# BUILDING PRODUCTS:

## Determining and avoiding pollutants and odours

### Results from a research project

BAM Bundesanstalt für Materialforschung und -prüfung

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# PREFACE

*To the Reader,*

This brochure highlights scientific investigations on building products, performed by the Federal Institute for Materials Research and Testing (BAM) in co-operation with the Hermann Rietschel Institute of the Technical University of Berlin and commissioned by the Federal Environment Agency (UBA). In the "Environmental and Health Provisions for Building Products – Determination and assessment of VOC and odour emissions" research project scientists studied building products used by building professionals and do-it-yourself enthusiasts for interior installation and decoration. It was found that certain products emit compounds which may impair not only the quality of the room air but also health and well-being of the occupants.

Because at our latitude we reside for the largest part of the day indoors – about 20 hours, most of that time within the own four walls – the quality of the interior air is of great importance. Unfortunately, good air quality cannot be taken for granted, not only because of the behaviour and habits of room users, but also because materials or products used in the building may be major sources of pollution. Describing these emission sources is the aim of this brochure.

Many building products used in the rooms, such as interior plaster or floor coverings and occupying large areas, may contribute to pollution of the interior air over the long term. If smell-intensive materials are given off, these can easily be detected and through extensive ventilation – which may be accompanied with increased energy consumption during the heating season – the room users can achieve a temporary remedy. Many emissions however remain unnoticed by our noses but may nevertheless impair our health over the medium or long term.

In view of the Energy Saving Ordinance this problem may be exaggerated, since the heat insulating and sealing measures required in the buildings reduce the natural air exchange rate which leads to an enrichment of undesired substances in the room air. Therefore, one of the key objectives of the German Action Programme Environment and Health is to reduce potential health-endangering emissions from building products. The Federal Environment Agency has integrated this requirement into the Basic Criteria for the "Blue Angel" environmental award. Therefore, in addition to ecological criteria, health aspects have increasingly become front line in the last few years.

The European Union is moving in the same direction and intends to nip this in the bud. The legal basis for this is the European Construction Products Directive, which Germany implemented in German law through the Construction Products Act. In addition to the traditional requirements, such as stability and behaviour in fire, building products must also fulfil requirements concerning hygiene, health and environmental protection. The Construction Products Directive has the result that the number of health and environmentally compatible building products on the market is increasing Europe-wide. However – 17 years after the Construction Products Directive having come into force – there are still tasks to take care of. This brochure presents some of these tasks and reports on the activities and results achieved in Germany so far.

Currently, national regulations are valid in the member states and must be notified to the European Commission. In Germany the Committee for Health-related Evaluation of Building Products (Ausschuss zur gesundheitlichen Bewertung von Bauprodukten – AgBB) has developed an evaluation procedure, the so-called AgBB scheme. This scheme has been a component of the "Principles for the health assessment of construction products used in interiors" since 2005 and has been used by the German Institute for Building Technology (Deutsches Institut für Bautechnik – DIBt) when certifying building products. This is the basis of determination and assessment of volatile organic compounds emitted from building products. A sensory, i.e. odour test has also been planned but is currently not yet practiced, because no generally recognized, co-ordinated and universally accepted method is available.

In the research project the scientists relied on the AgBB scheme as a basis for the investigation of building products. In addition, they developed and tested methods for sensory investigation and thus performed important preparatory work for a future sensory test.

In addition, this brochure contains interesting and useful information about valid legal regulations and references for intended building and decoration activities, which should be born in mind when purchasing products. We will be delighted if we can satisfy the demand for information from do-it-yourself enthusiasts, local health authorities and building supervision and environmental protection authorities as well as architects and civil engineers.

We thank all those involved for the specialist support. Without that this brochure would not have been possible.

*The Publishers, in November 2006*

# 1 WHY SHOULD BUILDING PRODUCTS BE TESTED?

We spend the largest part of the day – about 20 hours – in closed rooms. During most of that time we stay within the own four walls. The quality of interior air in our room therefore has a great importance for our health and well-being.

Unfortunately, good air quality cannot be taken for granted. It not only depends on what and how often the inhabitants ventilate (let fresh air into the room), what they do in the rooms and which household chemicals they use, but also on the various emissions, i.e. degassing from materials or products, which the flat was equipped with or the building was built from, that may impair the quality of the room air.

From the numerous investigations performed by experts or tests performed by scientists in studies to solve these problems, it is known that the volatile organic compounds in interiors are mixtures of materials, which have very different compositions and may exhibit large fluctuations in the concentration of individual compounds.

There are guideline values for some interior pollutants, which set reference points for the assessment of the quality of interior air. However, laws – like those for the assessment of the quality of exterior air – do not exist. A working group consisting of members of the Indoor Air Hygiene Commission associated with the Federal Environment Agency and the Working Association of the Senior State Health Authorities (also see www.umweltbundesamt.de/uba-info-daten/daten/irk.htm) identify such guideline values. Though the established guideline values are legally not obligatory, they have attained great importance in practice. When the values are exceeded, action is needed. Another guideline is the “Manual for Interior Air Hygiene in School Buildings” published by the Indoor Air Hygiene Commission, which also applies to flats. That which each person can contribute to a good room air quality, is described in the brochure “A healthier home – but how? Practical everyday tips” (see *Appendix 4 Reports, brochures, leaflets, internet addresses*).

In order to achieve good interior air quality, the actions concentrate on product related regulations (also see *Chapter 6 Characterising Health and Environmentally Compatible Building Products is not just a German Effort*). Building products require special attention because room users often have no influence on their selection and they are very expensive to remove from the building at a later date.

Building products are defined as products that are manufactured in order to stay in buildings over the long term (also see *Chapter 2 Which building product regulations do already exist?*). Accordingly, there is a great variety of product groups and products. They may consist of natural or artificial materials or of a combination (see Box 1).

Box 1

**What do building products consist of?**

Sand, gravel, natural stone, wood and cork, belong to natural materials while inorganic materials, such as cement, concrete, glass and ceramic(s), as well as a number of synthetically manufactured organic materials, e.g. plastics and synthetic resins to the artificial building products.

For example timber materials represent a combination containing wood and synthetic adhesives, or cork floor tiles usually carry a synthetic coating. Even in products which appear to be purely inorganic at first sight, small quantities of organic auxiliary materials may be contained. For example aerated concrete may contain organic hydrophobic agents to improve their moisture resistance.

## Organic products are the main emittents

Only insignificant or miniscule emissions of volatile organic compounds can normally be expected from the traditional building products, such as masonry units, full-mineral mortars, steel or glass, after installation. The situation is different in synthetically manufactured and natural organic materials. In addition to the basic chemical components, synthetic materials usually contain a number of inorganic and organic auxiliary materials for the improvement of product properties, for example softeners or flame retardants. But natural organic products, such as wood, wax and oil contain a variety of organic compounds, such as resins, solvents and other components. “Natural or Naturally Pure” does not mean that these products are free from undesired materials or pollutants.

Many smell-neutral or odorous substances may be emitted from such building products even at room temperature and thus impair the quality of interior air. The most well-known problematic materials include formaldehyde, PCB (polychlorinated biphenyls) and PCP (pentachlorophenol). They necessitated extensive and expensive remediation actions in the past. Therefore,

the legislator set restrictions or prohibitions in their application for the protection of the environment and health.

The maximum permissible concentrations in the products are regulated for these materials, but new materials are being added all the time. And this is not only due to the improved analytical methods which enable detection of an increasing number of materials at lower concentrations. Increasingly, manufacturers add auxiliary materials to conventional purely mineral building materials. This is to facilitate processing and installation, improve durability or make new applications possible. This leads to quantitatively and qualitatively changed emissions of organic and inorganic substances from these building products.

## Non-characteristic and wide-ranging health effects make the allocation of certain pollutants more difficult

The effects of volatile organic compounds detected in the interior are wide-ranging and may occur after a relatively short time. They may extend from just perceptible up to quite irritative on conjunctiva and nasal and throat mucous membranes, which can be accompanied with reddening, itching and sneezing and also effects on the nervous system which manifest in headaches, dizziness and tiredness. Hypersensitivity or allergy-increasing characteristics, particularly carcinogenic, mutagenic or toxic for reproduction properties may lead to long-term effects (see detailed explanation of the terms in *Appendix 3 Glossary*). However, it must be considered that such effects become more probable, the higher the concentrations of pollutants in the air. At low concentrations, and most cases are such, a clear attribution – symptom A comes from material B – is not or scarcely possible. Therefore, assessments of the effects of individual materials must always be accompanied with the additional comment of “at higher concentrations”.

Two syndromes, which environmental medical professionals connect with air pollution in the interior and were first described in the USA, have been in public discussion in Germany for some time.

The “Sick Building Syndrome” is an umbrella term. The key characteristic of this syndrome is that several people who live or work in a building complain of similar symptoms to those described above. The percentage of people who show these symptoms is greater than that in comparable buildings. Frequently, specialists cannot find any reason for the complaints. One fact is, however, remarkable: as soon as those concerned leave

the building, they start feeling better. The syndrome emerged in the 1980s, when ventilation rates were reduced in office buildings to save energy as a reaction to the energy crisis of the 1970s which led to the enrichment of indoor pollutants.

The medical profession and other experts are currently discussing the controversial topic whether and to what extent a relationship with chemical hypersensitivity (Multiple Chemical Sensitivity, MCS) reported by the persons themselves exists.

## Situation – unsatisfactory so far

Usually little is known about the emission behaviour of organic compounds and their effect on health and the environment, since systematic studies are missing. In some European countries, including Germany, manufacturers and associations try to provide information to users and consumers about the quality of building products using quality seals (also see *Chapter 6 Characterising Health and Environmentally Compatible Building Products is not just a German Effort*).

In order to estimate if emissions from building products may lead to health impairment, it is necessary to identify the emitted substances and know their concentration. However, an official method for the assessment of materials from a health point of view has so far been missing. This situation will improve in the future by the further implementation of the European Construction Products Directive and the German Building Product Act (also see *Chapter 2 Which building product regulations do already exist?*).

In view of the European Construction Products Directive the Federal Institute for Materials Research and Testing, in co-operation with the Hermann Rietschel Institute of the Technical University of Berlin and commissioned by the Federal Environment Agency carried out the "Environmental and Health Provisions for Building Products – Determination and assessment of VOC and odour emissions" **research project**. Certain parts of the project will be presented in the following chapters of this brochure. Building products have been dealt with, which are used by building professionals and do-it-yourself enthusiasts for interior installation and decoration. Scientists can decide whether the emissions pose a health risk based on the scheme compiled by the Committee for Health-related Evaluation of Building Products (see *Chapter 3 The AgBB scheme applies to the evaluation of emissions in Ger-*

*many*), whose practical suitability has been simultaneously tested in this context. To enable odour-intensive emissions to be tested for, the specialists developed suggestions for the procedure in the project, and since odour tests are also planned to be integrated in the evaluation scheme, they form the basis of an officially co-ordinated method.

# 2 WHICH REGULATIONS ALREADY EXIST FOR BUILDING PRODUCTS?

Europe-wide, about 20,000 various materials and products are on the market to be used in buildings. This market is not only imprecise, there is a distinct lack of systematic investigation into building products and data concerning health and ecological harm. This situation should be improved by the research project described in this brochure.

## The European Construction Products Directive and the German Construction Products Act are the legal foundations

The legal foundation is **the European Construction Products Directive**, whose full name is "Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products". It applies to building products which are intended to stay in buildings over the long term.

The Construction Products Directive is a "New-Approach directive". This means that only the objectives are specified, not the ways to achieve them. The Construction Products Directive includes six essential requirements as compiled in Box 2. The implementation **of Requirement No. 3 "Hygiene, Health and the Environment"**, which only now starts to attract gradually more attention, constitutes a subchapter of its own and is described in more detail here.

Box 2

| Essential requirements for building products[1] |
|---|
| No. 1 Mechanical resistance and stability |
| No. 2 Safety in case of fire |
| No. 3 Hygiene, health and the environment |
| No. 4 Safety in use |
| No. 5 Protection against noise |
| No. 6 Energy economy and heat retention |

[1] *From Annex I of the Construction Products Directive 89/106/EWG*

Harmonized European **product standards** and **approvals** (specifications) specify the criteria building products must meet in detail in order to fulfil these six essential requirements.

If a building product fulfils these requirements and verifications are provided for all relevant EC directives, the manufac-

turer may apply the **CE label** (Conformité Européenne – European conformity) to the product (see Fig. 1). He is then only allowed to market his product with this label. The CE label is therefore often called the "passport" for the European domestic market.

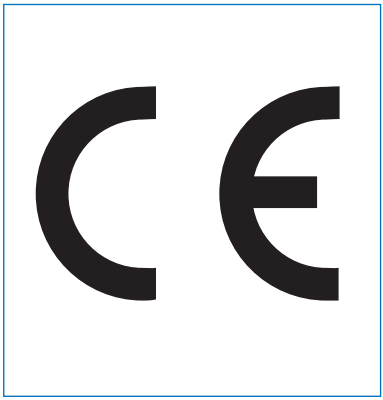


Fig. 1: CE is short for Conformité Européenne (European Conformity). The manufacturer confirms with the CE label the conformity of the product with the applicable EC guidelines and the adherence to the "essential requirements" specified therein.

Altogether about 500 to 800 product standards and 200 test standards are being planned within the Construction Products Directive. Some of them refer to product groups which may have critical effects on the interior air and on soil and groundwater. These product groups include for example floor and wall coverings, adhesives, screeds, wall and ceiling panels, timber materials, plasters, masonry units, seals, heat-insulating materials, cement and concrete.

The **German Construction Products Act** (Bauproduktengesetz, BauPG) of August 1992 implemented the European Construction Products Directive into German legislation. This is the situation for all directives of the European Union: they have to be incorporated by the member states with an act of their own. After several amendments the May 2004 version now applies. This law forms the legal basis for the application of the Construction Products Directive in Germany. Since building law lies within the jurisdiction of the individual States (Länder) in Germany, the Building Ministers' Conference amended the Model Building Code (Musterbauordnung – MBO). The Model Building Code is the sample for individual **Regional Building Codes of the States (Länder)**. It stipulates the method of use for the building products in the market provided with a CE label.

## ▼ National regulations apply first to "Hygiene, health and environmental protection"

Annex I of the Construction Products Directive contains the potential effects from buildings under **Essential requirement No. 3 "Hygiene, health and the environmental"**, which must not endanger hygiene and health (see Box 3). The release of toxic gas can be found amongst them.

The objectives the European Commission formulated nearly 17 years ago by issuing the Construction Products Directive on "Hygiene, health and the environmental" have not yet been achieved by some way. The European building product standards and approvals published so far barely consider environmental and health aspects.

The reasons for these problems in the implementation of the Construction Products Directive are diverse. The development of precautionary mechanisms and product-specific regulation is in many cases still at the beginning. The member states involved have only just started to determine critical emissions systematically in wider fields, no assessments are available for many old materials, authorities currently only develop evaluation patterns for building products in co-operation with the participants involved (also see *Chapter 7 What to do next?).*

**Box 3**

**What dangerous effects are not allowed to occur in a building?** [1]

the giving-off of toxic gas

the presence of dangerous particles or gases in the air

the emission of dangerous radiation

pollution or poisoning of the water or soil

faulty elimination of waste water, smoke, solid or liquid wastes

the presence of damp in parts of the works or on surfaces within the works

[1] *From Annex I of the Construction Products Directive 89/106/EWG, Essential requirement No. 3*

In order to avoid further delays in the implementation of the Construction Products Directive, the European Commission decided to postpone the incorporation of the environmental and health requirements to the so-called second standard generation. In addition to CEN (Comité Européen de Normalisation, European Committee for Standardization) and EOTA (European Organisation for Technical Approvals) the EC organised a team of experts on dangerous materials in building products and adopted a mandate (mandate is the term for an authoritative order) for the development of harmonized test methods for the essential requirement No. 3. These methods have to be

included in the second generation standards. This group includes the product standards relevant for interior use materials: gypsum adhesives, gypsum cardboards, flexible, textile and laminate floor coverings and heat-insulating materials. But still more adequate requirements for health and environmental protection are absent since the implementation of the mandate for the development of harmonized test methods will take some years to complete.

In the meantime **national regulations** still apply, to which the European harmonized standards and approval guidelines refer regarding the requirement of "Hygiene, health and the environment". In Germany an announcement of additional valid national regulations takes place semi-annually through the Building Regulation List and the list of Acknowledged technical rules for works (*Technische Baubestimmungen*)') via the German Institute for Building Technology. Both lists are reported to the European Commission by the Institute for **Notification** (registration, publication). This is necessary because national regulations can only be made legally valid after a notification. It must be emphasized that the Construction Products Directive enables the existing different protection levels in the member states to be maintained.

## ▼ Which authorities, institutes and committees participate in Germany in the implementation of the Construction Products Directive?

In Germany the **Federal Ministry of Transport, Building and Urban Affairs** leads in the implementation of the Construction Products Directive. The **German Institute for Building Technology** – a common institute of the Federal Republic and the States (Länder) – is authorised by law to issue European technical approvals and 'national technical approvals' *(allgemeine bauaufsichtliche Zulassungen*) as well as setting up the Building Regulation List in agreement with the highest construction supervision authorities of the States (Länder).

The Building Regulation List contains the legal requirements in form of technical regulations for building products, which must be uniformly valid for all States (Länder) in accordance with the Regional Building Codes of the States. The Building Regulation List B contains for example such building products which the manufacturers and distributors may introduce to the market and sell in accordance with the regulations of the member states of the European Union (including German regulations) and of the contracting states of the Agreement of the European Economic Area for the implementation of European Union's guidelines and which carry the CE label. The

German Institute for Building Technology participates in the drafting of standards and issues administrative requirements for the building industry. It acts together with the **ARGEBAU** Working Group of the Ministers of the States (Länder) responsible for building, housing and urban affairs to ensure that the building code is adhered to in the individual standard projects.

Implementing the scientific aspects of the essential requirement No. 3 "Hygiene, health and the environment" is taken care of by the **Federal Environment Agency**. The Federal Environment Agency participates in various national and European committees in the standardization of building products and apart from the German Institute for Building Technology it is currently the only specialist scientific authority in Germany that systematically represents the interests of environmental protection and health.

In order to standardize the evaluation criteria and create an obligatory common legal basis for the assessment of emissions from building products, the Committee for Health-related Evaluation of Building Products (AgBB) was founded in 1997 by the States' Working Group "Environment-related Health Protection" (Länderarbeitsgruppe "Umweltbezogener Gesundheitsschutz", LAUG) of the Working Association of the Senior State Health Authorities (Arbeitsgemeinschaft der Obersten Landesgesundheitsbehörden, AOLG). The Federal Environment Agency also acts as an agent for AgBB. At the end of 2000 AgBB published the "Procedure for the health-related evaluation of volatile organic compounds (VOC) from building products" scheme aimed at integrating these aspects in the standardization and building authority approval. Thus AgBB supplements the technical regulations for the implementation of the Construction Products Directive by requiring proof of health safety, initially nationally and later across the whole of the European Union.

*Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany* is dedicated to the AgBB scheme in this brochure. The AgBB scheme was not only the basis for the investigation in the research project described below, the Federal Environment Agency also directed the commission to develop further test methods under this scheme.

The AgBB scheme is a component of the **Principles for the health assessment of construction products in interiors**, which constitute the basis for the approval of building products by the competent German Institute for Building Technology. Based on these principles, the test laboratories must determine and assess not only volatile organic compounds, but the content of all materials within the building product to be approved.

The **notification** of the AgBB principles took place in 2005 within these approval principles – without any objection by the European Commission. This means for example that the commission did not see disproportionate trade barriers emerge on the European domestic market through use of these evaluation principles. Trade barriers are exclusively permitted if they are necessary to protect the environment and health. In 2006 the German Institute for Building Technology also announced the "Principles for assessing the effects of construction products on soil and groundwater" to the European Commission. The notification has currently not yet been completed (as at February 2007). The German Institute for Building Technology will also use these principles in the future as a basis for the evaluation and assessment of the environmental compatibility of building products in issuing general building authority approvals.

