EUROPEAN COLLABORATIVE ACTION

URBAN AIR, INDOOR ENVIRONMENT AND HUMAN EXPOSURE

Environment and Quality of Life

Report No 27

Harmonisation framework for indoor material labelling schemes in the EU

EUROPEAN COMMISSION
JOINT RESEARCH CENTRE
Institute for Health and Consumer Protection
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2010 EUR xxxxx EN

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The mission of the IHCP is to provide scientific support to the development and implementation of EU policies related to health and consumer protection. The IHCP carries out research to improve the understanding of potential health risks posed by chemical, physical and biological agents from various sources to which consumers are exposed.

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MANDATE: European Collaborative Action "**Urban Air, Indoor Environment and Human Exposure**" (formerly "Indoor Air Quality & it's Impact on Man")

For 24 years now the European Collaborative Action ECA "Indoor Air Quality & it's Impact on Man" has been implementing a multidisciplinary collaboration of European scientists the ultimate goal of which was the provision of healthy and environmentally sustainable buildings. To accomplish this task ECA is dealing with all aspects of the indoor environment including thermal comfort, pollution sources, the quality and quantity of chemical and biological indoor pollutants, energy use, and the ventilation processes which all may interact with indoor air quality. The work of ECA has been directed by a Steering Committee.

In order to provide a broader view on air pollution exposure in urban areas, both indoors and outdoors, the ECA Steering Committee decided to put more emphasis on the links between indoor and outdoor air quality and to focus its further work under a new title "*Urban Air, Indoor Environment and Human Exposure*". The focus of the renewed activity is urban & indoor air pollution exposure assessment, seen as part of environmental health risk assessment and also considering the needs of urban and indoor air quality management. The new approach hosts and supports the activities of the Joint Research Centre's Institute for Health and Consumer Protection in Ispra (Italy) dealing with Physical and Chemical Exposures and Health Effects.

This focussed activity proceeds within the broader framework of (i) health and comfort of the citizens, (ii) building technologies and source controls, and (iii) requirements of sustainability, energy efficiency and conservation of natural resources.

Specific examples of the working areas of ECA are:
- the relative importance of outdoor and indoor sources of pollution,
- the building-related interaction between outdoor urban air and indoor air,
- exposure to pollutants from the different urban outdoor and indoor sources and its relation to health and comfort.

By addressing such topics ECA will lay the ground for air quality management to minimise exposures to air pollutants. It will thus continue to contribute to pre-normative research needed by EC services and national authorities responsible for preventing pollution and promoting health, comfort and quality of life.

In this series the following reports have already been published.

Report No. 1: Radon in indoor air. EUR 11917 EN, 1988. *

Report No. 2: Formaldehyde emission from wood-based materials: guideline for the determination of steady state concentrations in test chambers. EUR 12196 EN, 1989. *

Report No. 3: Indoor pollution by NO2 in European countries. EUR 12219, EN1989.

Report No. 4: Sick building syndrome - a practical guide. EUR 12294 EN, 1989.

Report No. 6: Strategy for sampling chemical substances in indoor air. EUR 12617 EN, 1989.

Report No. 7: Indoor air pollution by formaldehyde in European countries. EUR 13216 EN, 1990. *

Report No. 8: Guideline for the characterization of volatile organic compounds emitted from indoor materials and products using small test chambers. EUR 13593 EN, 1991.

Report No. 9: Project inventory – 2nd updated edition. EUR 13838 EN, 1991.

Report No. 10: Effects of indoor air pollution on human health. EUR 14086 EN, 1991.

Report No. 11: Guidelines for ventilation requirements in buildings. EUR 14449 1992, EN.

Report No. 12: Biological particles in indoor environments. EUR 14988 EN, 1993.

Report No. 13: Determination of VOCs emitted from indoor materials and products. Interlaboratory comparison of small chamber measurements. EUR 15054 EN, 1993.

Report No. 14: Sampling strategies for volatile organic compounds (VOCs) in indoor air. EUR 16051 EN, 1994.

Report No. 15: Radon in indoor air. EUR 16123 EN, 1995.

