Material labelling

combined material emission tests and energy evaluations

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Material labelling: Combined material emission tests and sensory evaluations

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SUMMARY
To control the emission of pollutants from building materials, labelling systems have been introduced. Some of the systems combine measurements of volatile organic compounds according to 16000-9 and sensory evaluations. In Denmark, the sensory tests are performed by a minimum of 20 subjects. The subjects assess the air quality using a continuous acceptability scale and an odour intensity scale. In Germany the sensory evaluation system is being developed. The volumetric flow in the chambers is too low for direct sensory evaluation. Thus a system is developed to sample the air from air sampling bag. The air is evaluated by a panel of at least 10 persons using a reference scale. For the Finnish M1 label the sensory evaluations are performed by 5 to 10 subjects assessing air quality using a continuous acceptability scale and describing the odour using a list of odour profiles.

The purpose of the present paper is to compare and discuss the sensory test procedures of the different labelling systems.

KEYWORDS
Material labelling, Emission test, Sensory evaluation, Odour intensity, Acceptability

INTRODUCTION

Indoor air pollutants influence the health and comfort of building occupants. The pollutants are emitted by various sources. Among these sources, the building products are of particular importance, because these sources cannot be removed easily, and often the occupants are not in a position to decide in the selection of materials in rented flats, offices and public buildings. To control the emission of pollutants from building materials, labelling systems have been introduced in European countries. All of the systems have in common that they include measurements of volatile organic compounds; only some of them also combine these measurements with sensory evaluations. Measurements of chemical emissions are not enough to characterise the impact of materials on indoor air quality. The odour of the building product must also be evaluated because the devices do not measure or detect all possible compounds that may be present in the emissions and which may affect the sensory characteristics of the product. Sensory evaluation must be performed separately using human subjects as detectors.

Standardised methods are available for chemical emission testing. Methods for sensory evaluation are still being developed and validated.

Good perceived indoor air quality can be obtained with a combination of source control and adequate ventilation. Among indoor pollution sources, focus has been put on building materials. Different kinds of labelling schemes for emissions have been developed for building materials in some European countries (ECA-IAQ, 2005). The main purpose of labelling is to protect consumers from exposure to chemical pollutants and the resulting adverse health effects or annoyance caused by odours. EU experts agreed a decade ago that odour evaluations should be part of a labelling scheme (ECA-IAQ, 1997). Work was initiated, but up to now no consensus has been reached on which specific sensory method should be applied in labelling schemes (ECA-IAQ, 1999). As a consequence, different odour evaluations are included in the Danish "Indoor Climate Label", the Finnish "M1- Emission Classification of Building Materials" and in the French "CESAT - Evaluation of environmental and health-based properties of building products" (odour evaluation optional). The intention is also to introduce an odour evaluation in the German “Blue Angel” and AgBB (Committee for Health-related Evaluation of Building Products) scheme.

To harmonise the different sensory evaluation procedures, an ISO (ISO 146-6 WG 14) working group has been established under the lead of Finland to describe the sensory evaluation for the label process.

The main reasons for the use of this sensory evaluation test method are that the method is simple and reliable enough and thus admissible for trial in a court of justice.

METHODS

In the Finnish, Danish and Norwegian labelling systems a „**C**hamber for **L**aboratory **I**nvestigations of **M**aterials, **P**ollution and **A**ir **Q**uality“ CLIMPAQ (Nordtest 482, 1998) or similar small chamber is used for the emission test and for the sensory assessment. The CLIMPAQ is shown in Figure 1. This chamber works with a funnel or cone at the CLIMPAQ outlet. The airflow at the cone end is recommended to be 0.9 l/s (3.24 $m^3 h^{-1}$) (Nordtest 482, 1998). This is to ensure that even when taking a deep breath, the test person only breathes the air coming out of the chamber. To guarantee that the air is not mixed with the surrounding air, the cone must have a maximum opening angle of 12°, ensuring a homogeneous outflow of sample air. This airflow is higher than the airflow rate traditionally used for chemical emission testing in small test chambers with air exchange rates of 0.5 - 1 h^{-1}.

