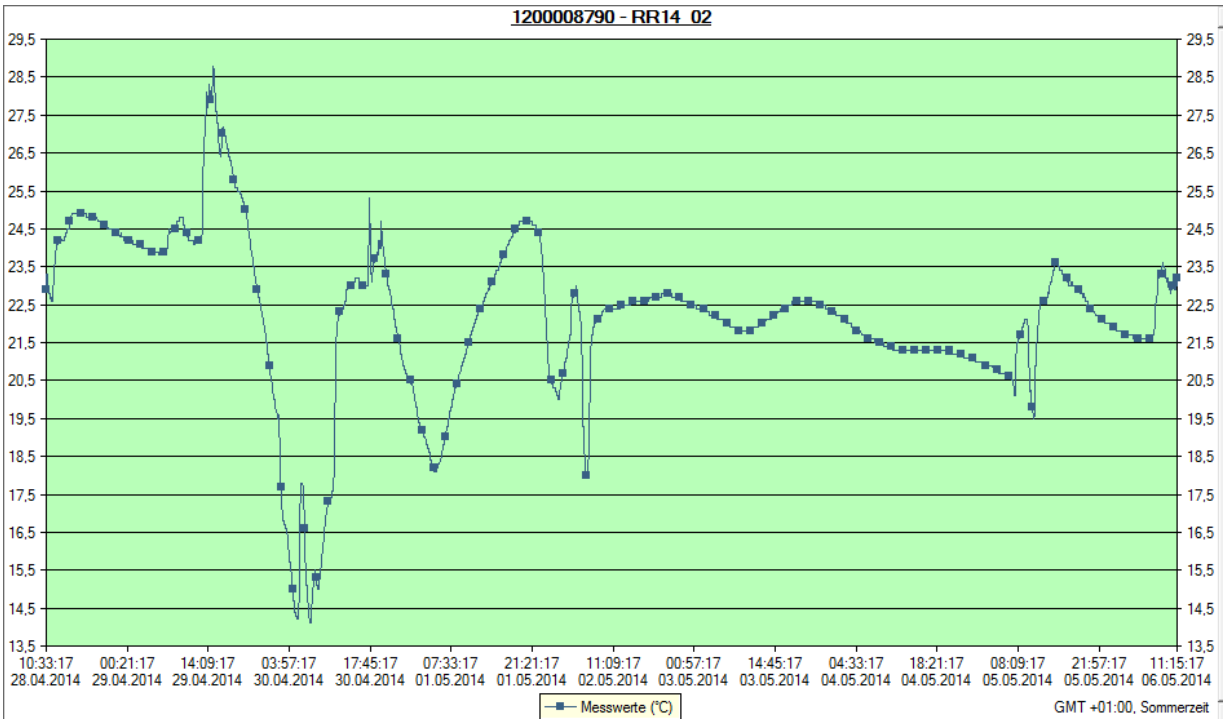


Figure 23 RR14_02 transport temperature data

Annex A.2 RR14_05

Keylog: 4.4°C to 32.2°C; mean 23.56°C

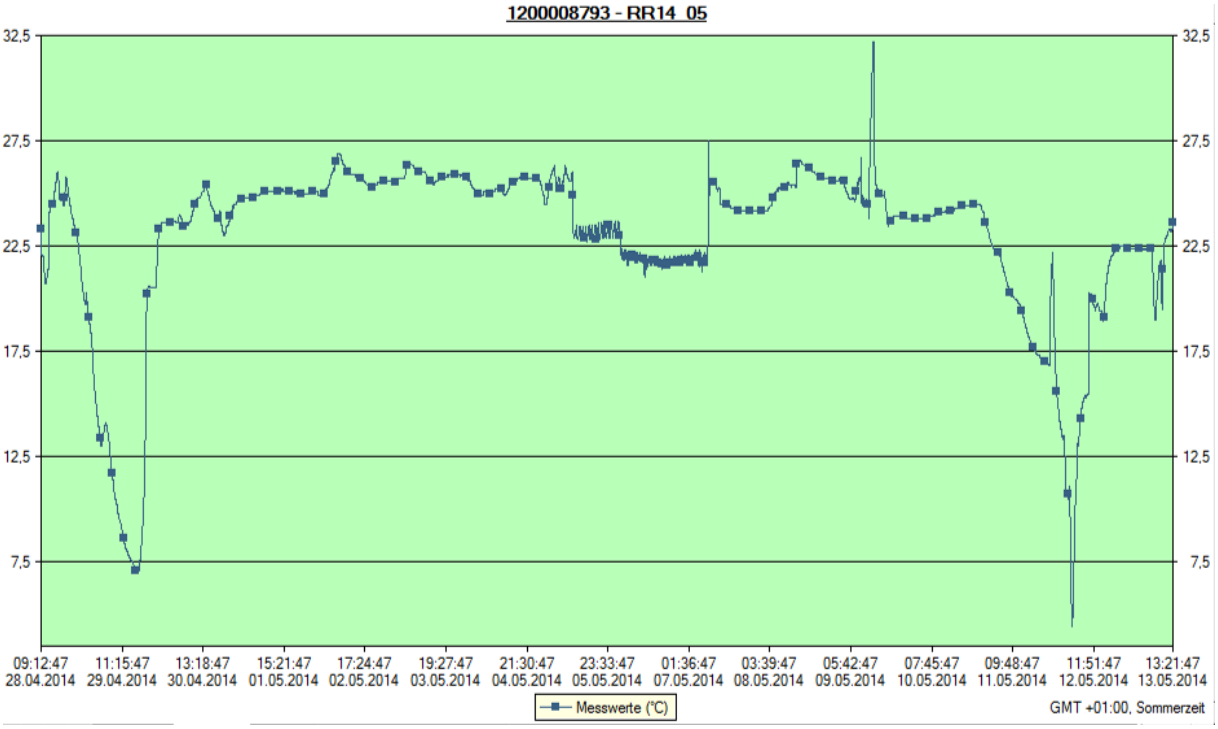


Figure 24 RR14_05 transport temperature data

Annex A.3 RR14_07

Keylog: 13.1 to 28.5°C; mean: 21.92°C

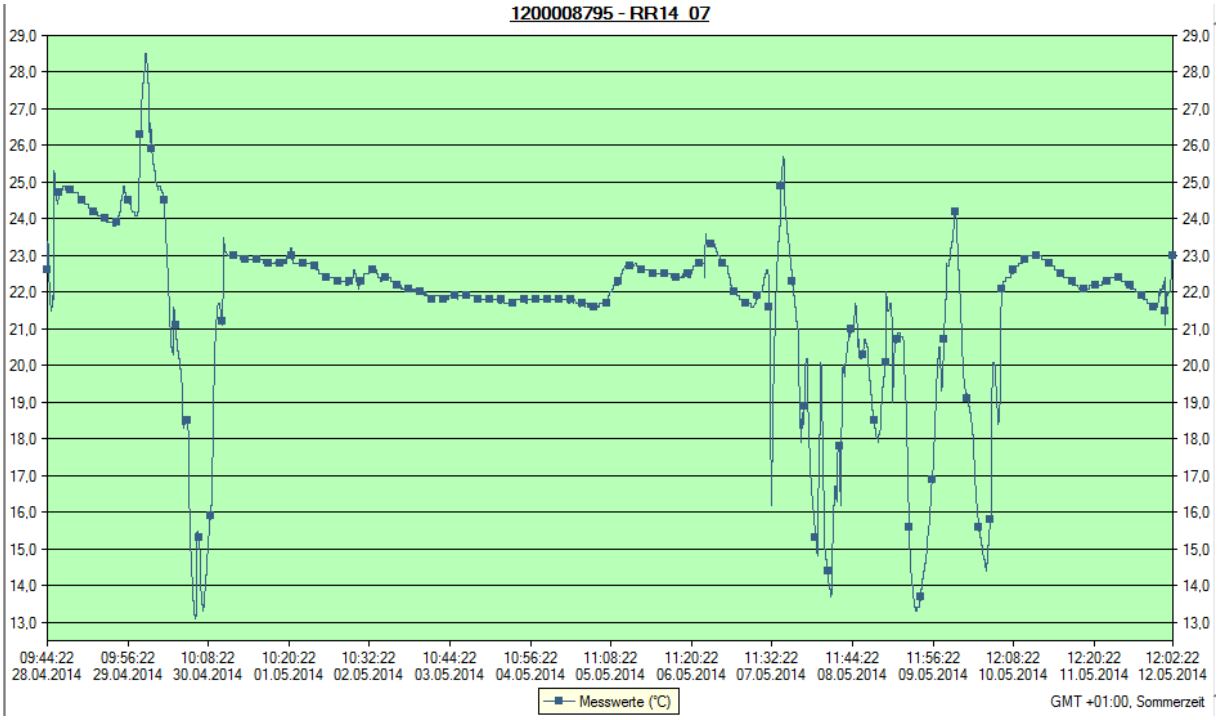


Figure 25 RR14_07 transport temperature data

Annex A.4 RR14_09

Keylog: 12.8 to 26.9°C; mean: 21.70°C

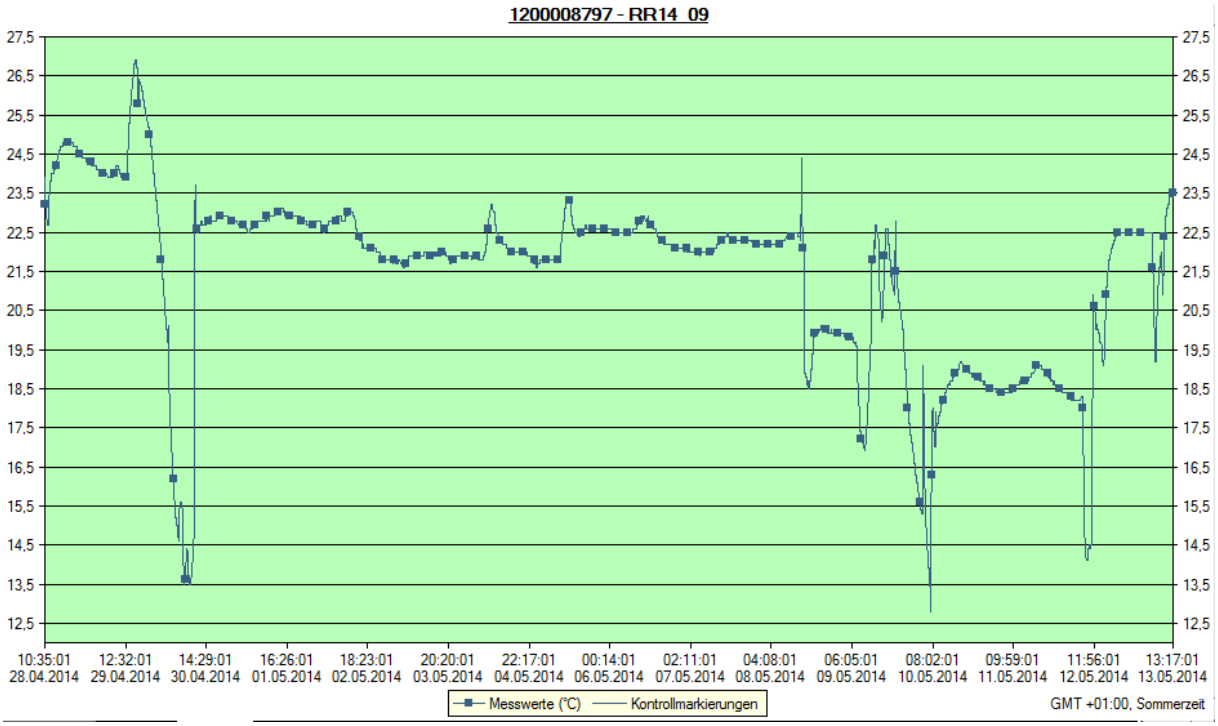


Figure 26 RR14_09 transport temperature data

Annex A.5 RR14_10

Keylog: 5.5 to 26.0°C; mean: 9.91°C

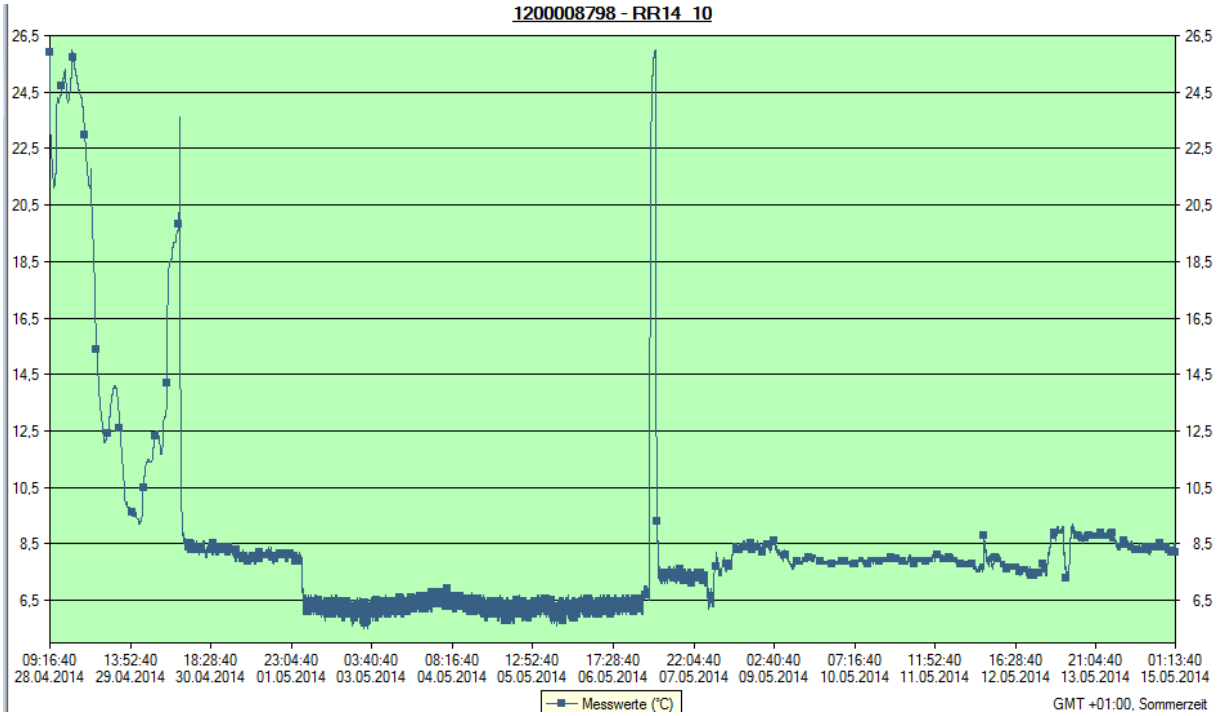


Figure 27 RR14_10 transport temperature data

Annex A.6 RR14_16

Keylog: 14.2 to 30.0°C; mean: 22.61°C

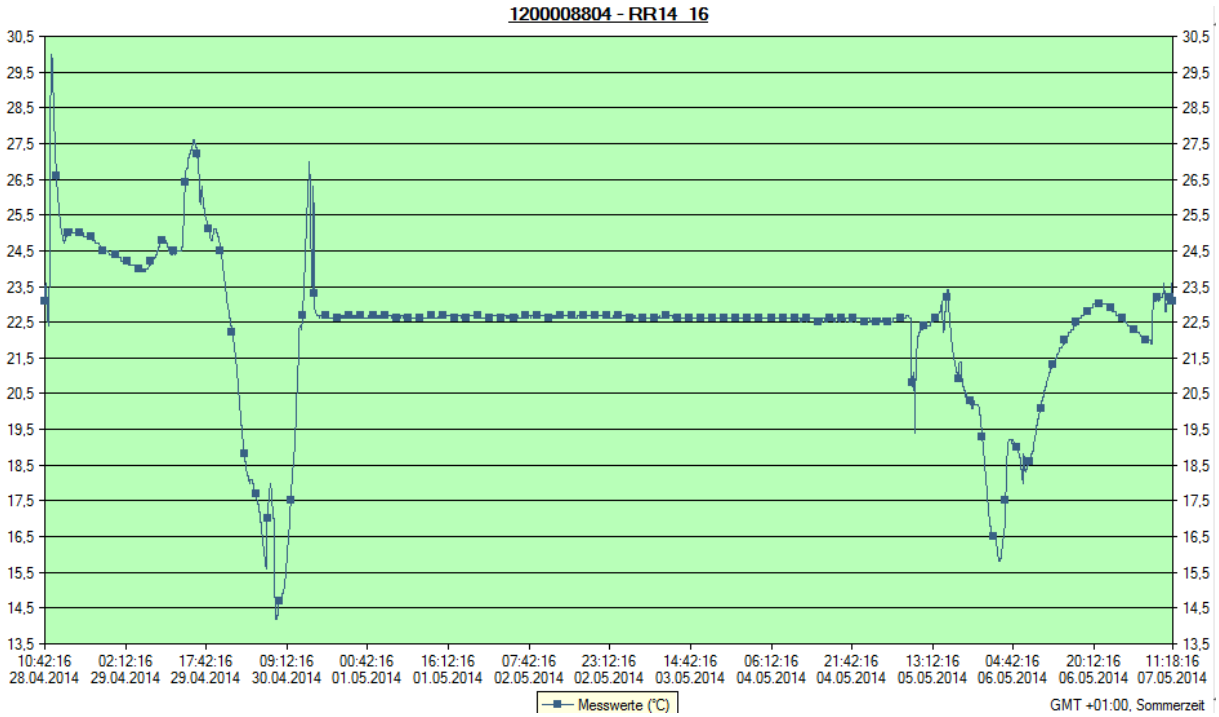


Figure 28 RR14_16 transport temperature data

Annex A.7 RR14_17

Keylog: 12.9 to 29.1°C; mean 22.35°C

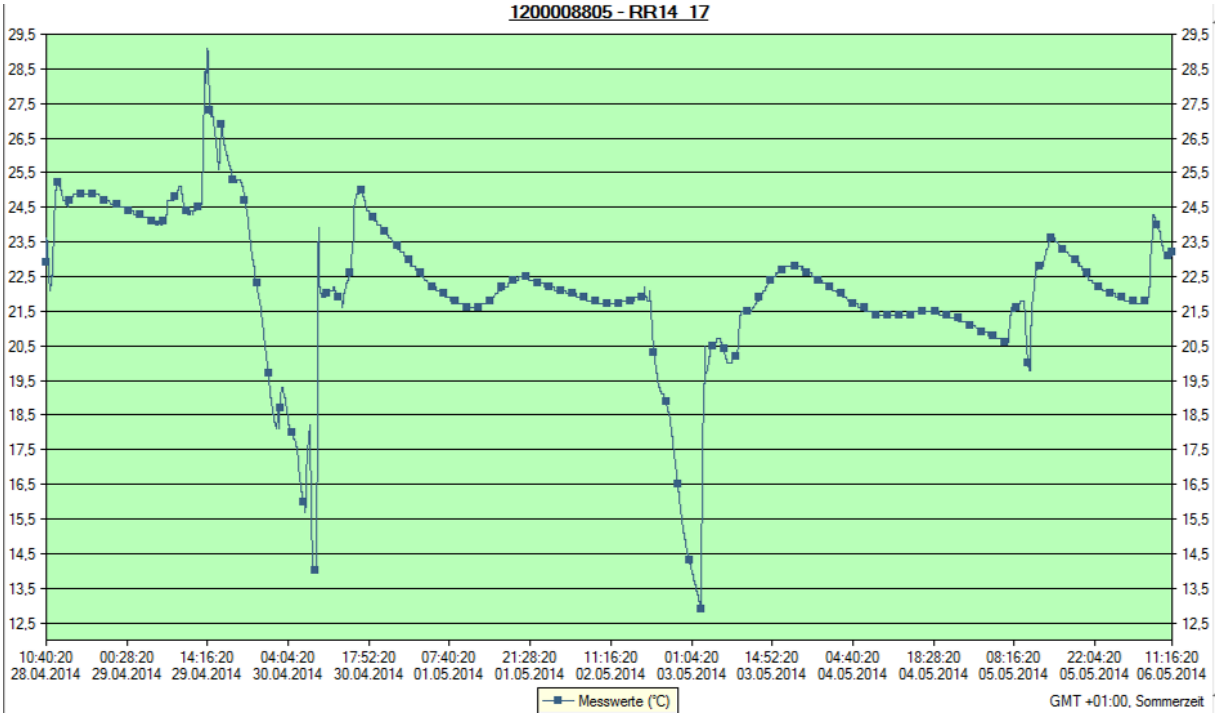


Figure 29 RR14_17 transport temperature data

Annex A.8 RR14_21

Keylog: 12.4 to 26.4°C; mean 22.92°C

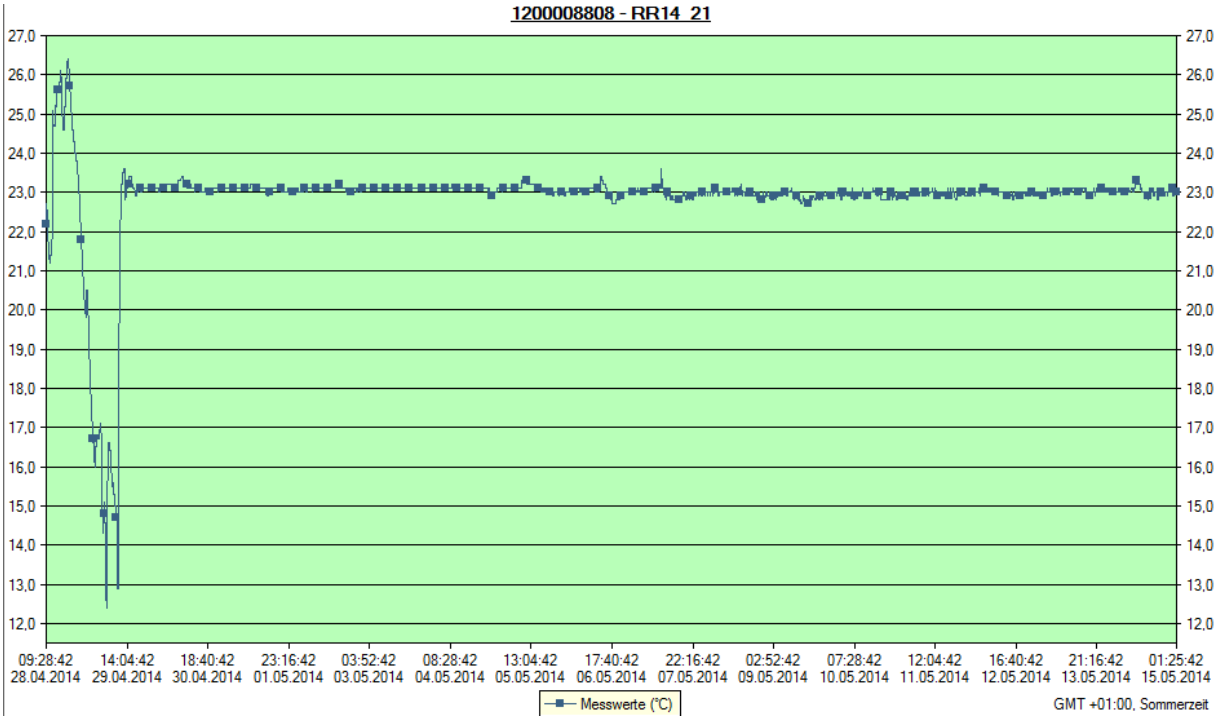


Figure 30 RR14_21 transport temperature data

Annex A.9 RR14_23