The development of scientific fundamentals is funded by the **Environmental Research Plan** of the Federal Ministry of Environment and commissioned by the Federal Environment Agency. The study "Implementation of Health and Environmental Criteria in Technical Specifications for Construction Products" submitted by the German Institute for Building Technology in May 2005 belongs to one of the current projects. For the first time it links the conditions of the state of the art to selected building products, hazardous materials, emissions and test and assessment methods, legal and voluntary regulations for a Europe-wide reference scheme. The study can assist the new team of experts of the European Commission for Hazardous Substances in building products and can be applied in the European standardization committees. The second study completed in 2006 was the research project "Environmental and health provisions for building products – determination and assessment of VOC and odour emissions" which is presented in this brochure. It was performed by the Federal Institute for Materials Research and Testing in co-operation with the Hermann Rietschel Institute of the Technical University Berlin. Highlights of this study are the methodical investigations into the emission behaviour of different building products and their assessment based on the AgBB scheme combined with odour assessment of the emissions based on a newly developed method. The Federal Environment Agency intends to use the compiled recommendations for odour measurements as a basis for a co-ordinated and generally recognized method for odour assessment in the AgBB scheme because sensory tests have been planned from the outset (see *Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany)*.

Based on the contract with the Federal Republic of Germany the **German Institute for Standardization** (Deutsches Institut für Normung e.V. – DIN)

is the institution authorised for standardisation in Germany and represents German interests in European standardization organizations and worldwide. The Institute is a quasi “round table” of all who have an interest in standardization and it determines the state of the art and includes existing knowledge of the German standards. Manufacturers, tradesmen, consumers, craftsmen and service providers as well as science, technical inspection and authorities belong to those interested. In 2003 the German Institute for Standardization published the **No 127 DIN Technical Report “Assessment of Building Products under Hygiene, Health and Environmental Aspects” (not available in English)** by the DIN Construction Sector Coordinating Committee “Environment and Health” of the Building and Civil Engineering Committee in DIN. This provides a comprehensive manual on formal issues, legal basics and state of the art on the implementation of the essential requirement “Hygiene, health and the environment” for those participating in standardisation in Germany.

# 3 THE AGBB SCHEME APPLIES TO EMISSION EVALUATION IN GERMANY

Based on the European Construction Products Directive, the European Collaborative Action (ECA) “Indoor Air Quality and Its Impact on Man” established a working group in 1992. This working group developed a concept for the assessment of emissions of volatile organic compounds from building products using the example of floor coverings. The concept was published in Report No. 18 entitled “Evaluation of VOC Emissions from Building Products” in 1997 which was pretty well the starting signal for the development of an evaluation scheme at a national level.


Fig. 2: Logo of the committee for the health-related evaluation of building products

In Germany, the environmental and health authorities together with the building authorities established the “Committee for Health-related Evaluation of Building Products” in 1997 or AgBB for short (see logo in Fig. 2). Based on Report No. 18, the AgBB developed the scheme for the health-related evaluation of volatile organic compounds from building products for indoor use. All German (DIN) and European (EN) as well as international standards (ISO) to be considered in the tests and assessments were specifically referred to. The AgBB scheme makes a uniform and above all comprehensible and objective assessment of building products possible (see more at www.umweltbundesamt.de/bauprodukte/agbb.htm). The AgBB assumes that by adhering to the test values specified in the scheme the minimum requirements of the building regulations for health protection are fulfilled as far as the emissions of volatile organic compounds are concerned.

In a test phase running from 2002 to 2004, manufacturers of building products voluntarily measured the emissions from their products. In that time there was no obligation for this within the approvals. The results were published at the hearing of the manufacturers on the **2nd specialist discussion on the procedure of the health-related evaluation of emissions of volatile organic compounds (VOC) from building products** in November 2004. The conclusion was: the AgBB scheme has been proved feasible (see Proceedings in *Appendix 4 Reports, brochures, leaflets, internet addresses*).

Whereupon the notification of the AgBB scheme took place within the "Principles for the health assessment of construction products used in interiors" of the German Institute for Building Technology in 2005 (*see Chapter 2 Which regulations already exist for building products?*). Thus the way was free for Germany to have a basis for the health-related evaluation of emissions of volatile organic compounds in approvals of building products by the German Institute for Building Technology which the other member states of the European Union must now also accept.

## Which substances and substance groups have to be determined?

For the health-related evaluation of substances emitted from building products the AgBB used contemporary information, which, in the most favourable case, contains knowledge about dose – response relationships. This enables the determination of those concentration levels below which there is no danger of impairment to human health.

The most extensive evaluation system is the Maximum Allowable Concentration (MAC or Maximale Arbeitsplatzkonzentration, MAK) valid for the work place which is specified by the Senate Committee for Testing Health-endangering Substances of the German Research Foundation, also called MAC Commission. The MAC values are the basis for the stipulation of work place limiting values in accordance with the Technical Rules for Hazardous Substances (Technische Regeln für Gefahrstoffe – TRGS) 900. If a hazardous substance in the air at the work place adheres to this value, no health impairment or nuisance is generally to be feared for those who deal with this substance under normal operating conditions over a 40-hour working week.

However MAC (MAK) values (or comparable work place values) are not so easy to transfer to inhabited interiors. The concentrations of undesired substances are generally higher at work places and the daily exposure of the employees much shorter (a daily average of eight hours) than of those who dwell in flats. The AgBB included these and certain other criteria (see Box 4) in the application to interiors, such as flats, schools and kindergartens, and used safety factors, usually 100, in specifying NIK values (NIK corresponds to the Lowest Concentration of Interest or LCI). The AgBB has so far specified LCI (NIK) values for 170 substances (as at September 2005) and compiled them in a list. There are also among them substances with a mutagenic or toxic-for-reproduction effect or with a suspicion of such effects (see explanation of the terms and abbreviations: *Appendix 3 Glossary*).

Box 4

| Criteria | Conditions in the flat | Conditions in the work place |
|---|---|---|
| Time of residence/ exposure | „Long-term"- exposure | Changing and regularly interrupted influence in the work place |
| Groups of risk | Children and old people | They do not occur in the work place at all or are specially protected (such as pregnant women and allergists) |
| Instrumental and medical monitoring | Missing, in principle undefined total exposure | Available |

A consideration of individual substances provides only an incomplete picture since people are always exposed to a number of volatile substances in buildings. The AgBB takes care of this circumstance by the **cumulative parameter** TVOC (see Box 5). It emphasises that this TVOC value cannot have a toxicological basis because of the varying composition of the mixture emerging into the interior air. However, experience shows that the probability of health complaints and nuisances increases with increasing TVOC concentration.

Because of the potential **odour perception** caused by volatile organic compounds the AgBB has also included the sensory test as a key element in the evaluation scheme. It has to be noted however that no co-ordinated and generally accepted method is available for odour assessment. Fundamental work has been performed in this respect by the scientists in the research project presented in this brochure.

## When is a building product suitable for use indoors?

The AgBB scheme suggests a stepwise procedure for the determination and assessment of emissions (see Fig. 3).

The testing institute tests the building products in test chambers to detect emissions in accordance with the specified regulations (see more in *Chapter 4 How to obtain emission data from building products?*). In so doing existing standards (DIN, ISO, EN) have to be considered. The specified test

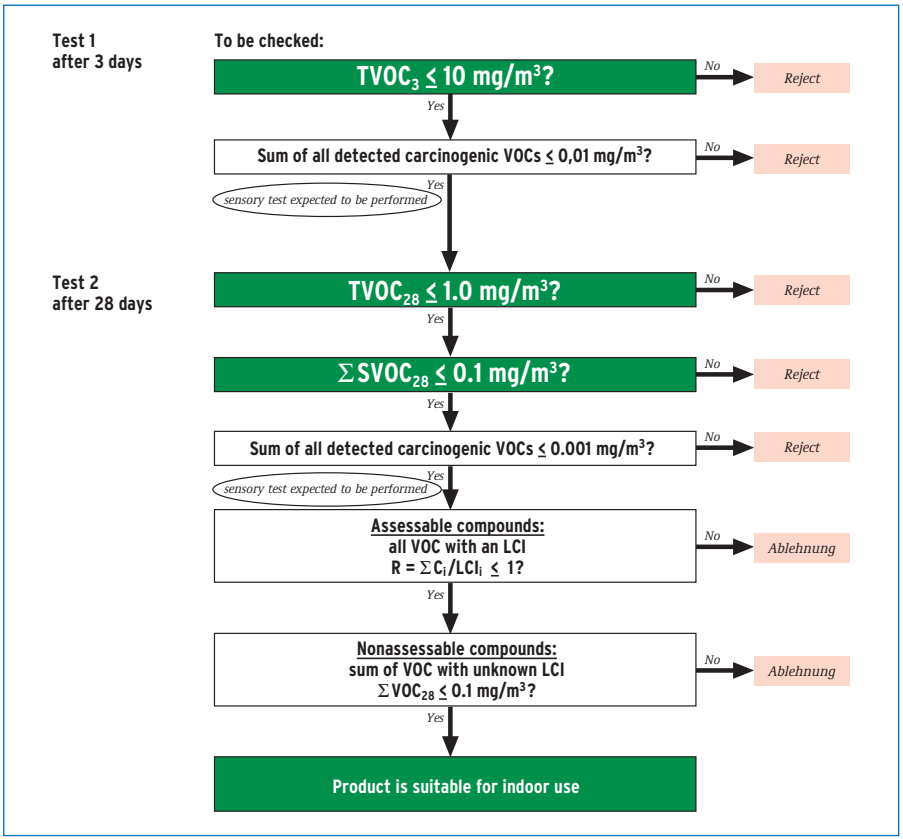



Fig. 3: Scheme for the health-related evaluation of VOC and SVOC emissions from building products (status September 2005)

conditions include an analysis of the chamber air at 3 and 28 days after starting the test for volatile organic compounds emanated from a material sample of the building products. In accordance with the classes of volatile organic compounds specified in Box 5 the concentration of the compounds has to be determined. Classification depends on the number of carbon atoms (C) which is shown as an index. If a compound exceeds a certain concentration, the testing institute detects this and determines its concentration (*also see Chapter 4 How to obtain emission data from building products?*).

If a building product fulfils the requirements of the AgBB scheme (see Box 6), no health impairment occurs in the room air when using this building product – based on today's knowledge.

## Box 5

| Classes of volatile organic compounds which have to be determined according to the AgBB scheme | | |
|---|---|---|
| VOC | Volatile organic compounds | All individual substances of volatile organic compounds in the range[1] of $C_6$ to $C_{16}$ |
| TVOC | Total volatile organic compounds | Sum of all individual substances of VOC with concentrations ≥ 5 µg/m³ [2] in the range of $C_6$ to $C_{16}$ |
| SVOC | Semi-volatile organic compounds | All individual substances of semi-volatile organic compounds in the range of > $C_{16}$ to $C_{22}$ |
| ΣSVOC | Sum of semi-volatile organic compounds | Sum of all individual substances of SVOC with concentrations ≥ 5 µg/m³ in the range of > $C_{16}$ to $C_{22}$ |

*[1] Retention ranges according to DIN ISO 16000-6;*
*[2] Data in microgram per cubic metre; 1 µg is one millionth of a gram*

## Kasten 6

| When is a building product suitable for use indoors? | |
|---|---|
| First measurement on day 3 | ▶ TVOC ≤ 10 mg/m³<br>▶ Sum of all detectable carcinogens ≤ 0.01 mg/m³<br>▶ Sensory test[2] |
| Second measurement on day 28 | ▶ TVOC ≤ 1.0 mg/m³<br>▶ Σ SVOC ≤ 0.1 mg/m³<br>▶ Sum of all detectable carcinogens ≤ 0.001 mg/m³<br>▶ Assessable substances: all VOC with LCI (NIK): R ≤ 1[1]<br>▶ Nonassessable compounds: Sum of all VOC without LCI (NIK): ≤ 0.1 mg/m³<br>▶ Sensory test[2] |

*[1] R is a ratio of measured VOC concentration to LCI (NIK),*
*[2] Included as a precaution, no co-ordinated method is currently available*
*1 mg is one-thousandth of a gram*

The AgBB principles, just like other test criteria to which the procedure data and the exclusion of certain hazardous materials belong to for example, is a component of the **principles for the health assessment of construction products used in interiors** which are used by the German Institute for Building Technology as an assessment basis in issuing general building authority approvals (see *Chapter 2 Which regulations already exist for building products?*). Building products with building authority approval are marked with the conformity (Übereinstimmung) label (Ü mark, see Fig. 4).

The additional reference "Emissions tested as per DIBt principles" indicates that a test took place in accordance with the AgBB principles. The first building product approved by the German Institute for Building Technology in 2005 was a textile floor covering. Meanwhile the Institute has approved rubber, PVC and linoleum floor coverings as well as laminate floors based on emission tests.

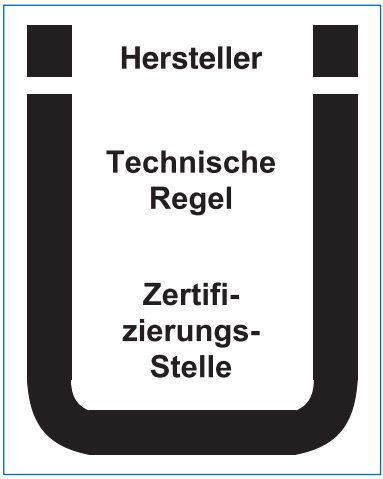



Fig. 4: Conformity (Übereinstimmung) label for building products (Ü mark)

Other building products should and will follow. Given issued approval, the manufacturer must attach the Ü mark with the information "Emission tested as per DIBt principles" either on the product, the packing or the enclosed note. The approved building products are published on the internet at www.dibt.de. However, charges are to be paid for the search of individual building products and their approval criteria, for example, whether they have been emission-tested.

# 4 HOW TO OBTAIN EMISSION DATA FROM BUILDING PRODUCTS?

Whether volatile organic compounds from building products can lead to impairment of health, can only be decided when the emitted substances and their concentrations are known. For this purpose measurements are necessary within an expensive investigation programme based on the AgBB scheme (see *Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany*).

In the research project presented here the laboratories of the Federal Institute for Materials Research and Testing and the Hermann Rietschel Institute jointly undertook to solve this task. They purchased common building products from ordinary shops, which normal consumers can also buy. Box 7 gives the individual product groups and the number of the products tested in each case. The product selection was an approximation only and was by no means representative.

**Box 7**

| Building products | Product groups | Number of the products tested |
|---|---|---|
| Liquid and gel products | Lacquers, glazes<br>Dispersion wall paints | 12 |
| | Synthetic-resin premixed plasters | 6 |
| | Adhesives | 4 |
| | Acrylic sealing compounds | 7 |
| | Silicone sealing compounds | 6 |
| Solid products | Glass-fibre non-woven fabric | 1 |
| | Laminate floor | 1 |
| | Cork floor coverings | 2 |
| | Timber materials | 8 |
| | Plasterboard | 1 |
| | Solid wood | 2 |

The scientists tested samples of these products under identical test conditions which ensured comparable and reproducible results. They analysed and assessed the air samples from the test chamber after a period of one, three, ten and 28 days that the material sample spent in the chamber.

The following description of the tests provides an impression of the individual stages of work. They included sampling and sample preparation, production of air samples containing the released volatile organic compounds in special emission chambers, chemical analysis of the emissions using modern high resolution devices and odour assessment by a group of panellists and an "artificial nose" (multi-gas sensor) as well as an IT supported evaluation of the results. More details can be found in the final report of the research project (also see *Appendix 4 Reports, brochures, leaflets, internet addresses*).

## The test begins by removing the packing

When testing **liquid and gel products** the scientists took samples of a specified quantity from the original closed sales units (tubes, tins, buckets) and usually applied them on odour-neutral and non adsorbent carrier tiles. The layer thickness depended on the data recommended by the manufacturer. After a drying period of one to two hours, each sample was individually placed into a test chamber.

Fig. 5: Applying sealing compound to a standard aluminium channel

The scientists usually put the sealing compounds into a standard aluminium channel (Fig. 5), while synthetic-resin premixed plasters (Fig. 6), adhesives, dispersion and latex wall paints as well as lacquers and glazes were applied to glass plates, primers to plasterboard (Fig. 7) and floor varnish to a screed sample using a trowel, thin film applicator or brush.

Dealing with **solid products**, such as timber material plates (chipboards and OSB), laminate and cork floor coverings, plasterboard and solid wood, the scientists took the samples from the centre of the pile or the package in order to reduce the influence of longer storage in the open air. They cut out samples of a specified size

Fig. 6: Synthetic-resin premixed plaster applied to a glass plate

Fig. 7: Application by brush of a primer on plasterboard, the edges of the plasterboard sample are covered with a self adhesive aluminium foil.

and closed the edges with a self adhesive aluminium foil, in order to obtain emissions only from the effective area of the product (Fig. 7).

## Material samples produce emissions in test chambers

The key item of the test programme was the emission or test chamber in which the material samples were kept for 28 days in accordance with the requirements of the AgBB scheme. The scientists operated the test chambers under constant conditions, in particular regarding temperature, relative air humidity and air exchange rate, since these parameters have a major effect on emission behaviour.

They used two different test chambers which worked according to the same principle: continuously cleaned air enters through an inlet the chamber in which the test sample is placed and the emissions captured. The contaminated air is then available for chemical and sensory testing. For this purpose the specialists took the air samples from sampling points. Contaminated air not needed for the measurement was removed from the system as exhaust air.

Fig. 8: Emission chamber (desiccator) with an OSB sample, capacity 20 litres

The Federal Institute for Materials Research and Testing tested all building products in a chamber, which is based on an improved **desiccator** (Fig. 8).

The Hermann Rietschel Institute additionally used the **CLIMPAQ** emission chamber (Chamber for Laboratory Investigations of Materials, Pollution and Air Quality, Fig. 9) for quality assurance of odour assessment.

The scientists used the CLIMPAQ to test duplicates of certain building products included in the investigation programme. They operated the chamber under the same constant conditions as the emission chamber used by the Federal Institute for Materials Research and Testing. A major difference was that the supplied air did not exhibit such a high degree of purity in the CLIMPAQ as in the other emission chamber. Contrary to the air samples for chemical analysis, sensory assessments only require that air samples are odour-neutral and barely contaminated. Influences from small quantities of substances in air scarcely have an effect when the odour is only perceptible at a higher concentration.

Fig. 9: View of the emission chamber CLIMPAQ with a capacity of approximately 35 litres. The room, which is intended for the material sample, is separated from the air supply and air exhaust by wire gauzes. They produce a laminar air flow encompassing the material sample.

## ▼ Which chemical compounds?

The scientists tested the air samples obtained from the test chambers for VVOC, VOC and SVOC (see Box 8). VVOC and VOC are given off at room temperature faster and at higher concentrations than SVOC. That is because their boiling point rises with increasing molecular weight. The analysis makes use of this different boiling behaviour.

The analysis system has a modular structure and some of the individual devices are coupled together.

**Box 8**

| Compounds | English abbreviation | Boiling range | | |
|---|---|---|---|---|
| Very volatile organic compounds | VVOC | < 0 °C | to | 50–100 °C |
| Volatile organic compounds | VOC | 50–100 °C | to | 240–260 °C |
| Semi-volatile organic compounds | SVOC | 240–260 °C | to | 380–400 °C |

Different **collection methods** were used depending on the volatile organic compound to be identified and the scientists took air samples of between 0.2 to 30 litres for the individual analyses. For this purpose they used collector tubes or cartridges which they attached to the emission chamber. A pump kept the air sample to be tested in continuous circulation through the collector. The volatile organic substances contained in the air sample were adsorbed by the solid phase in the collector. Carbotrap and Carboxen polymers on carbon basis were used as a solid phase to detect VVOC. Tenax TA (Fig. 10), also a polymer, was used as an adsorbent for VOC determination and additionally polyurethane foam for SVOC (Fig. 11).

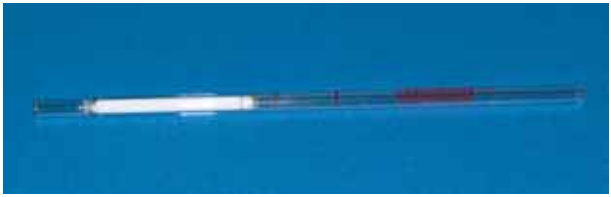


Fig. 10: Self-filled commercial Tenax TA collector tube for adsorption of VOC

Subsequently, the VOC mixtures adsorbed by the carrier materials of the collector tubes were removed by **desorption** for further analysis. This took place in the case of the Carbotrap/Carboxen and Tenax TA tube through the so-called thermodesorption method under a controlled heat effect. In contrast, the polyurethane foam was desorbed with acetone in an ultrasonic bath and the eluate was concentrated in a rotary evaporator. For the separation of the complex material mixture into individual compounds a sample was transferred into a **gas chromatograph** (see Box 9).