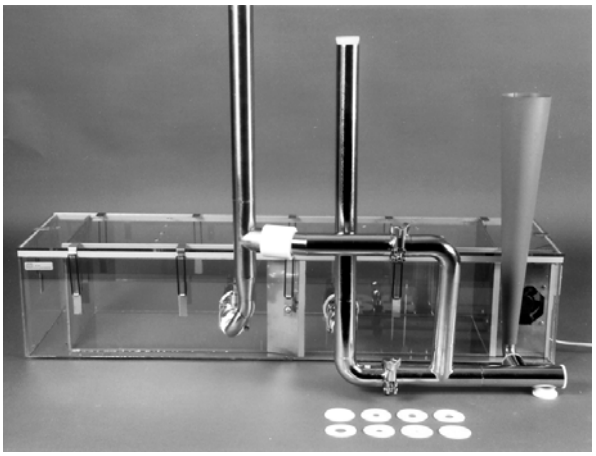


Figure 1. CLIMPAQ (*Nordtest 482, 1998*).

In the German labelling method, the emission test and the sensory evaluation are combined directly. The procedure includes test chambers in accordance with ISO 16000-9 for VOC emission tests. The volumetric flow in these chambers is too low for direct sensory evaluation, as described before. Thus the air is collected directly from the emission chamber exhaust air outlet in a 300 litre air sampling bag.

In the following sections only the sensory evaluation procedures will be described, not the emission test procedures.

The Danish Indoor Climate Labelling, DICL

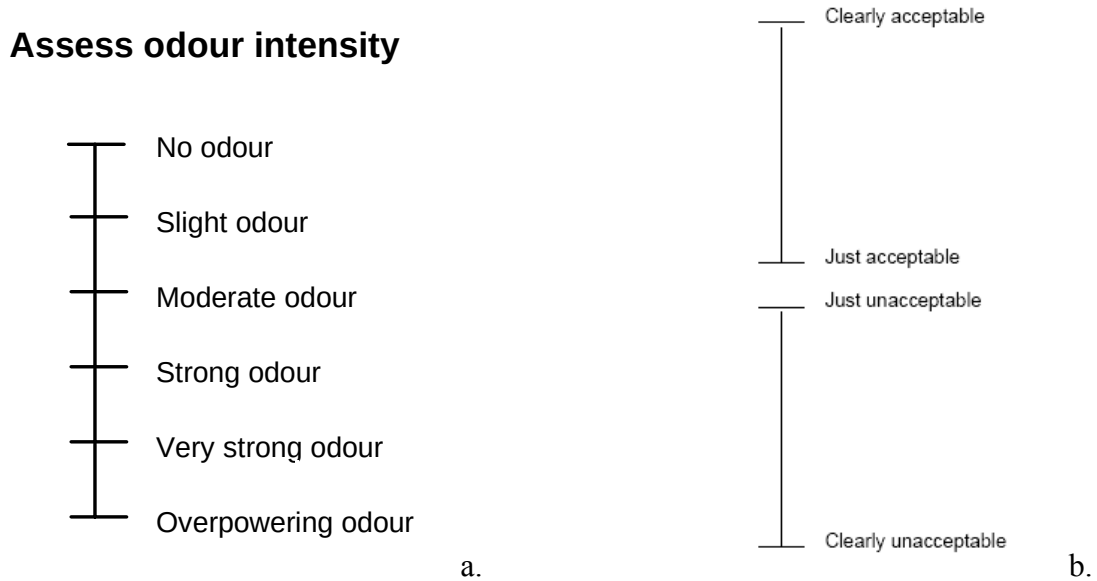
The sensory evaluation is carried out at the latest when the emission rate for all individual substances converted into concentration in the standard room is below half the threshold value for irritation.

According to the Danish sensory evaluation test method (DICL, 2005; DICL, 2007) the sample is stored in a CLIMPAQ or similar glass chamber. The sensory tests take place directly at the funnel of the chamber. The following questions are assessed during the sensory evaluation by a panel of at least 20 persons (Figure 3).

For the sensory evaluation the same area-specific volume flow is used as in the standard room (DS/INF, 1994). The threshold for acceptable air quality is (see Figure 2):

- Acceptability > 0 (0 = just acceptable)
- Odour intensity < 2 (2 = moderate odour)

The so-called indoor-relevant time-value is determined as the number of days required to fulfil both the criteria for the chemical analysis (concentration in the standard room of all individual detected substances below half the threshold value for irritation) and the sensory evaluation (acceptability and odour intensity).



a. b.

Figure 2. Assessment questions for the odour intensity (a) and the acceptability (b).

Figure 3. Assessment questions for the acceptability and the odour intensity.