Keylog: 11.7 to 28.8°C; mean: 21.86°C

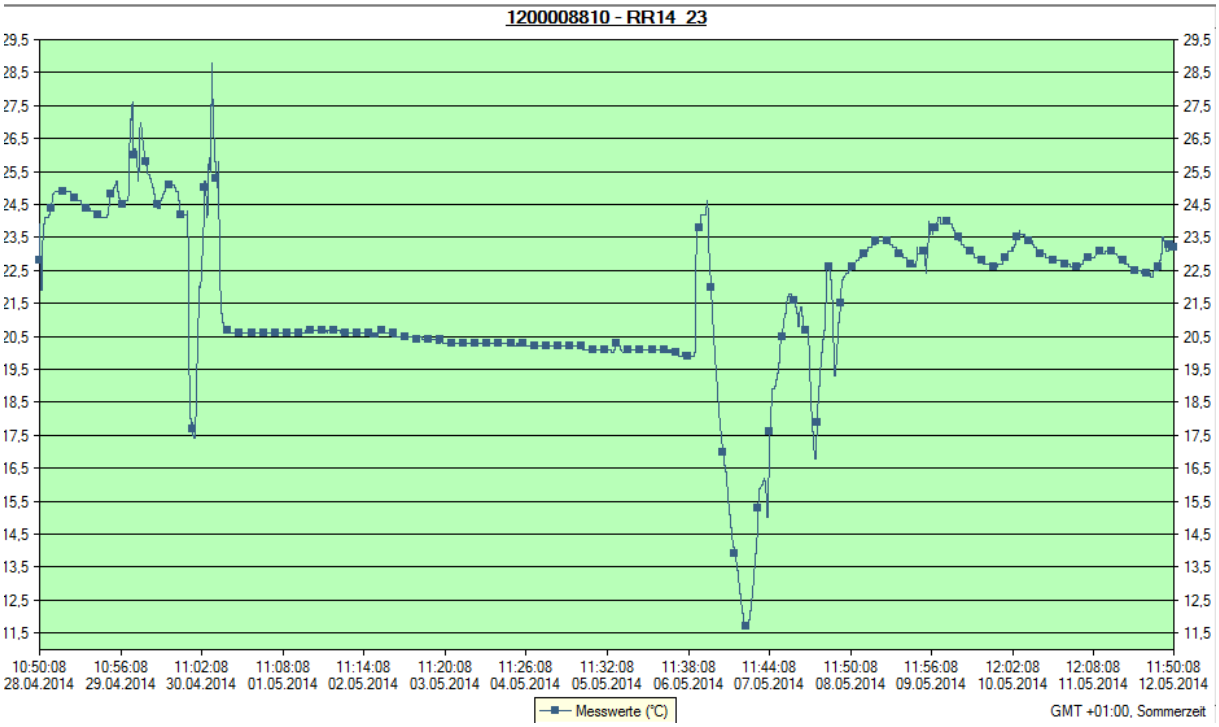


Figure 31 RR14_23 transport temperature data

Annex A.10 RR14_24

Keylog: 13.6 to 28.8°C; mean 22.67°C

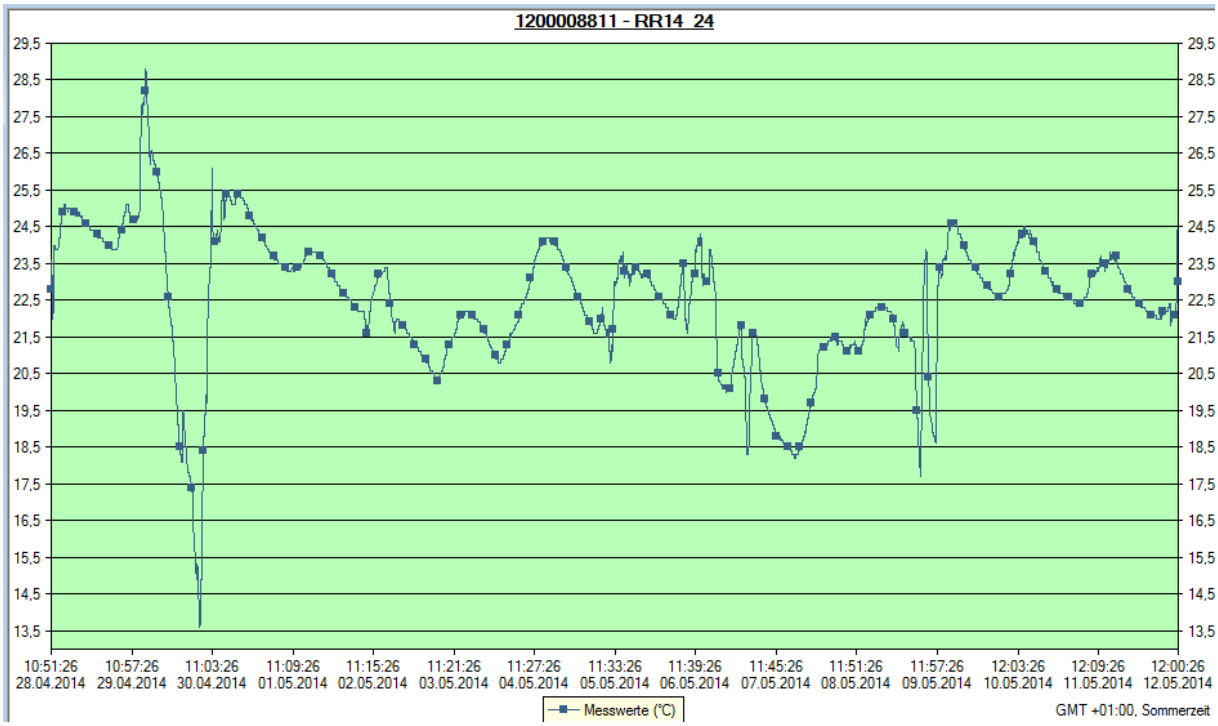


Figure 32 RR14_24 transport temperature data

Annex A.11 RR14_25

Keylog: 7.7 to 28.8°C; mean: 20.98°C

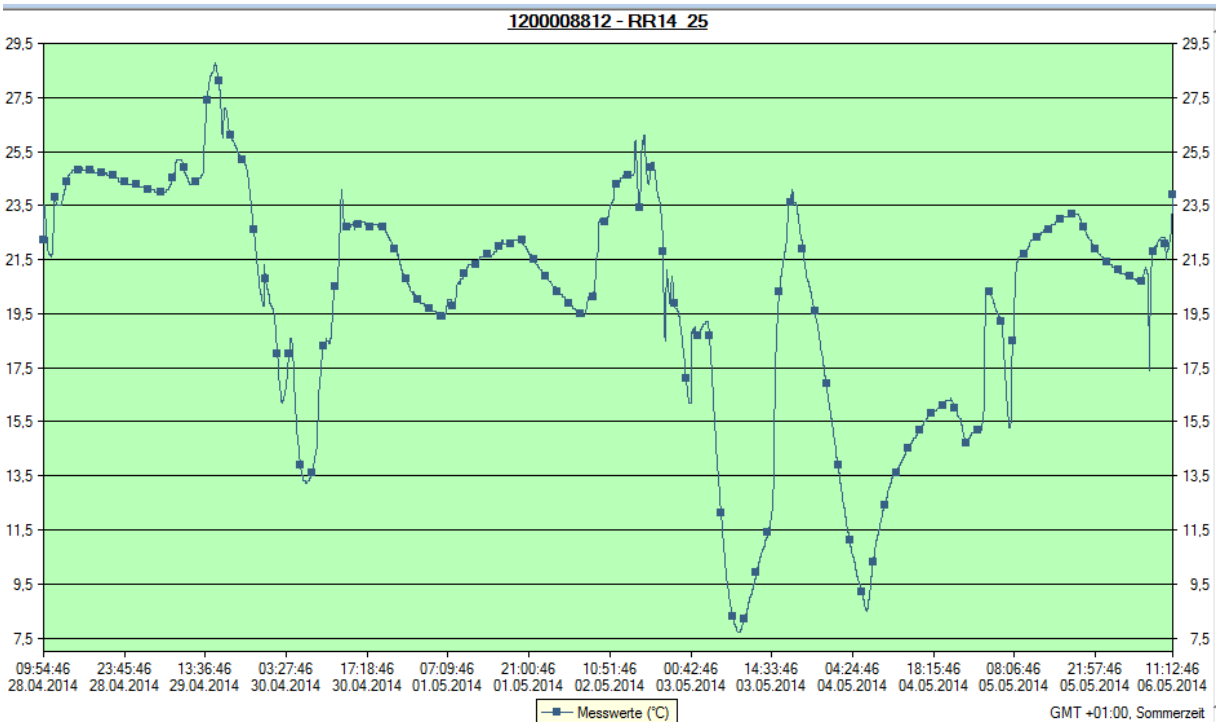


Figure 33 RR14_25 transport temperature data

Annex A.12 RR14_26

Keylog: 15.6 to 30.8°C; mean: 22.77°C

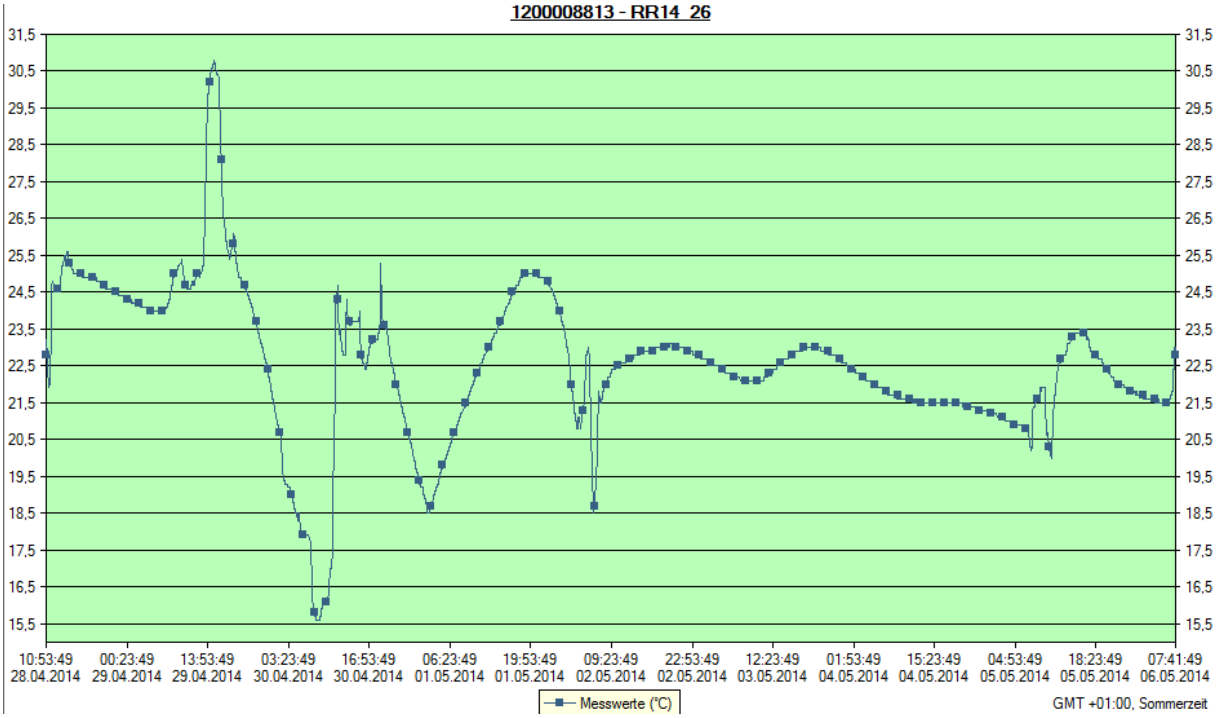


Figure 34 RR14_26 transport temperature data

Annex A.13 RR14_29

Keylog: 13.7 to 27.8°C; mean: 22.27°C

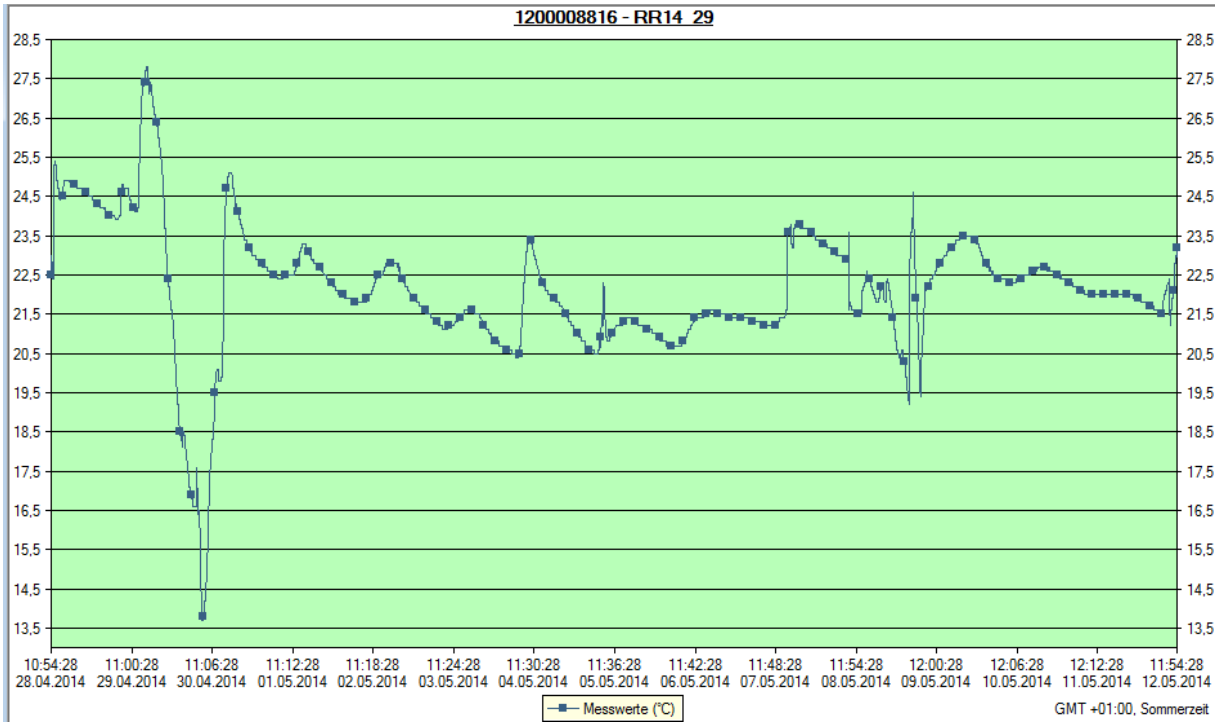


Figure 35 RR14_29 transport temperature data

Annex A.14 RR14_32

Keylog: 17.0 to 30.6°C; mean: 21.37°C

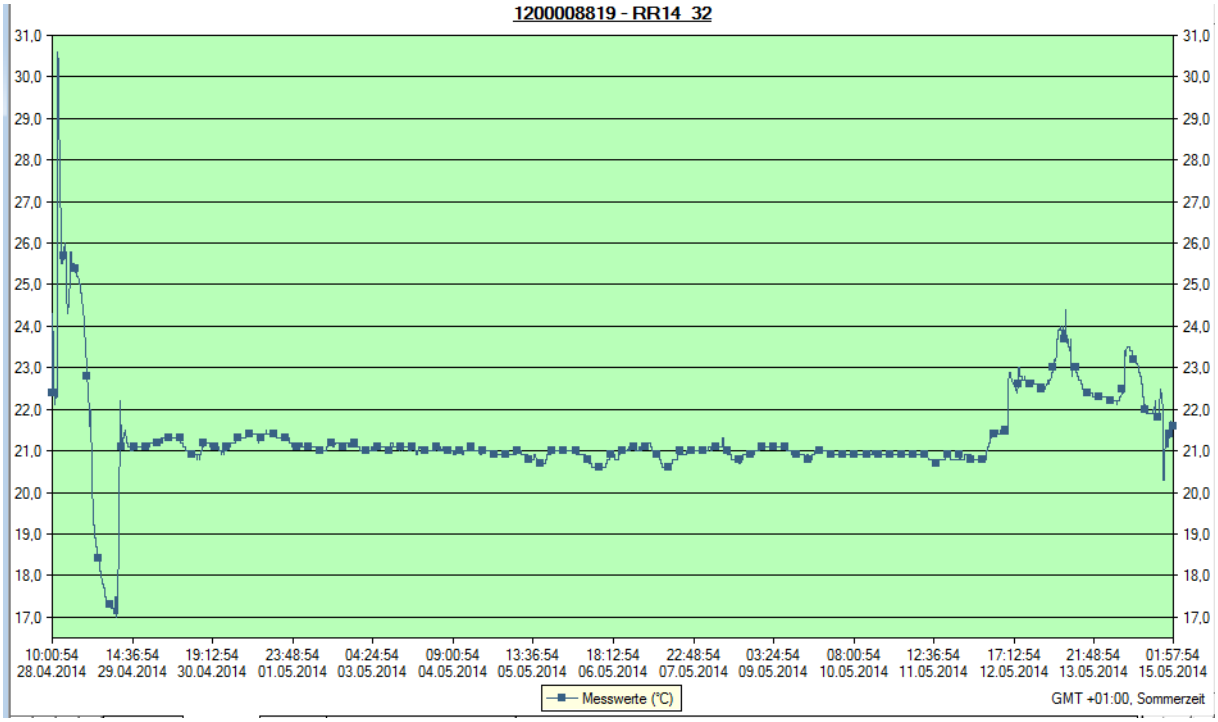


Figure 36 RR14_32 transport temperature data

Annex A.15 RR14_33

Keylog: 15.4 to 27.6°C; mean: 22.28°C

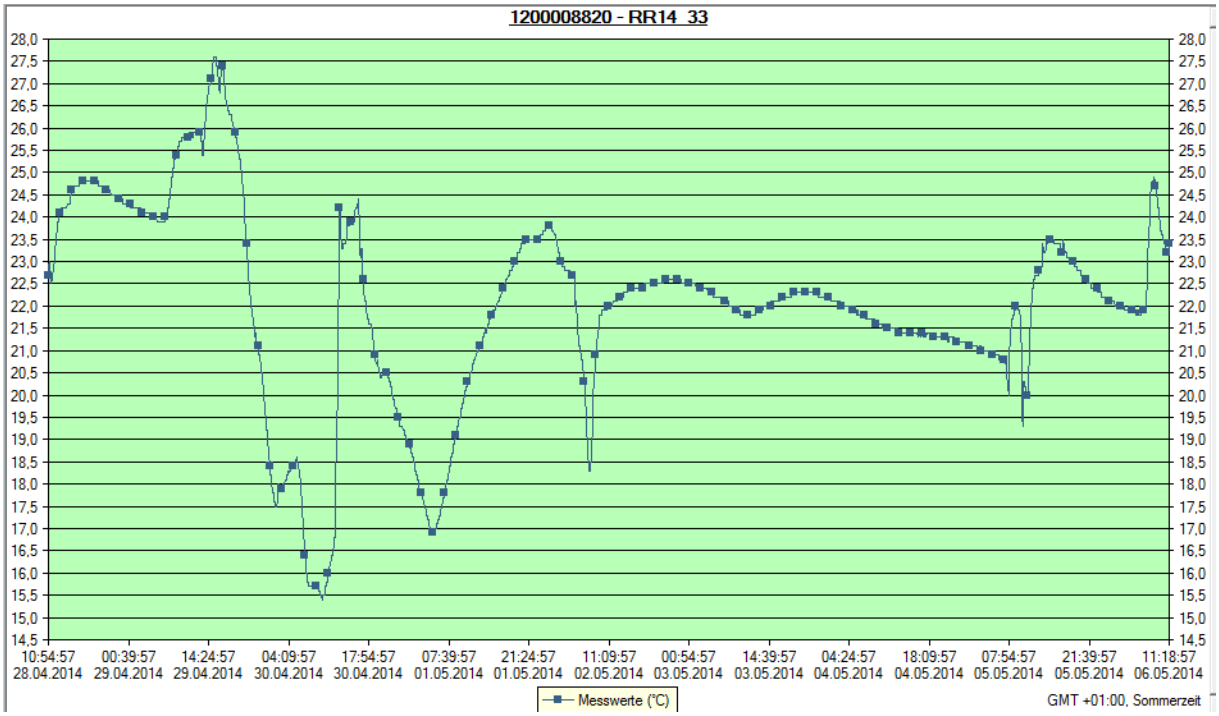


Figure 37 RR14_33 transport temperature data

Annex A.16 RR14_34

The data logger was not returned to BAM and therefore no temperature data are available.