Fig. 11: A collector tube equipped with polyurethane foam (white in the picture) for adsorption of SVOC shown during sampling.

The identification and quantification of the individual compounds were performed by coupling the gas chromatograph to a **mass spectrometer** (see Box 10).

Aldehydes and ketones are among the volatile organic compounds which can be proved very sensitively. They

Box 9

**How the gas chromatograph (GC) works**

Using a suitable system (syringe or thermodesorption), the sample is placed on the separating column which is in a temperature-controlled furnace or oven. It usually consists of a 30 to 60-m long, spirally coiled quartz capillary tube. The stationary phase is in the separating column. The mobile phase, usually helium gas, transports the compounds through the column. The material mixture is separated into individual compounds based on the distinctively strong interactions with the stationary phase. The lower the temperature and the stronger the interactions with the stationary phase, the slower the substances move through the column.

Depending on the retention time, the substance leaves the column, and produces an electronic signal downstream in the detector system. A flame ionization detector or – as in the research project – a mass spectrometer serves as a detector system (see Box 10).

The signals are recorded and processed using computer-aided techniques which enables the researcher to view and save them for assessment.

The resulting chromatogram shows the detector signals in the form of peaks as a function of the retention time. The peak area is a measure to accurately measure the concentration of the respective individual compound in the air sample. The number of peaks shows the number of individual compounds contained in the mixture.

Box 10

**How does the mass spectrometer (MS) work?**

A mass spectrometer consists of an ion source which fragments and ionizes the gaseous molecules from the sample by electron bombardment; a mass analyser which separates the ions according to their ratio of mass to charge number and a detector which measures the intensity of the striking ions. Thus a mass spectrum emerges which is characteristic of each compound with several mass peaks of different intensity – a kind of "finger print".

The identification is performed in the laboratory by comparison with well-known substances whose mass spectra and retention times are characteristic. If no comparative substances are available, a comparison with a mass spectrum library can be made using the software's own database. This software enables a three-dimensional illustration of the respective mass spectra attributed to the peaks in the gas chromatogram. A quantitative determination of a single compound is also possible by calibrating the system using standards.

rely on the reaction of these VOCs with the substance DNPH (2,4-dinitrophenylhydrazine). For the air samples the scientists therefore used a collector cartridge (Fig. 12), whose silicagel carrier was coated with DNPH. A subsequent elution enabled them to extract the resulting reaction product and separate it using a **high performance liquid chromatograph** into individual compounds after having loaded it onto the separating column with the help of an injector (see Box 11).

Fig. 12: Commercial collector cartridge which contains DNPH on a silica gel carrier for adsorption of aldehydes and ketones.

Chapter 5 describes the results of the test chamber measurements using the example of some chromatograms of emissions from building products.

As a **result of the analysis** the concentration of the identified compounds in

Box 11

**How does the high performance liquid chromatograph (HPLC) work?**

The sample is loaded on the separating column via a sample loop. Contrary to GC (Box 9) the mobile phase in the HPLC consists of a liquid, usually an organic solvent, often water. This transports the sample at high pressure through the column. The substance mixture gets separated into individual compounds as a function of the strength of the interactions with the stationary phase. The individual substances leave the separating column at its end at characteristic retention times and are then detected using a suitable detector.

Often, as in the research project, a so-called diode array detector is used. This detector produces a continuous spectrum in the UV wavelength range. The substances flowing through a flow measuring cell specifically absorb individual wavelength ranges. This produces substance-specific UV absorption spectra. A computer records the signals to produce chromatograms. It is also capable of illustrating the appropriate three-dimensional UV spectrum corresponding to each peak.

the chamber air sample is given in milligram (a thousandth of a gram) per cubic meter of air ($mg/m^3$) for the tested building product. In order to be able to make a health-related evaluation according to the AgBB scheme, the scientists calculated the respective sums of VOC and SVOC (TVOC and TSVOC) as well as the dimensionless R value (see more in *Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany*).

## ▼ ... and do they smell?

Despite steadily improving analytical methods and the development of artificial noses it is still not possible to replace the **human nose** in the determination of perceived air quality. The reason is that a nose can detect certain substances in concentrations far below the detection limit of instruments while it can also be insensitive to other substances.

The source strength perceived by humans can only be determined reliably if several people assess samples. The amount of air necessary for the smelling procedure is much greater than that needed for chemical analysis, since it must be enough for a group of ten panellists to increase meas-

uring accuracy; that is normally about 300 litres – based on the breathing volume of a person.

In the research project, the Hermann Rietschel Institute developed and used the Air Probe device for sampling and providing air samples from the test chambers (Fig. 13).

Fig. 13: Sampling and sample provision equipment Air Probe with a glass assessment funnel on the right. The panellist puts his nose over the funnel into the homogeneous flow of sample air for odour measurement.

A trained **panel** first evaluated the perceived odour intensity (unit: Π, pi) of the sample by comparing it to several other samples which contained a comparative substance – usually acetone – in linearly gradated concentrations (see Fig. 14).

Fig. 14: Comparative samples for the testing of odour intensity. The comparative samples correspond to concentrations between 0 and 15 pi. 1 pi corresponds to the odour threshold where the comparative material is just perceptible. The more intensive the panellist perceives an odour, the greater the value pi. The scale reached to 30 in the research project. The panellists are free to extrapolate odour intensities.

Subsequently, the panellists assessed the perceived quality, also called “hedonics”, on a nine-point scale between “extremely unpleasant” (– 4) and “extremely pleasant” (+ 4). For the IT supported evaluation the scientists typed the data into a mask on the computer (Fig. 15).

The **result** of the evaluation of odour intensity is indicated, as previously mentioned, in units of pi, while the hedonic assessment is dimensionless.

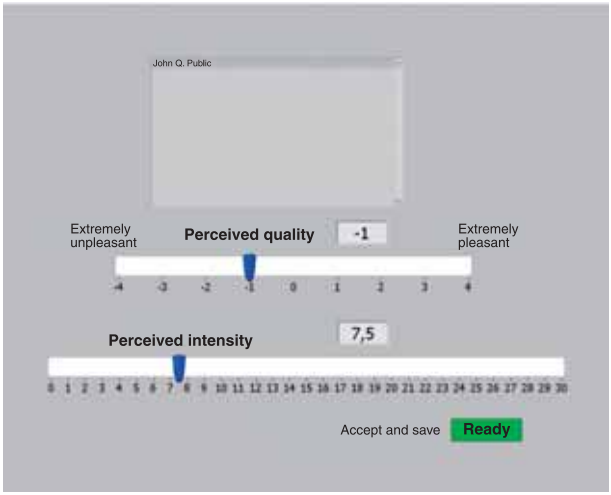



Fig. 15: Data acquisition software for sensory assessment of air samples

In each case the scientists calculated average values and standard deviations from the subjectively indicated scale values and established graphical relationships with TVOC concentrations or the individual compounds identified as measured on the day of investigation.

The scientists compared the assessment of the emissions by the panellists with those simultaneously taken by **multi-gas sensors**, or **artificial noses**, for some building products. They used the air samples from the CLIMPAQ for this purpose. The panel performed their subjective assessments of the perceived odour intensity at the funnel and the measurement of the substances in the sample air took place using the multi-gas sensor system.


Fig. 16: The Kamina artificial nose developed by the Karlsruhe Research Centre shown above an evaluation funnel in the measuring procedure

The artificial nose is based on a combination of different sensors in a measurement head which is washed around by a litre of the air sample for the investigation (Fig. 16).

The system used sensors consisting of metallic oxide which can adsorb both odour-generating and odourless organic compounds which in-

crease the electrical resistance measured in ohms. The **result** is a signal pattern which results from the sum of the signals. The IT supported processing of the signals provides qualitative and quantitative information about the strength of odour intensity.

It is a restriction that the evaluation of emissions from building products using the artificial nose is still in the development phase. The researchers investigated to what extent the artificial nose can provide something similar to the human nose using the technology available today and what development is still needed.

# 5 AND HERE ARE THE RESULTS OF THE TEST CHAMBER MEASUREMENTS

In the research project presented in this brochure the scientists tested and evaluated 50 different liquid, paste and solid building products according to health criteria for the emission of volatile organic compounds. Each was compared to the requirements of the AgBB scheme (see *Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany*). Lacquers and glazes, wall paints, synthetic-resin premixed plasters, adhesives, floor coverings, glass fibre non-woven fabrics, joint sealing compounds, timber materials and plasterboard as well as glued solid wooden boards were tested. The product selection was a generalisation only and was by no means representative. The scientists additionally tested some products in various combinations. For example they applied paint not only on "neutral" glass plates for the chamber test but also on other building products such as plasterboard or wood. They proved that the combination of different building products with one another can accelerate or inhibit the emissions.

The most important results were that 36 of the 50 products tested met the test values of the AgBB scheme. This means that these products fulfilled the minimum requirements of the building codes for the protection of health regarding the emission of volatile organic compounds. Table 1 contains the volatile organic compounds which caused complaints with regard to the products. Fourteen products, mainly sealing compounds and synthetic-resin premixed plasters, exceeded the limits. The results are represented in the following subchapters in detail for the respective product groups. Abbreviations and technical terms used in the comparison of the test results with the requirements of the AgBB scheme are described in *Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany* and in *Appendix 3 Glossary*.

The emissions came from volatile organic compounds which can lead to skin and mucous membrane irritation particularly at higher concentrations. In one of the products the scientists also detected benzene which is carcinogenic to humans.

One thing was clear: products from different manufacturers – even if they belonged to the same group of products – showed different results and there were complaints in some cases. The conclusion is that each product of distinct composition must be considered and tested as an individual case.

| Table 1: Volatile organic compounds, which led to complaints according to the AgBB scheme [1] | |
|---|---|
| **Volatile organic compounds** | **Detected in the products[1]** |
| Mixtures of n and iso-alkanes $C_7 - C_{16}$ or $C_{14} - C_{18}$ | Synthetic-resin premixed plaster |
| Benzene | Silicone sealing compound |
| Dipropylene glycol | Acrylic sealing compound<br>Synthetic-resin premixed plaster |
| Mixture of different esters | Floor varnish,<br>Synthetic-resin premixed plaster |
| Acetic acid | Chip board |
| Ethane diol | Acrylic sealing compound<br>Synthetic-resin premixed plaster |
| Methyl isothiazolinone | Synthetic-resin premixed plaster |
| Propane diol | Floor varnish |
| Siloxane | Silicone sealing compound |

*[1] R value >1 and/or main component when exceeding the concentrations of TVOC or SVOC and/or the carcinogens on third and/or 28th day*

It is pleasing that there are low-emission products in nearly all tested groups of products on the market which are granted the "Blue Angel" environmental award. Box 12 provides the information. These products are clearly the better choice (also see *Chapter 6 Characterising Health and Environmentally Compatible Building Products is not just a German Effort*, *Subchapter The Blue Angel is stricter than the AgBB scheme*).

Another key objective of the research project was to subject the volatile organic compounds which were released into the test chamber, not only to a chemical determination and identification, but also to a sensory, i.e. odour test. The sensory test is currently still a "to-do item" in the AgBB scheme. Because of missing conditions for the assessment, test institutes cannot carry it out as a routine test. The preliminary work performed by this research project made a major contribution to changing this situation.

The sensory assessment by panellists of odour intensity and odour quality provided additional information. The panellists found the emissions of all tested building products, in some cases even after 28 days, more or less intensive and – apart from a few exceptions – unpleasant.

Box 12

| Groups of products tested in the research project for which the "Blue Angel" environmental award will be granted | |
|---|---|
| Lacquers, glazes, primers | Low-pollutant paints and varnishes RAL-UZ 12a |
| Wall paints | Low-emission wall paints RAL-UZ 102 |
| Floor adhesives | Low-emission floor covering adhesives and other installation materials RAL-UZ 113 |
| Laminate floor and cork ready-flooring | Low-emission wood products and wood-base products RAL-UZ 38 |
| Cork floor covering | Flexible floor coverings RAL-UZ 120 |
| Joint sealing compounds | Low-emission sealants for interior use RAL-UZ 123 |
| Chipboards and OSB | Low-emission composite wood panels RAL-UZ 76 |
| Furniture plates from wood | Low-emission wood products and wood-based products RAL-UZ 38 |

Volatile organic compounds detected simultaneously failed to provide reference points for the evaluation as to which substances may have caused the unpleasant impressions. The following subchapters will present selected results and describe the actual situation as far as the use of the electronic "artificial nose" is concerned.

## The "multicoloured" scope of the lacquers and glazes

Painting with lacquers and other coating materials (see Box 13) not only has the aim of improving the appearance, but also to protect the surface. The paints may be smooth, textured, translucent, gloss, matt, water resistant or can be wiped off or particularly dirt and scratch-proof for the sealing of halls or parquets – just to name a few characteristics. Paints and lacquers are colloquially lumped together. Actually, the term 'paint' is reserved to the sensory perception of the eye. But one uses it in a compound form for dispersion wall paints (see *subchapter "Wall painting" and adhesive actions*).

The product range is multi-faceted. But these products in principle consist of solvents (or diluents), bonding agents, pigments, fillers and additives or auxiliary materials.

Box 13

**What are lacquers and glazes?**

Covering or multicoloured lacquers contain a very high fraction of pigments and they cover the surface texture of the base layer. Clear lacquers and many primers do not contain pigments.

The pigment fraction is low in glazes so that the surface texture shines through. Since the fraction of bonding agents is frequently also low, thin layers with a low protection effect develop. Glazes (varnish) are particularly used for wood.

Primers consist of a small fraction of bonding agents finely dispersed in solvents (including water).

Solvents keep the bonding agents and pigments in a liquid state. They evaporate after processing so that the painting dries, solidifies and creates a film. The solvents can be either water or organic solvents. The usually colourless bonding agents have "sticking" characteristics and connect the pigment with the respective sublayer. There are inorganic bonding agents, such as lime and cement, and organic ones made from natural and synthetic resins. Acrylates and polyvinyl acetates belong to this group. The resin particles are not soluble in water but are finely distributed and create dispersions. The pigment lends the desired colour effect to the painted surface. There are inorganic and organic as well as natural and synthetic pigments. Chalk, for example, which is also used as a filler, belongs to the natural inorganic pigments, while titanium white and cobalt-blue belong to synthetic inorganic ones. Indigo and chlorophyll rank among natural organic pigments. From a "pure chemistry" point of view there are synthetic organic pigments, such as the blue phthalocyanine. Various auxiliary materials lend further characteristics to the lacquer: they conserve, enable film formation or a certain elasticity or softness, prevent "skin formation" in the pot and yield a certain viscosity which makes the paint drip-free. Preservatives are biocide materials, which prevent the coating material in the pot from being made useless by micro organisms – mainly fungi. Manufacturers usually use formaldehyde releasers or isothiazolinone.

The researchers tested six different lacquers, among them a glaze (varnish). An **acrylate floor lacquer**, which is particularly suitable for sealing concrete, was tested on glass and screed (see Fig. 17). It is the only lacquer

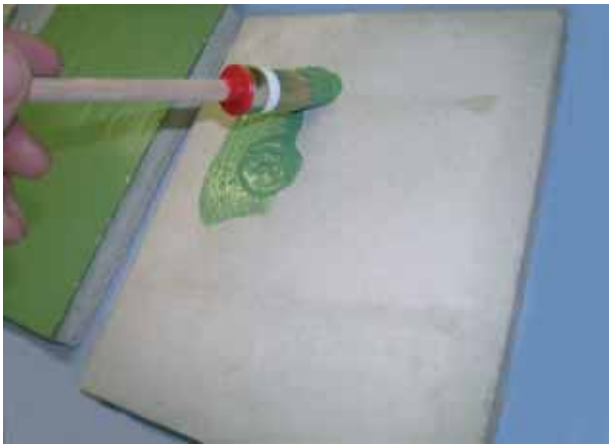


Fig. 17: Application by brush of an acrylate floor lacquer on screed in preparation for a test chamber measurement

which failed the health requirements of the AgBB scheme in both cases. Even on day 28, high emissions of volatile organic compounds – mainly esters but not fully identified – were detected. Applying it on screed, the R value was also exceeded by the excessive propylene glycol emission. The emission of this compound on glass was only very high on the first and third day and then dropped markedly. On screed, however, the initial concentration was not so high, but this value remained at a height which can give rise to complaint right up to day 28.

The reason for this can be seen in the carrier material. Screed is porous, so that lacquer components penetrate well into this material and are then emitted slowly. Toxicologists attribute a moderate sensitizing effect in humans to propylene glycol which manufacturers use as a solubility promoter.

All other tested products, such as an **alkyd resin floor varnish** and another acryl-based water-diluted **wood glaze**, **parquet sealing lacquer** on beech wood and a **multicoloured lacquer** covering on pine wood did not give rise to complaints. Beech and pine wood were glued solid wood. Both woods fulfilled the requirements of the AgBB scheme when tested on their own (see *subchapter Furniture from beech and pine)*. It is remarkable that terpene emissions increased from pine wood around the end of the chamber test after lacquer application, which scientists have not yet so far seen in this form. The concentrations were however not as high as to give rise to complaints.

The concentrations of TVOC or the identified odour-generating substances, such as propanediol, benzyl alcohol or acetic acid in the case of any of the two **floor varnishes** did not provide reference points for the perceived odour intensity. The panellists found the odour emissions equally intensive and comparably unpleasant in the hedonic effect.

The panellists found the odour equally intensive in both cases of the **pine wood plate with** and **without a lacquer coat** (see Illustration 1). It is interesting to note that the unpleasant impression of the pine wood board with glaze application decreased and shifted toward pleasant. This process is in very good agreement with the increasing emission of the terpenes, while there is again no correlation with TVOC emissions.

A **primer**, which – tested on its own – passed the health-related evaluation, was used by the scientists to treat plasterboard (also see subchapter *Timber materials and plasterboards for floors, linings and partitions*). The primer acted as a sealing layer and decreased the (otherwise) low formaldehyde emission from the plasterboard. This is due to the particularly finely dispersed bonding agent in the primer which blocked the pores of the absorbent material.

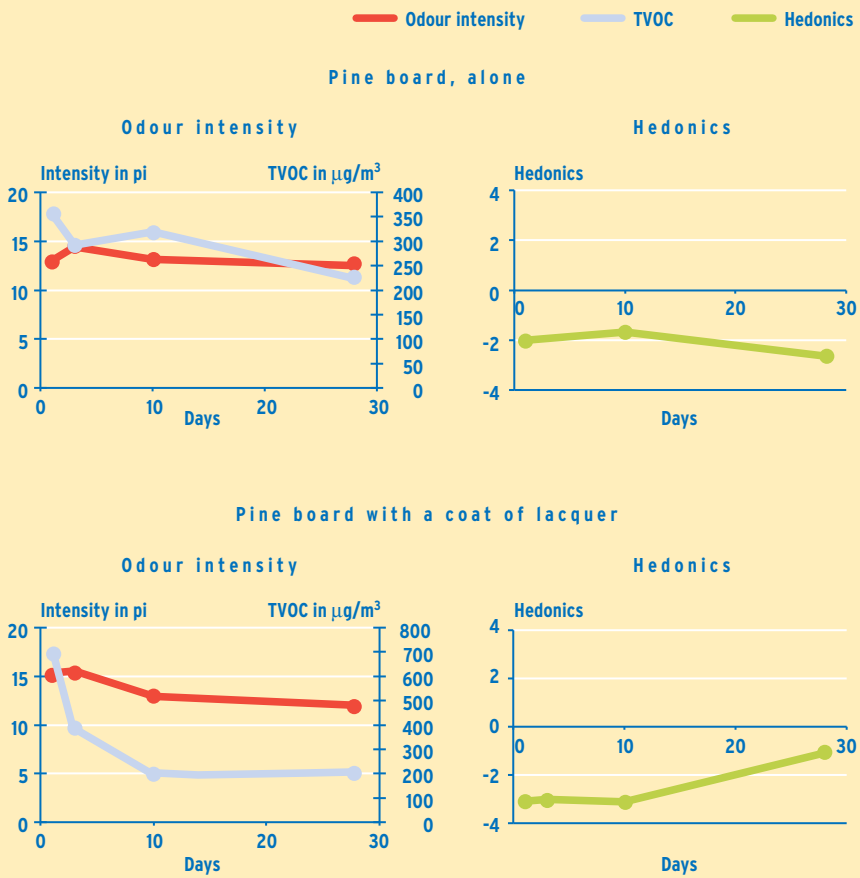
The panellists also observed this sealing effect in the sensory test. They perceived the emissions of the plasterboards treated with primer as less intensive than that of the untreated one (see Illustration 2).

