Sensory evaluation of building products - Results of a German round robin test

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SUMMARY

In the german research project a method had been developed and tested, which enables the simple and safe integration of sensory tests into current test procedures under the AgBB scheme (see below). The method can provide a proper amount of sample air to the panellists for assessment, regardless of the size of the emission test chamber.

A round-robin test is conducted to evaluate the combined emission/odour testing scheme. A standardized building product is evaluated by eight laboratories concerning chemical and odorous emissions. At each laboratory between six and fourteen members of an odour panel have scored the perceived intensity of the building product using a comparative scale based on acetone.

INTRODUCTION

The indoor climate and indoor air pollutants influence the health and comfort of the occupants of indoor spaces. Indoor air pollutants are emitted by a various sources. Among these sources, building products are of particular importance hence their selection is often not within the occupants' discretion and they cover large surface areas in a room.
Since VOC emissions are frequently able to be recognized, and can also lead to health impairment, sensory testing was included as an important aspect in the assessment scheme of the Committee for Health-related Evaluation of Building Products (AgBB scheme) [1]. Despite improving analysis possibilities and the development of artificial noses, replacing the human nose in the determination of perceived air quality has not been successful until today. Odours develop from a number of chemical substances but not all materials generate the perception of smell in humans. Many thousands of different substances can be detected in the room air, but even a quantitative determination of each single material would not enable a statement about the smell effect of a combination to be made.
Within the research project "Determination of emissions from building products using test chamber measurements and development of product-specific test conditions for low-emission building products" a new method to investigate the odour impression of the emissions of construction products was developed [2]. The odor measurements use the same chamber conditions like the VOC emission tests in accordance with EN 13419-1 [3]. Typically, chamber tests following this standard have exhaust air streams of much less than 0.7 liters per second, the minimum volume flow rate for odor measurements [4]. Therefore, the exhaust air of the chambers is collected in 300 l gas sampling bags.
A human panel assesses the air collected in the air sampling bags using a comparative scale of acetone/air mixtures, which help to determinate its intensity Π. The introduced perceived

intensity Π can only be determined with panels using a comparative scale. Unlike the acceptability method with large panels, the intensity of odorous substances in the air is determined by comparing different specified intensities of the reference material acetone. The smelling capability varies from human to human. Training and use of comparative sources ensure that the influence of subjective perception of the test result is reduced since all panel members evaluate air quality based on the same scale.
50 building products were tested in this project in emission chamber tests according to the provisions of the AgBB scheme. VOC emission tests were performed in each case on the first, third, tenth and 28th day and, in addition, the odour emission tests were conducted on selected products.

METHODS

In the project a laboratory comparison was planned to validate the odor measurement method. However, none of the other institutes possessed the same odor measurement instruments as the Herrmann Rietschel Institute, therefore a suitable procedure had to be found. Thus a timely graduated process was planned. A transportable version of the comparative scale was designed. The objective of this was to achieve a constantly adjustable acetone concentration in the sample air independent of the ambient conditions. The design scheme of the comparative scale is illustrated in Figure 1.
The comparative scale is in essence composed of three parts: sample air circulation, source of acetone and dosing device. The units in contact with air are almost wholly manufactured from stainless steel, glass or PTFE (polytetrafluoroethylene), which are practically odorless.