Annex A.17 RR14_35

Keylog: 13.7 to 29.5°C; mean: 21.24

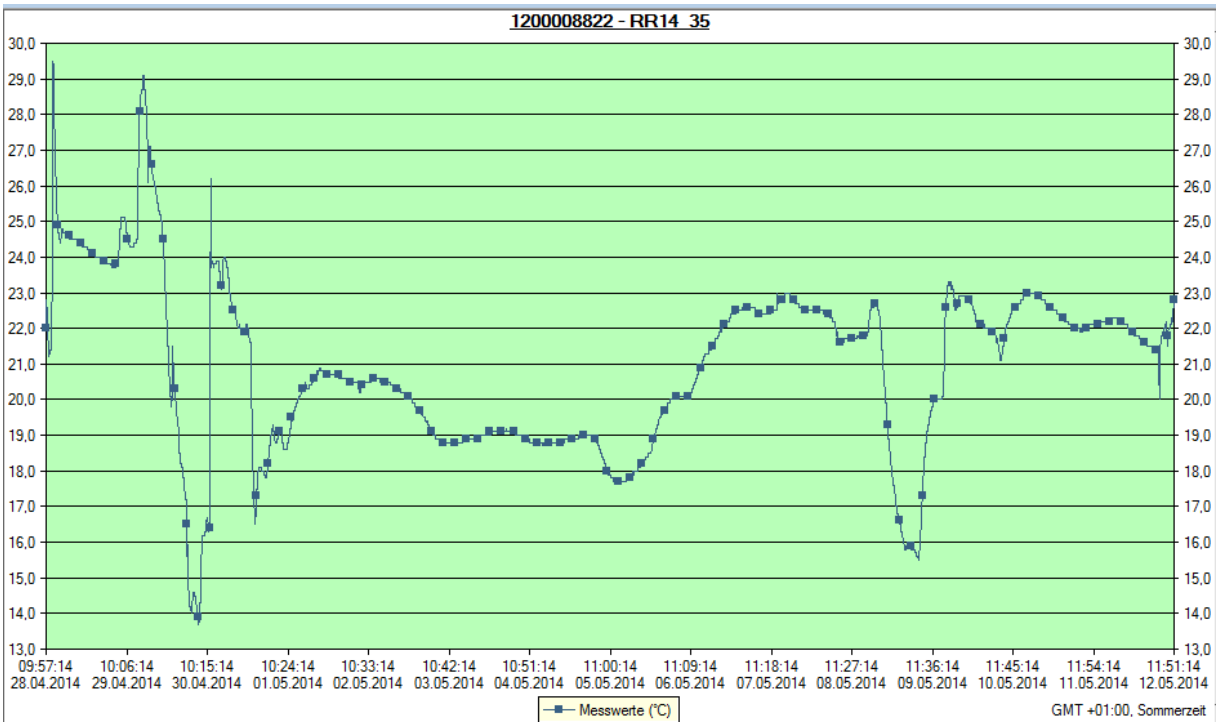


Figure 38 RR14_35 transport temperature data

Annex A.18 RR14_39

Keylog: 13.0 to 28.0°C; mean 22.69°C

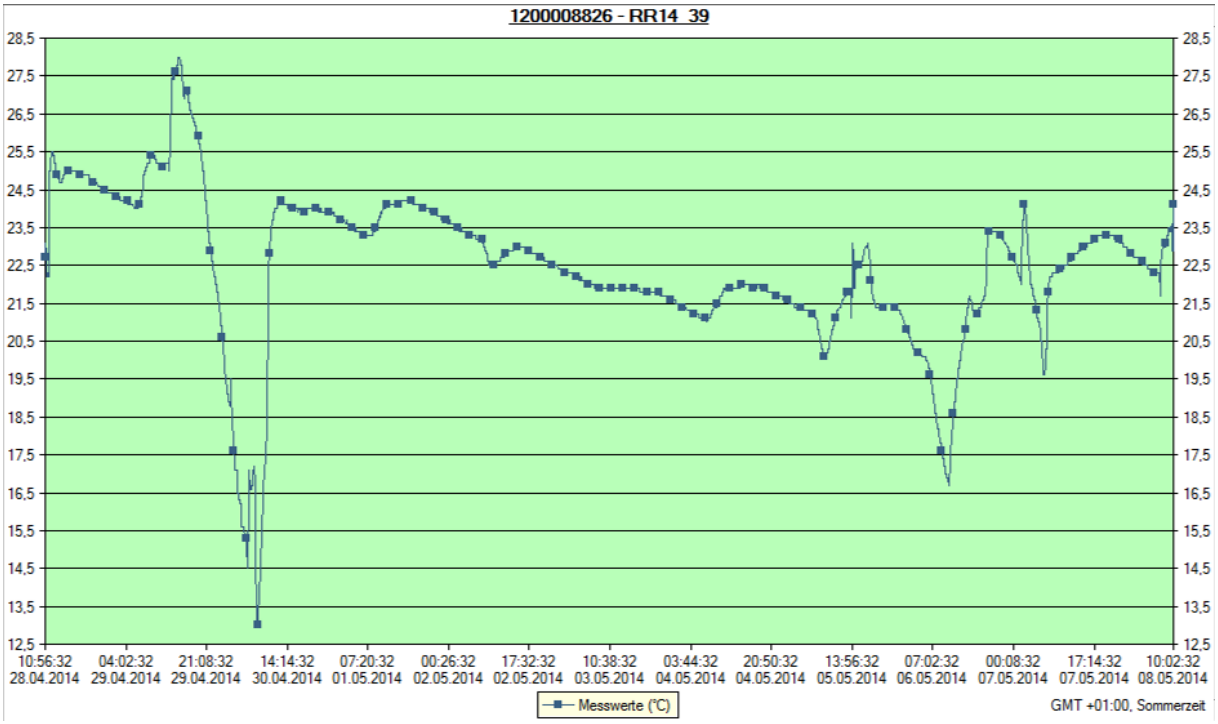


Figure 39 RR14_39 transport temperature data

Annex A.19 RR14_41

The data logger was not returned to BAM and therefore no temperature data are available.

Annex A.20 RR14_43

Keylog: 15.6 to 27.2°C; 22.56°C

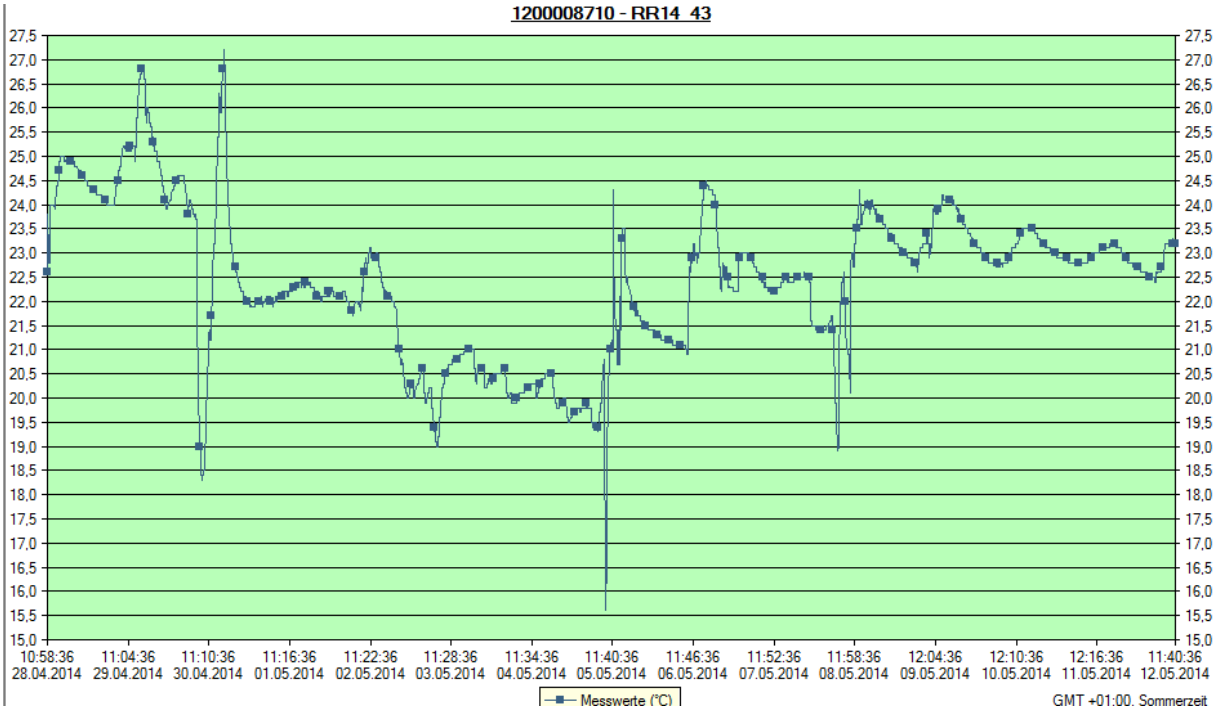


Figure 40 RR14_43 transport temperature data

Annex A.21 RR14_50

Keylog: 11.7 to 27.4; mean: 22.14°C

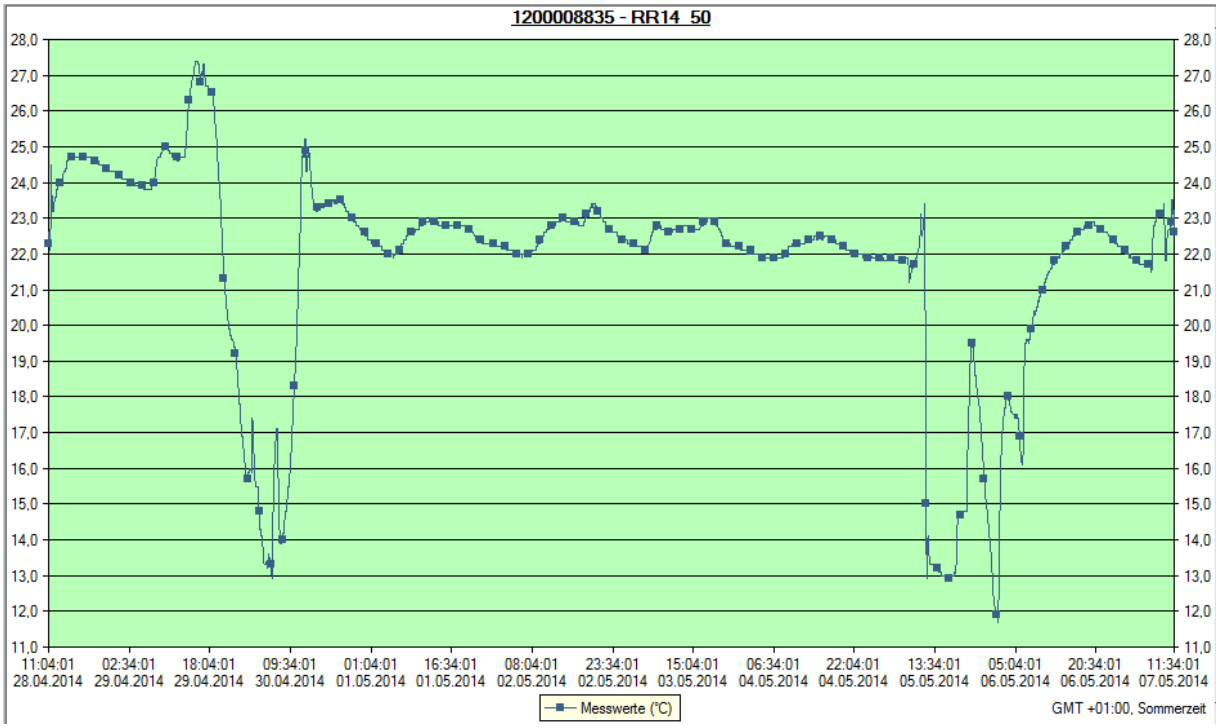


Figure 41 RR14_50 transport temperature data

Annex B. Data of Temperature and relative Humidity in the Institutes Emission Test Chambers

Annex B.1 RR14_02

Annex B.2 RR14_05

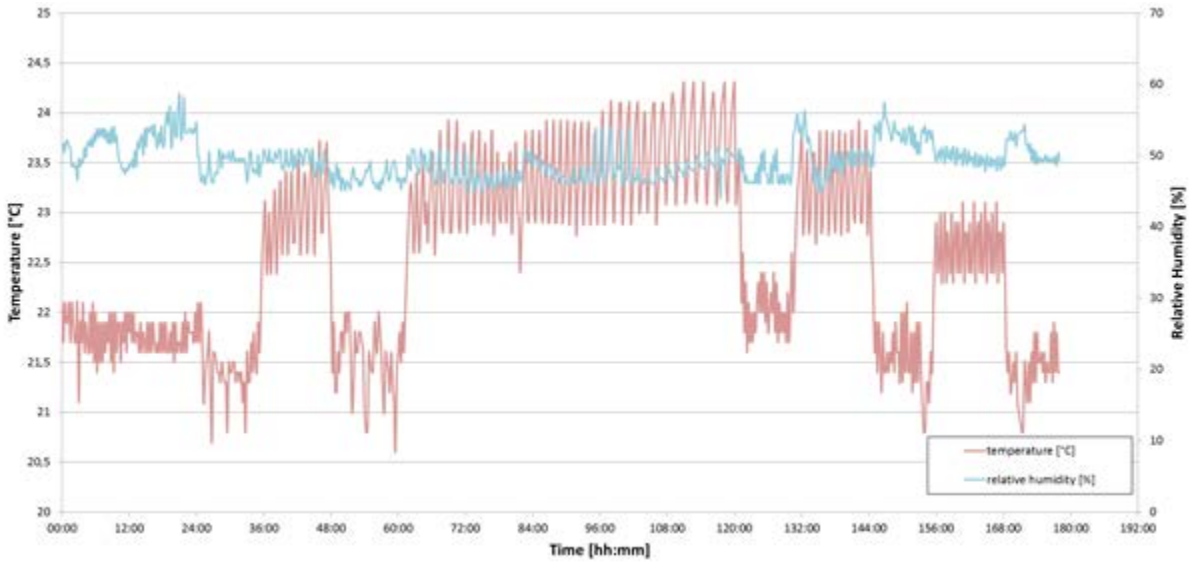
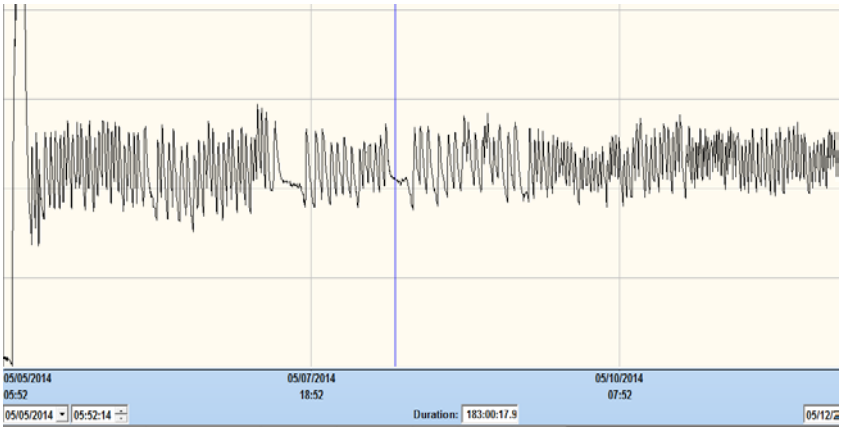


Figure 42 RR14_ 05 profiles of temperature and relative humidity in the emission test chamber

Annex B.3 RR14_07

A)



B)

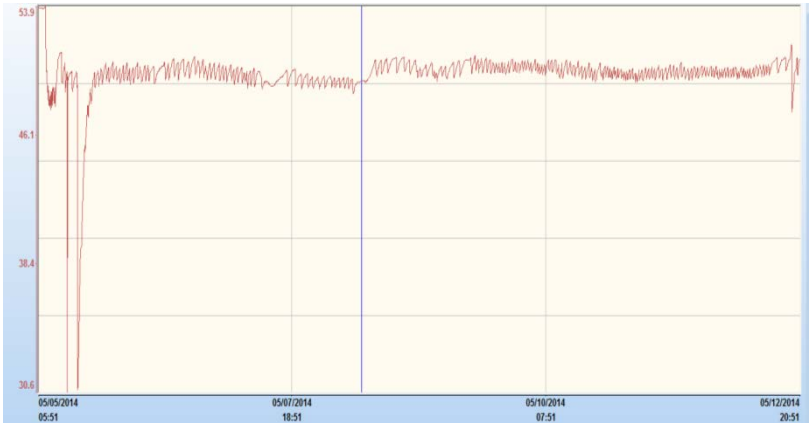
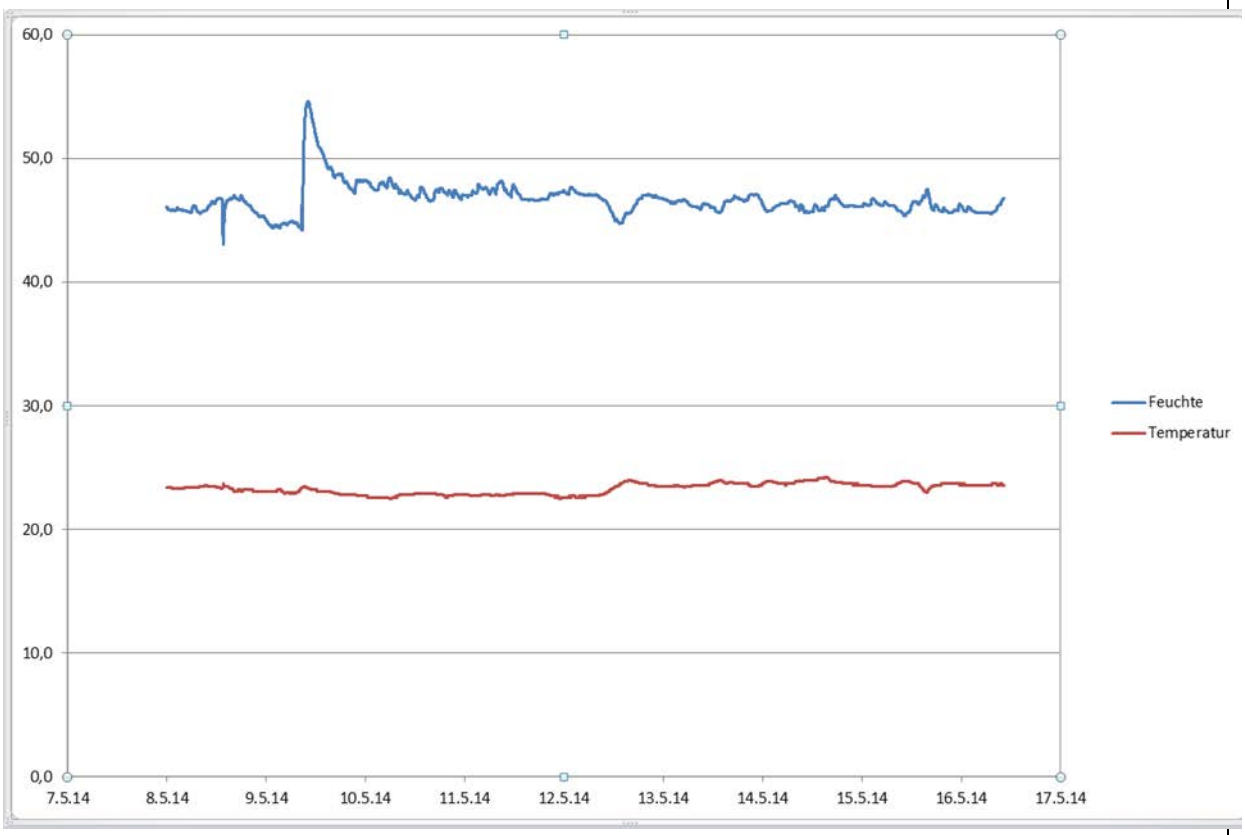


Figure 43 RR14_07 profiles of temperature (A) and relative humidity (B) in the emission test chamber

Annex B.4 RR14_09

A)



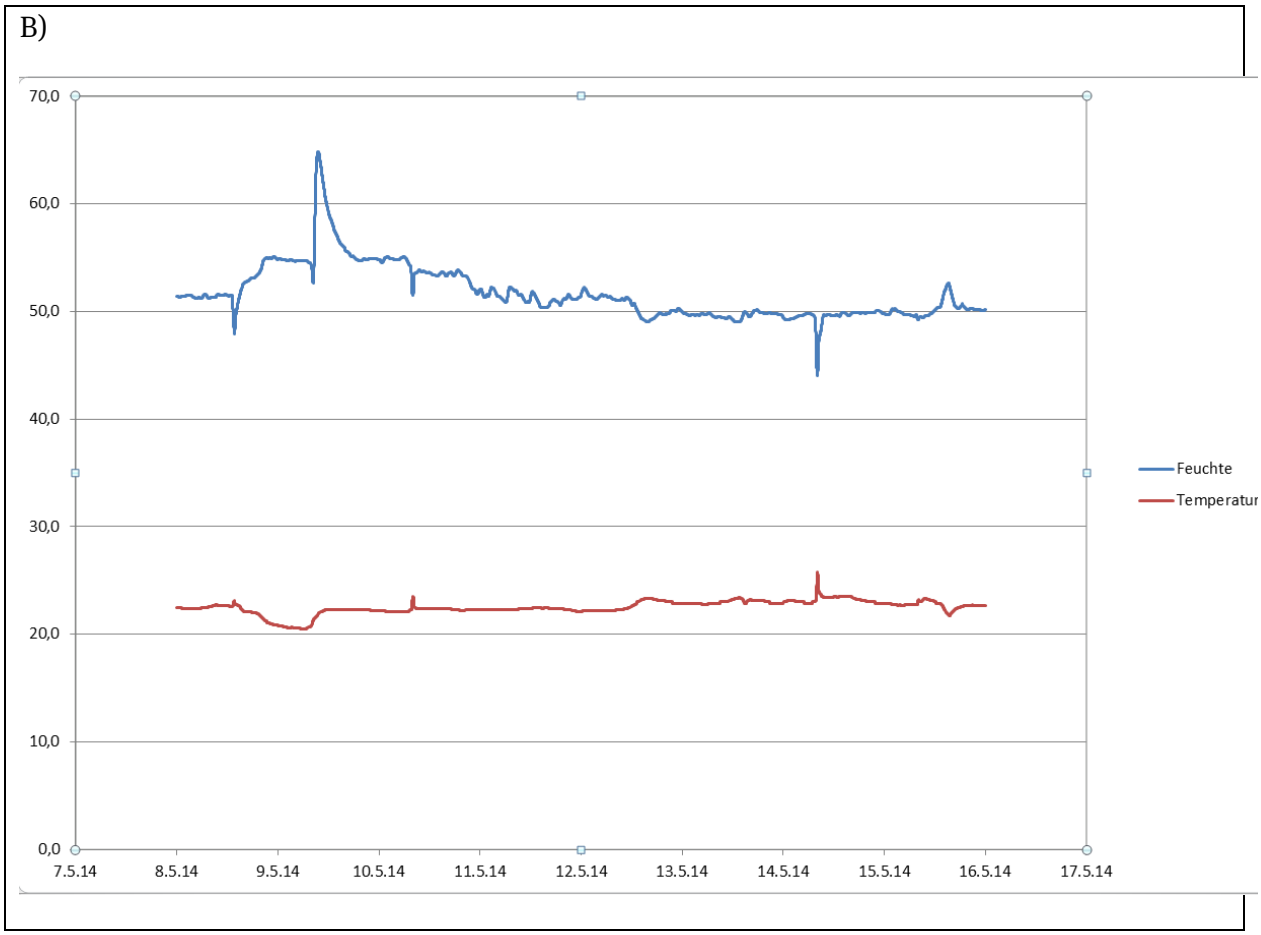


Figure 44 RR14_09 profiles of temperature and relative humidity in the emission test chambers (A) and (B)