The results of the test chamber measurements on the whole are satisfactory. It has to be emphasized that, among floor varnishes, alkyd resin which contains organic solvents fulfilled the requirements of the AgBB scheme regarding emissions while the water-based acrylate lacquer failed to do so. This shows that water solubility alone is not a satisfactory criterion for health or environmental compatibility, but a test according to the AgBB scheme must also be performed. It is known from other investigations that water-based acrylate lacquers usually meet the test values of the AgBB scheme. Alkyd resin lacquers contain a high fraction of solvents. It is indisputable that they evaporate during processing and the drying process and thus may have not only a have damaging health affect, but may also contribute to the emergence of a summer smog.

A comparison of the emission data with the requirements of the assignment basis for the Blue Angel is not possible in the case of lacquers and glazes, since this is based on a composition evaluation. Currently, a feasibility study commissioned by the Federal Environment Agency is investigating the possibilities of the revision of the criteria for the Blue Angel environmental award for low-pollution lacquers (see *Chapter 7 What to do next?, subchapter The Blue Angel gathers speed*).

## Illustration 1

Source: BAM 2006




**Comparison of the sensory tests of emissions from a pine wood board without (top) and with a coat of lacquer (bottom)**

*The left-hand side diagrams show the result of the perceived odour intensity and the concentration of TVOC. The ordinates on the left indicate the odour intensity in pi from 0 to 20 in this case; 1 pi corresponds to the odour threshold. On the ordinates on the right the concentration values of TVOC are shown in g per m³.*

*The right-hand side diagrams show the result of hedonic assessments. The scale division goes from − 4 "extremely unpleasant" to + 4 "extremely pleasant". The days of investigation are indicated on the abscissa (See explanation of the illustration in the text).*

## Illustration 2

Source: BAM 2006


**Comparison of the sensory tests of emissions from an untreated (top) and a gypsum cardboard treated with a primer (bottom)**

*Both samples have passed the health-related evaluation according to the AgBB scheme. Odour intensity clearly shows the sealing effect by the primer and panellists do not perceive the odour as so unpleasant (See explanation of the coordinates in Illustration 1).*

## "Wall painting" and adhesive actions

There are different possibilities for decorating the interior walls within a living space, which may include a simple coat of paint on the plastered wall up to coloured, printed, structured and paintable wallpapers as well as the use of different non-woven fabrics.

Dispersion wall paints belong to the most common paints. They consist typically of a dispersion of synthetic resin as a bonding agent in water (as a solvent), pigments, fillers such as calcium carbonate or quartz powder and further auxiliary substances such as preservatives – so-called in-can preservatives – and thickeners, antifoaming agents etc. (also see *subchapter "Multi-coloured" scope of lacquers and glazes*). Shops usually offer dispersion paints in white: they contain titanium white and can be dyed using full strength coloured pastes or stains.

All dispersion wall paints can be wiped after drying. Dispersion paints for humid areas exhibit a particularly high water resistance. They contain a high fraction of bonding agent and are frequently called "latex paints".

In the research project the scientists tested four **dispersion wall paints** and two **latex paints**. The pleasing result is that they fulfilled all requirements of the AgBB scheme. The emissions were altogether very low. This also applies to formaldehyde and methyl isothiazolinones, which were contained as in-can preservatives.

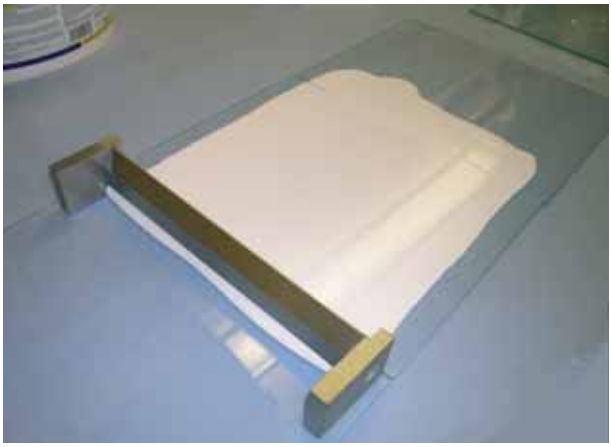


Fig. 18: Application of a dispersion wall paint on a glass plate with the help of a thin-film applicator in preparation for a test chamber measurement

The research programme also included a **glass fibre non-woven fabric**, which is a suitable wall covering for "heavy-duty" walls and rooms such as kitchens, corridors or cellars and exhibits a textile-like appearance. The non-woven fabric consists of glass fibres which are intertwined with one another and fixed using a synthetic-resin bonding agent.

Craftsmen also use non-woven fabrics to bypass tears in the plaster surface, to solidify and equalize critical sublayers because of their high tensile strength or can also be used as a base for further structures in dry construction and internal finishing. The glass fibre non-woven fabric is relatively heavy and needs a special adhesive. The user can apply the material in a dry state directly from the roll to the wall which has been covered with an adhesive and it can be cut to size on the wall. No softening time is needed.

For the tests in the test chamber the scientists attached the glass fibre non-woven fabric to a glass plate **using a non-woven fabric adhesive**. This combination fulfilled – like the adhesive on its own – the requirements of the AgBB scheme (also see *subchapter Adhesives for walls and floors*). Acetic acid and formaldehydes were however emitted on the first day somewhat more intensively than from the adhesive alone. Additionally ethanediol was emitted, which was detected on all measurement days and probably originated from the non-woven fabric. For the other compounds however a clear decrease in the concentrations was usually observed from the third day on.

When the non-woven fabric attached with non-woven fabric adhesive to the glass plate was provided with an **additional coat of dispersion wall paint**, a further sealing effect ensued which was observed as early as on the first day. An additional coat of dispersion wall paint also increased this effect on primed plasterboard (see *subchapter "Multicoloured" scope of lacquers and glazes*).

The sensory tests confirmed the sealing effect. The initial unpleasant odour impression reduced towards the 28th day even further. However there was no relationship with either the TVOC concentrations, or with that of the identified compounds. It was observed that the perceived odour intensity decreased slower than the decrease of the measured TVOC concentration.

## ▼ Smooth inner walls with synthetic-resin premixed plaster

Synthetic resin premixed plasters are pastes and, like mineral plasters, they are applied to the wall in order to achieve an even surface. They consist of plastic dispersions (acrylates, styrene-acrylates), additive (sand), thickeners, possibly other auxiliary materials and often solvents. In-can preservatives belong to the auxiliary materials.

They are biocide additives, which the manufacturer mainly adds to aqueous systems in order to prevent an infestation of the coating material by micro organisms – mainly fungi – during production and storage in the pot.

Compared with mineral plasters they are easier to process, they harden faster and enable various additional features (texture, paint, additives) and they yield a crack-free visco-elastic layer.

In the research project the scientists tested six different prefabricated synthetic-resin paste premixed plasters. Fig. 19 shows a sample of a synthetic-resin premixed plaster prepared for the chamber test, applied to a glass plate.


Fig. 19: Synthetic-resin premixed plaster sample on a glass plate prepared for a test chamber measurement, shown during weighing of the coated glass plate. Layer thickness recommended by the manufacturer.

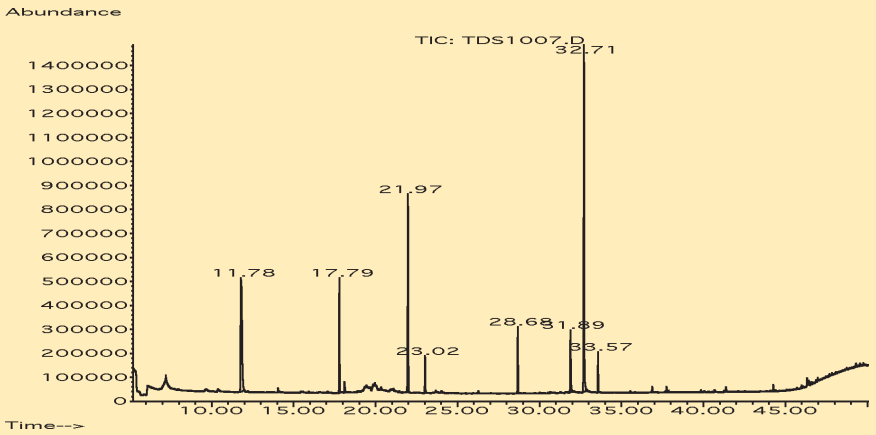
The results were however less favourable: only two out of six products passed the health-related evaluation according to the AgBB scheme. Illustration 3 shows the chromatogram of the emissions on the 28$^{th}$ day of a product which did not give rise to any complaint. In comparison, the chromatogram of a plaster which failed to meet the AgBB requirements (see Illustration 4) looks completely different. The failed plasters showed a marked increase in the TVOC concentration particularly on the 28th day. Basically, it was glycols or esters, alkanes and aromatics (boiling range $C_9$ to $C_{12}$), not identified more specifically (also see *Chapter 4 How to obtain emission data from building products?, subchapter Which chemical compounds?).* In one of the products carcinogenic substances were found on the third day – however within the permitted limit – the human carcinogenic benzene being among them, which can cause leukaemia, a malicious blood illness. Dipropylene glycol was detected in another premixed plaster which also showed a high R value. This is a compound which also led to a complaint in another acrylic sealing compound.

The highest concentration measured by the scientists in the test chamber was 1.8 mg/m$^3$ and was detected on the tenth day. It was still far below the MAC (MAK) value of 200 mg/m$^3$ (breathable fraction). When firms maintain this value at the work place for example in handling cooling lubricants, then the Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area of the German Research Foundation assume that pregnant women do not have to fear any embryo-damaging effect.

Three synthetic-resin premixed plasters contained a biocide: methyl isothiazolinone. Methyl isothiazolinone caused a product to exceed the value of such VOC for which no LCI (NIK) value exists on the 28th day. Methyl isothiazolinone can cause skin irritation and sensitization. In five plasters the scientists detected formaldehyde, which is also used as an in-can preservative, in one of the products the concentration was particularly high.

Source: BAM 2006

## Illustration 3

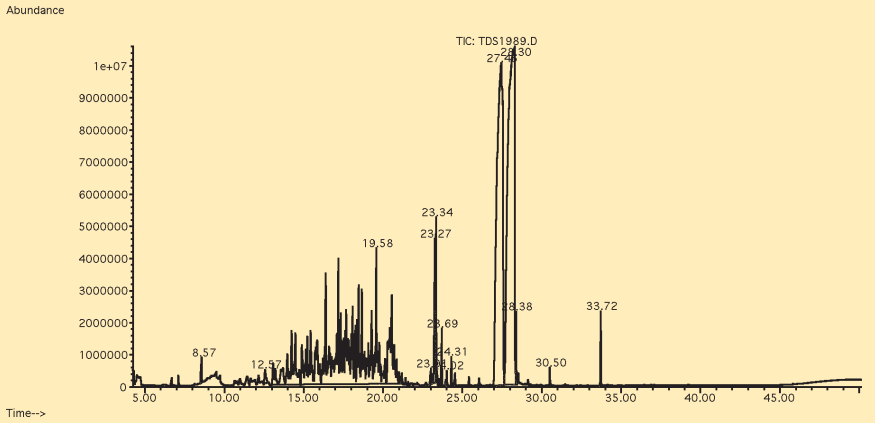



**GC/MS chromatogram of emissions on day 28 of a synthetic-resin premixed plaster which has passed the health-related evaluation according to the AgBB scheme**

*Retention time is indicated in minutes on the abscissa and signal intensity measured at the detector is shown on the ordinate. The number of the peaks reflect the number of detected compounds. The peak area is a measure for the concentration of the respective compound in the air sample. This product only exhibits a few peaks, i.e. the number of the volatile organic compounds and their concentration is low – based on the peak areas and heights.*

Source: BAM 2006

## Illustration 4




**GC/MS chromatogram of emissions on day 28 of a synthetic-resin premixed plaster typical for a product which has failed the health-related evaluation according to the AgBB scheme**

*Conspicuous is the height/surface of the peaks, particularly at retention times of 27.45 and 28.30 minutes (max. signal intensity on the ordinate is approximately 10 millions) and the number of the substances between 12 and 25 minutes (See explanation of the coordinates in Illustration 3).*

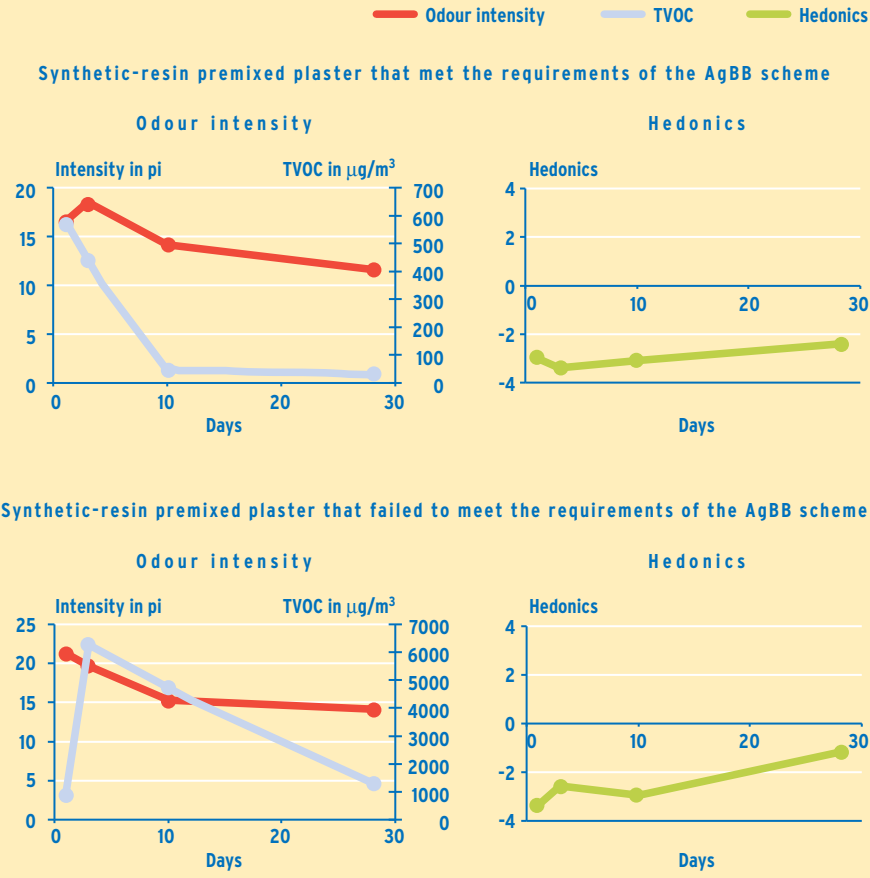
The lowest value measured on the 28th day was 160 µg/m$^3$. The AgBB scheme currently does not contain any test value for very volatile organic compounds (VVOC), to which formaldehyde belongs. Formaldehyde is an "old acquaintance": it irritates the mucous membranes and can cause hypersensitivity. The International Agency for Research on Cancer (IARC) of WHO classified formaldehyde as a human carcinogen. The Federal Institute for Risk Assessment assumes that no cancer-releasing effect should be expected in the upper respiratory tract of humans when the room air value is below 0.1 ppm (0.12 mg/m$^3$). The Ad-hoc Working Group of the Indoor Air Hygiene Commission and the Working Association of the Senior State Health Authorities followed this view and pointed out that the re-classification by the IARC does not necessitate any change of the guide value for formaldehyde of 0.1 ppm in interior air.

The odour emissions from that plaster which fulfilled the requirements of the AgBB scheme and from which the chromatogram in Illustration 3

comes were also perceived at the beginning by the panellists somewhat less intensive than from another plaster that did not meet the requirements (see Illustration 5).

Source: BAM 2006

## Illustration 5




**Comparison of the sensory tests of emissions from two synthetic-resin premixed plasters, one of which (top) met the requirements of the AgBB scheme, while another (bottom) failed to do so**

*It is conspicuous that panellists perceive the odour outgoing from the "failed" plaster comparatively somewhat more pleasant (See explanation of the coordinates in Illustration 1).*

## Adhesives for walls and floors

Adhesives are used in interiors on floors and/or walls for fixing textile and plastic coverings, cork boards and glass non-woven fabrics on a large area. The components of adhesives and coverings (and sublayers) may cause an interference. Floor coverings often inhibit the emissions from adhesives, so that a retarded release results – and thus a longer exposure for humans who stay in the room.

Adhesives are pastes and are nowadays usually dispersions in which the adhesive particles – predominantly synthetic resins (for example acrylates), but also natural resins (such as natural latex) – are finely distributed in water. They contain organic solvents (much less than previously) and fillers or softeners. They harden by water or solvent evaporation. In addition, there are reaction adhesives, which harden by a chemical reaction, two-component systems being the most common ones.

In the research project the scientists tested four different dispersion adhesives on synthetic resin bases: two **floor coverings**, a **cork** and a **non-woven fabric adhesive**. A positive result is that all four products met the health-related evaluation according to the AgBB scheme. Even better, the emissions were altogether so low that the tested floor adhesives would also fulfil the stricter criteria for assigning the "Blue Angel" environmental award for low-emission floor covering adhesives (RAL-UZ 113) (also see *Chapter 6 Characterising Health and Environmentally Compatible Building Products is not just a German Effort).*

However, the sensory assessment of one of the floor adhesives failed to yield good results. The panellists perceived the odour emissions as rather unpleasant and very intensive. Though intensity decreased gradually, the odour was still very strongly perceptible even after 28 days.

Cork and non-woven fabric adhesives contained formaldehyde releasers as in-can preservatives so that the scientists detected formaldehyde – even if in small quantities -in the test chamber.

Somewhat higher concentrations were emitted from the non-woven fabric adhesive. Based on the criteria for assigning the "Blue Angel" to floor adhesives as a basis for the evaluation of formaldehyde (RAL-UZ 113) (also see *Chapter 6 Characterising Health and Environmentally Compatible Building Products is not just a German effort*) these two adhesives in the result would also fulfil the requirements for the environmental award.

In a further investigation the scientists tested non-woven fabrics in **combination** with non-woven fabric adhesive and additional painting using a dispersion paint. The resulting sealing effects for the emissions are described in *the subchapter "Wall painting" and sticking actions*.

The odour intensity of the emissions from the non-woven fabrics adhesive alone was low at the beginning, increased strongly on the third day and then remained almost unchanged. But the odour emissions were not so striking in comparison to the floor adhesive, and the non-woven fabric adhesives yielded somewhat better results (Illustration 6). In combination with non-woven fabric the panellists felt the odour intensity was at first stronger and later somewhat weaker. However no correspondence of the odour impression with the concentrations of volatile organic compounds was recognized here either. The continuous unpleasant odour perception was noticeable for both adhesives.

## The proper way for laminate and cork

Floor covering is the top working layer of the floor and can be of various qualities and characteristics. The spectrum ranges from textile floor coverings in glued, loose or stretched version, plastic and linoleum coverings, non-woven fabrics and stone floors up to laminate and wood and cork floors with a sealed or unsealed surface. In the research project the scientists put a laminate floor, one cork ready-made flooring and one cork board for floors under the magnifying glass. Both cork floor coverings were provided by the manufacturers in a sealed version.