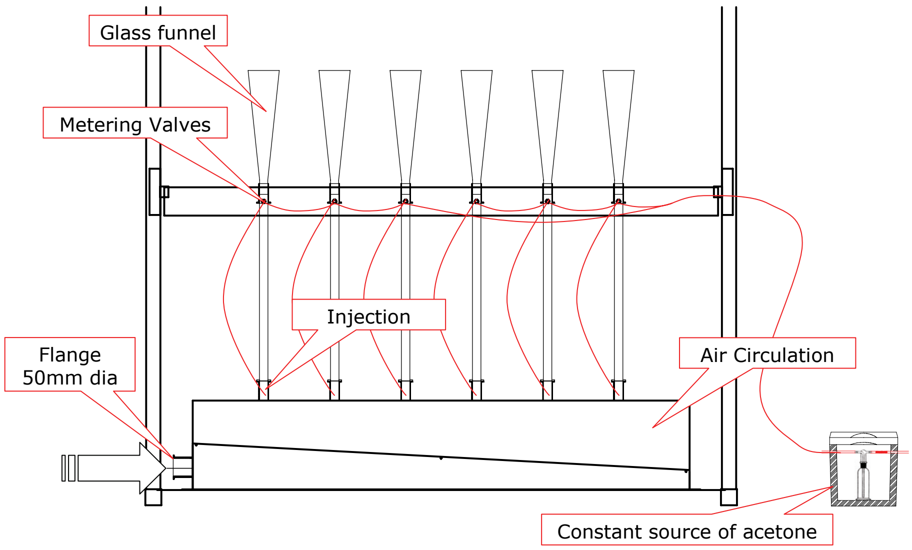

Figure 1: Scheme of the transportable comparative scale

Sample air circulation is connected via a flange to a suitable smell-neutral air supply. The sample air circulation provides constant flow rates between 0.9 and 1.0 l/s per marker (5.4 to 6.0 l/s for six markers) which ensures an undisturbed operation. The constant source of acetone consists of a pressure-resistant wash bottle and a cooling device. The acetone filled wash bottle is supplied with compressed air which is pumped through and then enriched. Cooling prevents an over saturation of the compressed air and a consecutive condensation in the pipes. The acetone fog is effectively separated by a stainless steel filter from the enriched air.

The six funnels are supplied with the constant air/acetone mixture via a distribution hose. A metering valve per funnel regulates the amount of the acetone/air mixture added to the sample air within the range of 0 to 1150 mg m^{-3}.
Six different mixes of acetone concentrations in the range between 20 mg m^{-3} (0 pi) and 300 mg m^{-3} (15 pi) help the panellists gain their orientation in determining the perceived intensity of an unknown sample. In addition, the comparative scale enables uniform assessment criteria on different testing days and facilitates the standardisation of the method. The comparative scale was equipped with its own fan unit for an independent mobile operation. An electronic fan control unit enables the exact adjustment of the total flow to provide a supply for the comparative scale.
In view of the need of mobility, the AirProbe [5] was further developed for the laboratory comparison. To achieve a better and more constant provision of sample air, the operational principle was fundamentally changed (Figure 2).