The Finnish building material labelling system M1

The Finnish building material labelling system (first established in 1995 and revised in 2000) has three categories, with M1 representing low emitting materials. Materials are labelled according to the chemical and sensory emissions measured after 4 weeks. The labelling criteria in different M-classes (test specimen age 28 days) are shown in Table 1.

Table 1. The Finnish building material classification requirements of different emission classes (M1, 2000).

	M1	**M2**	**M3**
TVOC, µg/(m²h)	< 200	< 400	≥ 400
Formaldehyde, µg/(m²h)	< 50	< 125	≥ 125
Ammonia, µg/(m²h)	< 30	< 60	≥ 60
Sensory assessment percent of unsatisfied	<15%	<30%	≥30%
Carcinogens IARC group 1	< 5 µg/(m²h)		

The sensory evaluation is performed according to the instructions given in the Finnish Classification of Building Materials (*M1, 2000*). The evaluation is made using the acceptability scale from -1 (clearly unacceptable) up to +1 (clearly acceptable) with +0,1 corresponding to just acceptable and -0,1 to just unacceptable. The subjects are also asked about the acceptability of the odour in a binary "yes/no" question. For a more sophisticated odour description, a profiling list is included (see Figure 4).

- Emission chamber in accordance with ISO 16000-9, 10, 11 CLIMPAQ, 1m³, etc.
- For sensory tests the materials are brought in two days before the test, when the acceptability of the empty test chamber is better than 0.5
- 0.9 l/s at the outlet
- 5 persons, test for acceptability and descriptors
- The acceptability test is done twice with a two minute break
- If the acceptability is in between -0.4 and 0.4, a second test with 5 additional persons is necessary

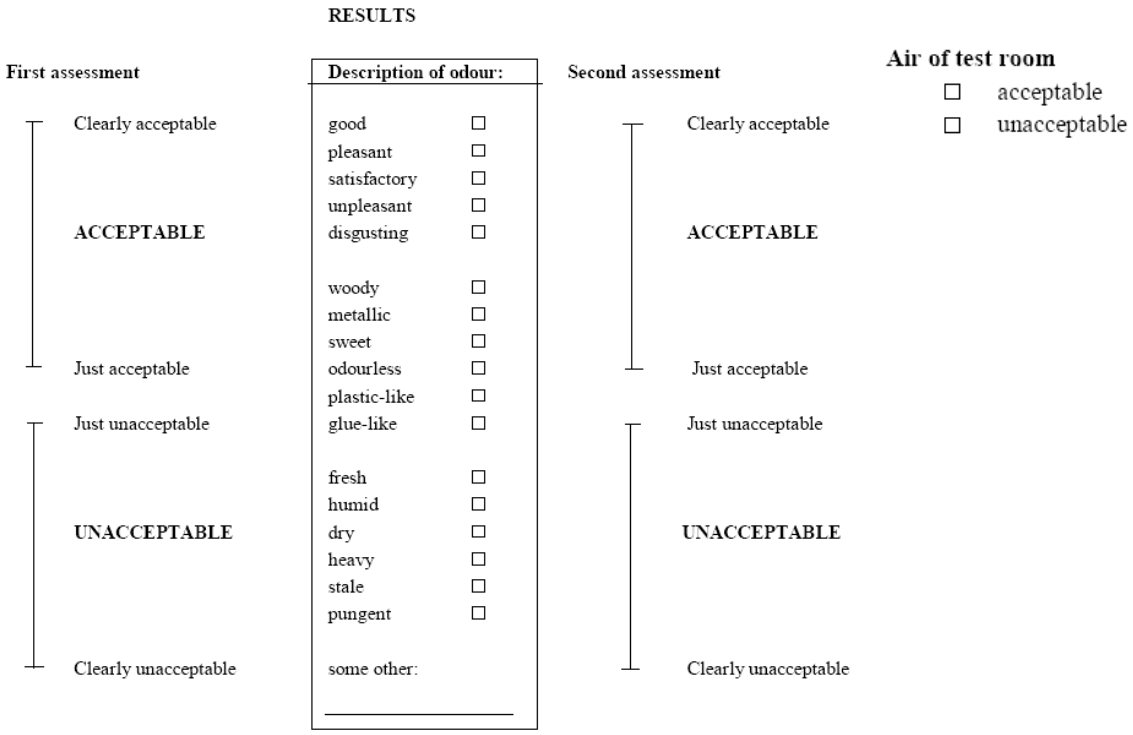


Figure 4. Assessment questionnaire for the sensory evaluation of the M1 classification procedure of Finland (M1, 2000).