Annex B.5 RR14_10

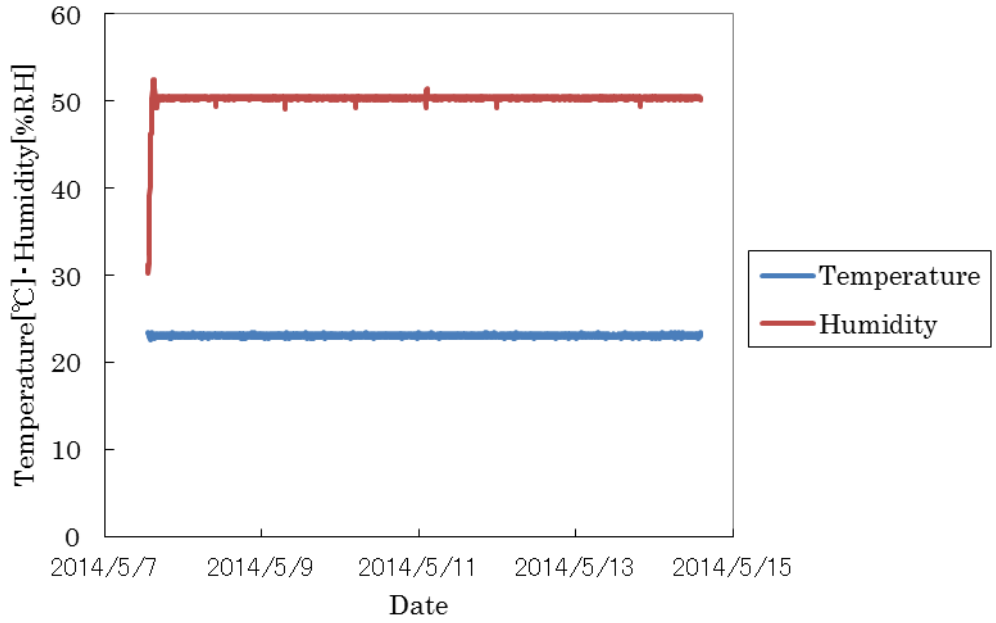
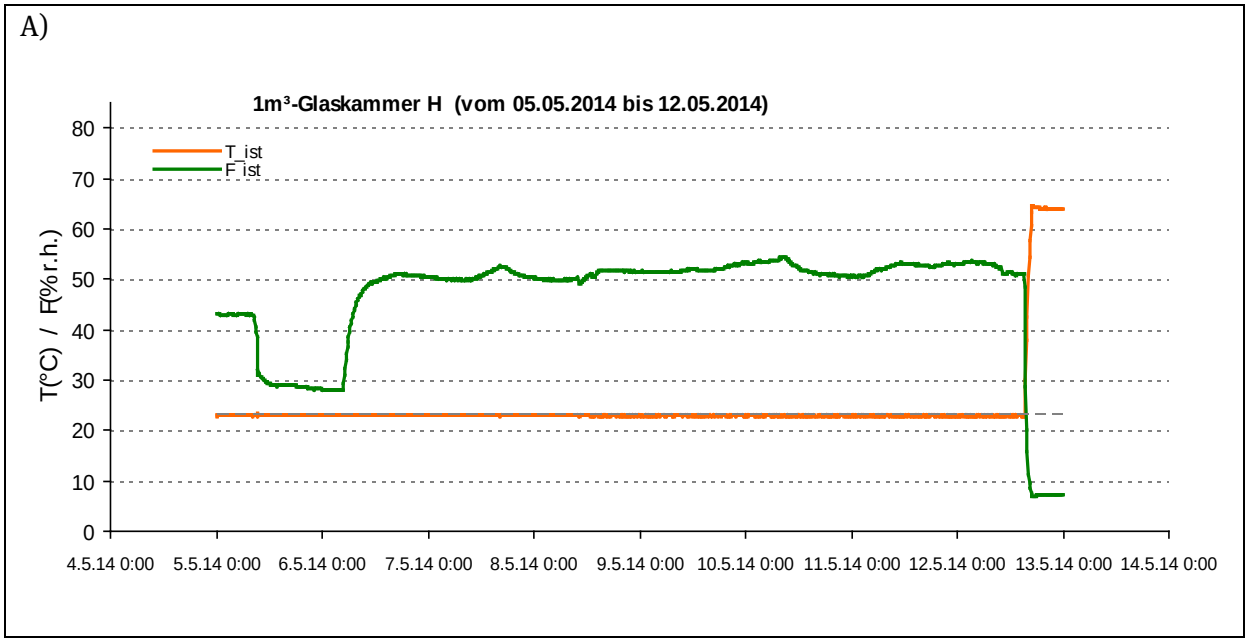


Figure 45 RR14_10 profiles of temperature and relative humidity in the emission test chamber

Annex B.6 RR14_16



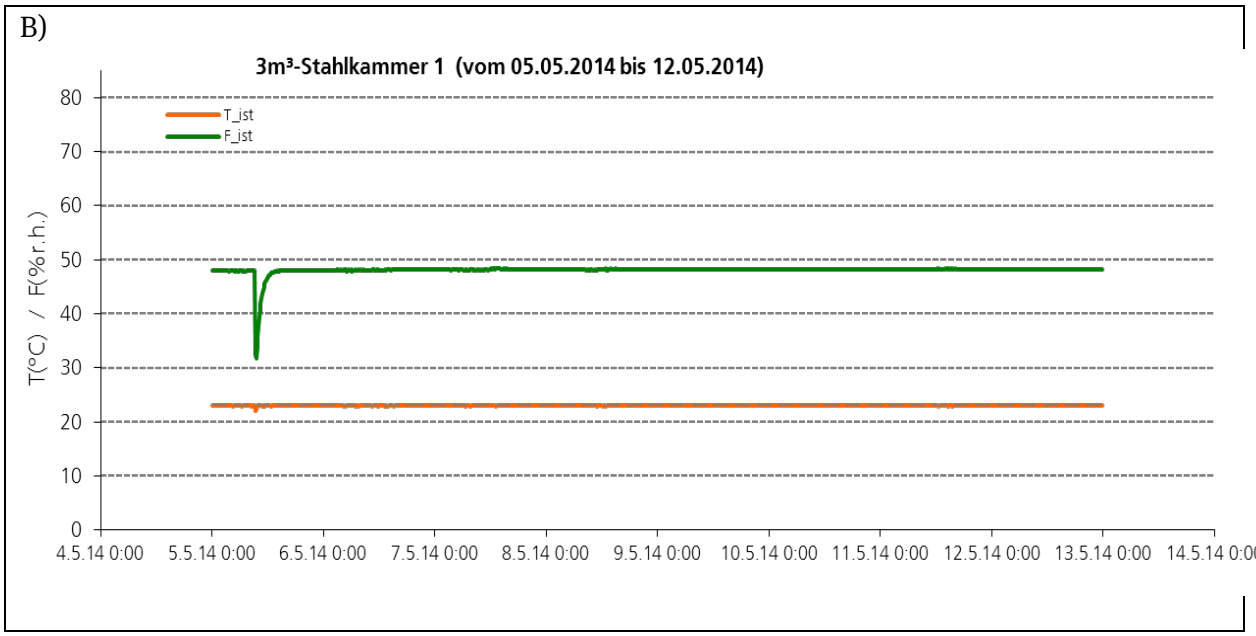


Figure 46 RR14_16 profiles of temperature and relative humidity in the emission test chambers (A) and (B)

Annex B.7 RR14_17

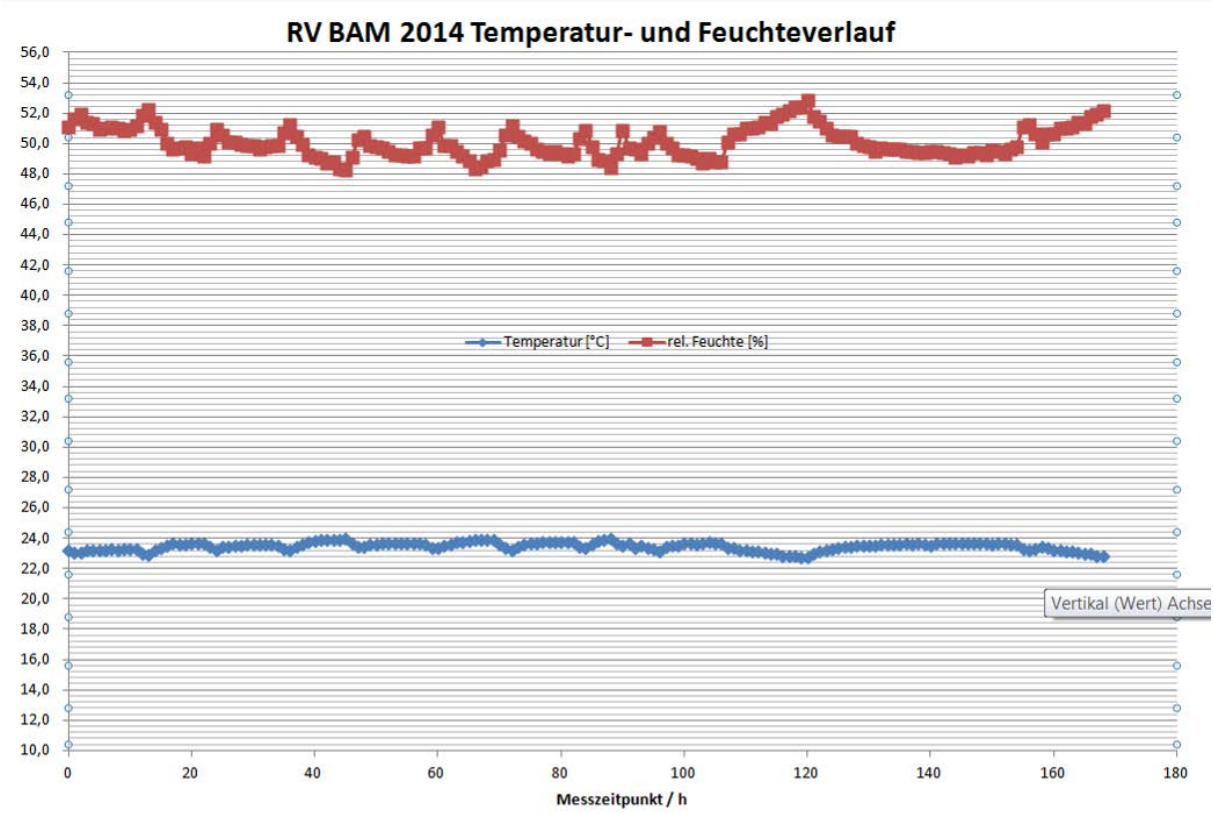


Figure 47 RR14_17 profiles of temperature and relative humidity in the emission test chamber

Annex B.8 RR14_21

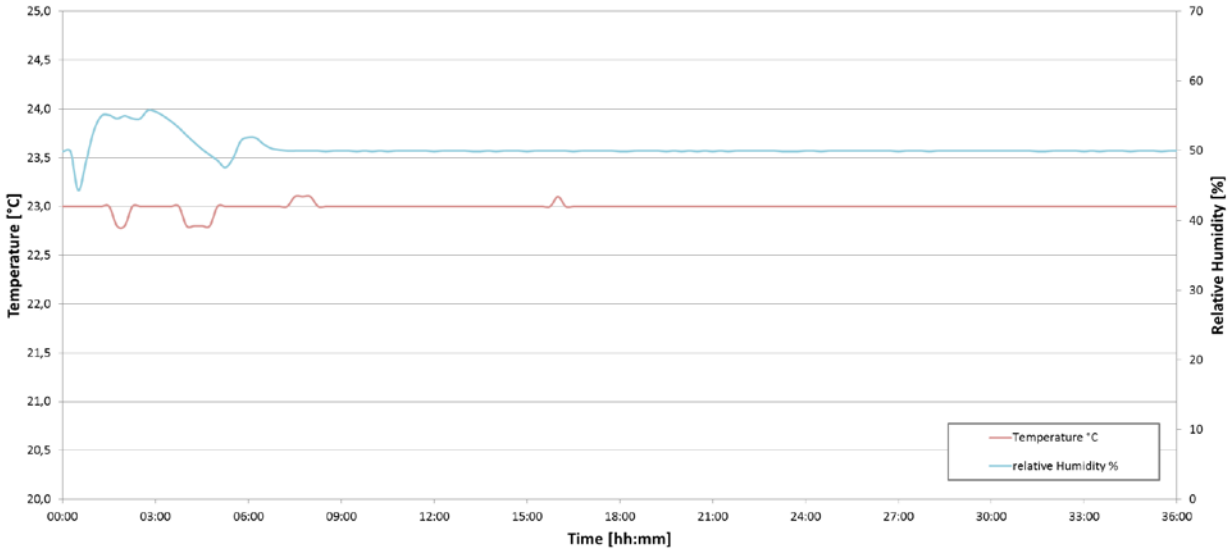
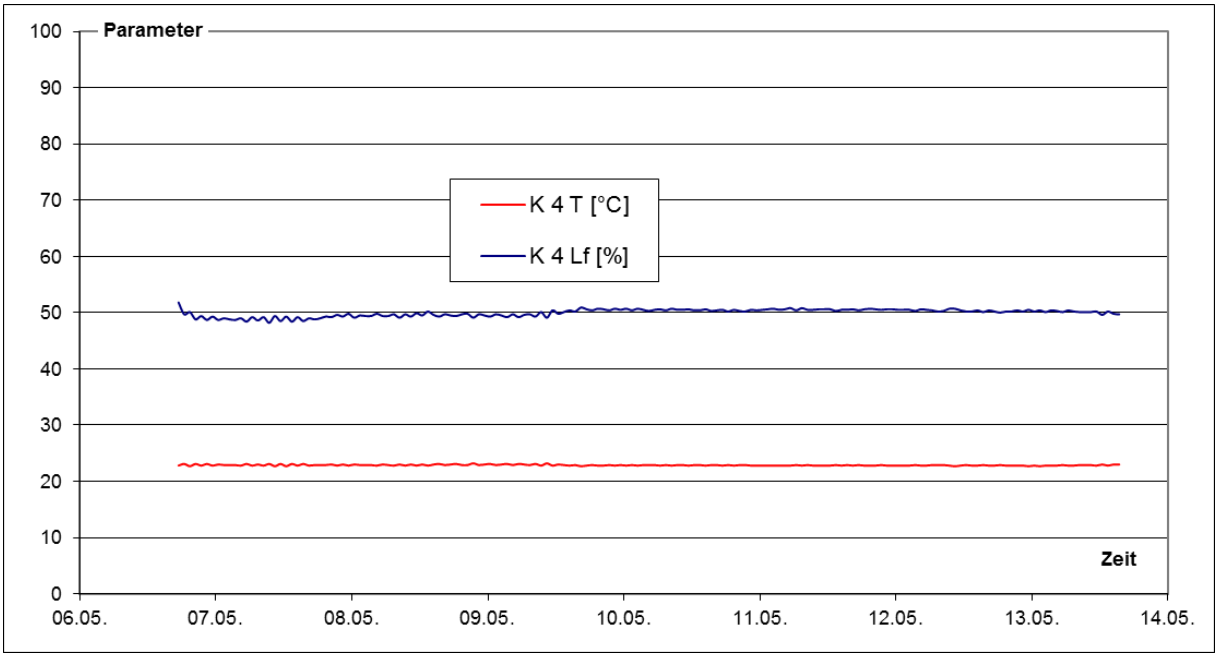


Figure 48 RR14_21 profiles of temperature and relative humidity in the emission test chamber

Annex B.9 RR14_23

A)



B)

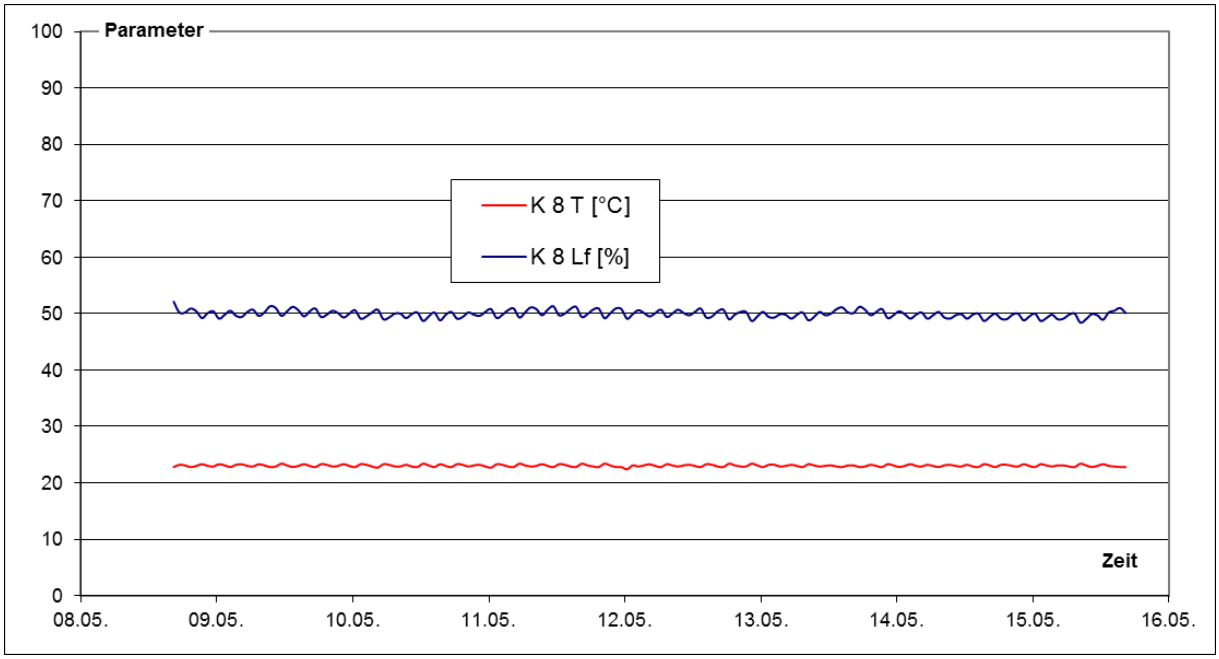
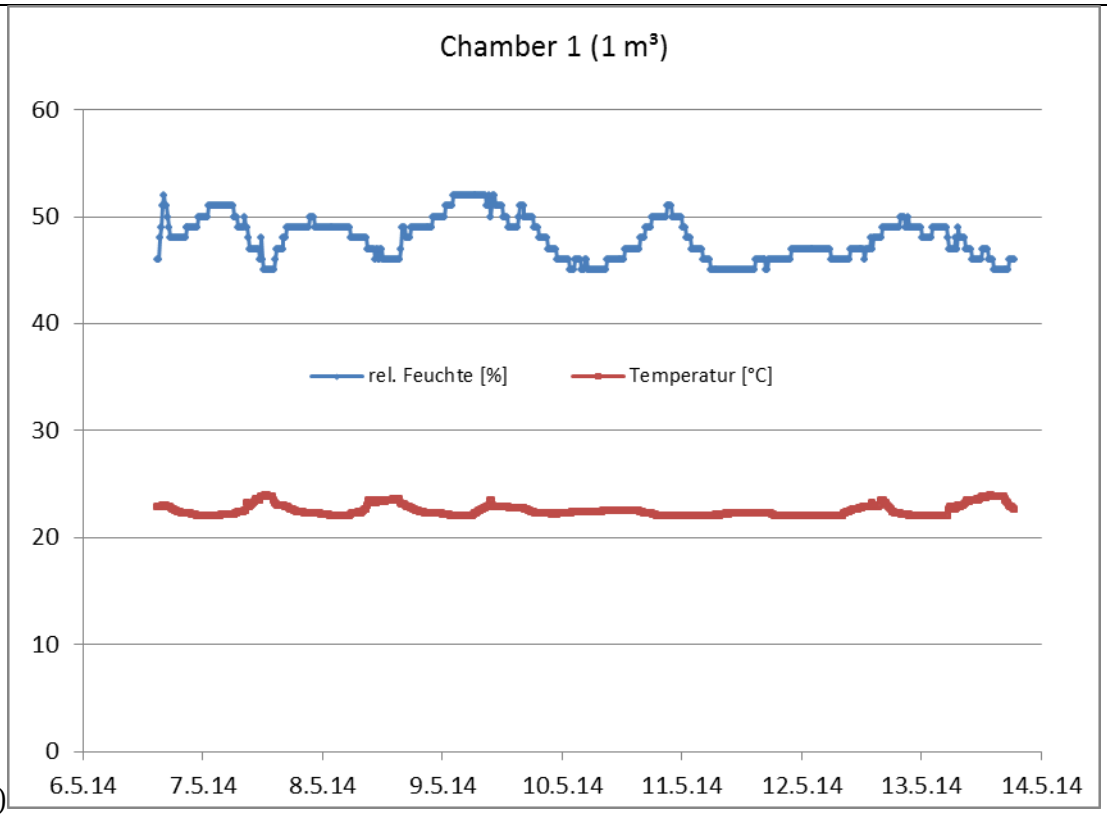


Figure 49 RR14_23 profiles of temperature and relative humidity in the 60 L (A) and 225 L (B) emission test chamber

Annex B.10 RR14_24

A)



B)