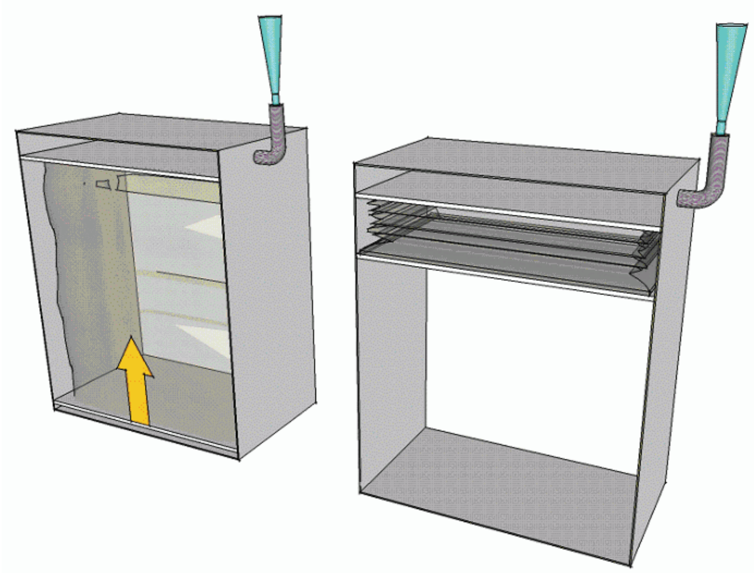

Figure 2: Operational principle of sample provision in AirProbe II

The sample provision in AirProbe II is based on the principle of a press. The sample container in AirProbe II is between an upper fixed plate and a mobile lower plate or piston. When the lower plate is moved at a constant speed, a constant flow rate is produced from the sample container, which is attached to a high-grade steel pipe leading to the glass assessment funnel. Based on a pressure difference measurement at an orifice, the flow rate can be calculated and indicated on a display. The piston velocity can be changed with a potentiometer over a wide range. The panellists have a longer time for assessment, since only the operation of a switch is needed during the smelling procedure to provide the full flow rate. In the period between two smelling procedures the flow rate is reduced to a minimum to prevent a back flow. Due to a smaller average flow rate up to 12 panellists can perform an assessment at the glass funnel. The body of AirProbe II consists of a light aluminium transportation box with the external dimensions 1200 x 800 x 510 mm.
The equipment was sent from participant to participant. The experimental setup only remained with each participant for three weeks. In this time an eight-day chamber test combined with chemical analysis and sensory testing with a minimum of six panelists of sample air was performed. Because of the new sensory testing the participants were instructed in a one-day introductory course in the handling of devices and the measurement technique. In addition to the air quality manual, extensive documentation and detailed guidance on the test methodology were available to the participants. Brief device-related descriptions were compiled during the tests for quick orientation.

In addition to the innovative odour tests, an emission chamber test was also performed in accordance with DIN EN ISO 16000-9 to -11 and/or -6 [6] within the interlaboratory comparison. Planning the emission chamber tests was a challenge, since all participants had to carry out the tests under the same conditions over a longer period. Thus a roll or stacked commodity, which would age in the course of time, had to be rejected. Instead, a sample had to be selected which remains stable during a period of at least six months. Furthermore the sample had to exhibit good measurable emissions and at least a clear, well identifiable odour. The choice finally fell on an acrylic sealing compound, which can be prepared very reproducibly for the tests. The acrylic sealing compound was placed in an aluminium standard channel, levelled with a trowel and placed into the chamber after a short waiting period. Emission and odour tests on air from the chamber were carried out on the first, third and eighth days. The odour transport containers were filled at the chamber exit. When this was done in chambers smaller than 1 m³, the container had to be filled dynamically over night. At the 1 m³ chamber it was easy to exchange the tank contents three times within one hour, so that the odour sample could be taken directly before the assessment. For the third measurement day additional tubes were sent, which the participants loaded simultaneously to their sampling. They were then analysed by the Federal Institute for Materials Research and Testing (BAM) to decide whether the chamber influences or analysis caused deviations between the results of the institutes. The good comparability of the VOC data of the chamber test shows that the different participants largely had the same test conditions in the chambers. Each participant additionally received another standard solution, which could be used for the quantification of the emissions.

RESULTS

After completing the tests in the institutes, the data sets were conveyed to the Hermann-Rietschel-Institute for assessment. All laboratories involved managed to complete the sensory assessments despite the short time. Six to 18 panellists per laboratory participated in the tests. Between 69 and 76 individual values were produced each test day. Figure 3 illustrates the results from the laboratories.