The German building material labelling system

Up to now the sensory evaluation is not part of the labelling system in Germany. For the chemical analysis of the air samples, emission chambers in accordance with ISO 16000-9, 10, 11 are used.

Currently there are efforts to introduce sensory evaluations into the labelling schemes Blue Angel and Committee for Health-related Evaluation of Building Products (AgBB). In research projects a system for odour assessment is being investigated. The odour of the sample is not assessed directly at the emission chamber exhaust, because of the low air flow. Therefore the air is sampled in a 300 litre bag. The bag is then transported to an air quality lab, and the air from the bag is evaluated by a panel of at least 10 persons using a reference scale. The use of sampling bags for measuring perceived air quality and intensity was investigated in a PhD thesis by Müller 2002 (see Figure 5).

Figure 5. Sampling procedure at the exhaust of the emission chamber (20l chamber).

When assessing the perceived intensity of unknown samples, panel members have to rely on a comparative scale of acetone/air mixtures, the so-called references, which help to determine intensity. The intensity of odorous substances in the air is determined by a comparison with different specified intensities of the reference substance acetone. The smelling capability varies from human to human. Training and the use of comparative sources ensure that the influence of subjective perception of the test result is reduced, since all panel members evaluate the sample air in comparison to the same references. The objective of this construction was an adjustable stable acetone concentration independent of the ambient conditions in the sample air. The design scheme of the comparative scale is illustrated in Figure 6. The references are in essence composed of three parts: supply air distribution unit, source of acetone and dosing device. The units in contact with air are almost wholly manufactured from stainless steel and glass, which are practically odourless.

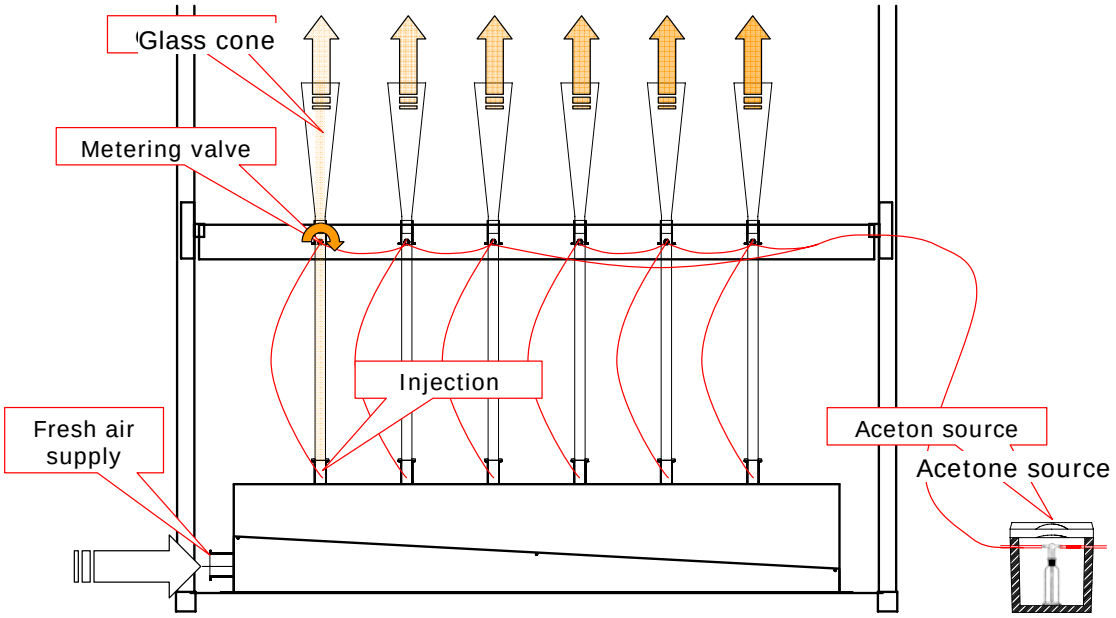


Figure 6. Scheme of the comparative scale.

The measurement variable of the perceived odour intensity measured by a panel using a comparative scale of reference substances is defined as II. The unit of the measurement variable Π is pi. The comparative scale at Hermann-Rietschel-Institut consists of six different acetone/air mixtures.
The lower limit of the comparative scale is derived from the odour threshold. Different experiments with dynamic and static olfactometry at TUB resulted in an average odour threshold of approximately 20 $mg_{acetone}/m^3_{air}$. The determined value is well within the range of 15-35 $mg_{acetone}/m^3_{air}$ which can be found in the literature according to the VOCBASE of Jensen and Wolkoff.