Report No. 16: Determination of VOCs emitted from indoor materials and products: Second interlaboratoriy comparison of small chamber measurements., EUR 16284 EN, 1995.

Report No. 17: Indoor air quality and the use of energy in buildings. EUR 16367 EN, 1996.

Report No. 18: Evaluation of VOC emissions from building products –solid flooring materials., EUR 17334 EN, 1997

Report No. 19: Total Volatile Organic Compounds (TVOC) in indoor air quality investigations. EUR 17675 EN, 1997

Report No. 20: Sensory evaluation of indoor air quality, EUR 18676 EN, 1999.

Report No. 21: European Interlaboratory Comparison on VOCs emitted from building materials and products, EUR 18698 EN, 1999.

Report No. 22: Risk assessment in relation to indoor air quality, EUR 19529 EN, 2000.

Report No. 23: Ventilation, Good Indoor Air Quality and Rational Use of Energy, EUR 20741 EN, 2003.

Report No. 24 Harmonisation of indoor material emissions labelling systems in the EU, Inventory of existing schemes, EUR 21891 EN, 2005.

Report No. 25: Strategies to determine and control the contributions of indoor air pollution to total inhalation exposure (STRATEX), EUR 22503 EN, 2006

Report No. 26: Impact of Ozone-initiated Terpene Chemistry on Indoor Air Quality and Human Health, EUR 23052 EN, 2007

* out of print

Abstract

ECA-IAQ (European Collaborative Action, Urban Air, Indoor Environment and Human Exposure), 2010. Harmonisation framework for indoor material labelling schemes in the EU, Report No 27. EUR xxxxx EN. Luxembourg: Office for Official Publications of the European Communities

Harmonisation of indoor material labelling schemes in the EU is an important aspect of the European Commission's policy making process in the field of indoor air quality and associated health effects. This report describes the outcome of recent activities and a roadmap setting out the steps being taken by a preparatory working group led by the European Commission for establishing an EU wide harmonised framework for labelling schemes (which consists of core and optional criteria) and obtaining broad consensus through open consultation.

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EXECUTIVE SUMMARY

Emissions from construction products can constitute a significant source of indoor pollution. A wide range of volatile organic compounds (VOCs) and formaldehyde can be released, and concentrations can be particularly elevated in new buildings and following refurbishment. A number of national and industry focused labelling schemes for low emitting products exist in Europe and each has its own specific requirements for testing and criteria for product evaluation. This results in significant costs to industries wishing to provide low emitting products in different European markets and is also potentially confusing for consumers willing to make informed choices among a variety of available products in the market.

In response to this concern, and to further encourage the development and application of low emitting products, a preparatory EU expert group convened by the European Commission's Joint Research Centre (JRC) was established to promote and seek consensus on the scope for harmonisation of the indoor material labelling schemes and also to elaborate a harmonised framework for indoor labelling schemes in Europe.

This report describes the consensus achieved on a harmonised framework for labelling schemes in Europe during the preparatory phase of the project among the representatives of the Danish (DICL) and Finnish (M1) labelling schemes and the German and French evaluation systems (correspondingly AgBB and AFSSET). This framework includes common core criteria on testing and evaluation methodologies to be accepted by consensus and optional criteria to be applied locally for those substances/factors for which no consensus exists yet. The criteria were established taking into consideration the results of round robin testing of products performed according to the individual schemes involved in the first phase and the on-going work within the European standardisation body (CEN) to prepare a harmonised test method to determine the emission of dangerous substances from construction products in support of requirements for health safety and environment under the Construction Products Directive (89/106/EEC).

The recommendations made by the preparatory WG are summarised below:

GENERAL FRAMEWORK:
A harmonised framework for indoor material emissions labelling schemes in EU should comprise core and optional requirements for both the chemical characterisation and the health evaluation of material emissions.