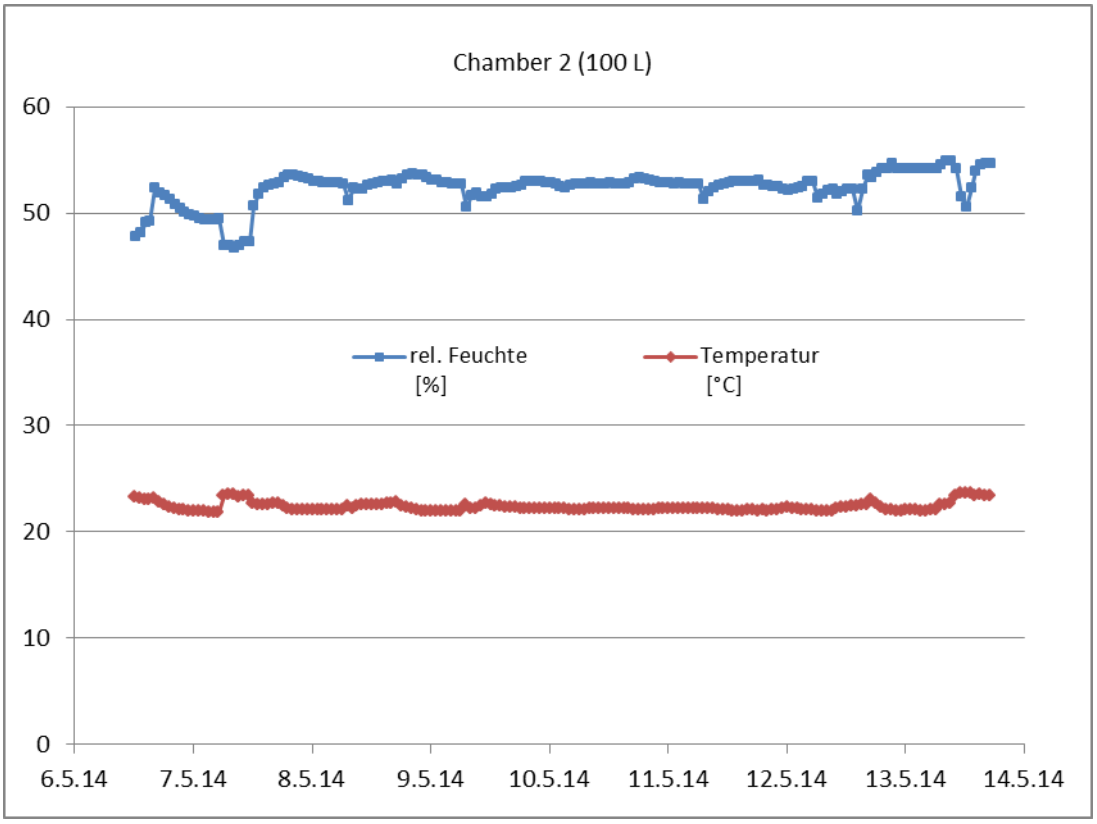
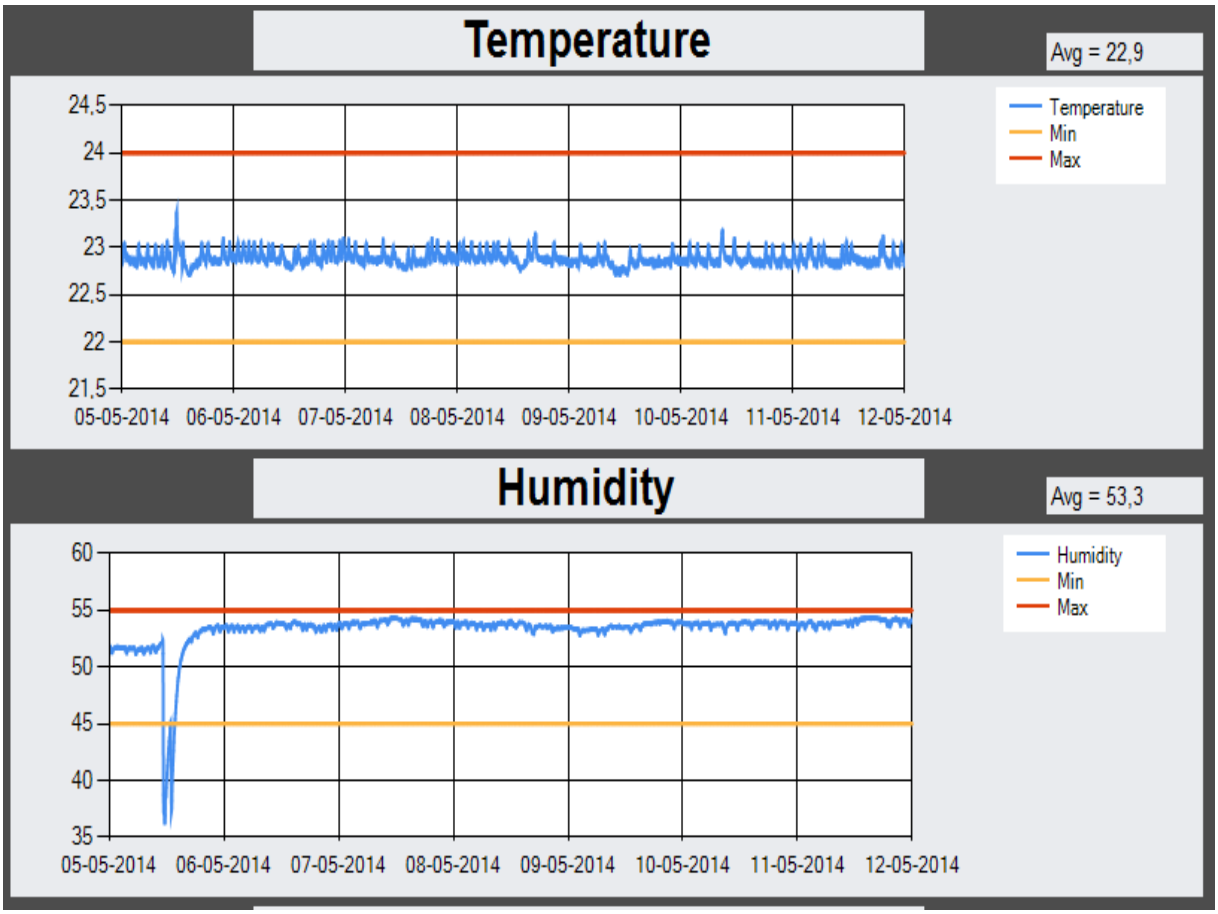


Figure 50 RR14_ 24 profiles of temperature and relative humidity in the 1m³ (A) and the 100L (B) emission test chamber

Annex B.11 RR14_25

A)



B)

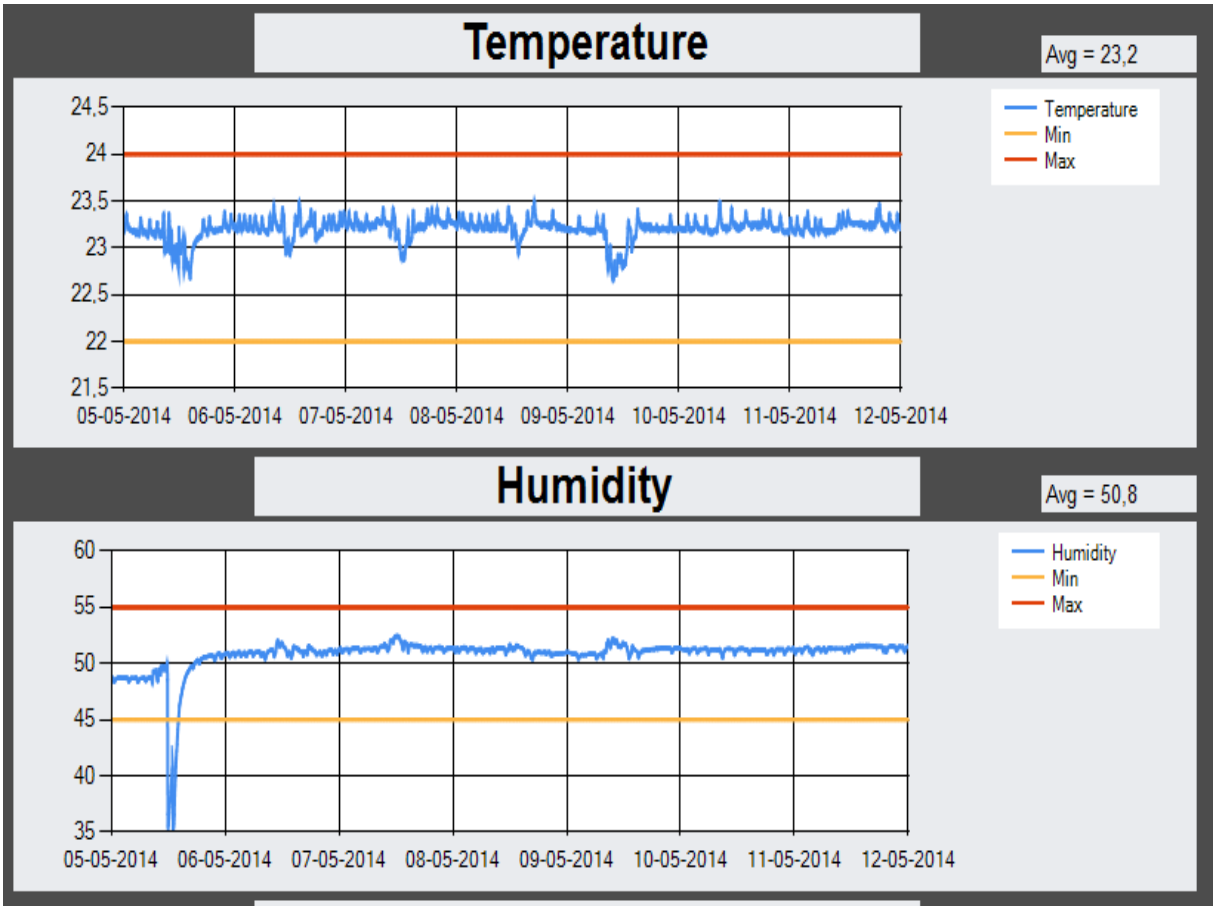


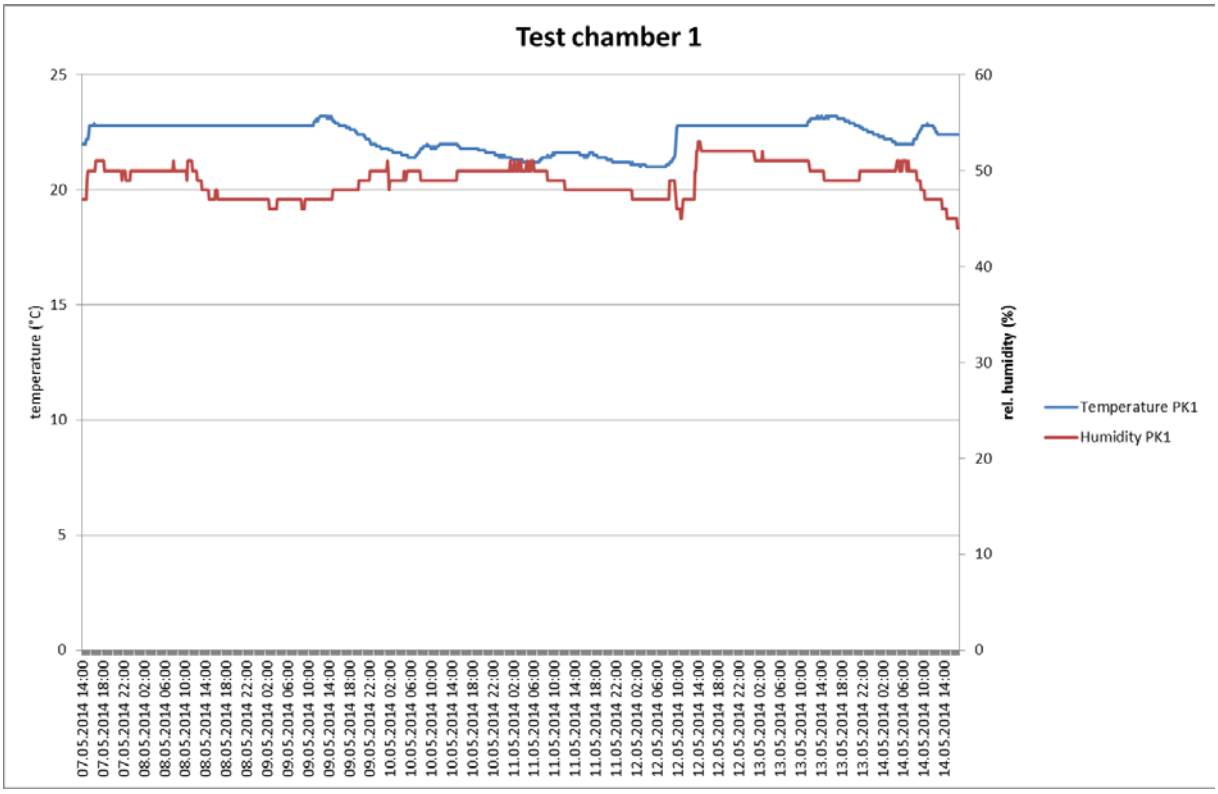
Figure 51 RR14_25 profiles of temperature and relative humidity in the emission test chambers (A) and (B)

Annex B.12 RR14_26

The profiles of the temperature and relative humidity in the emission test chambers were not transmitted to BAM.

Annex B.13 RR14_29

A)



B)

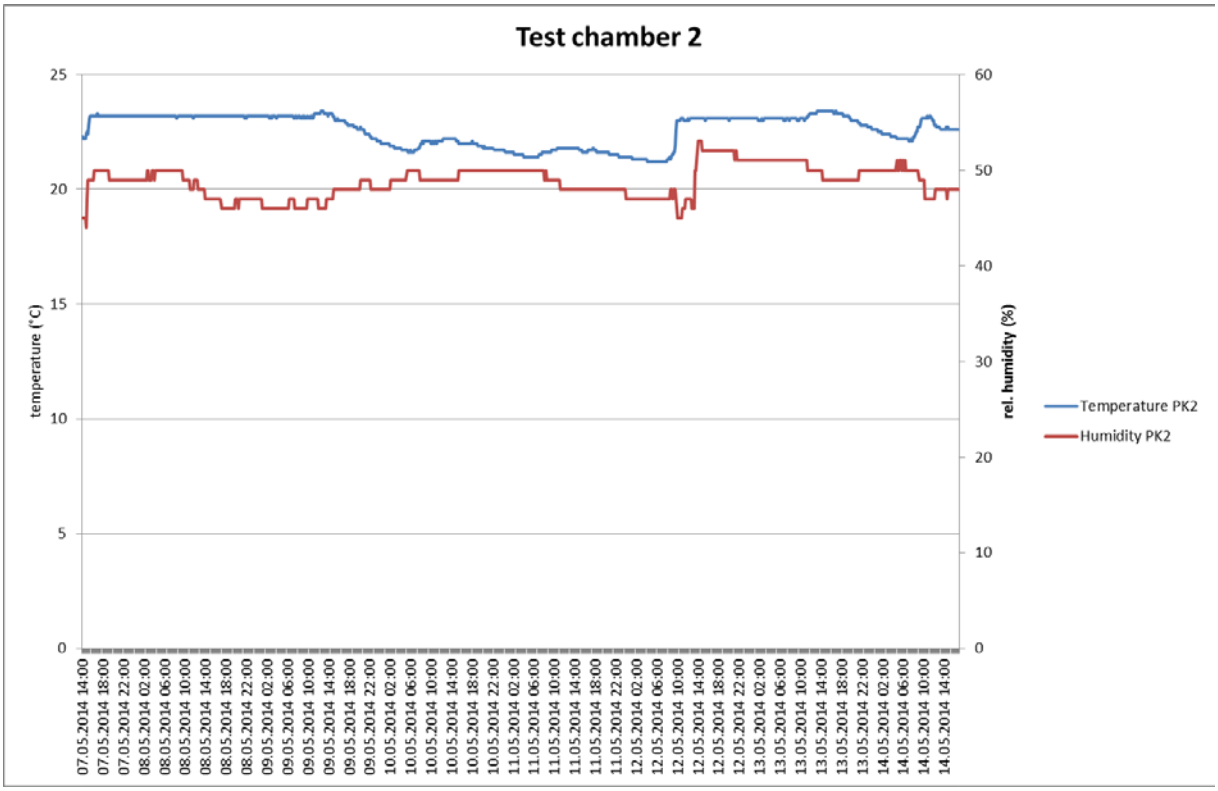
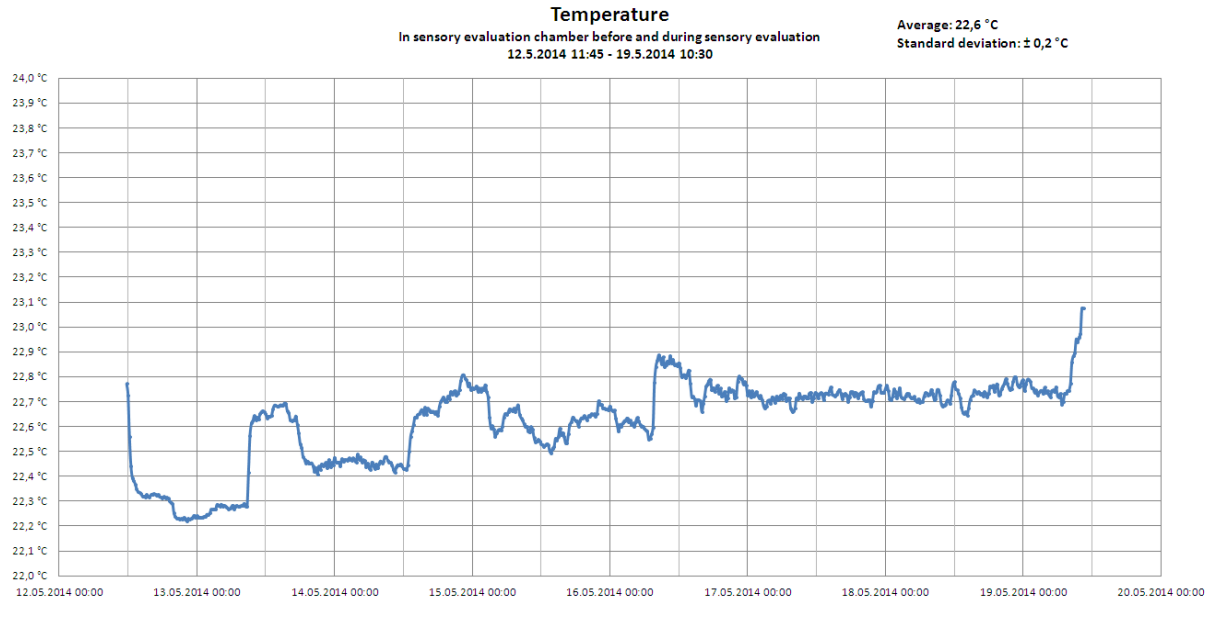


Figure 52 RR14_29 profiles of temperature and relative humidity in the emission test chambers (A) and (B)

Annex B.14 RR14_32

A)



B)

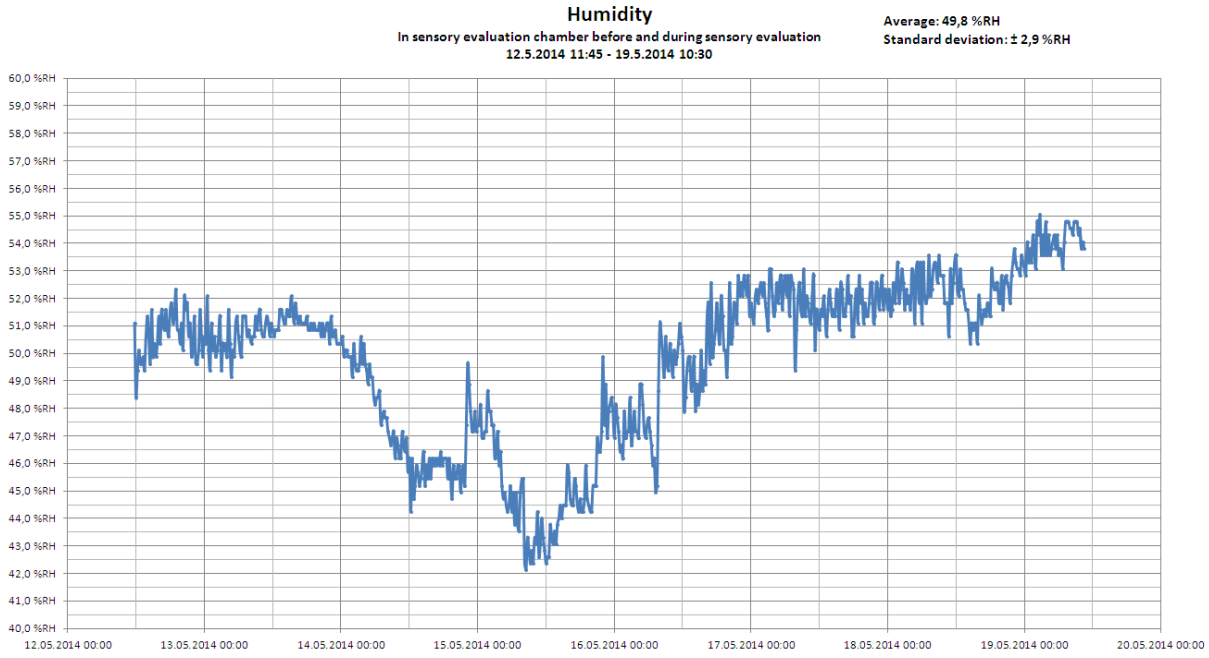
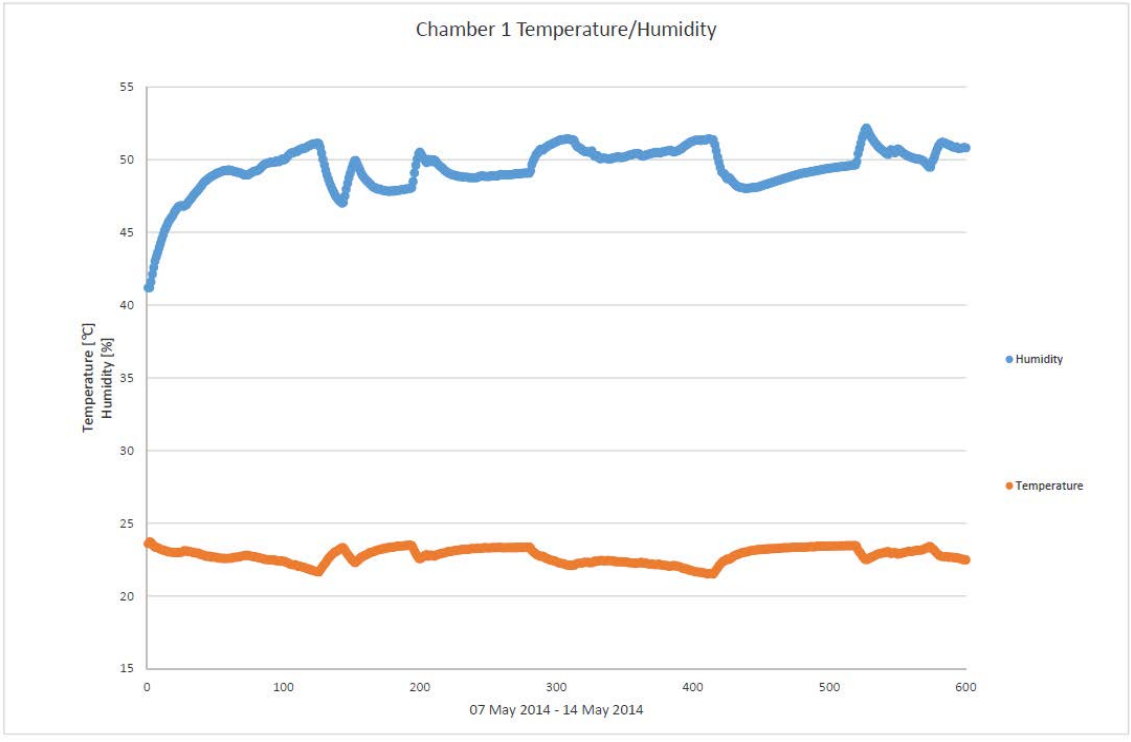