Fig. 20: Cork floor board sample prepared for a test chamber measurement

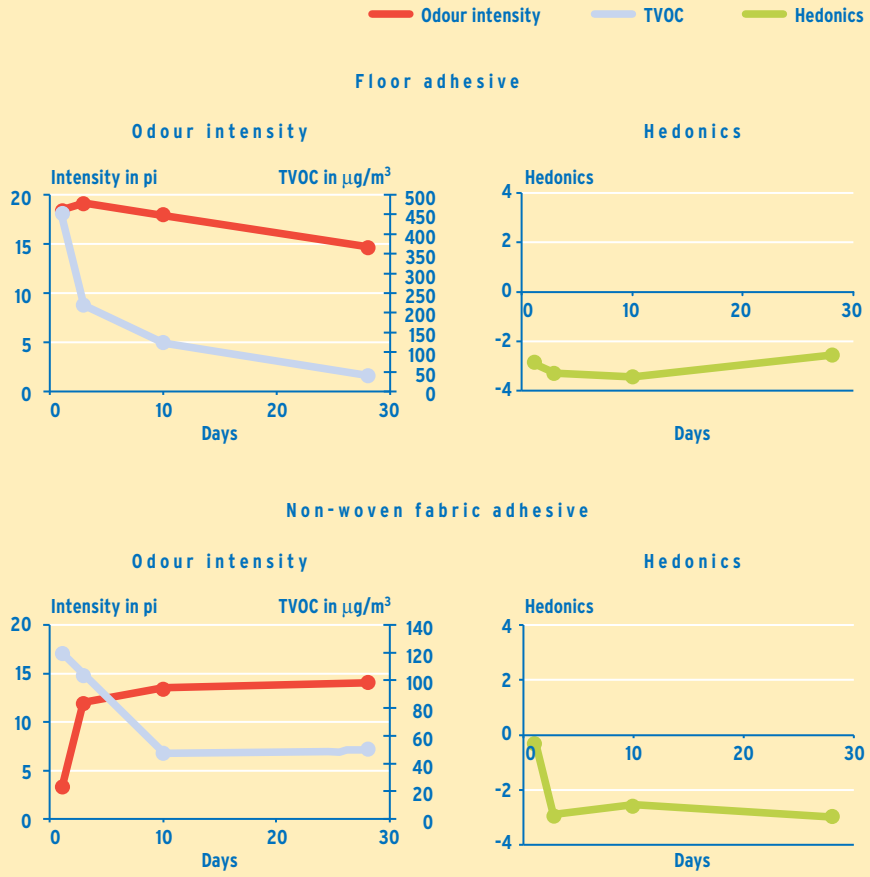
The base structure of the **laminate floor** is a carrier board of timber, which is grooved and feathered. There is also a decoration on the top surface (usually imitation wood, stone or marble).

The top and bottom surfaces are sealed with a transparent coat of synthetic resin for wear and moisture protection. Contrary to parquets, laminates are relatively cheap, but have a shorter service life.

**Cork coverings** are made of the bark of cork oak, which is native to the Mediter-

Source: BAM 2006

## Illustration 6




**Comparison of the sensory tests of the emissions from a floor adhesive (top) and a non-woven fabric adhesive (bottom)**

*Both adhesives have fulfilled the requirements of the AgBB scheme. The panellists assess the odour intensity of the non-woven fabric adhesive at the beginning much better than the floor adhesive, but the intensity for both of them became similar after 28 days (See explanation of the coordinates in Illustration 1).*

ranean area. The bark is rough-ground and pressed to form boars under the influence of heat which makes the resin in the cork oak stick together. "Heavy-duty" floor coverings from cork are treated with synthetic resins (partly phenol formaldehyde resin). To ensure higher stability against mois-

ture or mechanical damage – for instance by sand grains due to walking or chair shifting at the dining table – manufacturers cover the working surface with wax, synthetic or natural resin lacquer or a plastic film. Cork boards for floors, which are fully glued to the underlay, and cork ready-made flooring, which is easier to install, are commercially available. The latter one has a somewhat thinner cork layer, which is placed on a timber carrier with grooves and feathered edges similar to laminate.

Cork floors have a warm surface and a very good sound insulation against step impact but are susceptible to mechanical damage.

All three products – laminate floor, cork board for floor and cork ready-made flooring – tested by the scientists, passed the AgBB scheme requirements. But both sealed cork floor coverings – in particular the cork board – exhibited a high benzophenone emission, which decreased only marginally over the 28 days observation period. Benzophenone is a component of the covering lacquer and initiates UV hardening. This substance is suspected to have hormone-like effects at higher concentrations. The “unspent” benzophenone, absorbed by the cork during painting, obviously diffused slowly from the cork through the coat of varnish and gassed off. But the small concentrations that emerged did not lead to any complaint.

The emissions from the three tested floor coverings were very low and would also fulfil the requirements of the Blue Angel. The laminate floor and the cork ready-made flooring fell within the area of application of the Blue Angel for low-emission wood and timber products RAL-UZ 38 while cork boards for floors fell into that of the environmental award for flexible floor coverings RAL-UZ 120 (also see Box 12).

The odour emissions from the cork board were found to be more intensive than from the cork ready-made flooring by the panellists. However, it was not possible to establish any relationship with the concentration of the odour-generating benzophenone.

## ▼ Joints sealed with acrylic and silicone

Joint sealing compounds fill in cracks, holes, seams and joints. They have a good adhesion, are weather-proof and flexible at low temperatures. The specialist uses different sealing compounds depending upon the type of joint, size of the load and requirement for paint applicability, most frequently those of acryl and silicone which were tested by the scientists.

Paintable **acrylic sealing compounds** harden to form a flexible mass by evaporating water and solubility promoters. Solubility promoters are responsible for the water solubility of the acrylate polymer particles. The sealing compound shrinks by up to 25 per cent due to the loss of water. Manufacturers frequently use glycols as solubility promoters, which are then emitted as main components from the sealing compounds.

The scientists tested seven different products in the test chambers. Two of them failed to meet the requirements of the AgBB scheme because of their emissions on the 28th day, which mainly exceeded the R values of dipropylene glycol or ethanediol. Dipropylene glycol, which was also detected in one of the synthetic-resin premixed plasters (see *subchapter Smooth inner walls with synthetic-resin premixed plaster*), exhibited the highest concentration on the first day with 6.9 mg/m$^3$. It clearly lay below the MAC (MAK) value just like the synthetic-resin premixed plaster.

One of these "failed" products, – see chromatogram in Illustration 7 – was kept in the test chamber for 570 days. The result showed that ethanediol, which belongs to somewhat volatile glycols, was emitted during this entire period.

Odour emissions from one of the acrylic sealing compounds, which passed the health-related evaluation according to the AgBB scheme, was found by the panellists not as intensive as the product which failed, and was assessed as rather pleasant. The product with a higher odour intensity probably showed the best correspondence with the concentration of propylene glycol whose odour was perceptible at higher concentrations.

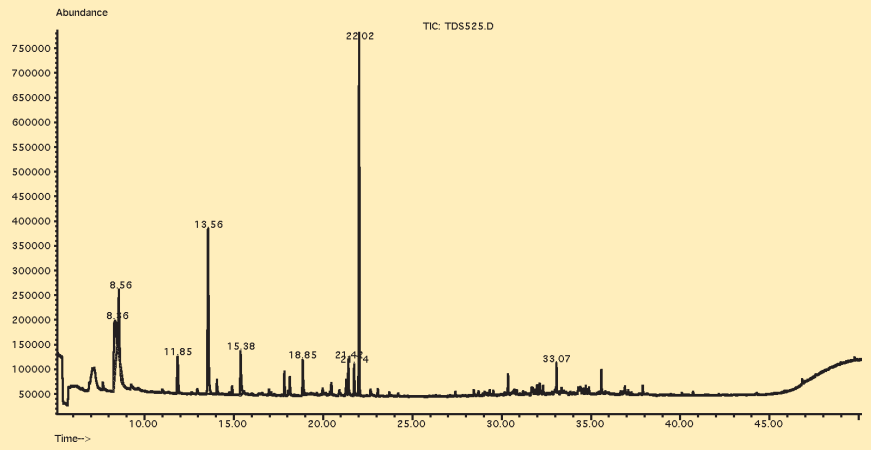
The specialists mainly use **silicone sealing compounds** in the sanitary area, because there, a high water-resistance is of utmost importance. They are cross-linked in contact with air and form a flexible, non-paintable material.

The complete hardening usually takes some days. Different materials are gassing off during this time – depending on the type of cross-linking system in the mass.

Six different products were tested in the research project, four of them were acidic and two neutrally cross-linking. Illustration 8 shows the chromatogram of the emissions of an acidic cross-linking silicone sealing compound on the 28th day.

Source: BAM 2006

## Illustration 7




**GC/MS chromatogram of emissions on day 28 of an acrylic sealing compound which has failed the health-related evaluation according to the AgBB scheme**

*(See explanation of the coordinates in Illustration 3).*

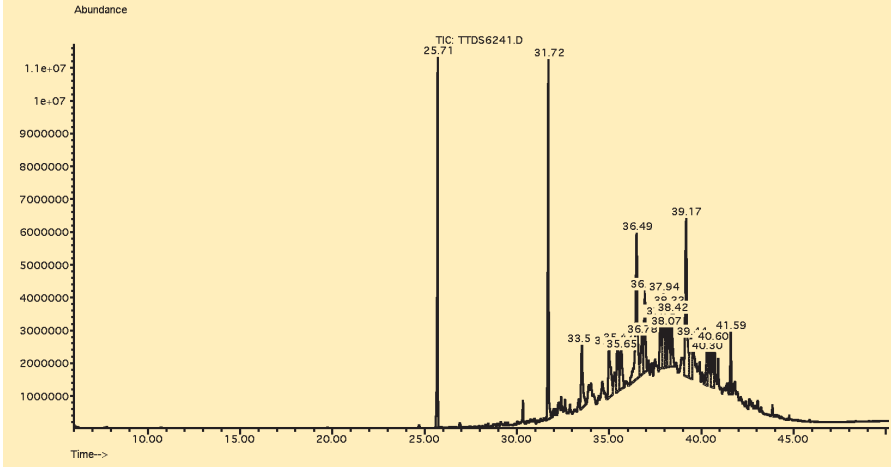
The result of the test chamber measurement was unfavourable throughout: none of the six products passed the health-related evaluation according to the AgBB scheme. The main reason being the high concentration of VOC and in some cases SVOC which was seen on the 28th day. Various cyclic siloxanes, a production-related pollution of the silicone, were conspicuous. They evaporate slowly, are odourless and do not cause irritation. The Committee for Health-related Evaluation of Building Products has not specified any LCI (NIK) value so far. Alkanes ($C_{14}$ – $C_{18}$) contributed substantially to the entire emission in one of the products, and benzene, a carcinogen, led to a complaint in another product on the third day. It was possibly that a production-related pollution occurred in this case since various aromatic hydrocarbons were also found in this sample.

Alkanes in higher concentrations can lead to mucous membrane irritation, headache, nausea and dizziness.

The emissions from the two neutral cross-linking silicone sealing compounds are very different, but the odour was similarly intensive. TVOC or individual substances failed to provide any reference points for the result of the sensory assessment in these products either. On the contrary, despite

Source: BAM 2006

## Illustration 8




**GC/MS chromatogram on day 28 of an acidic cross-linking silicone sealing compound which has failed the health-related evaluation according to the AgBB scheme**

*A "hill" is noticeable among the peaks due to a mixture of a large number of SVOC with retention times very close to each other (See explanation of the coordinates in Illustration 3).*

the continued decrease in concentration the panellists classified one of the sealing compounds on the tenth day as even more unpleasant than at the beginning.

## Timber materials and plasterboard for floor, linings and partitions

Timber materials are characterised in comparison to solid wood by a higher resistance to deformation and are also lower-priced. The manufacturers produce boards from them, which are more easy to use for linings, partitions and floor boards beneath the actual working layer. They can also be used to produce furniture.

Timber materials consist of wood chips to dust particles commonly from wood industry residues. The wood particles are hot pressed with natural or synthetic bonding agents and thus glued together. Depending upon the pressure applied during production, porous timber materials with low strength or dense materials with high strength are produced. Chipboards

and OSB (oriented strand board) were tested in the research project for the use as flooring boards.

**Chipboards** consist of wood chips, usually pine wood. Various combinations of urea, melamine, phenol-formaldehyde adhesives and polymeric di-isocyanate resins are used. They exhibit various physical properties and resistance to hot and cold water and thus determine the field of application and service life of the chip board products.

The chipboard tested in the research project failed to meet the requirements of the AgBB scheme. The reason was the high emission of acetic acid, which resulted from a higher fraction of hardwood splinters. Acetic acid vapours may cause irritation in conjunctiva and mucous membrane of the respiratory system.

In the sensory tests the panellists found the odour unpleasant and very intensive during the entire test period. The odour intensity shows a similar profile to that of the concentrations of the emitted acetic acid.

**OSB** is a multi-layer board manufactured from approximately ten centimetres long and one centimetre wide batons (strands). The large flat batons provide this timber material with a typical "woody" OSB structure (see Fig. 21), which is also used as a decorative element.

Because of the long slim batons the bending strength is greater than in normal chipboards. For gluing purposes the manufacturers use melamine-urea-phenol-formaldehyde and polymer isocyanate adhesives.

Fig. 21: OSB samples prepared for a test chamber measurement

The result of the test chamber measurements was favourable this time: none of the seven tested products gave rise to any complaint according to the AgBB scheme. The alpha-pinene and delta-3-carene terpenes, typical for pine wood, were among the emissions. The concentrations of

these compounds were altogether so low that no unfavourable health effects should be expected.

It is very encouraging that formaldehyde emissions from today's timber materials are substantially lower than in the 1970s and 1980s. Bonding agents rich in formaldehyde were extensively used at that time for chipboard production which was the very substance that triggered the discussions over interior pollutants at that time.

The sensory test, shown in Illustration 9, indicated differences in the perceived odour intensity in two OSB with comparable TVOC concentrations: the panellists found the odour of the emissions of OSB 1 in comparison to OSB 2 somewhat weaker and even assessed it at the end of the test as pleasant. In these building products there are a number of odour-active compounds, such as aldehydes and carbonic acids. But none of the detected compounds provided any reference point for the perceived odour intensity or hedonic assessment.

Specialists frequently use **plasterboard** indoors. It can be used to build partitions which are later relatively easy to remove or change. When used as a "dry liner" they can be fastened to the raw brick-work either using an initial binder or a sub-structure.

Plasterboards consist of a gypsum core, with a layer of cardboard on either side. This gives stability to the gypsum and can easily be processed. A disadvantage is that it is sensitive to moisture and needs a lot of paint if no primer is applied. For use in the kitchen and bath so-called impregnated "moisture resistant" plasterboards are used which makes it difficult for moisture to penetrate. A primer serves to seal and solidify the surface of this very absorbent building material.

The "moisture resistant" plasterboard tested in the research project fulfilled the requirements of the AgBB scheme. The moderate formaldehyde emissions probably originated from the cardboard casing. The treatment of the **plasterboard with a primer** worked like a barrier layer, so that formaldehyde was hardly detected.

The sealing effect was also confirmed by the sensory test: the panellists found the odour intensity much weaker than that from the untreated plasterboard (also see *subchapter "Multicoloured" scope of lacquers and glazes*).

## Illustration 9

Source: BAM 2006


**Comparison of sensory tests of emissions from two different OSB, both of which have passed the health-related evaluation according to the AgBB scheme**

*Both OSB 1 and OSB 2 have fulfilled the health-related evaluation according to the AgBB scheme. The TVOC concentration curves are similar, but they differ in the odour perception (See explanation of the coordinates in Illustration 1).*

## Furniture made from beech and pine

Glued wood is a high-quality wood composite of several layers glued to a strong wooden board. The individual solid wooden boards are often not only glued together but also provided with teethed profiles to increase stability.

In the research project the scientists tested unpainted shelves made from glued **beech and pine wood**. Both solid woods passed the health-related evaluation according to the AgBB scheme. Because of their low emissions they would also fulfil the requirements of the Blue Angel for low-emission wood products and wood-based products RAL-UZ 38.

Fig. 22: Application by brush of an acryl-based lacquer on a glued solid wooden board in preparation for a test chamber measurement

The sensory test provided similar results as far as perceived odour intensity was concerned in both wood samples. But the panellists found the emissions from the pine wood board more unpleasant.

Following these investigations the scientists applied a coat of lacquer to both solid wooden boards (Fig. 22) and again placed them into the test chamber. The results are described in the *subchapter "Multicoloured" scope of lacquers and glazes*.

## "Artificial nose" advancement

For some time there have been efforts to perform the sensory assessment of emissions using measuring instruments, the so-called multi-gas sensors also called "electronic" or "artificial nose" – instead of people (also see *Chapter 4 How to obtain emission data from building products?, subchapter …and do they smell?*).

The name “electronic” or “artificial nose” stems from the desire to copy the operation of the human nose. However, a direct identification of an individual substance and the assessment of the acceptability is not yet possible. Smelling is a very complex physiological procedure. Inhaled odour-generating volatile substances release a stimulus in many different smell receptors in olfactory area which nerves then transfer to the brain. An odour impression from the many signals is only developed there and includes both the perception of odour intensity and hedonics, i.e., whether humans find an odour pleasant or unpleasant, and possibly recognition of the smell sample.

In certain fields, for instance food industry or wine blending, artificial noses have already been introduced. The objective is usually whether or not the sample exhibits a certain signal pattern which is typical for the product and characterizes a certain quality.

The use of panellists, i.e. the human nose, is not only very time consuming in comparison to the artificial nose, but the sensory assessment is connected with individual subjective fluctuations and is therefore difficult to reproduce. In order to compensate for these fluctuations, several people are usually involved in the sensory evaluation of a sample.

It follows from the preceding subchapters that the comparison of the results of chemical analysis with the results of odour assessments did not furnish any relationship. So for example the human nose was still able to perceive odours when the chemical analysis was far from being capable of detecting any volatile organic compounds. The measured concentrations also usually failed to provide any clue for the results of odour assessment. The panellists found the odour of some synthetic-resin premixed plasters, which had failed the health-related evaluation of the AgBB scheme, comparatively more pleasant than that of a product which fulfilled the requirements.

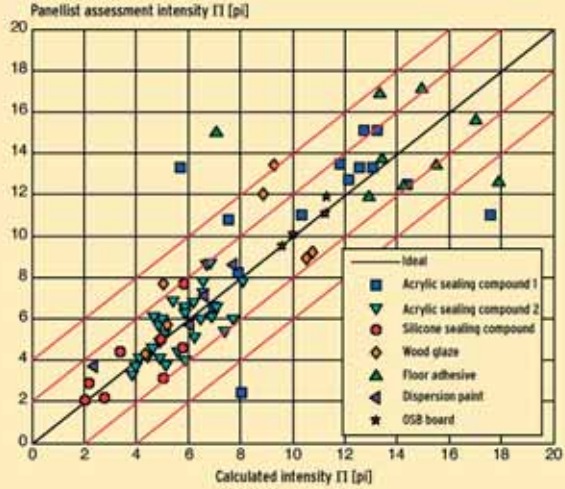
In the research project presented in this brochure the scientists tested some building products to see whether and to what extent the artificial nose was capable of sensory assessment of emissions. Also, because of the fact that health-endangering compounds may be among these emissions which the panellists are exposed to during the smelling procedure. Compared to the previous application possibilities the scientists expect the artificial nose not only to be able to recognize certain signal patterns in the sensory test of emissions from a building product, but also to recognise odour intensity so making it possible to assess the hedonic quality of the perceived odour.

These additional investigations included seven selected building products, five of which met the requirements of the AgBB scheme: a wood glaze, a dispersion wall paint, an OSB, a floor adhesive and an acrylic sealing compound. Two products, another acrylic and a silicone sealing compound, which failed the AgBB scheme were also included.

Illustration 10 shows that the odour intensity determined by the artificial nose is in a fairly good agreement with the odour intensity assessed by the panel – except for one outlier. The experts envisage that the development of sensors and sensor systems with higher sensitivity and the capability of determining a broader spectrum at volatile substances will improve the accuracy of the determination of the odour intensity of building products. The result is positive despite the limitations of this measurement technique, es-

Illustration 10

Source: BAM 2006




**Comparison of odour intensities determined by panellists and an artificial nose**

*The ordinate is the scale for odour intensities determined by panellists and the abscissa gives the scale of those obtained by the artificial nose. The diagram shows the result of a mathematical-statistical regression analysis, which includes the test results of all days of measurement. In the case of a full agreement of the values the measurement points are on the diagonal through the origin. Additionally the deviations of ± 2 pi and ± 4 pi are indicated in red. Most measurement points lie fortunately within ± 2 pi.*

pecially as the artificial nose, as opposed to the human nose, can detect odourless compounds or those whose odour threshold is much higher for the human nose.

The comparable determination of odour intensity enabled the scientists to perform the first step with the artificial nose which will be included in future work. In addition, it is important to develop and train the artificial nose in its hedonic assessment – if necessary aided by further statistical methods.

# 6 CHARACTERISING HEALTH AND ENVIRONMENTALLY COMPATIBLE BUILDING PRODUCTS IS NOT JUST A GERMAN EFFORT

Germany is a country with high environmental awareness and strict health and environmental requirements. But they are far from all being German inventions – and this applies to building products as well.

The European Construction Products Directive requires all member states of the European Union to adhere to the No. 3 essential requirement "Hygiene, Health and the Environment". Since harmonized European regulations have so far been missing, national regulations apply until further notice (also see *Chapter 2 Which regulations already exist for building products?*).

