

## Round robin tests of odour and VOC emissions from building products– what have we learned so far?

Wolfgang Horn, Olaf Wilke, Matthias Richter

Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany, wolfgang.horn@bam.de.

**Abstract.** Emission testing of volatile organic compounds (VOC) and odour from materials and products is commonly based on emission test chamber measurements. These measurements are often the basis of mandatory or voluntary labelling procedures. To ensure the comparability of results from different testing laboratories their performance must be verified. For this purpose, round robin tests (RRTs) are conducted. Bundesanstalt für Materialforschung und -prüfung (BAM) offers such a RRT every two years using well characterised test materials with defined VOC emissions. In addition to the VOC quantification, the evaluation of odour is also implemented in the round robin tests. At the beginning, only perceived intensity (PI) was tested but over the years also the acceptance evaluation was considered. In principle, the results of PI and acceptance evaluation are comparable. The advantage of PI is the lower number of panel members necessary for one evaluation.

**Background.** The evaluation of construction products or building materials being “low-emitting” is based on measurements using third-party emission test chambers. In practice, these measurements are performed by various commercial laboratories, for which reason the quality of the tests might vary. So it happens that testing of one material leads to different results at different laboratories. To keep this variation as small as possible and to ensure comparable results, the participation in RRTs should be implemented in a laboratory’s quality management system (Wilke et al., 2021). Additionally, to the widespread VOC tests also odour measurements are carried out for labelling procedures (M1-classification, Danish Indoor Climate Labelling or Blue Angel in Europe). Consequently, odour evaluation should be incorporated into comparison tests. The odour measurement procedures are described in ISO 16000-28 (PI, hedonic tone and acceptance). For the Blue Angel evaluation, a limit value of 7 for the PI was defined to be acceptable by the AgBB (*Ausschuss zur gesundheitlichen Bewertung von Bauprodukten*: Committee for Health-related Evaluation of Building Products). The acceptance is OK for results of zero or above.

**Aims.** Quality assurance is one of the main parts for reliable measurement results of a laboratory. Therefore, BAM offers RRT every two years for laboratories that measure VOC or odour emissions for the purpose of health-related evaluation and labelling.

**Methods.** For the organization of RRTs, BAM developed reference materials based on a water-based lacquer system to which VOC mixtures of about 10 compounds in varying composition were added. However, a few compounds were regularly added to see a development in the measurement variations over the years. The lacquer systems were applied in Petri dishes, dried and then sent to the RRT participants. Before that, they were tested for homogeneity, stability and reproducibility. The participants were asked to load their chambers for VOC-tests as well as odour evaluation about 7 days after preparation of the sample. The time of evaluation was the 7<sup>th</sup> day after loading. All participants measured in their own chambers with their own sampling and analytical systems. The VOC standards for calibration were prepared individually. Statistical data analysis was carried out by using the software PROLab Plus A and their customized statistical approaches (QuoData GmbH) based on ISO 13528 with robust statistics and z-scores. For successful participation, a relative standard deviation (RSD) of 30% must not be exceeded for 80% of the results. Since 2014 the evaluation of the data is based on the mean value and standard deviation of a group of expert laboratories, which are defined as those

having successfully participated in three consecutive round robin tests organized by BAM.

**Results.** The results of VOC measurements in test chambers and of the odour evaluation for the time span from 2008 to 2021 are given in Table 1. For VOCs, the results of the RRTs are given in combined values like mean of RSDs of the VOCs. Individual results were published by Wilke et al. (2021). The first two lines give the relative number of compounds with RSDs below or equal to 30 %. The third and fourth line give the mean values of RSD of all VOCs for this RRT. The results show that the number of VOC measured with RSDs below or equal 30 % has improved over the years to 83 %. In the 2021 RRT, two compounds with concentrations below 10  $\mu\text{g}/\text{m}^3$  were used for the evaluation. At this low level RSDs above 30 % can be found very often, because this is quite close to the limit of quantification.

**Conclusions.** For more than 10 years, BAM is organizing RRTs for VOC-emissions and odour evaluation in emission test chambers with participants from the EU and worldwide. A value of less than 30 % for the mean relative standard deviation is today's state-of-the-art for VOC measurements by means of emission test chambers. However, the results for some compounds show that it is possible to reach RSDs of about 20 % for individual VOCs. To achieve this, it is necessary to have a continuous control of test chamber conditions and analytical performance. The BAM data reveal that the comparability of test chamber measurements could be improved within the last decade.

The comparison of results of both main odour evaluation procedures (PI and acceptance) shows a good comparability. For a successful testing in labelling procedures, PI values above 7 or an acceptance below 0 is necessary. In the Table, PI values above 7 correspond to negative acceptance. Due to the pandemic phase in 2021, most laboratories could not realise higher numbers of panel members. For a good reliability 10 to 12 for PI or 15 and more panel members for acceptance evaluation are necessary.

**Keywords.** Building products, chamber tests, round robin, proficiency test, VOC, odour

**Table 1**

Results of the round robin tests are given with the parameter of relative standard deviations (RSDs; %). 30 % is the defined limit value for the evaluation of results.

		2008	2009	2012	2014	2016	2018	2021
<b>VOC</b>	<b>VOC RSD ≤30% AL</b>	80	33	38	33	63	83	58
	<b>VOC RSD ≤30% EL</b>		<b>67</b>	<b>38</b>	<b>56</b>	<b>75</b>	<b>83</b>	<b>83</b>
	<b>Mean RSD AL</b>	22	36	34	39	29	28	31
	<b>Mean RSD EL</b>		<b>29</b>	<b>32</b>	<b>31</b>	<b>28</b>	<b>27</b>	<b>23</b>
	<b>Number of VOCs</b>	5	6	8	9	8	12	12
	<b>No: AL/EL</b>	28/-	37/26	46/28	55/24	49/21	50/24	51/27
<b>Odour</b>	<b>PI</b>			<b>4.4</b>	<b>6.5</b>	<b>9.1</b>	<b>10.7</b>	<b>10.3</b>
	<b>Hedonic</b>			-0.4	-0.5	-1.9	-2.3	-1.9
	<b>Mean of PM</b>			12	11	12	10	10
	<b>No: Laboratories</b>			14	17	15	10	9
	<b>Acceptance</b>				<b>0.33</b>	<b>-0.3</b>	<b>-0.41</b>	<b>-0.39</b>
	<b>Mean of PM</b>				15	17	20	15
	<b>No: Laboratories</b>				5	13	13	10

AL: all laboratories; EL: expert laboratories; PM: Panel Members

## Reference

Wilke, O., Horn, W., Richter, M., & Jann, O. (2021). Volatile organic compounds from building products - Results from six round robin tests with emission test chambers conducted between 2008 and 2018. *Indoor Air*, 31, 2049-2057. <https://doi.org/10.1111/ina.12848>