EMISSION TESTING OF INDOOR MATERIALS:
Emission testing should be based on harmonised European standards, when available. The issues of product sampling and sample preparation are a crucial part of emission testing. Procedural details need to be further elaborated before final recommendations can be made. Products should be tested for their emissions as they are placed in the market. The WG supports the work of CEN TC351 and recommends the usage of the validated harmonised testing standard for measurement of VOC's and formaldehyde when this will become available. Until harmonised standards become available, ISO 16000-series standards should be used for measurement with the following exceptions: (1) Emission testing should include two chamber air sampling times (day 3 and 28) and (2) Reference room size: use the normative proposal of CEN TC 351 instead of the ISO 16000-9 informative annex B.

The WG proposes the development of a detailed protocol for calibration of all target compounds (LCIs) suitable for efficient, and as far as possible, automated analysis with appropriate sensitivity, including for carcinogens.

EVALUATION OF INDOOR MATERIAL EMISSIONS:
For the evaluation of indoor material emissions, the preparatory WG agreed to refer to the EU-carcinogens classification. EU carcinogens determined through the harmonised protocol are volatile compounds measurable by ISO-16000. An EU group should be established to prepare a common list of carcinogens fulfilling the above criteria. If carcinogens are detected after 3 days, the test can be stopped. The evaluation criteria should cover all contaminants of concern to health and comfort and be based on scientific evidence when available. The LCI-approach is currently the most feasible strategy to assess the health effects of compounds from buildings materials. An expert group should be initiated to propose common European LCI-criteria. Criteria should be set also for substances not having LCI values (i.e., “non-assessable” substances). TVOC should not be used alone as an indicator for evaluating health effects from indoor material emissions. A common approach for TVOC definition along with an upper limit for TVOC should be established. Sensory evaluation is considered to be an important part in the assessment of material emissions. Results have shown that chemical characterization of emissions is not a good predictor of sensory effects. Therefore it is important to complement the chemical assessment of material emissions with sensory evaluation. This WG supports the work of ISO TC146/SC6 in creating a standard for sensory evaluation. A draft standard ISO/CD 16000-28 on "Determination of odour emissions from building products using test chambers" was developed in early 2010. It includes both, acceptability evaluation using an untrained panel and perceived intensity measurement with a trained panel. It also combines the odour evaluation chamber technique with the harmonised testing standard (model room) prepared by CEN TC351. The practical implication of the implementation of the ISO standard should be discussed and clarified at a later stage.

DATA HANDLING AND REPORTING:
A shared data handling and reporting tool (e.g. as the DIBt’s ADAM Excel sheet) could be used as a basis for a future harmonised European system for documentation and evaluation of data. Additional features like an import tool and integration of alternative LCI-lists are feasible improvement options.

The next step foresees the setup in 2010 of an expanded working group /committee /forum with representatives from labelling schemes in Europe and a wider range partners and stakeholders affected by this topic. The task of this expanded WG/committee/forum will be to finalise the details and achieve broader consensus on the harmonised framework of the European labelling scheme through open consultation. The broader consensus would enable the efficient implementation of the harmonised framework of indoor labelling schemes in a wider and integrated context of safe, healthy, energy efficient and sustainable buildings within the EU and outside. This could be implemented by the aforementioned forum to potentially operate over a long term basis to underpin incentives and policy measures for the sustainable labelling of products and buildings under a common ‘umbrella’ involving as many strategic partners affected as possible.

The intention is to align the harmonised framework across various legislative mandates, such as, Construction Products Directive (89/106/EEC), Energy Performance of Buildings Directive – EPBD (2002/91/EC), EC Lead Market Initiative (COM(2007)860), Integrated Product Policy (IPP), Chemicals Policy (REACH), Green Public Procurement, Thematic Strategy on Urban Environment

(COM(2004)60), Integration of Environmental Aspects into European Standardisation (COM(2004)206), etc. The harmonised framework once finalised will be then forwarded for adoption by the EC policy process.

1. INTRODUCTION

1.1 Background and objectives

Emissions from construction products can constitute a significant source of indoor pollution. A wide range of volatile organic compounds (VOCs) and formaldehyde can be released, and concentrations can be particularly elevated in new buildings and following refurbishment. Recently the DG RTD funded EnVIE co-ordination action on indoor air quality and health effects estimated that, substantial short to medium term benefits at low cost can be expected from harmonised testing and labelling of all building materials, equipment and consumer products (i.e. 10% of the estimated risk reduction potential in EU-27 corresponds to 30000 DALYs/y). A number of national and industry focused labelling schemes for low emitting products exist in Europe and each has its own specific requirements for testing and criteria for product evaluation. This results in significant costs to industries wishing to provide low emitting products in different European markets and is also potentially confusing for consumers willing to make informed choices among a variety of available products in the market.