The legally stipulated CE labelling and reference to fulfilled DIN standards on products represent only a limited seal of approval for health and ecological interests. The German Institute for Building Technology and the Federal Environment Agency criticize this situation and see the necessity for a revision of the standards of the first generation in further implementing the Construction Products Directive. This is the result of the report "Implementation of Health and Environmental Criteria in Technical Specifications for Construction Products" commissioned by the Federal Environment Agency. Based on the example of floor coverings, the authors of the study suggest revisions in order to actually meet the requirements of the No. 3 essential requirement "Hygiene, Health and the Environment" in the future. Thus not only the formaldehyde class E1 (formaldehyde release up to 0.1 ppm), but also E2 (formaldehyde release from 0.1 to 1.0 ppm) may be included in the CE labelling for different building materials. The German Institute for Building Technology and the Federal Environment Agency complain that formaldehyde regulations contradict German legislation. Manufacturers and salesmen have not been allowed to sell for example timber materials of formaldehyde class E2 in Germany for a long time. Because the situation is meanwhile similar in other member states, the European Commission CEN required the floor covering standard and all relevant standards to be provided with a footnote which expresses that products beyond E1 may be forbidden in some member states.

## What do our European neighbours do?

Assessment systems for the labelling of low-emission building products exist not only in Germany, but also in some neighbouring European countries. They are usually based on a voluntary agreement and are therefore particularly favourable for the development of their own domestic market. However, due to different protection levels this has led to trade barriers on the European market which have now to be dismantled by harmonization, i.e. through uniform regulations in the member states.

Fig. 23: Logo of the European Collaborative Action "Urban Air, Indoor Environment and Human Exposure"

One step in this direction is report No. 24 with the title **"Harmonisation of Indoor Material Emissions Labelling System in the EU. Inventory of Existing Schemes"** published in 2005. This was drafted by a working group of the European Collaborative Action "Urban Air, Indoor Environment and Human Exposure" (see Fig. 23). The working group, to which two experts of the Federal Environment Agency belonged as German representatives, evaluated the labelling scheme practiced in the individual member states.

The working group looked to see whether the labelling is a voluntary (private) industrial label, whether the State supports it and whether it is bound to legal requirements. The result is summarized in Table 2 – without claiming completeness. Only labels having the support by the State are listed.

In addition, the working group assessed further labels which go back to private initiatives and are extensively used by different manufacturers in a number of countries. They include "natureplus" of natureplus e.V. for various building products, "GUT" Carpets tested for a better Living Environment (Gemeinschaft umweltfreundlicher Teppichböden e.V.), "EMICODE EC 1" Association of the Control of Emissions in Products for Flooring Installation (Gemeinschaft Emissionskontrollierte Verlegewerkstoffe e.V.) and the "Scandinavian Trade Standards".

The working group found that most label systems are based on a similar methodology and the testing institutes determine the emissions according to EN or ISO standards or similar methods.

**Table 2: Assessment of emissions from building products for interiors in Germany and in other member states of the European Union[1]**

| Member state | Label system | Legal status |
|---|---|---|
| Denmark and Norway | Indoor Climate Label | On a voluntary basis, supported by the government |
| Germany | AgBB scheme[2] | Bound to legal requirements[2] Approval by a government institute |
| | Blue Angel | On a voluntary basis, supported by the Federal Ministry of Environment and the Federal Environment Agency |
| Finland | M 1 emission classification of emissions from building materials | On a voluntary basis, supported by the ministries for environment, agriculture and forestry |
| France | CESAT scheme (assessment of environmental and health aspects in building products) | On a voluntary basis, supported by the ministries for environment, health, building and labour |
| Austria | Austrian Environment Label | On a voluntary basis, labelling by the Ministry for Life |
| Portugal | LQAI scheme (Assessment by the Laboratorio da Qualidade do Ar Interior) | On a voluntary basis, supported by public institutions and private organisations |

[1] *Based on the No. 24 Report "Harmonisation of Indoor Material Emissions Labelling Systems in the EU. Inventory of Existing Schemes"*

[2] *Part of the "Principles for the health assessment of construction products used in interiors" for the approval of building products by the German Institute for Building Technology, regional building codes of the states (Laender) form the legal basis. The tests according to the AgBB scheme are currently only obligatory for floor coverings.*

It came to the conclusion that some assessment patterns represent a good discussion basis for a harmonized assessment system, and emphasised the AgBB scheme and the GUT method for certain product groups as examples.

Some labelling systems also consider sensory tests.

But the methods are very different; also documentation on reliability and reproducibility is missing. Still much work is needed in this area. It is possible to build a bridge to the research project presented in this brochure because it is a promising initiative for the sensory test regarding odour intensi-

ty, which is a good starting point for further investigations (see *Chapter 4 How to obtain emission data from building products?* and *Chapter 5 And here are the results of the test chamber measurements*).

## Various eco labels are in use

Meanwhile a number of labels and advertisements for health and environmentally compatible building products are used in the interior. “But can one really rely on them?” consumers ask. When reliability is missing, they go for a product which has a reasonable price and is comfortable to use but may less health and environmentally compatible.

Nowadays health and environmental protection is important for a large part of the population. This is the outcome of the representative public polls “Environmental Awareness in Germany” carried out and regularly commissioned by the Federal Environment Agency supported by the Environmental Research Programme of the Federal Ministry for the Environment. Many people also want to make a contribution through their personal consumer behaviour, but are often insufficiently informed as to which possibilities they have.

Fig. 24: Euro flower, the environmental symbol of the European Commission. The symbol includes the entire life cycle of a product (production, application/consumption and disposal). There are lacquers and glazes, wall paints and floor tiles labelled with the euro flower.

The poll in 2004 showed that the Blue Angel environmental label (Fig. 26) is known to the large majority (83 per cent) and half of them pay attention to this label when doing their shopping. Unfortunately the tendency was somewhat declining in 2006. However, other labels, such as the “Euro Flower” or the European symbol for environmental protection (Fig. 24) were only known to about one fifth of those asked in 2004. Conclusion: there is still information deficit.

Environmental labels, also called eco labels are granted by license and label providers upon the request of the manufacturer, i.e. on a voluntary basis in accordance with the respective guidelines, which differ in their requirements from each other. The scope of the products labelled so far is very wide. It includes lacquers and glazes, wall paints,

wallpapers, products for flooring (adhesives), floor coverings, wood and timber materials, sealing materials and foils, insulation materials and mineral building materials, such as cements, plasters, mortars, masonry items and roof tiles. The scope of the eco labels is just as extensive, so that there are often several environmental labels within the same product groups.


Fig. 25: Cover page of the North Rhine-Westphalia brochure – more in Appendix 4 Reports, brochures, leaflets, internet addresses

The large number of labels and seals makes a comparison difficult and discourages consumers and owners alike. Therefore it is important not only to publicise the individual environmental labels but also to make the award criteria transparent.

A very clear brochure in North Rhine-Westphalia succeeded in an outstanding way in achieving this goal. Coordinated by the Ministry for Environment and Nature Protection, Agriculture and Consumer Protection the State of North Rhine-Westphalia published the brochure entitled **The North Rhine-Westphalia Action Programme Environment and Health. Environmental label for building products. Select building products purposefully – a decision making aid** (Fig. 25) in 2004 (see *Appendix 4 Reports, brochures, leaflets, internet addresses*).

In this comprehensive documentation of about 80 pages there are fifteen eco labels for building products described in detail concerning specific quality, environmental and health criteria – based on a poll of license and label providers. The publishers came to the conclusion that only a few environmental labels actually compete with each another within a product group, consumers can now decide which criteria are important to them and which environmental labels they take into account.

In addition to the internal criteria, the publishers looked to see if the respective awarding criteria are publicly accessible and thus transparent as well as the assignment being made for a time limited period. This criterion was also important for them because a continuous development of the product requirements can only be ensured in this way. Purchase suggestions at the end of each chapter help the consumer to make a decision to purchase a product according to their personal requirements.

Since 2005 there has been another building product label which is legally certified according to the "Principles for the health assessment of construction products used in interiors" by the German Institute for Building Technology. It can be recognized by the **Ü mark with the additional reference "Emissions tested as per DIBt principles"**. This reference means that an investigation took place in accordance with the AgBB scheme (see *Chapter 2 Which regulations already exist for building product? and Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany*). Meanwhile textile floor coverings, rubber, PVC and linoleum floor coverings as well as laminate floors must carry this label. Contrary to an eco label this labelling is not voluntary, but compulsory in law (also see Table 2).

## The Blue Angel is stricter than the AgBB scheme

The eco labels evaluated in the brochure from North Rhine-Westphalia include the Blue Angel from Germany – the oldest environmental label in the world. It was introduced by the Ministers of the Federal Republic and the States (Länder) responsible for environmental protection in 1977. The Eco-labelling Board composed of representatives of different social groups adopted the first six awarding criteria. Today approximately 3,700 products and services carry the Blue Angel in 80 product categories; more can be found on the internet at www.blauer-engel.de.

The Eco-labelling Board distinguishes products with the Blue Angel which are environmentally friendly in their overall aspects and at the same time meet superior requirements for health and safety as well as fitness for use upon the request of the manufacturer. Economical use of raw materials, production, service life and disposal are just as important criteria.

Owner of the trademark for the environmental label of the Blue Angel is the Federal Ministry for Environment, Nature Protection and Reactor Safety. The German Institute for Quality Assurance and Certification (Deutsches Institut für Gütesicherung und Kennzeichnung e.V. – RAL) is entrusted with the assignment of the Blue Angel. The independent Eco-labelling Board is involved which decides about the technical requirements, the State (Land), in which the manufacturer or provider has its base and the Federal Environment Agency. |The latter is responsible for drafting the requirements of awarding the Blue Angel, and the Federal Environment Agency also acts as the agent for the Environmental Label Jury.


Fig. 26: Logo for low-emission floor covering adhesives and other flooring installation products RAL-UZ 113

The test methods developed by the Federal Institute for Materials Research and Testing and other institutions serve for the determination of the emissions according to the awarding criteria of the Blue Angel. The German Institute for Quality Assurance and Certification only accepts the emission tests for the Blue Angel when it has been performed by a test institute recognized by the Federal Institute for Materials Research and Testing.

This guarantees that these institutes master the measurement method and comparable results are obtained.

The different requirements of the Blue Angel and the AgBB scheme regarding the emission limitation of volatile organic compounds can be clarified by the example of floor adhesives, for which the environmental label RAL-UZ 113 has been granted (see Fig. 26), since the test is performed closely adhering to the AgBB scheme (details can be found at http://www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm).

Low-emission and solvent-free floor adhesives are only granted the environmental label RAL-UZ 113 when they do not contain any poisonous, carcinogenic, genotype-changing or toxic-for-reproduction materials and if they contain only certain biocides in very small quantities when used as in-can preservatives. This material must be declared on the sales units, including the telephone number where allergists can receive information.

In comparison to the AgBB scheme the requirements of RAL-UZ 113 (selected as an example) for the emission of volatile organic compounds are stricter, i.e. the test values of the products for flooring must meet considerably lower concentrations (see Table 3). In addition, formaldehyde and acetaldehyde, which are not yet considered in the AgBB scheme, may not exceed 0.05 ppm in the test chamber on the third day of the measurement.

All in all, building products, which passed the health-related evaluation according to the AgBB scheme, fulfil the minimum legal requirements. In 2005 the German Institute for Building Technology started the assessment of floor coverings; other products should follow (see *subchapter Various eco*

**Table 3: Requirements for the emissions of volatile and semivolatile organic compounds in floor adhesives**

| | Day 3 in the test chamber | | Day 28 in the test chamber | |
|---|---|---|---|---|
| **Substances[1]** | **Blue Angel[2]** | **AgBB scheme** | **Blue Angel[2]** | **AgBB scheme** |
| TVOC ($C_6$ – $C_{16}$) | ≤ 1 mg/m³ | ≤ 10 mg/m³ | ≤ 0.1 mg/m³ | ≤ 1.0 mg/m³ |
| TSVOC (> $C_{16}$ – $C_{22}$) | N/A | N/A | ≤ 0.05 mg/m³ | ≤ 0.1 mg/m³ |
| Carcinogens | ≤ 0.01 mg/m³ sum | ≤ 0.01 mg/m³ sum | ≤ 0.001 mg/m³ per indiv. value | ≤ 0.001 mg/m³ sum |
| Sum VOC without LCI (NIK) | N/A | N/A | ≤ 0.04 mg/m³ | ≤ 0.1 mg/m³ |
| R value | N/A | N/A | ≤ 1 | ≤ 1 |

[1] *See explanations in Chapter 3 The AgBB scheme applies to the evaluation of emissions in Germany*

[2] *Concentration data are converted into mg/m3 for better comparability*

*labels are in use*). However, if someone does not want to wait so long and wants to do more for health and environment, they are well advised to choose Blue Angel products. One finds them on the internet at http://www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm, Products & Label users, menu option "→ search for products".

The leaflet "Blue Angel product guide. Building environmentally friendly – living healthily" provides a rapid overview (see *Appendix 4 Reports, brochures, leaflets, internet addresses*).

# 7 WHAT TO DO NEXT?

Building products may emit volatile organic compounds which impair the quality of interior air. Some of them are odourless and can have an "unnoticed" unfavourable effect on health, others can be more or less "smelt" and can at least impair one's well-being.

The results of the research project described on the preceding pages confirm that even after 17 years since the European Building Product Directive came into force, there is still a problem. Still it is considered as a guide for owners and consumers that they should not use building products indoors "without closer inspection".

Therefore it is understandable that experts from politics and science attribute a high priority to efforts of tackling the impairment of interior air caused by building products. This is all the more necessary since the energy conservation requirement, which came into force in 2002, will lead to increased hermetic sealing of buildings following repair and reconstruction. Therefore "natural air exchange" through leaky windows and doors is diminishing with the consequence that undesired substances can be enriched in the room air.

The European Construction Products Directive, being a "New-Approach directive", identifies the essential requirements, including those for health and environmental protection, as its main objectives, while the European Commission delegates the specification of technical details and implementation to standardization and approval bodies. The commission relies on two different aspects which have to be connected (also see *subchapter The responsibility of authorities grows*). While standardization has an organizational structure under private law and is placed on a voluntary basis (see Box 14), approvals are granted under the auspices of the Federal Government (also see Box 15) with standards being the basic components of approval principles for building products.

An extensive quantitative and qualitative determination of hazardous material emissions from building products into the environment is still missing. European building product standards and approvals published so far scarcely consider environmental and health aspects. There are different reasons for this. The development of precautionary mechanisms and a product-specific regulation approach is still at its beginning.

**Box 14**

CEN (Comité Européen de Normalization – European Committee for Standardization) is one of the three officially recognized large standardization organizations in Europe.

In 1961 the national standardization committees of the member states of EEC and EFTA (European Free Trade Association) created CEN with its seat in Brussels.

The 29 CEN members co-operate in developing voluntary European Standards (EN) within various branches of industry and service requirement. The objective is to promote free trade, product safety, labour and consumer protection, interoperability of networks, environmental protection and utilization of research results. Experts and trade associations, consumers and other social interest groups take part in CEN's work.

The German Institute for Standardization e.V. (DIN) represents Germany in CEN.

**Box 15**

The EOTA (European Organization for Technical Approvals) is the umbrella organization in which the notified competent bodies which issue European technical approvals in EU and EFTA member countries are represented. It is a non-profit organization.

The EOTA was established in 1990 based on the Construction Products Directive and has its seat in Brussels.

The key task is to develop the European Technical Approval Guideline (ETAG) and to coordinate European technical approvals. It co-operates closely with the services of the European commission, EFTA, CEN, European commercial representations and trade associations.

The German Institute for Building Technology is the member in EOTA for Germany.

Testing institutes now only systematically determine critical emissions while the assessment of many old materials is still outstanding in a number of fields. The member states have only just developed assessment schemes for building products.

However, clear orders by the European Commission to CEN and EOTA have been missing.

In order to reduce these deficits, Germany developed a suggestion for a "Dangerous Substances Mandate ", which planned an addition of the existing product mandates to CEN and EOTA on test methods using second-generation standards for dangerous substances. That prompted the European Commission to develop an internet data base of dangerous substances, call up a team of experts and issue mandate M/366 to CEN. Without claiming completeness this brochure presents some of the activities.

## An internet data base on dangerous substances regulations in building products is under construction

Since no complete information was available to the European Commission as to which requirements exist in the member states for the implementation of the No. 3 requirement "Hygiene, Health and the Environment" and which test and conformance certificates are required, the Commission started to develop the data base "Legislation on Dangerous Substances in the Field of Construction Products" (working title). This data base should contain all notified national regulations for building products with environmental and health implications. It is hosted by the Secretariat "Construction" within the General Directorate Enterprises of the European Commission.

The Federal Environment Agency, in cooperation with the German Institute for Building Technology, provided the German contribution in 2001 which was one of the first ones. In the meantime the concept of the data base has changed. Now, in addition to substances, users can also enter products as search words. Thus the circle of users is increased. The data base not only helps developers of product standards to obtain information about up-to-date test methods, but manufacturers can more easily check which regulations their products fall under. In the future consumers should also be able to carry out data base searches. However, the revised version is currently in the test phase and is only accessible for registered users (status: February 2007). It is beyond any doubt that the data base promotes the work of harmonization.

## An expert group for dangerous substances in building products has been set up

The European Commission set up the Expert Group for Dangerous Substances in Building Products at the end of 2004, whose official designation

is: “Commission Expert Group on Dangerous Substances in the Field of Construction Products” and stems from an ad-hoc group set up in 2002.

It is comprised of representatives of trade associations, CEN and EOTA from different EU and EFTA member countries. German experts also work in this expert group: the Federal Environment Agency represents Germany and the German Institute for Building Technology represents EOTA. The expert knowledge of this expert group should also be available to the technical committees of CEN and EOTA if needed.

The expert group is currently developing a concept to classify building products without excessive test costs. This differentiates between products for which the effects on environment and health can be assessed as harmless without testing (wt) and without further testing (wft). The study “ Safe construction products for health and the environment: How much testing is necessary to implement the EC Construction Products Directive?” (see *Appendix 4 Reports, brochures, leaflets, internet addresses*) gives suggestions for an innovative shaping of the concept. In addition, the expert team is preparing a manual for the authors of technical specifications (formal product descriptions).

## Standard work becomes legislation work

The European Commission commissioned CEN (see Box 14) to compile standards which can help in proving whether products agree with the substantial requirements of the relevant European guidelines. However, in a special case of the Construction Products Directive these harmonized standards are not only a potential aid, but will be obligatory after a transition period.

Thus for example the CEN Technical Committee (TC) compiled 264 “Air properties” ISO standards for test chamber measurements, which also took into account the AgBB scheme. Experts from the Federal Institute for Materials Research and Testing and the Federal Environment Agency also took part in developing these standards.

In April 2005 CEN received the mandate M/366 (mandate is the term for an order for standardization) to develop test methods for the release of dangerous substances from building products. The mandate covers the release of dangerous substances into interior air, soil and groundwater. In April 2006 the Technical Committee (TC) 351 “Construction Products: Assessment of the release of dangerous substances” was constituted to complete this mandate in CEN, while the Working Group (WG) 2 “Construction products – Assess-

ment of release of dangerous substances – Emissions into indoor air" handled the interior air problem.

It is assumed that TC 351 will use the experience of TC 264 regarding the development of test methods for emission measurement.

German interests are represented by the Federal Environment Agency's experts in TC 351 and WG 1 as well as in WG 2. The Federal Environment Agency can thus have a direct influence on drafting standards to include health aspects. These committees have used the following scheme and reports as key guidelines: the AgBB principles, the DIN Technical Report 127 "Assessments of building products under hygiene, health and environmental aspects" (not available in English) as well as the studies "Implementation of Health and Environmental Criteria in Technical Specifications for Construction Products" presented by the German Institute for Building Technology in 2005 and "Environmental and Health Provisions for Building Products – Determination and Assessment of VOC and Odour Emissions" presented by the Federal Institute for Materials Research and Testing as the leading institute in 2006. The latter two the reports result from research projects commissioned by the Federal Environment Agency.

It is obvious that there is insufficient time to take into account the health and ecological interests in the second-generation standards, due in 2006 onwards, for the implementation of the Construction Products Directive and it will not be possible in 2007 either. CEN can only rudimentarily achieve its goals. The missing technical and regulatory conditions must be provided for the next revisions of the harmonized building product standards, which usually take place every five years at the latest. This means that the national regulations will continue to apply for some time to come.