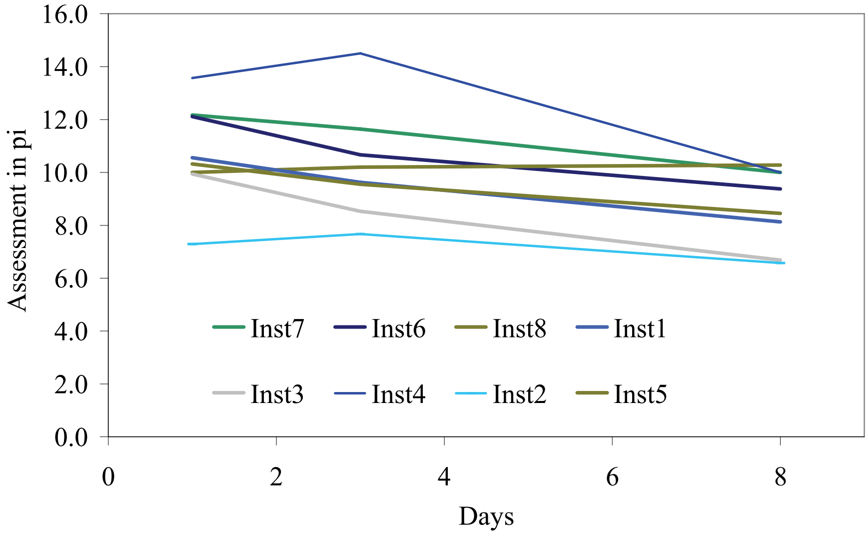

Figure 3: Intensity of all laboratories

The test days are plotted on the abscissa and the perceived intensity Π on the ordinate. The results of each institute were calculated as an arithmetic average of the individual answers for each test day.

The results of Institutes 2 and 4 were excluded from further consideration in the assessment. Technical problems in the test procedure in one of the institutes and deviation from the procedural regulations in the second institute provided results under non-comparable test conditions. Technical problems in AirProbe II forced Institute 8 to do a short-term modification during the test run, which may be an explanation for the horizontal profile of intensity assessments. Since all other boundary conditions were adhered to in this Institute and AirProbe1 is in principle suitable for the execution of the tests, the results were included in the overall assessment. Figure 4 shows the cleaned laboratory results and the average value of all laboratory results.

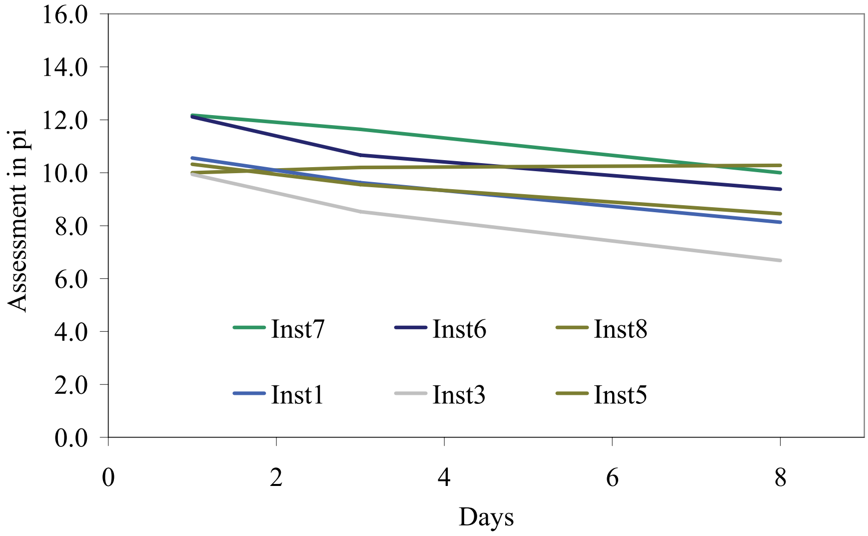

Figure 4: Cleaned intensity, average of all laboratory results

In addition to the medium standard deviation, Figure 5 also shows the maximum deviation of the laboratories from the average value of all laboratory results for a better assessment of the test results.