In response to this concern, and to further encourage the development and application of low emitting products, an EU expert group convened by the EC's Joint Research Centre (JRC), Ispra, was established to promote and seek consensus on the scope for harmonisation of the indoor material labelling schemes at EU level. This group published a report (ECA, 2005) that critically reviewed the characteristics of existing schemes, identified the main similarities and differences between them and recommended further steps towards convergence:

- The need for common procedures of testing and analysis with the possibility of one emission test being sufficient to allow labelling in accordance with the different schemes; this could be achieved in advance of full harmonisation.
- Need for round robin tests to validate the common procedures.
- Need for appropriate quality control of testing.

Subsequently the initiative was taken forward by a conference organised in the context of the German EU presidency in Berlin (UBA, 2007) and gave rise to the formation of a preparatory working group with representatives of the Danish (DICL), and Finnish (M1) labelling schemes and the German evaluation system (AgBB), as well as representatives of emission test laboratories in the UK, France, Finland, Denmark and the EC JRC, Italy. The step taken forward was the development of a harmonised evaluation framework for a common European labelling scheme for emissions from building materials. The need for harmonisation of labelling schemes is also included in the agenda of the EC's expert group on indoor air and among the main recommendations issued by the DG RTD funded EnVIE co-ordination action on indoor air quality and health effects (EnVIE, 2008). This activity is actually coordinated by JRC in close liaison with DG Enterprise, DG SANCO, DG ENV and DG ENER of the European Commission.

This report presents the outcome of the work of the preparatory working group and provides a firm basis for continuing the process of harmonisation of material emission labels. It sets out the consensus among experts and representatives of various European labelling schemes and proposes

that the work is continued under the guidance of an enlarged group that includes a representation from a wide range of stakeholders.

2. HARMONISED FRAMEWORK FOR INDOOR MATERIAL LABELLING SCHEMES IN EU

2.1 Existing indoor labelling schemes in EU

The existing labelling schemes have been developed during the last 20 years and they reflect the development in the IAQ research and the increase in the public awareness of IAQ problems. A critical review of existing labelling schemes in the EU is provided by ECA Report 24 (2005). Some of the schemes have been developed by government agencies and NGOs from the interest of protecting the public from health and comfort problems caused by material emissions. Other schemes have been developed by industry branch organisations to set common development targets for the industry. Figure 1 represents the different assessment traditions for indoor material labelling in the EU.