## The responsibility of authorities increases

The new initiative of the Construction Products Directive suggests that institutes for standardization under private law must also define public interests such as environmental and health protection in detail. However, these interests fall within the responsibility of authorities, therefore it is crucial that authorities participate in the elaboration of standards. This participation is expressly seen as being based on the contract between the Federal Republic of Germany and the German Institute for Standardization, the green book for the development of European standardization and the report of the Commission fore Standardization in view of the new initiative.

The competent authorities must adjust to these new conditions. Therefore the Federal Environment Agency introduced the implementation of the environmental and health protection as a key aspect in the European building standardization process in 2000. The Federal Institute for Materials Research and Testing, responsible for the interacting fields "material – chemistry – environment – safety", contributes to numerous specialist committees, legal bodies and standard-setting institutions in drafting the technical rules and safety regulations and represents Germany in national and supranational organizations.

Standardization is based on the principle of consent by all social organizations concerned, but in practice it is strongly shaped by the interest of manufacturers. This is also the case because the building product industry is organized almost entirely Europe-wide and represents their interests primarily at a European level.

The national approval authorities have also organized themselves on a European level in the EOTA (see Box 15) and formed groups similar to CEN. These groups compile requirements for approvals regarding health and environmental protection. The German Institute for Building Technology, whose key activity is in the field of approvals, supports the activities on a European level and cooperates with the numerous working committees created by CEN and EOTA to promote health and environmental protection on a European level.

In contrast, environmental protection agencies still act predominantly within their national boundaries. To develop common strategies, the European environmental protection authorities must co-operate more closely.

A concentrated action of the environmental protection authorities can only prevent the European standards from being at as a low level as a mere "smallest common denominator" and omitting the issues of environmental and health protection.

The Federal Environment Agency therefore first established contacts with the environmental protection authorities in neighbouring countries concerned with the Construction Products Directive. The so-called EPA (Environmental Protection Agency) network, founded by the national environmental protection authorities in 2003 as suggested by the European Environmental Agency, helped to improve the co-operation of the national environmental protection authorities in Europe. Currently, national environmental protection authorities from 28 countries – the Federal Environment Agency includ-

ed – and the European Environmental Agency take part in the activity of the EPA network.

In addition to the 25 "old" member states of the European Union, Iceland, Norway and Croatia are also represented. The network pursues the goal of promoting the exchange of experience and opinion on questions of common interest in the practical implementation of the environmental policy.

## Developing sensory tests

The effect of odour from volatile organic compounds is a quality of a building product not to be ignored. Therefore, as a precaution, the AgBB included the sensory testing into the AgBB scheme. However, recognized standardized methods are missing for the determination and assessment, so that these tests do not currently take place within the approvals according to the principles of the German Institute for Building Technology for the health-related evaluation of building products in interiors. The Federal Institute for Materials Research and Testing and the Hermann Rietschel Institute of the Technical University of Berlin closely co-operate in this area to improve the methods of sensory testing. In the research project presented in this brochure they successfully developed and tested a method based on available national and international experience to assess the odour intensity of building products using a group of panellists. The results show that sensory assessment of the emissions cannot currently be replaced by analytical methods, since in most cases the odour assessment of a building product does not correlate with the measurement of emissions of volatile organic compounds.

Also, the scientists developed a promising model using an artificial nose as a technical measuring instrument to be employed simultaneously with the human nose. To what extent a hedonic assessment – as performed in the research project – should be included in the sensory test of building products, requires further discussion among experts.

The experts anticipate new results from the project "Innovative Sensor System for Measuring Perceived Air Quality and Brand Specific Odours". This project is headed by the Hermann Rietschel Institute within the 6th Framework Program of the European Union and deals with the further development of the artificial nose. It started in September 2006 and presumably the results will be available at the end of 2009.

Another nine renowned institutes from five European countries, the Federal Institute for Materials Research and Testing included, will take part in this project.

## The Blue Angel gathers momentum

The Blue Angel award criteria for the environmental label RAL-UZ 12 "Low-pollutant paints and varnishes" has been in force in its current version since 1998 and is exclusively based on a prescriptive assessment in which the Federal Environment Agency has included the precursors – e.g. pigments – over the last few years. Since this procedure is very complex and pushes the boundaries, the Eco-labelling Board now consider it necessary to change the concept of the assessment.

The Fraunhofer Institute for Wood Research, Wilhelm Klauditz Institute, Braunschweig, has been commissioned by the Federal Environment Agency to investigate the possibilities of a new concept for the Blue Angel. Work is being currently performed in the experimental research project entitled "Feasibility studies for new environmental labels: Blue Angel – revising the criteria for low-pollutant paints and varnishes" and is funded by the Environmental Research Programme of the Federal Ministry for the Environment (project number 205 95 357 – 2). The proposals are expected at the end of 2007. The researchers will include the findings from the project presented in this brochure (see *Chapter 5 And here are the results of the test chamber measurements, subchapter "Multicoloured" scope of lacquers and glazes*).

## Germany is well placed

Germany has made its contribution to improving the quality of interior air. In addition to health and environmentally compatible products, which are specifically marked with the Blue Angel and have already been on the market for a considerable time, for the first time, floor coverings are available whose approvals included a health-related assessment of emissions. Currently, national regulations apply in Germany for the approval of building products in the interior which guarantee a high level of protection for human health.

In the future, harmonized European standards will replace the national regulations. Many environmental and health aspects can only succeed through

a European majority in CEN and in the Standing Committee for the Building Industry, which has an advisory function and was created based on the Construction Products Directive.

In the committees, in which they act on a European level, the Federal Institute for Materials Research and Testing, the Federal Environment Agency and the German Institute for Building Technology therefore submitted not only well-founded suggestions for an ambitious level of protection, but have committed themselves to their implementation. Harmonized methods that adhere to the basic requirement No. 3 “Hygiene, Health and Environmental Protection” are the guarantors for meeting another requirement of the Building Product Directive: dismantling trade barriers.

# APPENDIX 1

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# APPENDIX 2

## List of illustrations

The following persons kindly provided photographs, free of charge, for the illustration of the brochure:

Bitter, Frank, HRI: *Figure 16*

Horn, Wolfgang, BAM: *Cover photo, Figure 5 to 8, 10 to 12, 17 to 22*

Kasche, Johannes, HRI: *Figure 9, 13 to 15*

# APPENDIX 3

## ▼ Glossary

**AgBB** Committee for Health-related Evaluation of Building Products (Ausschuss für die gesundheitliche Bewertung von Bauprodukten); founded in 1997 by the States' Working Group "Environment-related Health Protection" (Länderarbeitsgruppe "Umweltbezogener Gesundheitsschutz", LAUG) of the Working Association of the Senior State Health Authorities (Arbeitsgemeinschaft der Obersten Landesgesundheitsbehörden, AOLG). → The Federal Environment Agency acts as an agent for AgBB.

**AgBB scheme** The detailed description reads: "Health-related Evaluation Procedure for Volatile Organic Compounds Emissions (VOC and SVOC) from Building Products"; the → notification took place in 2005; it is a component of the "principles for the health assessment of construction products used in interiors", which are the basis for the approval of building products by the competent authority → DIBt; approved products receive → the Ü mark with the additional indication "Emissions tested as per DIBt principles"

**APUG** Action Programme Environment and Health; agency in → UBA; → BMU and → BMG presented the APUG to the public in 1999; → BMELV has also participated since 2002; the federal senior authorities involved are the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS), Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR), Robert Koch Institute (RKI) and → UBA

**BAM** Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung); federal body within the authority of → BMWi

**BMAS** Federal Ministry of Labour and Social Affairs (Bundesministerium für Arbeit und Soziales)

**BMELV** Federal Ministry of Food, Agriculture and Consumer Protection (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz)

**BMG** Federal Ministry of Health (Bundesministerium für Gesundheit)

**BMU** Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit)

**BMVBW** Federal Ministry for Traffic, Building and Housing (Bundesministerium für Verkehr, Bau- und Wohnungswesen)

**BMWi** Federal Ministry for Economics and Technology (Bundesministerium für Wirtschaft und Technologie)

**Carcinogenicity** Property of a material likely to cause cancer; there are various committees which classify these; the → AgBB relies on the European → Directive 67/548/EEC which distinguishes between three categories (substantially shortened definitions):
Category 1 substances are known to have a carcinogenic effect in humans
Category 2 substances should be regarded as if they are carcinogenic for humans, since sufficient evidence is available from appropriate animal studies and other relevant information
Category 3 substances give rise to concern because of a potential carcinogenic effect in humans; some evidence is available from appropriate animal studies, but they are insufficient to place the substance into Category 2

**CE-label** CE means Conformité Européenne (French for European Confirmity); the manufacturer confirms with the CE label the conformity of the product with the applicable EC guidelines and the adherence to the "essential requirements" specified therein; the European Commission created the CE label to ensure the free traffic of goods and products that are safe for the final consumer within the European Marketing Area (Europäischer Wirtschaftsraum EWR) and the European Community (EC) therein

**CEN** Comité Européen de Normalization (French for European Committee for Standardization); founded in 1961 by the national standardization committees of the member states of EEC and EFTA (European Free Trade Association) with its seat in Brussels

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| **Contamination** | Pollution of air, food or drinking water, soil, surface and groundwater with undesired substances |
| **DIBt** | German Institute for Building Technology (Deutsches Institut für Bautechnik); a common institute of the federal government and the States (Länder) for the uniform fulfilment of building engineering tasks within the area of public law |
| **DIN** | German Institute for Standardization (Deutsches Institut für Normung e.V.); the competent institution in Germany for standardization work based on the contract with the Federal Republic of Germany; DIN represents German interests in world-wide and European standardization organizations |
| **Directive 67/548/EWG** | European Directive for Harmonization of the Legal and Administrative Regulations for the Classification, Packing and Labelling of Hazardous Substances of 27 June 1967; meanwhile there are several amendments and adjustments; the current classifications are published in the Directive 2004/73/EG of the Commission of 29 April 2004 for the twenty-ninth adjustment of the Directive 67/548/EEC of the Commission for the Harmonization of the Legal and Administrative Regulations for the Classification, Packing and Labelling of Hazardous Substances to the technical progress |
| **Emission** | Discharging or releasing solid, liquid or gaseous materials or noise from stationary or mobile equipment which are also called emittents; emissions stress or contaminate air, water or soil |
| **EOTA** | European Organization for Technical Approvals; umbrella organization, in which the notified bodies for issuing European technical approvals in the European Union and EFTA member countries are represented; founded in 1990 with its seat in Brussels |
| **Exposure** | Exposing an organism or special goods to illness-promoting/damaging → noxious substances (pollutants, noise, pathogens, radiation) of various frequency and intensity |
| **EC** | European Community; EC has replaced the term EEC (European Economic Community) |

**EU** European Union

**Guide values** In contrast to → limiting values they only have a guiding character; the guide values for pollutants in interior air are toxicologically justified based on single-material considerations; the ad-hoc working group of the Indoor Air Hygiene Commission (Innenraumlufthigiene-Komission, IRK) of → UBA and the Working Association of the Senior State Health Authorities (Arbeitsgemeinschaft der Obersten Landesgesundheitsbehörden, AOLG) compile these values:
If pollutants reach or exceed the guide value II (Richtwert RW II), immediate action is necessary – for example prompting a decision about remediation to reduce → exposure, since this concentration represents a health risk to sensitive persons if they stay in the rooms over a long period
The guide value I (Richtwert RW I) indicates the concentration of a substance, which, according to current knowledge, does not constitute any impairment to health even during lifelong exposure; an excess is connected with an excessive, hygienically undesired contamination; → precautionary measures require an action to be taken, even if the concentration ranges between guide value I and guide value II; guide value I is derived from guide value II by introducing an additional factor (usually 10); this factor is a convention; guide value I can serve as a remediation target value, it should not be exceeded, the actual value should really remain below it.

**Health** Condition of complete mental and psychical well-being or soundness; freedom from disease or abnormality (according to the definition from the founding declaration of → WHO in 1948)

**Hedonics** Description of odour quality; odours can be determined depending on sensation on a nine-grade assessment scale between “extremely pleasant” and “extremely unpleasant”; pleasant odours have a stimulating and improvement effect , unpleasant and strange odours lead to bad temper, aggressiveness, nervousness or awake the escape instinct

**Limiting value** Legally binding; value fixed by laws and regulations for the concentration or dose of a noxious substance for example in air, drinking water or food which may not be exceeded; the legisla-

tor specifies a limiting value based on scientific findings including social aspects; the new requirements imply that the public should take part in the total process of the risk handling (risk estimation, assessment and management)

**MAC values** Maximum Allowable Concentration (Maximale Arbeitsplatzkonzentration, MAK); the concentration of a substance as gas, vapour or suspended matter in (breathing) air at the work place, at which no health impairment is to be expected, even if the person employed is normally exposed to this concentration 8 hours per day, maximum 40 (42) hours weekly (shift operation); MAC values apply to healthy persons of employable age; the Senate Committee for Testing Health-endangering Substances of the German Research Foundation supervises the MAC values annually, updating them when new findings are available and publishing them; MAC values are the basis for the stipulation of work place limiting values in sense of → TRGS 900

**Mutagenicity** Property of a material to change the genotype; it can lead to inheritable genetic damage; there are various committees, which make classifications; the → AgBB relies on the European → Directive 67/548/EEC which distinguishes between three categories (substantially shortened definitions):
Category 1 substances are known to have a mutagenic effect in humans
Category 2 substances should be regarded as if they are mutagenic for humans, since sufficient evidence is available from appropriate animal studies and other relevant information
Category 3 substances give rise to concern because of a potential mutagenic effect in humans; some evidence is available from appropriate mutagenicity studies, but they are insufficient to place the substance into Category 2

**Notification** Proclamation; notified regulations are regulations communicated by the member states to the European Commission in accordance with Directive 98/34/EG or Article 95 EEC contract, which the European Commission has approved of

**Noxious substance** Cause of illness or damage, which may be of a biological/microbiological, chemical or physical nature

**OSB** Oriented strand board; used as building boards for house building, interior installation and furniture production

**Precautionary principle** Principle of environmental politics, according to which environmental political measures must be performed in such a way that environmental impacts are in principle avoided or decreased at least so far as it is possible according to the state of the art while adhering to proportionality

**Risk** Probability of occurrence of an event, for example an illness; often indicated as number of illnesses among 10,000 or 100,000 inhabitants; to minimize health risks from the environment, there are also → limiting values, → guide values and restrictions of application

**SVOC** Semi-volatile organic compounds, boiling range between 240 – 260 °C and 380 – 400 °C; at room temperature building products and furnishings may emit SVOC, for example softener, in small concentrations over a longer period; there are also → VVOC and → VOC

**Toxic for reproduction** Property of a material to impair reproduction;
there are various committees, which make classifications; the → AgBB relies on the European → Directive 67/548/EEC which distinguishes between three categories (substantially shortened definitions):
Category 1 substances are known to impair fertility in humans or are known to cause developmental toxicity (teratogenic) in humans
Category 2 substances should be regarded as if they impair fertility in humans or as if they cause developmental toxicity in humans, since clear results in appropriate animal studies where effects have been observed or other relevant information
Category 3 substances give rise to concern because of a potential to impair fertility in humans or damage embryos in humans because suitable data is available from suitable animal tests or other relevant information to give rise to a strong suspicion, but the findings are not sufficient to classify the substance into Category 2

**TRGS 900** Technical rules for hazardous substances (Technische Regeln für Gefahrstoffe); work place limiting values, which reflect the state

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| | of the art in technology, occupational medicine and industrial hygiene as well as other secured scientific findings for activities with hazardous substances, including their classification and labelling; they are set up by the Committee on Hazardous Substances and adapted to the development; the Federal Minister of Labour and Social Affairs publishes the TRGS in the Federal Paper (Bundesarbeitsblatt, BArbBl.); the work place limiting values are specified based on → MAC (MAK) values |
| **TSVOC** | Sum of the concentrations of all determined → SVOC in a mixture |
| **TVOC** | Sum of the concentrations of all determined → VOC in a mixture |
| **UBA** | Federal Environment Agency; federal senior body within the authority of → BMU |
| **Ü mark** | Conformity (Übereinstimmung) label; the manufacturer confirms the agreement with the technical rules or proofs of applicability of standardised building products manufactured with the Ü mark by himself; the manufacturer must mark building products with general building authority approval by the → DIBt with the Ü mark; the additional information "Emission tested as per DIBt principles" shows that an investigation and an assessment took place in accordance with AgBB principles |
| **VOC** | Volatile organic compounds, their boiling range is between 50 – 100 °C and 240 – 260 °C; benzene is an example; VOCs are emitted from building products and furnishings at room temperature in lower concentrations than → VVOC and in higher concentrations than → SVOC |
| **VVOC** | Very volatile organic compounds, their boiling range is between < 0 °C and 50 – 100 °C; formaldehyde is one of them; there are also → VOCs and → SVOCs |
| **WHO** | World Health Organization |

# APPENDIX 4

## ▼ Reports, brochures, leaflets, internet addresses

These materials are compiled without claiming completeness.

### Research report: fundamental to the brochure

Horn, W., O. Jann (Federal Institute for Materials Research and Testing), J. Kasche, F. Bitter, D. Müller (Hermann Rietschel Institute of the Technical University of Berlin): Environmental and Health Provisions for Building Products – Determination and assessment of VOC and odour emissions. Final report of a research project commissioned by the Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Project number: 202 62 320. Berlin, 2006

### From the Federal Institute for Materials Research and Testing

Federal Institute for Materials Research and Testing,
Presidential Staff Office,
Corporate Communication, Press Office.
Unter den Eichen 87,
D-12205 Berlin
Internet: www.bam.de
email: info@bam.de
phone: + 49(030) 8104-1013
fax: + 49 (030) 8104-3037

- Federal Institute for Materials Research and Testing, Department VII: Safety of Structures (Leaflet), March 2006
- Federal Institute for Materials Research and Testing, Department IV: Biology in Materials Protection and Environmental Issues. (Leaflet), May 2006
- Federal Institute for Materials Research and Testing, Department IV: Environmental Material and Product Properties (Leaflet), June 2006
- Federal Institute for Materials Research and Testing, Department IV: Material and Environment (Leaflet), September 2006
- Jann, O., O. Wilke, D. Brödner (Federal Institute for Materials Research and Testing): Development of a test method for the determination of the emission of volatile organic compounds from coated timber materials and furniture. (in German only: Entwicklung eines Prüfverfahrens zur Ermittlung der Emission flüchtiger organischer Verbindungen aus beschichteten Holzwerkstoffen und Möbeln.) Final report of a research project commissioned by the

Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Project number: 295 44 512/02. Berlin, 1999. Published by Federal Environment Agency (ed): Texts No. 74/99. ISSN 0722-186X.

- Kemmlein, S., O. Hahn, O. Jann (Federal Institute for Materials Research and Testing): Emission of flame retardants from building products and consumer goods. (in German only: Emissionen von Flammschutzmitteln aus Bauprodukten und Konsumgütern) Final report of a research project commissioned by the Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Project number: 295 44 512/02. Berlin, 2003. Published by Federal Environment Agency (ed): Texts No. 74/99. ISSN 0722-186X.
- Wilke, O., O. Jann, D. Brödner (Federal Institute for Materials Research and Testing): Investigating and identifying low-emission adhesives and floor coverings. (in German only: Untersuchung und Ermittlung emissionsarmer Klebstoffe und Bodenbeläge) Final report of a research project commissioned by the Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Project number: 298 95 308. Berlin, 2003. Published by Federal Environment Agency (ed): Texts No. 27/03. ISSN 0722-186X.

Other publications in adjacent technical areas can be found in the literature data base of the Federal Institute for Materials Research and Testing (BAM) at www.bam.de/php/publica/publ.php. This data base, which contains all reports and publications of BAM scientists, can be searched for keywords.

## From the Hermann Rietschel Institute

Technical University of Berlin
Hermann Rietschel Institute for Heating and Air Conditioning
Marchstr. D-410587 Berlin
Internet: www.hermann-rietschel-institut.de

Some of the listed publications can be downloaded from www.hermann-rietschel-institut.de/html/publikationen/.