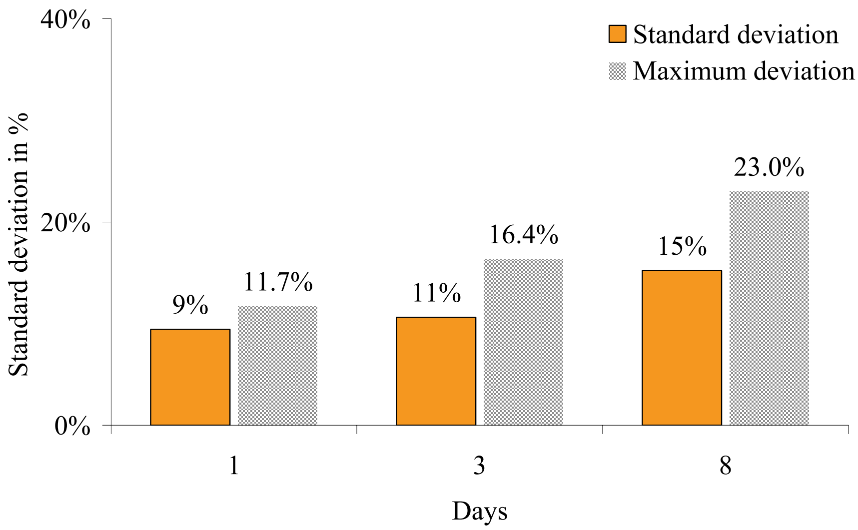

Figure 5: Medium standard deviation and maximum deviation of the laboratories from the average of all laboratory results

The medium standard deviation is between 9% on the first test day and 15% on the last test day. The maximum deviation is between 11.7% and 23%. These reasonably good values from a first co-operative test could be improved by a focused selection of the panellists.
Since the laboratories involved exclusively used 1-m³ chambers for test execution, the Herrmann Rietschel Institute carried out additional tests in 1-m³ and 20-litre chambers.

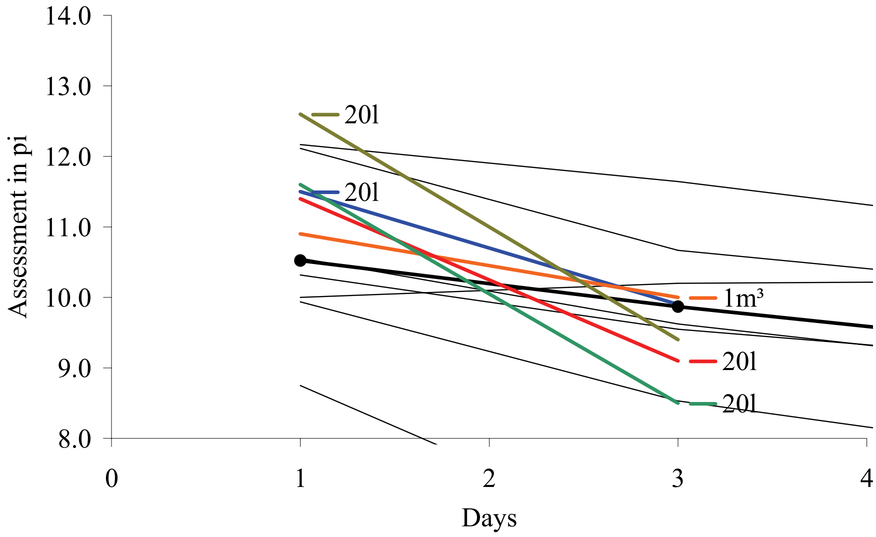

Figure 6: Intensity assessment of samples from the 20-litre and 1-m³ chambers

The investigations are limited to the first and third test day. Figure 6 shows an enlarged excerpt of the two test days. The curves show that the chamber size obviously has no influence on the sensory assessment.

DISCUSSION

The results of odour assessment show that newly developed devices, guidelines and test descriptions allow comparable intensity assessments to be obtained between the laboratories for the selected building material, although the laboratories involved had little or no experience with sensory assessment of building materials.

The good overall result of the co-operative test is illustrated in Figure 7. In addition to the standard deviation of the laboratories from the overall mean, the maximum deviation of the individual laboratories over the entire test period is also shown for a better assessment. With a standard deviation of 9% (first test day) to 15% (eighth test day) very good results were obtained under the conditions specified above. The Hermann Rietschel Institute achieved a very constant deviation of only 4 % from the general mean with trained panellists under optimised laboratory conditions over the entire test period.