Figure 53 RR14_32 profiles of temperature (A) and relative humidity (B) in the emission test chamber

Annex B.15 RR14_33

A)



B)

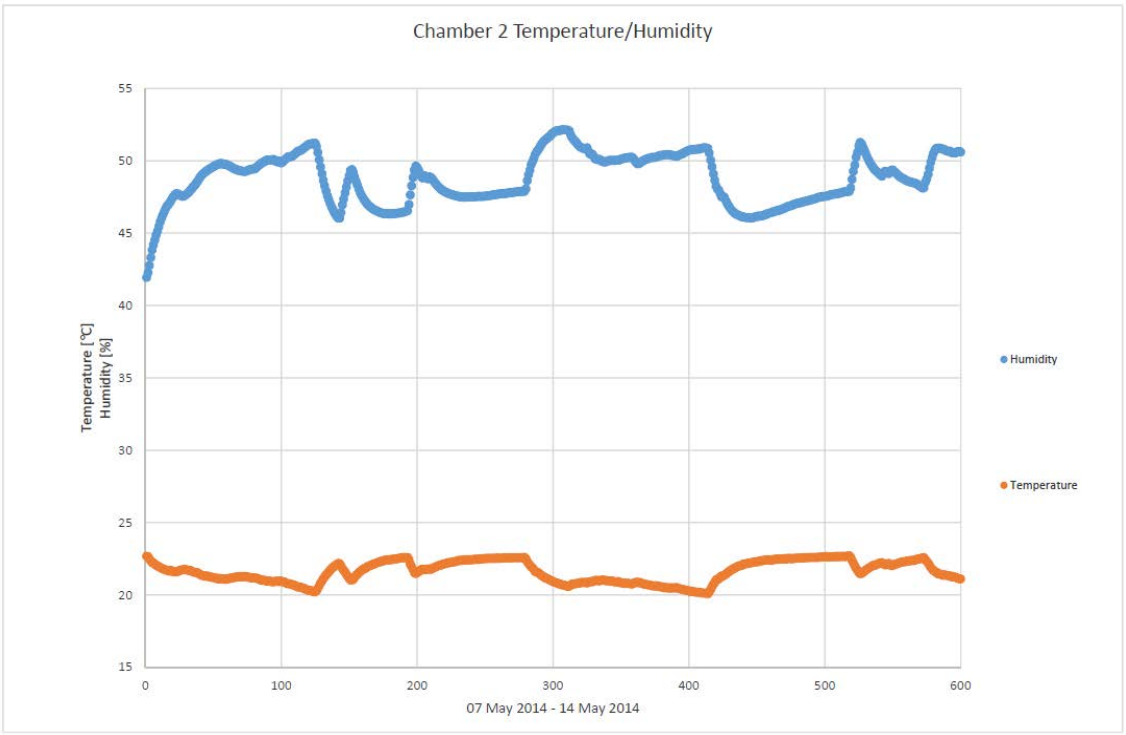
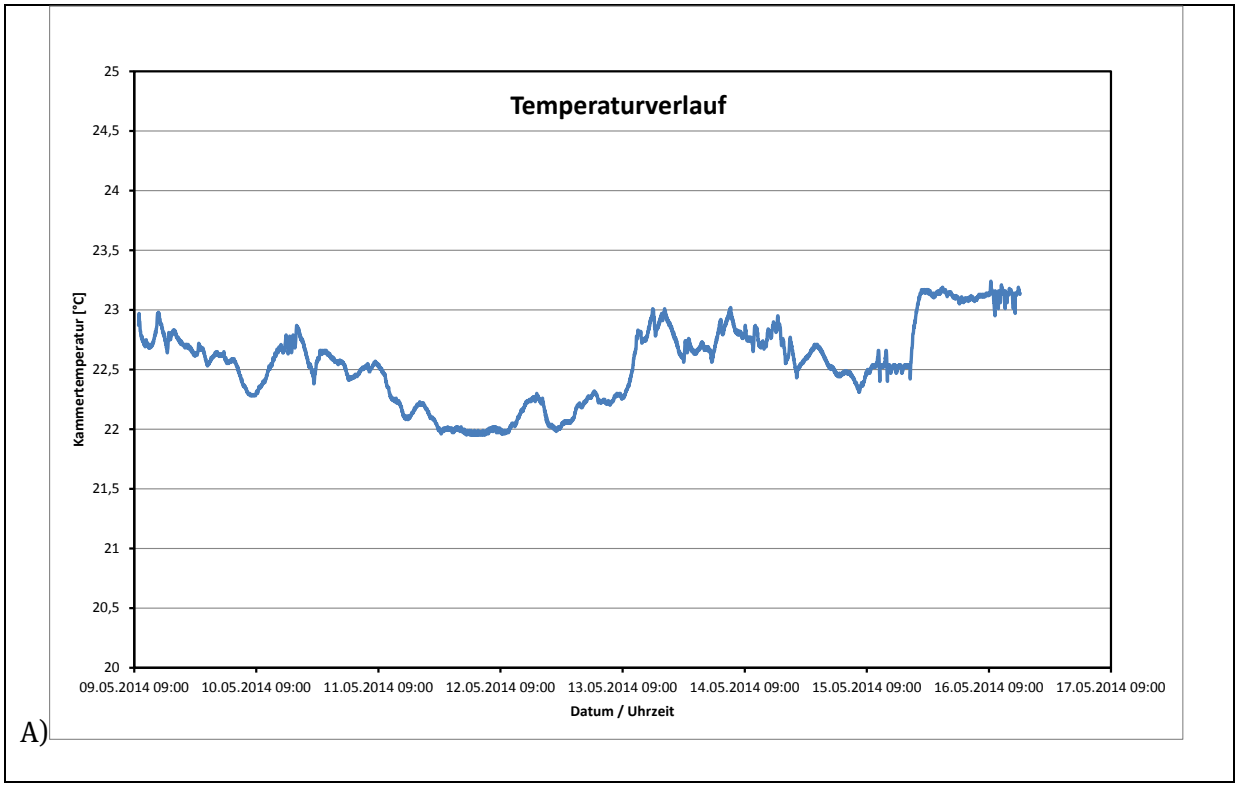


Figure 54 RR14_33 profiles of temperature and relative humidity in the emission test chambers (A) and (B)

Annex B.16 RR14_34



A)

B)

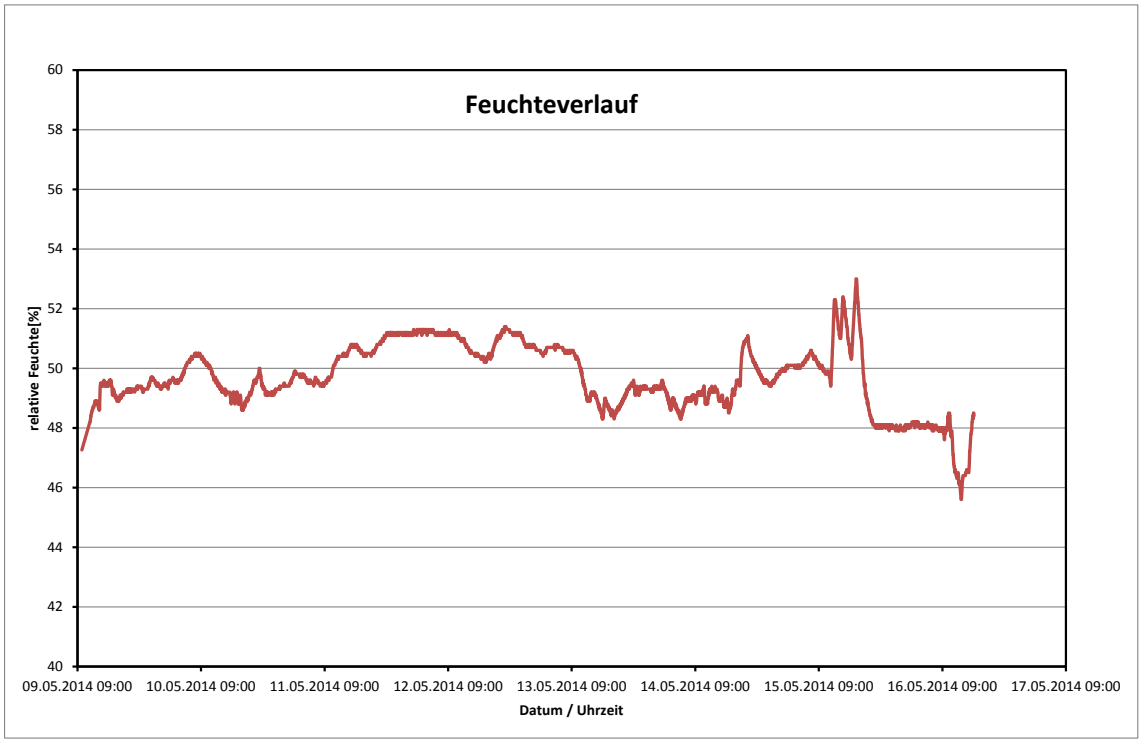
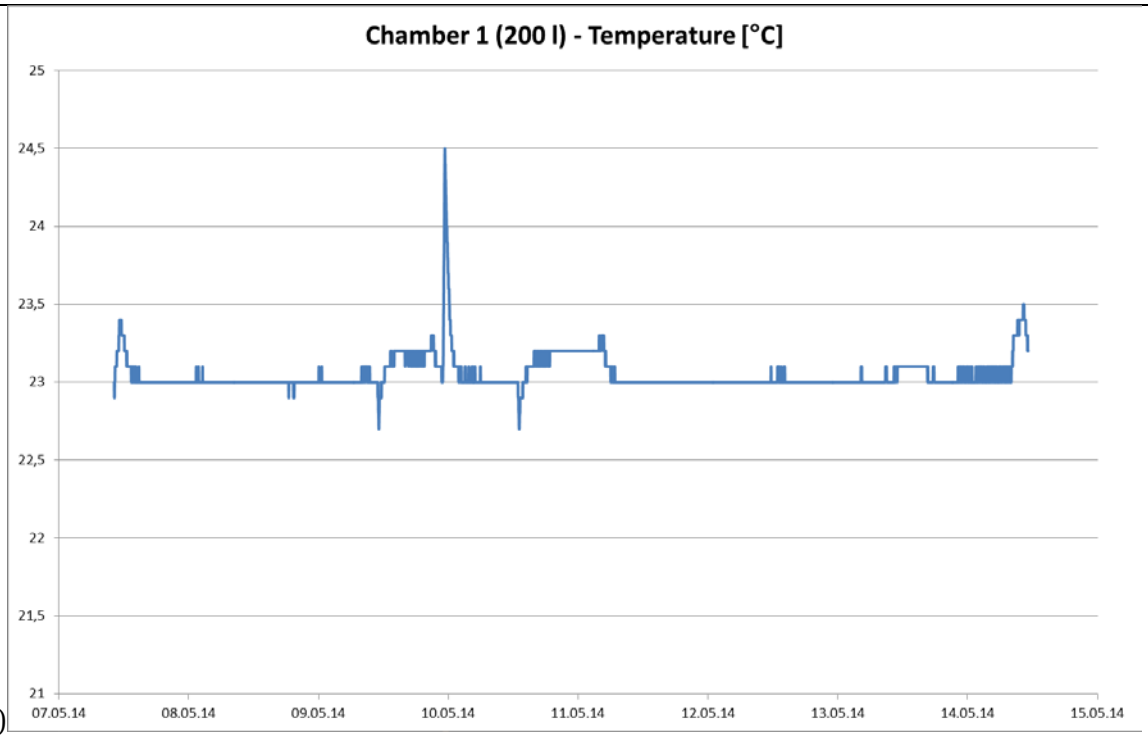


Figure 55 RR14_34 profiles of temperature (A) and relative humidity (B) in the emission test chamber

Annex B.17 RR14_35

A)



B)

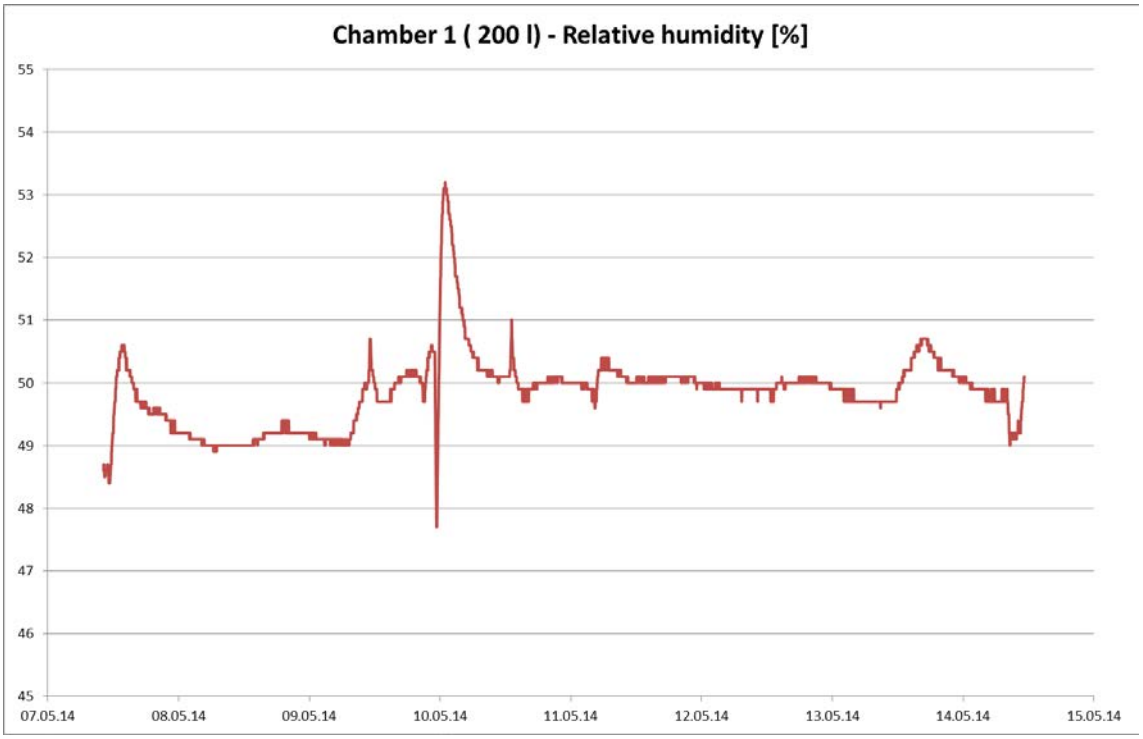
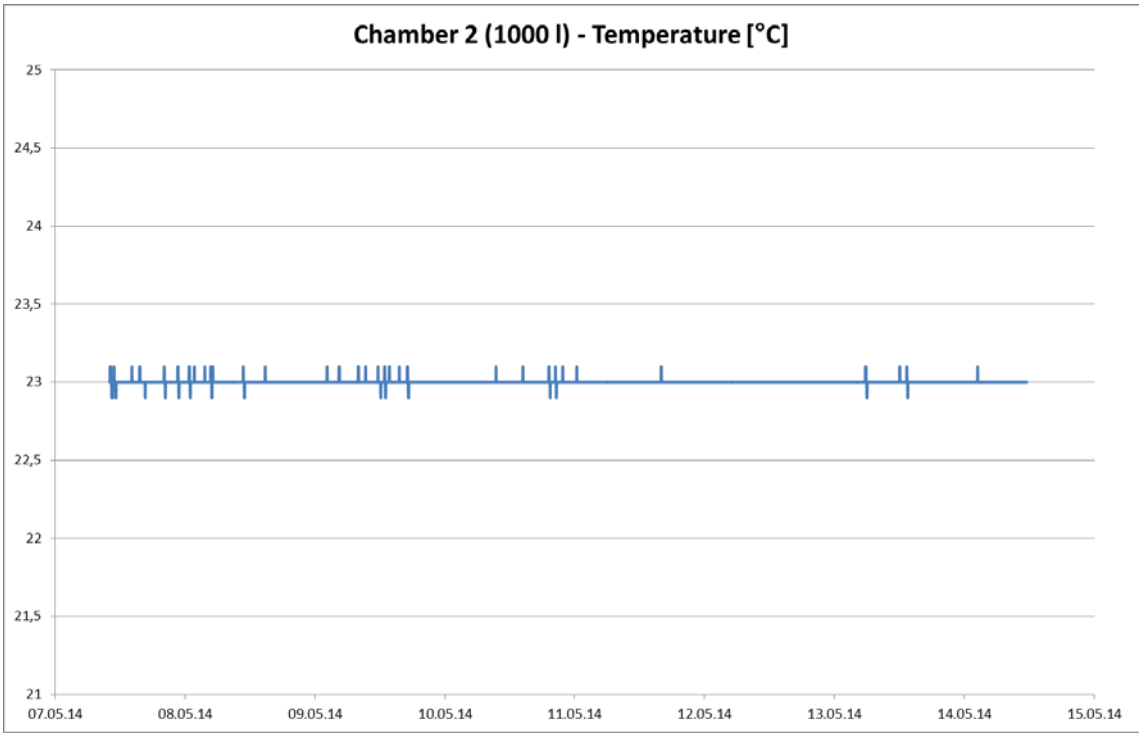


Figure 56 RR14_35 profiles of temperature (A) and relative humidity (B) in the 200L emission test chamber

A)



B)

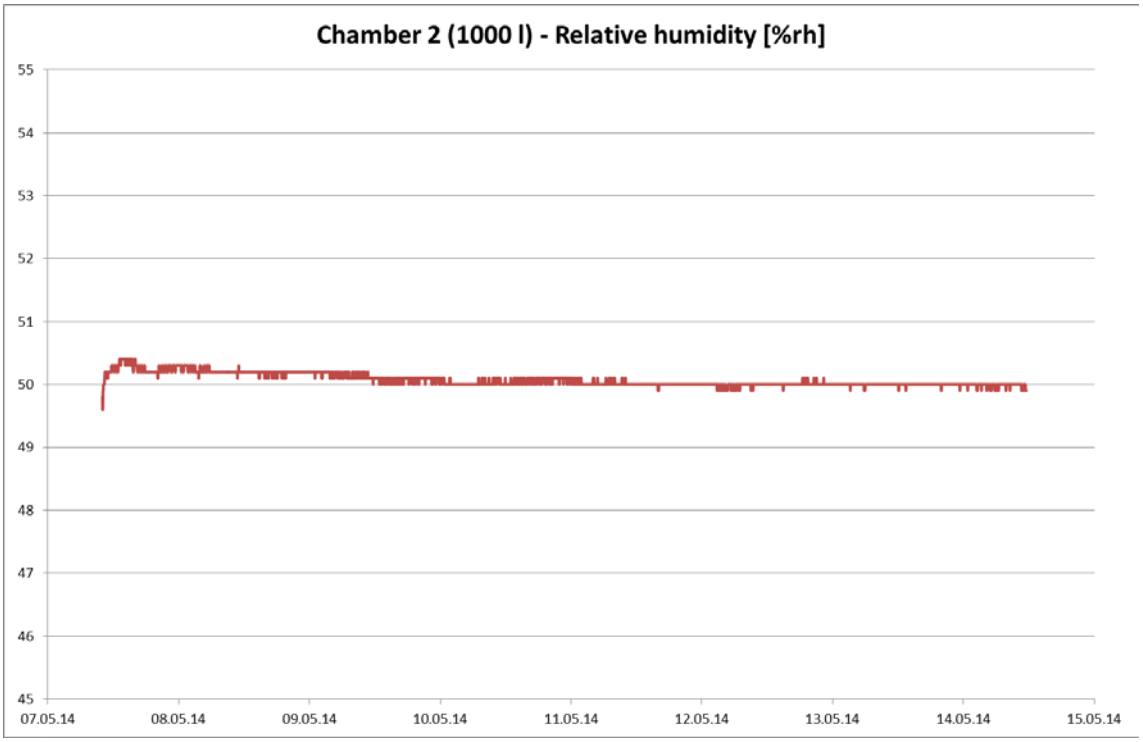
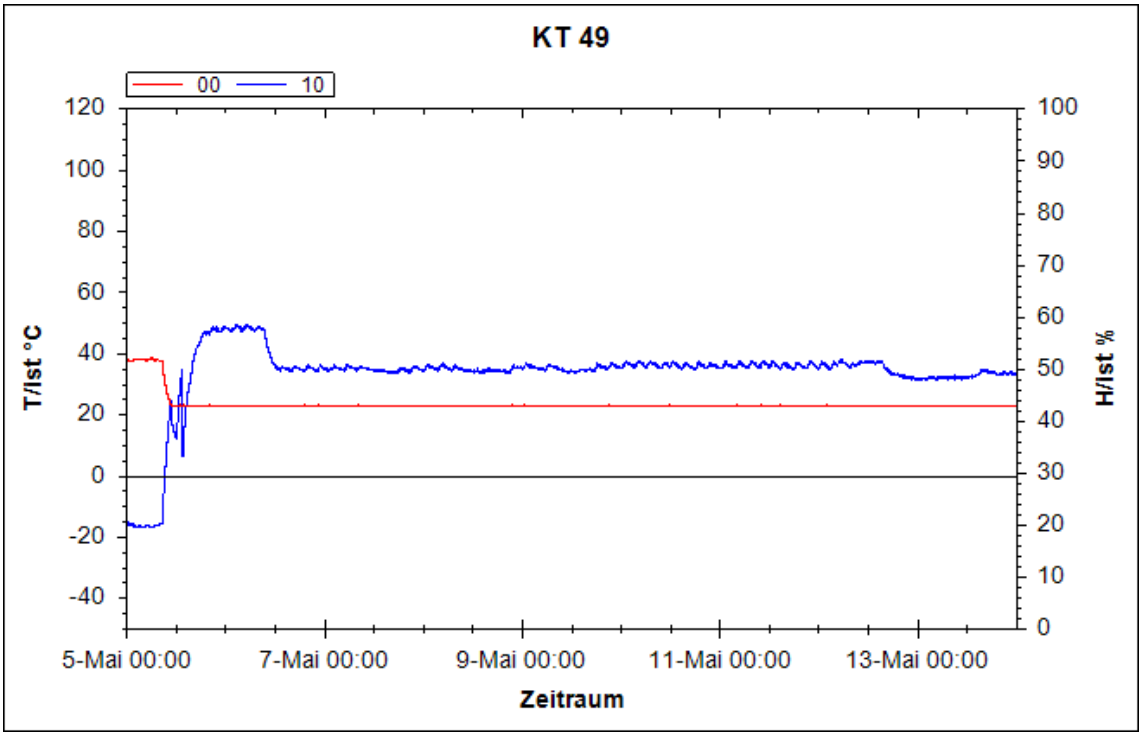