- 0 pi expresses a concentration of 20 $mg_{acetone}/m^3_{air}$.
- Assessments below the odour threshold of 0 pi are not reasonable

The steps and the range of the reference acetone concentrations can be varied according to the measurement task. The first bisection experiments conducted at the TUB resulted in a reasonably good linear correlation for the response curve of acetone up to 400 mg acetone/m³ air. According to this correlation, one unit of the reference scale is defined as 20 mg acetone/m³ air. Larger concentrations lead to a non-linear scale set-up.

DISCUSSION AND CONCLUSIONS

If sensory evaluations are to be included in labelling methods, it must be assured that the measurements are appropriate to define legal limits. It is important to define the accuracy needed for that purpose, since cost-effectiveness and measurement accuracy are concurrent objectives in sensory measurements with human panels.

The accuracy for sensory measurements is defined by the tolerated probability of error in terms of a confidence interval around the estimated mean value $\bar{x}$, measured by the panel, which includes the true mean value μ of the population of values with a defined confidence $(100\% - \alpha)$, where α is the probability of error. The width of the confidence interval is a function of the panel size n, the estimated standard deviation s and the two-sided quantile $t_{(100-\alpha/2);n-1}$, which itself decreases with increasing panel size and probability of error α.

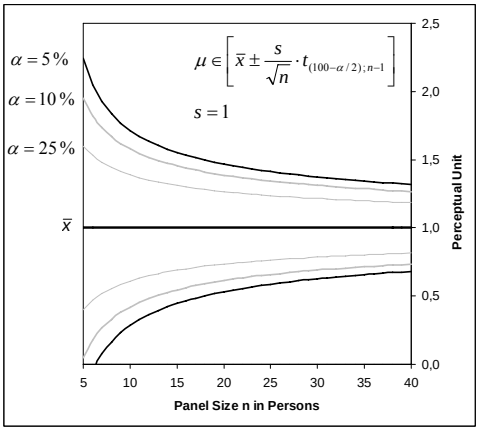


Figure 7. Standardised width of a confidence interval around an estimated mean value $\bar{x}$ of 1, independent of the perceptual unit used. Multiplication with the actual estimated standard deviation s results in the corresponding confidence interval (5%, 10% or 25% probability of error).

Since the methods for sensory evaluation use different kinds of scales, it is difficult to compare the impact of the resulting confidence interval. If an acceptability value of 0.3 was measured with a panel consisting of 10 persons with an estimated standard deviation of 0.4, the impact on the calculated PD value is an interval of 30%, in which the true PD value is situated, tolerating a probability of error of 10% (Figure 8). The probability of error must not exceed reasonable values to retain effectiveness in law, thus the estimated standard deviation is the most influential parameter to improve accuracy, followed by the panel size. This has to be taken into account when defining the panel for the sensory measurements. The boundary conditions to obtain effectiveness in law for the sensory measurements used in the labelling methods for building products need to be defined.

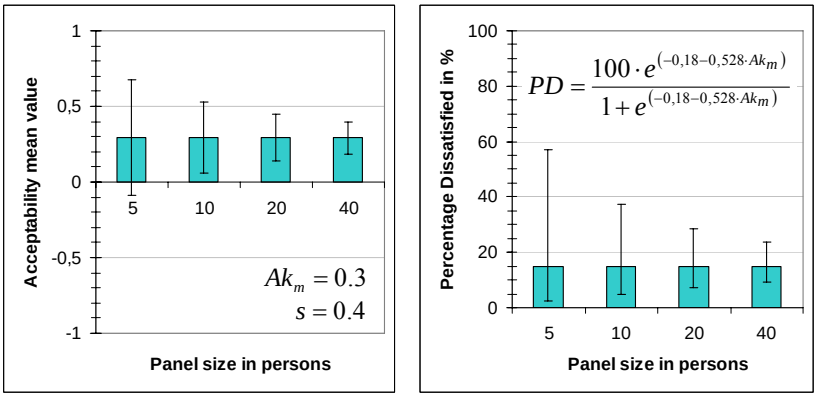


Figure 8. Impact of the 90% confidence interval in acceptability on the calculated PD value.

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