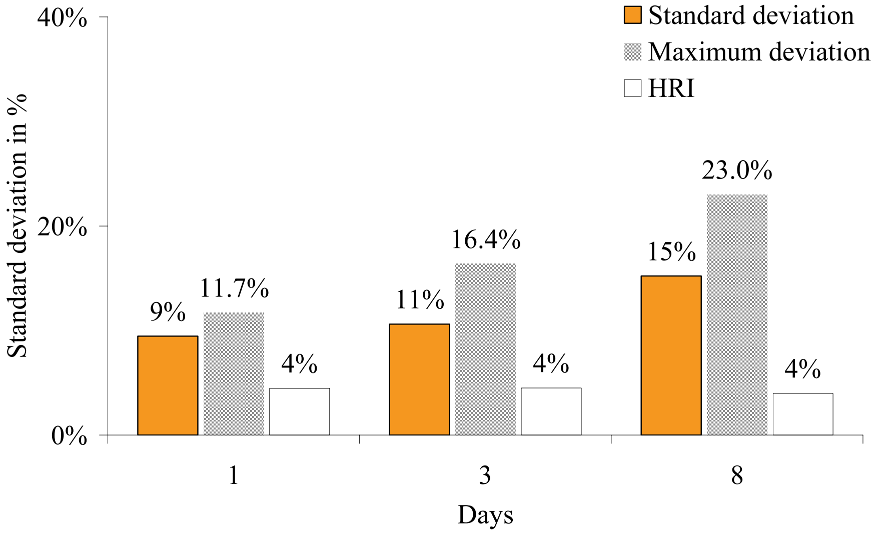

Figure 7: Standard deviations of the laboratory results

Figure 8 shows the medium standard deviation of the individual answers from a laboratory and the maximum deviation over the test days. It provides information as to how large the dispersion of the individual answers of the panellists of a laboratory is on a particular test day. The maximum standard deviation here shows the enhancement potential of the results if a focused selection of the panellists was undertaken.

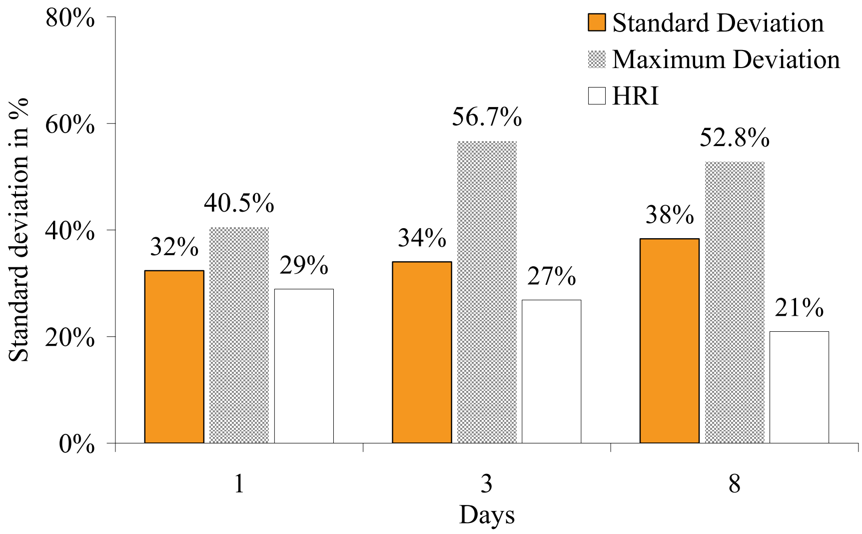

Figure 8: Medium standard deviation and maximum deviation of the individual answers of the individual laboratories, standard deviation of the Herrmann-Rietschel-Institute

The standard deviations of the Herrmann-Rietschel-Institute, which works with a focused selection of trained panellists under optimised ambient conditions and whose staff members have been familiar with the method for years, are accordingly well below the medium standard deviation.

Since the co-operative test was only performed on a single building material sample due to time constraints, other co-operative tests would be necessary for a possible validation of the method where several building materials were tested by panelists.

ACKNOWLEDGEMENT

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