Figure 57 RR14_35 profiles of temperature (A) and relative humidity (B) in the 1000L emission test chamber

Annex B.18 RR14_39

A)



B)

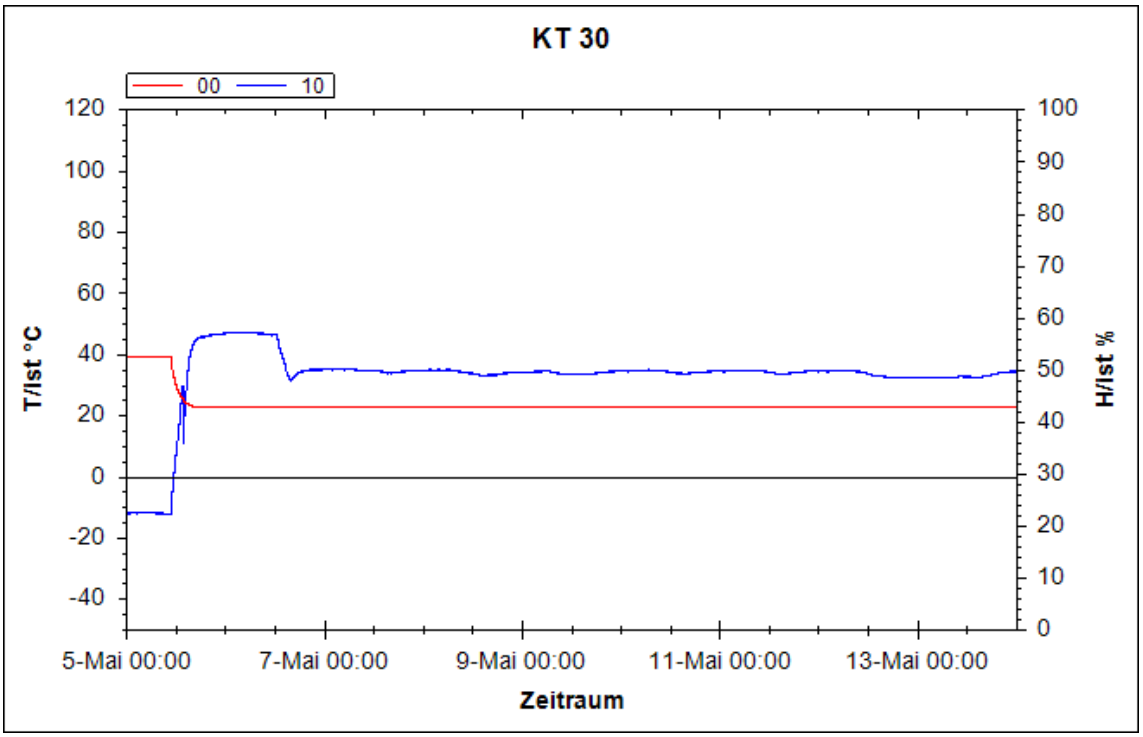


Figure 58 RR14_39 profiles of temperature and relative humidity in the emission test chambers (A) and (B)

Annex B.19 RR14_41

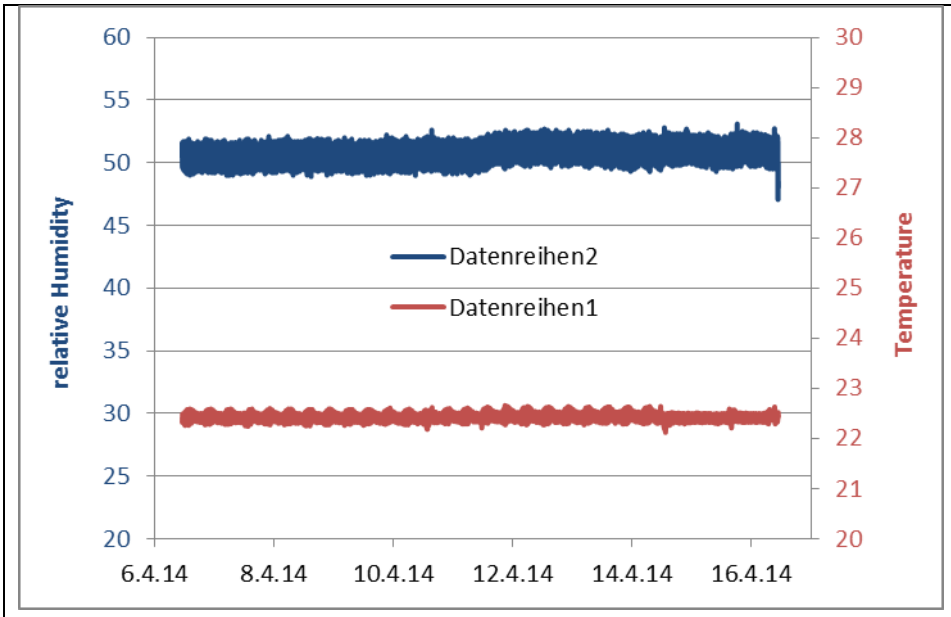


Figure 59 RR14_41 profiles of temperature and relative humidity in the emission test chamber

Annex B.20 RR14_43

The profiles of the temperature and relative humidity in the emission test chambers were not transmitted to BAM.

Annex B.21 RR14_50

The profiles of the temperature and relative humidity in the emission test chambers were not transmitted to BAM.

Annex C. Questionnaire regarding the Data Loggers

Questionnaire for the data loggers:

RR-VOC-G-BAM-2014

VTT Expert Services Ltd
Biologinkuja 7
FI-02150 ESPOO

BAM Federal Institute for Materials Research and Testing
Division 4.2 "Materials and Air Pollutants"
Christian Krocker
Unter den Eichen 87
12205 Berlin
Germany

Data-Logger of VTT Expert Services Ltd

Dear Participant

Please return this sheet together with the data logger (see below) to BAM. (The data logger is in the small brown envelope in the package.) Close to the "OK" a green light should blink, then everything is ok.

Please enter the date of arrival and date of unpacking in this form.

Lab-Code	'RR14_01'
Date of arrival	
Date of unpacking	
Remarks	

Slide this sheet of paper in the envelope of the data logger, seal it and return it to the above given address of BAM (is already on the envelope).
Thank you for your assistance

Best regards

Christian, Olaf, Wolfgang, Michael and Laura

Annex D. Standard Operation Procedure (SOP) for the RR14

Overall Directions

and

Standard Operation Procedure

Odour Measurements | Round Robin Test 2014

1. Overall Directions

1.1 Panel Leader

The panel leader is the "person whose primary duties are to manage panel activities and recruit, train and monitor the assessors" [1]. Therefore the panel leader is responsible for the panel and the conduction of odour assessments. They have to ensure that the panel members keep to the behavioural rules (section 9.3 of [1]) and to exclude panel members "in case of bad practice compromising the quality of the measurement" [1]. Such bad practice might be indicated by the infringement of behavioural rules (using strongly odorous deodorant or perfume, smoking, eating within the time frame of the measurement) or by assessments that significantly deviate from the set point values (calibration with acetone intensities).

A constant supervision of the panel members during the acetone calibration and the samples assessment is strongly recommended.

Moreover the panel leader has to make sure that assessment conditions like background odours of the test room and chamber, noises and exposure to light are within undisturbing limits (section 6 of [1]).

1.2 Panel and Panel Training

Panel members have to be chosen according to ISO 16000-28 and the training has to be conducted according to Annex G of the ISO 16000-28. The example of a programme for the training of a panel is a suggestion but summarises the main points.

First, the panel members have to get accustomed to the acetone as reference substance and that is achieved by comparing unknown acetone concentrations with those of the comparison scale. On the second day of training the panel members begin to get accustomed to the smell of building products and learn to assess their intensity by using the comparison scale and by repressing the emotional effect of the odour.

There are two important objectives in this training. The first is to enable the panel members to deal with acetone and to guarantee that they are able to perceive the acetones odour intensity. The second objective is to enable the panel members to compare unknown sample odours with the characteristic odour of acetone without considering their hedonic tone.

The institutes should make sure that their panel members are sufficiently accustomed to the comparison of acetone-acetone and acetone-sample odour combinations.

2. Standard Operation Procedure

2.1 Handling of Samples and Loading of the Emission Test Chambers

The shipped sample is a lacquer that is doped with several substances that also might be found in indoor air or might be emitting from building products or furniture.

For the round robin test the lacquer is filled in Petri dishes that are sent to the participants in air tight wrappings. One dish has to be used per an air flow rate of 100 L/h. That means, that one Petri dish requires an air flow rate of 100 L/h, 2 dishes 200 L/h and so on.

Considering the fixed chamber volume, the ventilation rate has to be adjusted to the number of inserted Petri dishes. This number was calculated by BAM, based on the information gained from the questionnaire we sent to the participants in preparation for the round robin test 2014.

The particular number of Petri dishes is given in each covering letter send to the institutes on **17th of April 2014**.

The petri dishes should be arranged in the middle of chamber like typical installations. Please add a photo of the dishes inside the chamber to your results.

2.2 Provision of the Odour Samples

The odorous air samples as well as the acetone reference odours have to be provided with an air flow of at least 0.6 L/s and a maximum of 1.0 L/s. The used cones should have an opening angle of 12° [1, 3]. The opening itself should be no smaller than 7 cm in diameter. According to experience as well as to flow measurements including the visualisation of the air flow using fumes, keeping to those pre-settings assures an equal distribution of the air flow, supports the homogeneity of acetone-air-mixtures and prevents (provided that a correct positioning of the nose is guaranteed) the dilution of the sample with ambient air.

To generate the odour samples for the round robin test the emission test chambers have to be loaded with the lacquer samples. Subsequently the samples have to remain in the emission test chambers until day 7 after loading.

VOC samples should be taken according to short documentation shipped together with the samples. The filling of bags (Tedlar ®, Nalophane ® or FEP) with the odorous air from the emission test chambers shall be carried out in close connection to the VOC sampling. It has to be communicated along with the results of both VOC and odour measurements if the filling of bags is conducted before or after the VOC sampling. Particularly when using small chambers with low flow rates the filling of bags should be done before the VOC sampling.

Further directions regarding the sampling can be found in the UBA-texts 21-2007 p 34:
http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3247.pdf

2.3 Conduction of the Odour Measurement

2.3.1 Perceived Intensity

The perceived intensity (pi) is measured according to ISO 16000-28. Before the measurement with the trained assessment panel starts the acetone concentrations of the referencing scale have to be determined and recorded (at least 5 measuring points per provided concentration). The same determination and recording of data has to be conducted after completing the odour measurement session. The used instruments and the method of calibration have to be communicated as well.

Panel members have to wait in an odourless separate (or separated) room from the test laboratory (≤ 4 pi background intensity of the room, chapter 6.8.1 of [1]) during the whole odour measurement session. The odour measurement itself has to be conducted as follows and is generally applicable to panels based on staff of the institutes as well as panels based on students or other external members. Important are the 5 to 10 minutes acclimatisation prior to the calibration and a regeneration period of at least 5 minutes between acetone-acetone and/or acetone-odour sample measurements.

1 **Acclimatisation:**

panel members remain at least 5 minutes before the measurement session starts in the odourless room (chapter 9.3 of [1])

a) objectives of the session might be explained by the panel leader and behavioural rules might be brought to mind again
b) the panel leader has the opportunity to check behavioural rules especially regarding application of strongly smelling deodorants and perfumes | panel members who do not keep to the rules have to be excluded consequently

2 **Test for ability to smell on the day of measurement:**

one after another the panel members smell in ascending order once at every acetone concentration to ensure that they are able to smell the acetone itself and that they are able to distinguish between the intensities

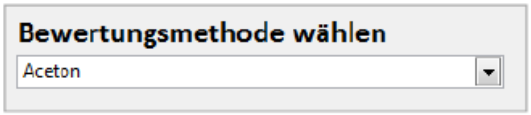
panel members who are not able to do so have to report this to the panel leader

3 **Calibration of panel members:**

two unknown acetone intensities have to be assessed by the panel members, therefore one panel member after another has to:

a) smell at the unknown acetone concentration and estimate the intensities range
b) smell at the estimated acetone concentration or the next lower intensity
c) if necessary smelling back and forth known and unknown acetone concentration is possible, always keeping in mind to start from the lower intensity when possible
d) 90 sec per assessment have to be adhered to (if a panel member is not able to finish in this time another attempt might be made after a 5 minutes regeneration period)

measurement results have to be recorded using the provided **software LQ-Basic (chapter 2.4)** using the measurement option "acetone" (Bewertungsmethode wählen → Aceton)



at the end of every cycle the software will show you instantly the results including deviations from the actual value and the 90% confidence intervals, measurement results with deviations higher than 2 pi [3] will flash red

another cycle with the inaccurate members has to be conducted (panel members are informed that their measurement was incorrect but **not** if it was too low or too high) - how to run through this second cycle is described in the softwares little handbook.

panel members that are too inaccurate again have to be excluded from the measurement

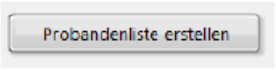
2.4 Record of Measurement Data

A software developed by the German Hochschule für Technik und Wirtschaft Berlin (HTW) has to be used and can be downloaded from:

https://www.dropbox.com/l/e4fDGVqFmUTcT7f2SQz00f?

Unfortunately this program was developed in German. Therefore a small handbook is provided by BAM. It translates and explains the most important things regarding the round robin test RR-VOC-G-BAM-2014.

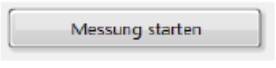
First of all a list of panel members has to be generated using the button "Probandenliste erstellen".



Please save the panel member list as follows:

ID_PanelMember_RR-VOC-G-BAM-2014.xls or *.xlsx

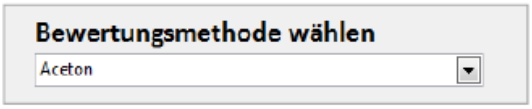
Thereafter the button "Messung starten" has to be used.



Following multiple options of choice regarding the assessment method (drop-down-menu "Bewertungsmethode wählen") are available.

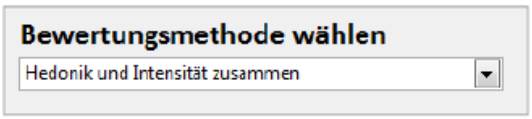
If you intend to measure the perceived intensity it is recommended to conduct the "Aceton" measurement at first to check the ability of the panel members to smell sufficiently on the measurement day.

The results will be saved automatically to your desktop as "Aceton.xlsx".



Afterwards the assessment of the actual sample should be carried out. Depending on what and how you intend to assess, there are different measurement methods available:

"**Hedonik und Intensität zusammen**" has to be chosen when the perceived intensity and the hedonic tone shall be measured by the same (trained) assessment panel.



"**Intensität**" **and** "**Hedonik**" have to be chosen separately when the perceived intensity shall be measured with the trained panel while the hedonic tone shall be measured with an untrained panel.

Please save the measurement results as follows depending on the assessment method you chose:

ID_PerceivedIntensityHedonicTone_RR-VOC-G-BAM-2014.xls or *.xlsx

or

ID_PerceivedIntensity_RR-VOC-G-BAM-2014.xls or *.xlsx

or

ID_HedonicTone_RR-VOC-G-BAM-2014.xls or *.xlsx

3. Report

3.1 Emission Test Chambers and Samples

- clean air system
- date and time of unpacking of the sample
- date and time of loading the chamber(s)
- picture of the empty and the loaded chamber(s)
- air exchange rate, supply air flow rate
- continuous temperature profile of the chamber(s)
- continuous air humidity profile of the chamber(s)

3.2 Comparison Scale

- type of provision of acetone gas
- diameter of the opening before the cone
- air flow rate at the cones opening [L/s] for each cone
- acetone concentration at each cone (before the measurement)
    - at least 5 measuring points per provided concentration
- acetone concentration at each cone (after the measurement)
    - at least 5 measuring points per provided concentration
- used instrument(s) for the acetone measurement (FID, PID, ...)
    - method of calibration (acetone test gas, ...)

3.3 Odour Measurement

- measurement using bags or direct assessment at the emission test chamber(s)
- material of bags and where required (e.g. Tedlar®) type of pre-treatment
- size of bags
- date and time / duration of the filling of bags
- filling before or after the sample drawing for the VOC measurement
- diameter of the bags opening in mm
- size and material of the utilised cone

3.4 Measurement Results

- please hand them in as they are produced by the software LQ-Basic
    - ID_PanelMember_RR-VOC-G-BAM-2014.xls or *.xlsx

    and

    - ID_PerceivedIntensityHedonicTone_RR-VOC-G-BAM-2014.xls or *.xlsx

      (or whichever method you chose)

[1] ISO 16000-28

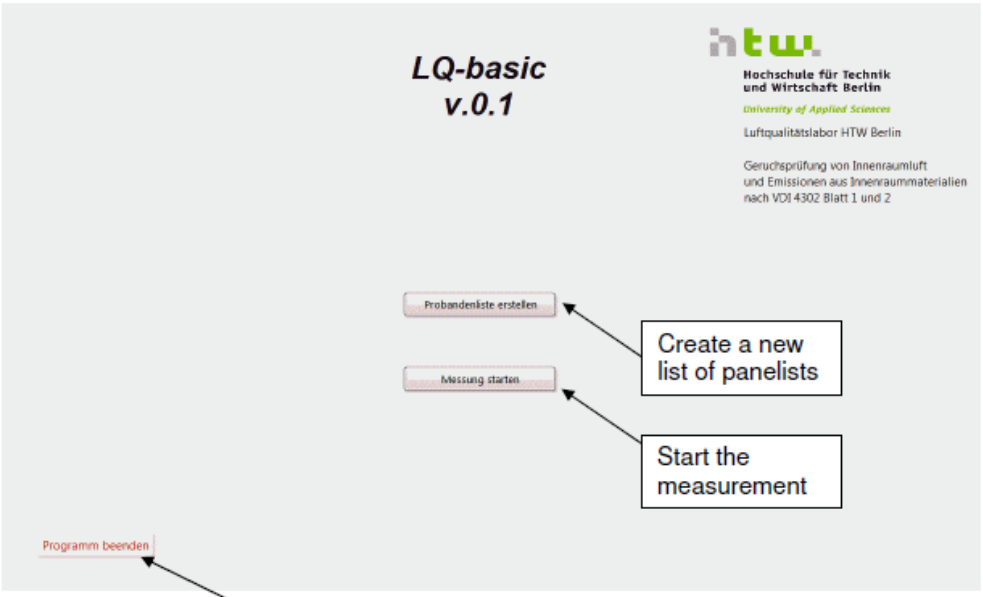
[2] ISO 16000-9

[3] VDI 4302-1

Annex E. Manual for the LQ-Software

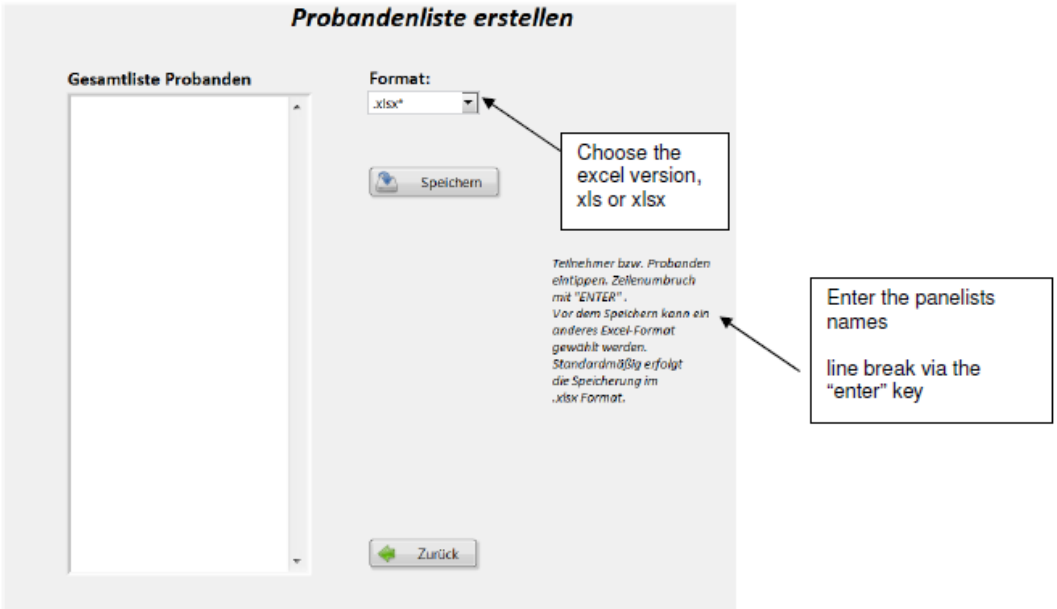
How to use LQ-basic v.0.1

You can download the software via the following link:
https://www.dropbox.com/s/t44j6fb0drchqsp/LQ.zip?n=125224021
After the installation you should see this window if everything worked well.