- Müller, B.: Development of a device for sampling and provision of air samples for the determination of perceived air quality. (only in German: Entwicklung eines Gerätes zur Entnahme und Darbietung von Luftproben zur Bestimmung der empfundenen Luftqualität.) Thesis TU Berlin. October 2002

- Böttcher, O.: Experimental investigations for the calculation of perceived air quality. (Experimentelle Untersuchungen zur Berechnung der empfundenen Luftqualität.) Thesis TU Berlin. February 2003
- Yoon, Yong-Sang: Statistic investigations about determination methods of perceived air quality. (Statistische Untersuchungen zu Ermittlungsmethoden der empfundenen Luftqualität.) Thesis TU Berlin, May 2004
- Kasche, J., A. Dahms, B. Müller, D. Müller, W. Horn, O. Jann: Olfactory assessments of building materials. (Olfaktorische Bewertung von Baumaterialien.) 7th Workshop "Odour and emissions from plastics" (Geruch und Emissionen aus Kunststoffen), Kassel 2005
- Bitter, F., D. Müller: Assessment method for the determination of the smell material delivery of building materials using sensor systems. (Bewertungsverfahren zur Bestimmung der Geruchsstoffabgabe von Baumaterialien mit Sensorsystemen.) gi Gesundheitsingenieur 126 (8), 2005, 173-179. Oldenbourg Industrieverlag, München
- Bitter, F., D. Müller: Measurement of the perceived odour intensity of building materials with multi gassensor systems. Indoor Air 2005, 10th International Conference on Indoor Air Quality and Climate, Sep. 4-9, 2005 in Beijing, China
- Müller, B., D. Müller, W. Horn, O. Jann: The use of gas sampling bags for evaluating the odours of building materials. Indoor Air 2005, 10th International Conference on Indoor Air Quality and Climate, Sep. 4–9, 2005 in Beijing, China
- Kasche, J., A. Dahms, B. Müller, D. Müller, W. Horn, O. Jann: Emission and odour measurement of construction products. CERTECH, Emissions and Odours from Materials Conference 2005 in Brüssel
- Bitter. F., D. Müller: Measurement of perceived odour intensity of building materials uisng multi-gas sensor systems. (Messung der empfundenen Geruchsintensität von Baumaterialien mit Multigas-Sensorsystemen.) DKV Annual Convention 2005 Würzburg
- Kasche, J., A. Dahms, D. Müller, W. Horn, O. Jann: Olfactory assessment of building materials. (Olfaktorische Bewertung von Baumaterialien.) DKV Annual Convention 2005 Würzburg


## From the Federal Environment Agency


Federal Environment Agency
Central Information Service ZAD
Wörlitzer Platz 1
D-06844 Dessau
Internet: www.umweltbundesamt.de
email: info@umweltbundesamt.de
phone: + 49 (0340) 2103-2689
fax: + 49 (0340) 2104-2285

- Committee for Health-related Evaluation of Building Products: Health-related Evaluation Procedure for Volatile Organic Compound Emissions (VOC and SVOC) from Building Products. Status September 2005. Download from http://www.umweltbundesamt.de/building-products/archive/AgBB-Evaluation-Scheme2005.pdf
- Committee for Health-related Evaluation of Building Products, German Institute for Building Technology and Federal Environment Agency (ed): 2nd technical discussion on health-related evaluation procedures for volatile organic compound emissions (VOC) from building products. (in German only: 2. Fachgespräch zur Vorgehensweise bei der gesundheitlichen Bewertung der Emissionen von flüchtigen organischen Verbindungen (VOC) aus Bauprodukten.) 25 November 2004. Download from www.umweltdaten.de/publikationen/fpdf-l/2898.pdf
- Federal Office for Radiation Protection, Federal Office for Consumer Protection and Food Safety, Federal Institute for Risk Assessment, Robert Koch Institute and Federal Environment Agency (ed): Environmental Health in Germany. Everyday Examples. 2005 edition. Berlin, October 2005
- Federal Office for Radiation Protection, Federal Institute for Risk Assessment and Federal Environment Agency (ed): A Healthier Home – but how? Practical advice for everyday life. Berlin, March 2005
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Federation of German Industries e.V. and Federal Environment Agency (ed): Environmental information for products and services. Requirements, instruments, examples. Bonn and Berlin, 2004
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Environmental Label Jury, RAL German Institute for Quality Assurance and Certification, Federal Environment Agency (ed): Product guide Blue Angel. Building environmentally friendly, living healthily. (in German only: Produktwegweiser Blauer Engel. Umweltfreundlich bauen, gesund wohnen.) Download from www.blauer-engel.de/deutsch/news_infos/publikationen.htm
- Ehrnsperger, R. und W. Misch (German Institute for Building Technology): Implementation of Health and Environmental Criteria in Technical Specifications for Construction Products. Final report of a research project commissioned by the Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Project number: 200 62 311. Berlin, 2005. Published by Federal Environment Agency (ed): Texts No. 06/05. ISSN 0722-186X. Available exclusively as download from www.umweltbundesamt.de
- Rheinberger, U. and D. Bunke (Öko-Institut e. V.): Safe construction products for health and the environment: How much testing is necessary to imple-

ment the EC Construction Products Directive? Final report of a research project commissioned by the Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Project number: 202 95 384. Dessau, 2006. Published by Federal Environment Agency (ed): Texts No. 05/07. ISSN 1862-4804. Download from www.umweltbundesamt.de

- Indoor Air Hygiene Commission of the Federal Environment Agency (ed) Manual for interior hygiene in school buildings. (in German only: Leitfaden für die Innenraumhygiene in Schulgebäuden.) Berlin, 2000
- Federal Environment Agency (ed): Adhesives. Ideas and information on handling adhesives. (in German only: Klebstoffe. Tipps und Informationen zum richtigen Umgang mit Klebstoffen.) Berlin
- Federal Environment Agency (ed): Paints and lacquers. Ideas and information on handling paints. (in German only: Farben und Lacke. Tipps und Informationen zum Umgang mit Anstrichstoffen.) Berlin 2001
- Federal Environment Agency, Department "Environmental information" (ed): Wood preservation. Ideas and information on handling wood preservatives. (in German only: Holzschutz. Tipps und Informationen zum richtigen Umgang mit Holzschutzmitteln.) Berlin, 2001
- Federal Environment Agency, Department "Material-related product questions" (ed): Furniture for healthy living? How? – Where? – What? (in German only: Möbel für gesundes Wohnen? Wie denn? – Wo denn? – Was denn?) Berlin 2002
- Federal Environment Agency (ed): The Blue Angel has many faces. The Environmental Label Jury. (in German only: Der Blaue Engel hat viele Gesichter. Die Jury Umweltzeichen.) Berlin, 2003
- Federal Environment Agency, Department "Rational energy production and use" (ed): Energy piggy bank. Information on heat protection and saving heating energy for home owners and house builders. (in German only: Das Energie-Sparschwein. Informationen zum Wärmeschutz und zur Heizenergieeinsparung für Eigenheimbesitzer und Bauherren.) Berlin, 2003
- Federal Environment Agency und RAL German Institute for Quality Assurance and Certification e.V. (ed): The Blue Angel – a guide. – Healthy living. (in German only: Ratgeber Blauer Engel – Gesund wohnen.) Status November 2005
- Federal Environment Agency and RAL German Institute for Quality Assurance and Certification e.V. (ed): The Blue Angel – a guide. Environmentally conscious household. (in German only: Ratgeber Blauer Engel – Umweltbewusster Haushalt.) Status November 2005
- Federal Environment Agency and RAL German Institute for Quality Assurance and Certification e.V. (ed): The Blue Angel – a guide. How to build en-

vironmentally friendly. (in German only: Ratgeber Blauer Engel – Umweltfreundlich bauen.) Status November 2005
- Federal Environment Agency (ed): Attack of the black dust. The phenomenon “black flats”. Causes – effects – remedy. Including the brochure Help! Mould in the house. Causes – effects – remedy. (in German only: Attacke des schwarzen Staubes. Das Phänomen “Schwarze Wohnungen” Ursachen – Wirkungen – Abhilfe. Einschließlich Broschüre Hilfe! Schimmel im Haus. Ursachen – Wirkungen – Abhilfe.) Berlin, 2004
- Federal Environment Agency (ed of the English edition) and European Environmental Agency: Late lessons from early warnings: the environmental issue report No 22 01/2002 1896–2000. Copenhagen 2001
- Federal Environment Agency (ed): REACH. REACH for users. (in German only: REACH. REACH für Anwender.) Dessau, 2005

## Further documents of other publishers

- Institute for Occupational Safety and Health BGIA (Berufsgenossenschaftliches Institut für Arbeitsschutz) (ed): BGIA-Report 1/2006: List of dangerous materials 2006. Dangerous materials in the work place. (in German only: Gefahrstoffliste 2006. Gefahrstoffe am Arbeitsplatz.) The list, normally published annually, contains the stipulated classifications and labelling of materials and preparations in accordance with Directive 67/548/EWG (including amendments) as well as materials specified in the TRGS 905 “List of carcinogenic or toxic-for-reproduction materials”. The list also contains limiting values in air (TRGS 900 “Work place limiting values”) and work place biological tolerance values – BAT (TRGS 903). Download from www.hvbg.de/d/bia/pub/ rep/rep05/bgia0106.html
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (ed): Concept of the Federal Government for the Improvement of Air Quality in Interiors. (in German only: Konzeption der Bundesregierung zur Verbesserung der Luftqualität in Innenräumen.) Bonn, September 1992
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety: Improvement of air quality in interiors. Selected key actions from the BMU’s point of view. (in German only: Verbesserung der Luftqualität in Innenräumen. Ausgewählte Handlungsschwerpunkte aus Sicht des BMU.) Bonn, 2005. Download from www.bmu.de/chemikalien/downloads/doc/35141.php
- German Institute for Building Technology (ed): DIBt Publications (in German only: DIBt Mitteilungen). ISSN 1438-7778. The German Institute for Building Technology publishes its work and provides information on current technical building-authority regulations for planning and implementation safety of all involved in building activity. The journal is published by Ernst & Sohn

Publishers, Berlin, a Wiley Company, and is available online for a charge at http://www.wiley-vch.de/ernst-sohn/zeitschriften/dibt/dibt_info.html

- German Institute for Building Technology: Approval principles for health-related evaluation of building products in interiors, DIBt Publications (in German only: Zulassungsgrundsätze zur gesundheitlichen Bewertung von Bauprodukten in Innenräumen, DIBt-Mitteilungen), 35 (2004) 119–141
- European Collaborative Action "Indoor Air Quality and Its Impact on Man": Report No 18 Evaluation of VOC emissions from building products. Solid flooring materials. EUR 17334 EN. ISBN 92-828-0384-8. Office for Official Publications of the European Communities, Luxembourg, 2005. Download from www.jrc.cec.eu.int/pce/eca_reports/ECA_Report18.pdf
- European Collaborative Action "Urban Air, Indoor Environment and Human Exposure": Report No. 24. Harmonisation of indoor material emissions labelling systems in the EU. Inventory of existing schemes. EUR 21891 EN. ISBN 92-79-01043-3. Office for Official Publications of the European Communities, Luxembourg. 2005 (www.jrc.cec.eu.int/pce/eca_reports/ECA_Report24.pdf)
- European Commission: What's the Eco-label? Download from http://ec.europa.eu/environment/ecolabel/index_en.htm
- Ministry for the Environment and Nature Conservation, Agriculture and Consumer Protection of North Rhine-Westphalia, Ministry for Building and Transport of North Rhine-Westphalia and Research Institute for Land and Town Development and Civil Engineering of North Rhine-Westphalia (ed): North Rhine-Westphalia Action Programm for Health and Environment. Houses and flats. Health-conscious modernization. (in German only: Aktionsprogramm Umwelt und Gesundheit Nordrhein-Westfalen. Häuser und Wohnungen. Gesundheitsbewusst modernisieren.)
- Ministry for the Environment and Nature Conservation, Agriculture and Consumer Protection of North Rhine-Westphalia, Ministry for Town Building and Housing, Culture and Sport of North Rhine-Westphalia and Research Institute for Land and Town Development and Civil Engineering of North Rhine-Westphalia (ed): North Rhine-Westphalia Action Programm for Health and Environment. Manual of health-conscious modernization. Residential buildings from 1950 to 1975. (In German only: Aktionsprogramm Umwelt und Gesundheit Nordrhein-Westfalen. Leitfaden Gesundheitsbewusst modernisieren. Wohngebäude von 1950 to 1975.) October 2004
- Ministry for the Environment and Nature Conservation, Agriculture and Consumer Protection of North Rhine-Westphalia, Ministry for Town Building and Housing, Culture and Sport of North Rhine-Westphalia and Research Institute for Land and Town Development and Civil Engineering of North Rhine-Westphalia (ed): North Rhine-Westphalia Action Programm for Health and Environment. Purposeful selection of building products – a decision-

support tool. (in German only: Aktionsprogramm Umwelt und Gesundheit Nordrhein-Westfalen. Bauprodukte gezielt auswählen – eine Entscheidungshilfe.) October 2004

## Selected internet addresses

- **Action Programm for Health and Environment, APUG**
  www.apug.de
  Federal Ministry for the Environment (BMU) and Federal Ministry of Health (BMG) introduce APUG 1999 to the public. The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has also contributed since 2002. The senior federal authorities involved are the federal Office for Radiation Protection (BfS), the Federal Institute for Risk Assessment (BfR), the Robert Koch Institute (RKI) and the Federal Environment Agency (UBA).The initiative makes a contribution to establishing a connection between the political fields of environmental, health and consumer protection at the level of the Federal Ministries and senior federal authorities involved. The message of the initiative is: environment and health belong together.

- **Working Association of Ministers and Senators Responsible for Town Construction, Building and Housing (Abeitsgemeinschaft der für Städtebau, Bau- und Wohnungswesen zuständigen Minister und Senatoren, ARGEBAU)**
  www.is-argebau.de
  The ARGEBAU is the building ministers' conference which confers once a year and which the Federal Minister responsible for building also regularly attends. It receives reports from working committees, addresses suggestions to the Federal Government and issues resolutions, which are important for the development of town construction, building and housing in the States (Länder). The building ministers' conference for example agrees on a sample building code, which is the fundamental of the State (Land) building regulations which lie within the legislative competence of the States (Länder). The implementation of the European Building Product Directive (89/106/EEC) of 21 December 1988 into national law required amending all state building regulations and the sample building code as well as the creation of the instrument of the Building Regulation List.

- **Committee for the Health-related Evaluation of Building Products, AgBB**
  www.umweltbundesamt.de/bauprodukte/agbb.htm
  The AgBB was founded in 1997 by the States' Working Group "Environment-related Health Protection" (Länderarbeitsgruppe "Umweltbezogener Gesundheitsschutz", LAUG) of the Working Association of the Senior State Health

Authorities (Arbeitsgemeinschaft der Obersten Landesgesundheitsbehörden, AOLG). In addition to the State (Land) health authorities, the Federal Environment Agency (UBA), the German Institute for Building Technology (DIBt), the Working Group of the Ministers and Senators of the States (Laender) responsible for building, housing and urban affairs (ARGEBAU), the Federal Institute for Materials Research and Testing (BAM), the Federal Institute for Risk Assessment (BfR) and the Coordinating Committee "Environment and Health" of the Civil Engineering Standardization DIN Construction Sector (DIN-KOA 03) are also represented in AgBB. The Federal Environment Agency acts as an agent for AgBB.

### ▶ Blue Angel

www.blauer-engel.de

The Blue Angel is the oldest environmental label in the world. The Ministers of the Federal Government and the States (Länder) responsible for environmental protection introduced this label, and it is issued on a voluntarily basis. Using this symbol, industry, trade and craftsmen can transparently prove their environmental competence. The Blue Angel is thus a practical guide for consumers. Today approximately 3,700 products and services carry the Blue Angel in 80 product categories.

### ▶ German Institute for Building Technology, DIBt

www.dibt.de

The German Institute for Building Technology (Deutsches Institut für Bautechnik, DIBt), with its seat in Berlin, is a common establishment of the Federal Government and the States (Länder) for the uniform fulfilment of civil engineering tasks within the area of public law. These are mainly: the issuance of European technical approvals for building products and systems, the issuance of general building authority approvals for building products and designs, recognition of test, supervision and certification bodies for tasks for the Ü mark and the CE label of building products, the announcement of the Building Regulation Lists A and B and the list C for Building Products.

### ▶ German Institute for Standardization e.V., DIN e.V.

www2.din.de

DIN, with seat in Berlin, is the institution responsible for standardization work in Germany. It represents the German interests in the world-wide and European standardization organizations. The Federal Republic of Germany recognized this status in a common contract on 5 June 1975. DIN is the round table, at which manufacturers, trade, consumers, handicraft, service companies, science, technical inspection and the State meet, i.e. all, who

have an interest in standardization, to determine the state of the art and include it in German standards in view of new findings.

- **Indoor Air Hygiene Commission, IRK**
  www.umweltbundesamt.de/uba-info-daten/daten/irk.htm
  The IRK is a commission of the Federal Environment Agency (UBA), which was established by the then Federal Institute of Health in 1984 and, after its resolution in 1994, was continued by UBA. The members come predominantly from scientific organizations in Germany and competent specialist State (Land) authorities. The commission advises on issues and problems of interior air hygiene and delivers recommendations and statements. They can be downloaded just as the specified guide values for interior air from the website of IRK.

- **Network for Environmentally Compatible Building Materials and Building Products (Netzwerk für umweltverträgliche Baustoffe und Bauprodukte), UBB**
  www.umweltbaustoffe.nrw.de.
  The Ministry for Town Building and Housing, Culture and Sport of North Rhine-Westphalia initiated the network, in order to increase the acceptability for environmentally compatible building products. Various federations, organizations, institutions and enterprises of the building industry in the fields of production, trade, planning, execution and use belong to it.

- **Federal Environment Agency, UBA**
  www.umweltbundesamt.de/bauprodukte/
  The UBA develops scientific fundamentals for the implementation of the essential requirement No. 3 “Hygiene, Health and the Environment” of the European Construction Products Directive and is involved in the standardization of building products in different national and international committees. Interested persons can look for current publications, which can be downloaded free of charge from
  http://www.umweltbundesamt.de/building-products/index.htm

## Notes

The brochure "Building Products: Determining and avoiding pollutants and odours – results from a research project" is based on the investigations within the research project

*Environmental and Health Provisions for Building Products – Determination and assessment of VOC and odour emissions*

The research was headed by the Federal Institute for Materials Research and Testing (BAM) in close co-operation with the Hermann Rietschel Institute (HRI) of the Technical University of Berlin. The project was commissioned by the Federal Environment Agency and supported by the funds of the Environmental Research Programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

The final report was drafted by Dr. Wolfgang Horn, Dr.-Ing. Oliver Jann (BAM), Johannes Kasche, Frank Bitter and Prof. Dr.-Ing. Dirk Müller (HRI) in November 2006. The report can be downloaded from the Federal Environment Agency's website or borrowed from the Federal Environment Agency's library free of charge indicating the project number 202 62 320.

The project was supported by an Expert Advisory Panel which comprised the project team and the following people in alphabetic order: Karsten Aehlig, Institut für Holztechnologie gGmbH, Dresden; Peter Braun, ALAB GmbH, Berlin ; Simone Brandt, UBA; Dr. Jürgen Bremer, Industrie- und Umweltlaboratorium Vorpommern GmbH, Greifswald; Doris Brödner, BAM; Martina Bröge, Institut für Holztechnologie gGmbH, Dresden; Arne Dahms, HRI; Christine Däumling, UBA; Nicole Dommaschk, Deutsches Institut für Bautechnik, Berlin; Dr. Oliver Hahn, BAM; Dr. Frank Jungnickel, LGA QualiTest GmbH, Nürnberg; Elevtheria Juritsch, BAM ; Sabine Kalus, BAM; Dr. Frank Kuebart, eco-Umweltinstitut GmbH, Köln; Werner Lindenmüller, TÜV Süd AG, München ; Dr. Bernd Maciej, LGA QualiTest GmbH, Nürnberg ; Dr. Birgit Müller, HRI; Dr. Olaf Paulus, Industrie- und Umweltlaboratorium Vorpommern GmbH, Greifswald; Dr. Wolfgang Plehn, UBA; Christian Scherer, Fraunhofer-Institut für Bauphysik, Holzkirchen; Nicole Schulz, Fraunhofer-Institut für Holzforschung/Wilhelm-Klauditz-Institut, Braunschweig; Wilfried Schwampe, TÜV Nord GmbH, Hamburg; Dr. Erik UhdeFraunhofer-Institut für Holzforschung/Wilhelm-Klauditz-Institut, Braunschweig; Dr. Detlev Ullrich, UBA; Dr. Michael Wensing, Fraunhofer-Institut für Holzforschung/Wilhelm-Klauditz-Institut, Braunschweig, and Dr. Olaf Wilke, BAM.

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