With the button "Programm beenden" you close the program.

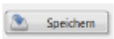
The first Step you have to take is the creation of a list of panelists that will evaluate the odour.



Please enter your Panel Members into the list. With the "enter"-key you start a new line.

Later the panelists can choose their names from the list.

The format of the list will be an Excel-file.

Press 

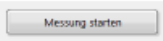
to save the list. Please save the list as follows:

ID_PanelMember_RR-VOC-G-BAM-2014.xlsx or *.xls.

The ID is part of your labcode: (RR14_ID). Please make sure you choose a place on your PC that you will find afterwards! Some files will be saved on the Desktop. So you can also use this default level.

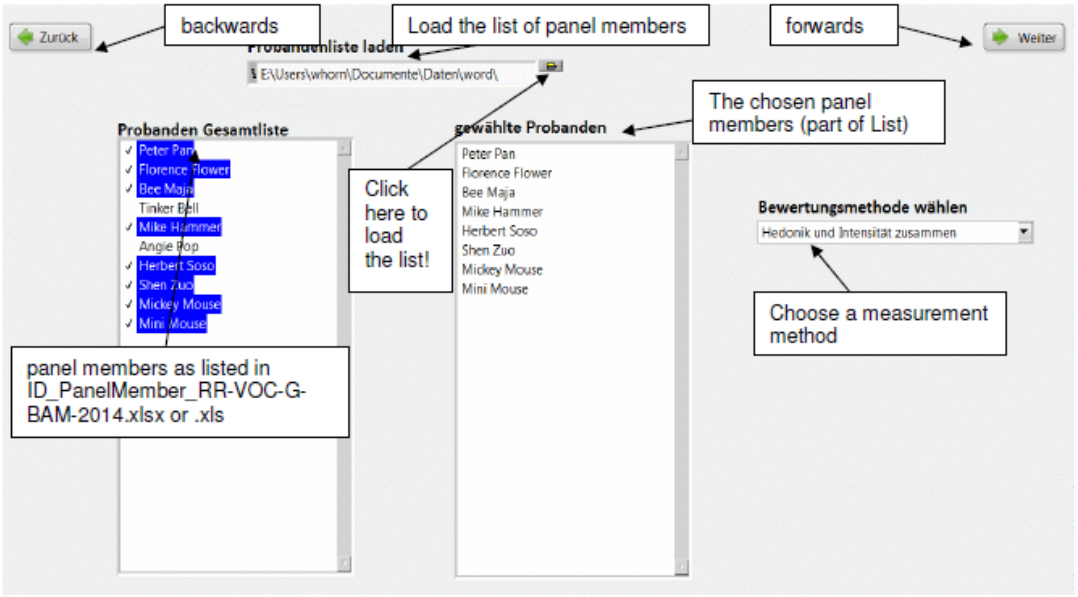
Press 

to return to the start page.

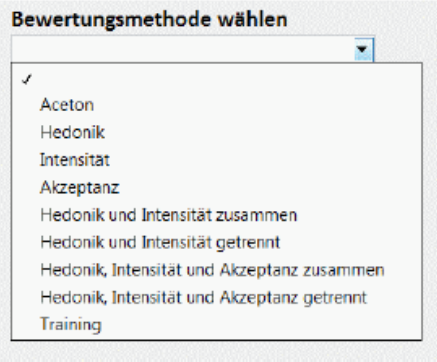
Now press 

to start the measurement!

Here you have to choose your list of panel members for the form field "Probandenliste laden". The panel members saved to the list will appear in the field "Probanden Gesamtliste". By clicking on each name you will copy them to the field "gewählte Probanden" and they will be available for the current odour measurement.



Next you have to choose between different measurement methods which are listed below:



Aceton evaluation of unknown acetone concentration (used for the calibration prior to the current odour measurement)

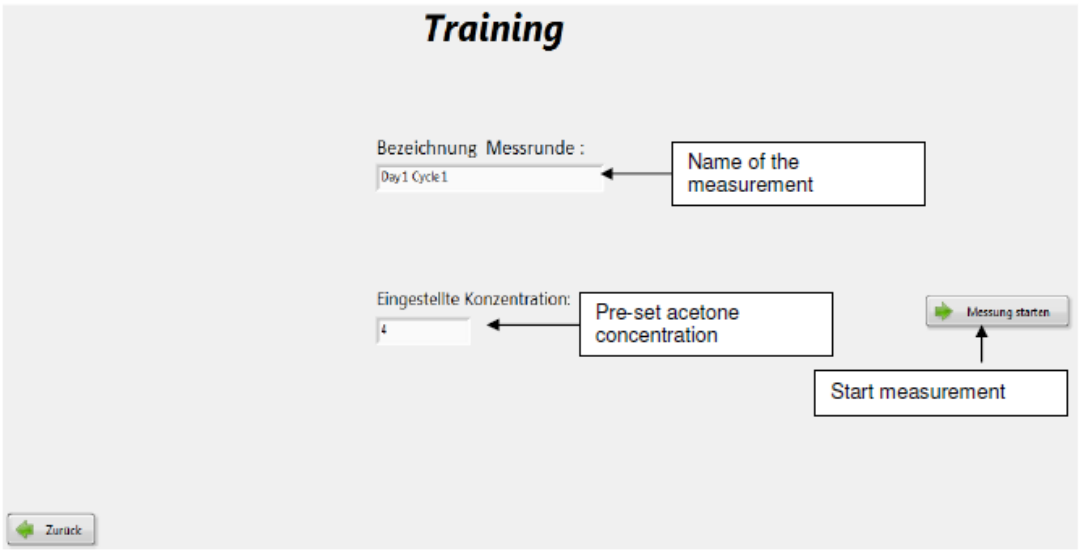
Hedonik	evaluation of hedonic tone
Intensität	evaluation of perceived intensity
Akzeptanz	evaluation of acceptability
Hedonik und Intensität zusammen	hedonic tone and perceived intensity both together
Hedonik und Intensität getrennt	hedonic tone and perceived intensity both but one after another
He. In. u. Ak. zusammen	hedonic tone, perceived intensity and acceptability all three together
He. In. u. Ak. getrennt	hedonic tone, perceived intensity and acceptability all three separated
Training	overall trainings procedure (acetone concentrations)

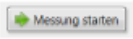
The general procedure will be as follows:

1. Choose participating panel members from the complete list on the left side. Checked names will appear in the right list as well.
2. Choose the method of evaluation: e.g.
   - hedonic tone and perceived intensity together,
   - acetone (daily training),
   - training or
   - perceived intensity (alone).
3. Press 

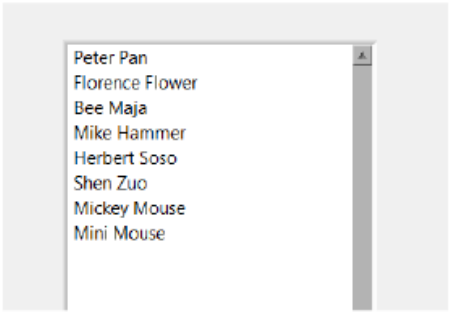
for the next page.

If you choose Training you will see the following pages and have to fill in a name for the measurement cycle ("Bezeichnung der Messrunde") as well as the pre-set acetone concentration ("eingestellte Konzentration").

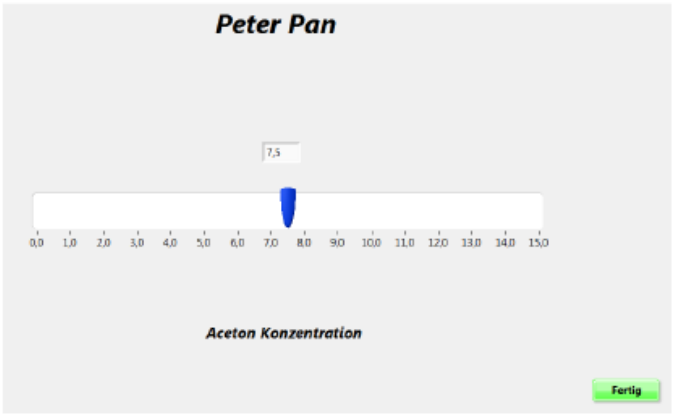


When filled in please press  ("Start measurement")

Here the list of the participants appears. Each participant selects their name from the list via double-click and get to the acetone measurement scale.



Each panelist marks their assessment value on the screens scale (with the mouse). Then they press  "ready". The same procedure will start for the next panelist and so on.

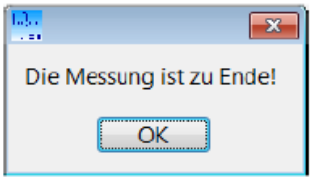


If a panellist selects the wrong name they can go backwards to the names list by pressing 

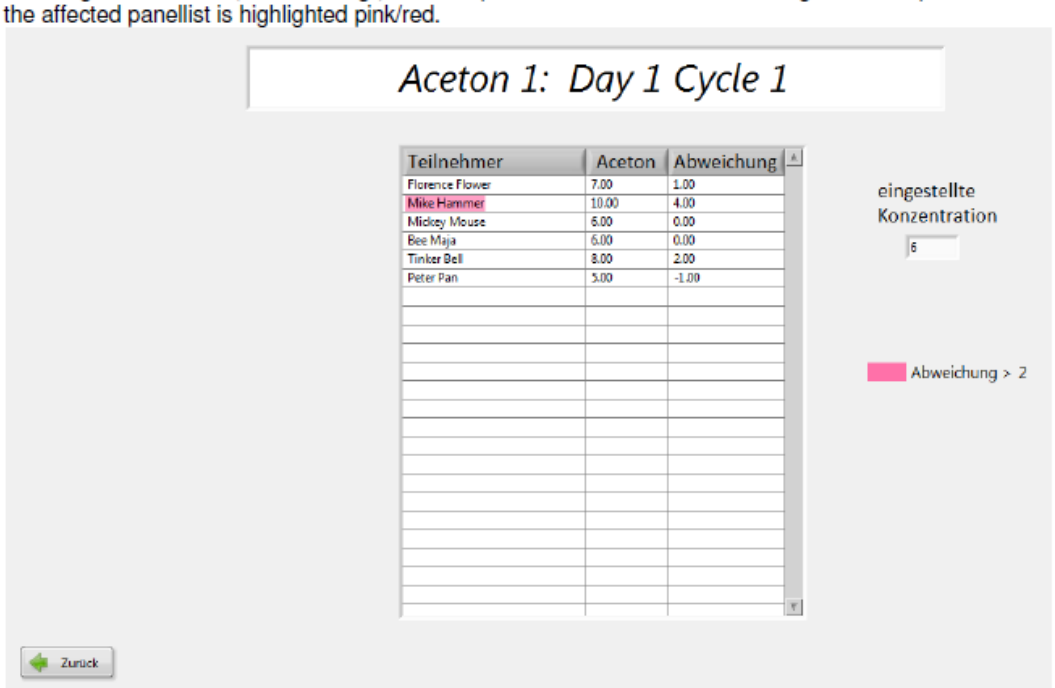
. and choosing the correct name. (this has to be done before the evaluation of the intensity is marked. When marked in the scale, the button 

will disappear and be substituted by “Fertig” (“finished”). There is no way to modify the evaluation then.

When all panellists have done their assessment for the current sample the following message appears: (“The measurement is completed!”)



The panellists may **not** press “OK”. This is only allowed to the **panel leader** because the next screen appears immediately after pressing “OK”. It shows the measurement results of the completed cycle including the deviation (“Abweichung”) from the pre-set value. Is the deviation higher than 2 pi the name of the affected panellist is highlighted pink/red.



Than press 

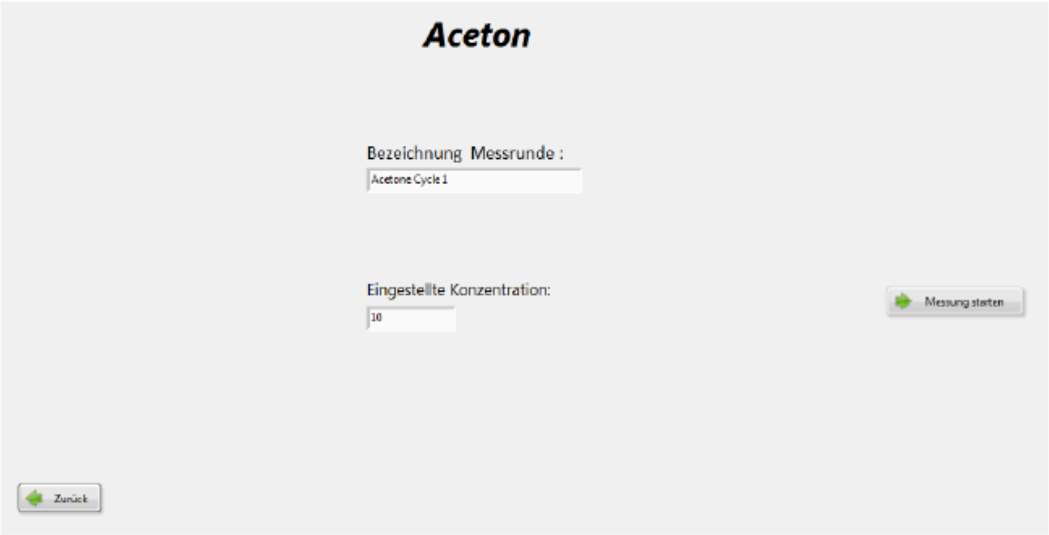
“back” and you can start the next run e. g. “Day 1 Cycle 2”

You can find the results of this evaluation on the desktop of the used PC. An excel-file named "training" was generated there automatically. All further evaluations will be added to this file while using the "training" method for the measurements. (Same sheet new date given).
If you want to get separated files for every training day you should cut and paste each file to the destined folder. A new file will be generated on your desktop if there is no previous excel-file "training" anymore.

Regarding the round robin test itself three assessment methods are applicable:

- Intensität und Hedonik zusammen | perceived intensity and hedonic tone together (trained panel)
- Intensität | perceived intensity (trained panel)
- Hedonik | hedonic tone (untrained panel)

It is recommended to conduct the "Aceton" measurement before any of the above assessment methods to check the ability of the panel members to smell sufficiently on the measurement day.
To do so the assessment method "Aceton" has to be selected instead of "Intensität und Hedonik zusammen", "Intensität" or "Hedonik". The following screen will be displayed. The procedure is analogue to that of the "training" method (see above).



The results of this procedure are saved as an excel-file "Aceton" on the desktop of your computer automatically. All measurements conducted while this file stays on the desktop will be saved there.

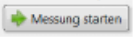
Panel members whose evaluation deviate more than 2 pi from the pre-set acetone concentration will be marked in pink on the screen as in the "training" method as well.
Regarding that this procedure serves as calibration of the panel members, they get the information that their evaluation was not correct (no information relating to whether the evaluation was too high or too low might be given!) and the chance to evaluate the same acetone concentration again.
This can be done by clicking "zurück" (back) and "beenden" (quit) and deselecting panel members who got the acetone concentration right. This way only panel members with incorrect evaluations have to assess the same concentration again by clicking "weiter" again and "Messung starten". The name of the measurement-cycle may stay the same.
Panel members who are not able to evaluate the acetone concentration within the limit of 2 pi even in the second attempt have to be excluded from the measurement!

Please do not forget to select all participating panel members again when assessing another acetone concentration!!!

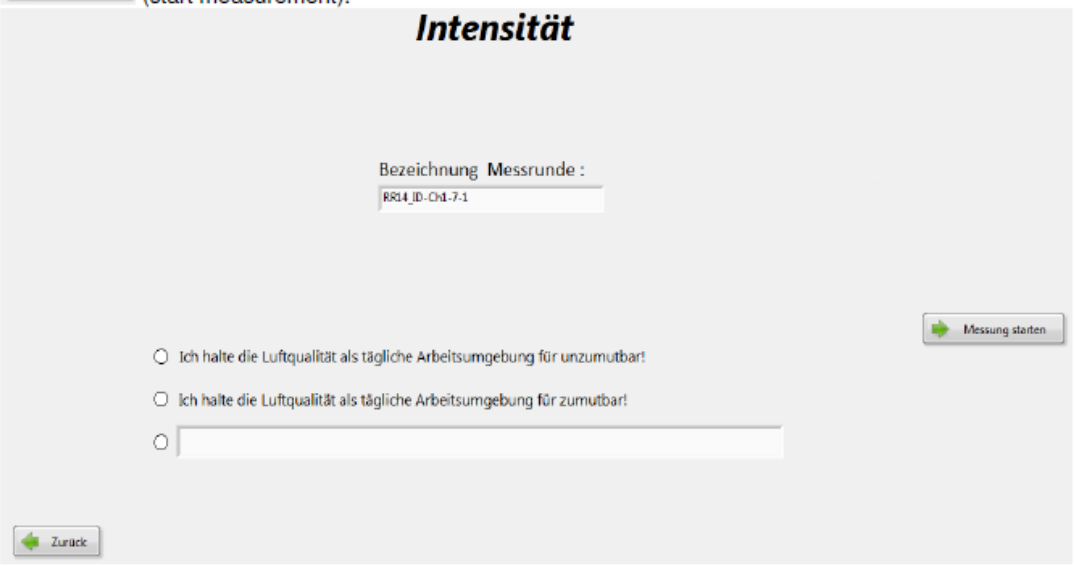
Afterwards the assessment of the actual sample should be carried out

"**Hedonik und Intensität zusammen**" has to be chosen when the perceived intensity and the hedonic tone shall be measured by the same (trained) assessment panel.

"**Intensität**" **and** "**Hedonik**" have to be chosen separatelywhen the perceived intensity shall be measured with the trained panel while the hedonic tone shall be measured with an untrained panel.

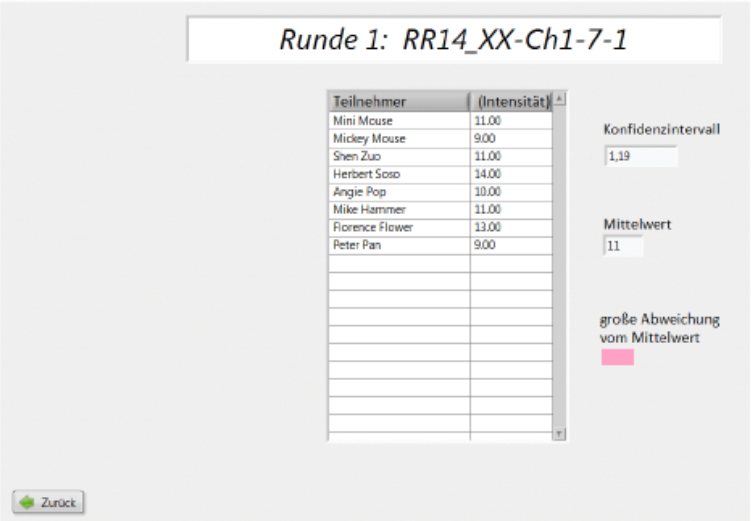
Please enter a Name for this measurement cycle: e. g. RR14_ID-Ch1-7-1 (ID that is included in your Labcode: (RR14_ID).; Ch1 for "1st Chamber", 7 for "day 7" and 1 for "first cycle") and then press 

(start measurement).



Then the panel members evaluate the perceived intensity of the sample as described above.

After all panelists have done their measurement the "Die Messung ist zuende!" (measurement is finished)-Button will appear and the following page will be displayed after clicking.



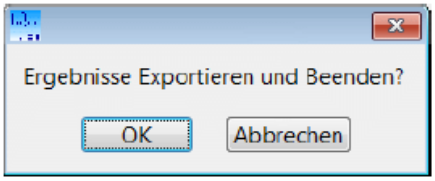
You receive the 90 % confidence interval ("Konfidenzintervall") directly. This correlates to the information if themeasurements accuracy is sufficient or not. If the measurement was inaccurate (90 % confidence interval above 2 pi) it has to be repeated.

The next step is to press 

"back" where you can start the next measurement RR14_ID-Ch1-7-2 for example or you press 

"quit" if there are no more samples to be measured.

The field "Ergebnisse Exportieren und Beenden?" appears (Export results and quit?) where you should choose "OK" to save the measurement data.
You will asked to enter a name of the Excel-file (please be aware of the folder where you save the file).



Please save the measurement results as follows depending on the assessment method you chose:

ID_PerceivedIntensityHedonicTone_RR-VOC-G-BAM-2014.xls or *.xlsx
or
ID_PerceivedIntensity_RR-VOC-G-BAM-2014.xls or *.xlsx
or
ID_HedonicTone_RR-VOC-G-BAM-2014.xls or *.xlsx

The resulting excel-file looks like this:

	A	B	C	D	E	F	G	H	I
1	***Ergebnisliste***								
2							Datum: 09.04.2014; Uhrzeit: 17:25		
3		***Intensität (PI)***							
4									
5									
6									
7	Runde 1: RR14_XX-Ch1-7-1						Ich halte die Luftqualität als tägliche Arbeitsumgebung für un		
8	Mini Mouse	11					Mini Mouse		
9	Mickey Mouse	9					Mickey Mouse		
10	Shen Zuo	11					Shen Zuo		
11	Herbert Soso	14					Herbert Soso		
12	Angie Pop	10					Angie Pop		
13	Mike Hammer	11					Mike Hammer		
14	Florence Flower	13					Florence Flower		
15	Peter Pan	9					Peter Pan		
16	Konfidenzintervall:	1,19							
17	Standardabweichung:	1,77					Anzahl: JA:	0	NEIN: 0
18	Mittelwert:	11							
19									
20									
21									
22									
23		Datum	Mittelwert Int	Konfidenzinte	Standardabw	Standardabw	Konfidenzintervall Max.	Halbes Konfidenzinter	
24	Runde 1: RR14_XX-Ch1-7-1	4,17E+04	11	9,81	12,77	9,23	12,19	1,19	
25									

The results for the other measurement methods look almost alike. To save the data this way is essential for us regarding the data analysis so please **do not change anything in the excel-files** after the measurement is finished!

Please transmit the measurement results until no later than 13th of June 2014

via e-mail and additionally a signed version of your result pages to:

BAM Federal Institute for Materials Research and Testing
Division 4.2 "Materials and Air Pollutants"
Olaf Wilke
Unter den Eichen 44-46
12203 Berlin, Germany