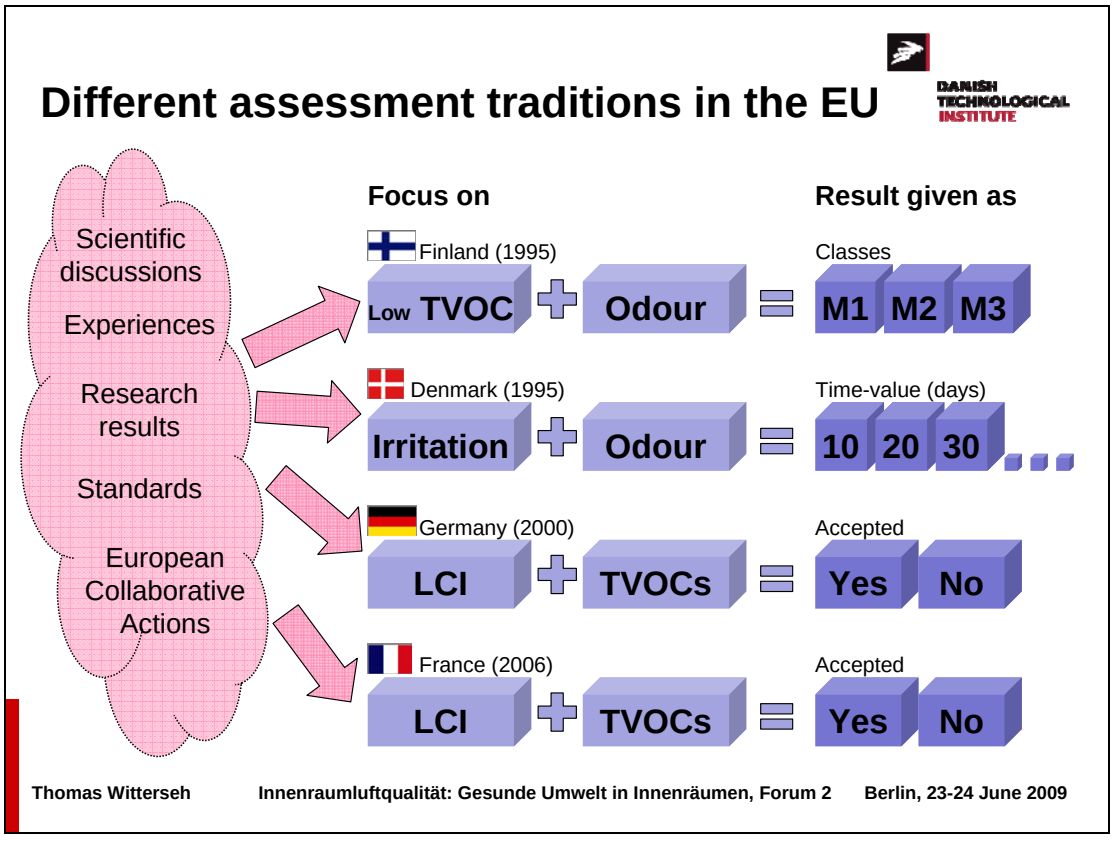

Figure 1. *Different assessment traditions for indoor material labelling in the EU*

Significant reductions in material emissions have also been achieved by the development work encouraged by the voluntary schemes. The voluntary labelling system in use in Finland has over 1500 products that meet the criteria. The emissions from these products are (as estimated by a material testing laboratory) approximately one fifth of the level of the early 1990's. In Denmark, the

Danish Indoor Climate Label has in several cases been a tool for development towards lower emitting products (for example, sealing of open edges and drilled holes in kitchen and wardrobe cabinets made of particle board). A voluntary label can be used in marketing of building products which has increased the companies' interest towards the scheme. In some countries successful voluntary schemes led to a lowering of material emissions for many products.

For example, GUT established a system for the emission testing of textile floor coverings in 1990. The test was performed in test chambers with loading factor of 0.4 and an air-exchange rate of 0.5/h. During the first years the VOC-thresholds could constantly be reduced (5000 µg/m³ in 1990; 1000 µg/m³ in 1991; 500 µg/m³ in 1994; 300 µg/m³ in 1997) as the sources for VOC-emissions from final products could be identified. Based on an agreement between EPDLA (European Polymer Dispersion- and Latex-Producers Association) to regulate the content of volatile organic compounds in polymer dispersions the emissions of carpet specific VOC could be reduced by 80% (e.g. styrene).

In 2004 GUT adopted the AgBB-System (based on the ECA 18 proposal) to evaluate carpet emissions. The emission test is performed in line with the German test requirements and ISO 16000 series recommendations. A carpet will receive a GUT-license if, during the emission test the following criteria are met after 3 days in the test chamber (TVOC = 300 µg/m^3; VOC without LCI = 100 µg/m^3; SVOC = 30 µg/m^3; R<=1). Whereas in the first years the overall reduction of VOC-emission was the focus, the main issue today is the reduction of compound specific emission. Besides these listed VOC thresholds, individual thresholds for some odorous carpet relevant substances like 4-PCH additionally exist.

Several labelling schemes have a strong position in their local markets and are recognized by industry as well as construction clients, designers and consumers. There are thousands of building products that have been labelled according to these schemes. However, in some countries the existence of many different labelling schemes may create confusion to the end user and also create unnecessary costs to industry. While there is a need to harmonise the labelling schemes on a European level, the new scheme should evolve from the existing ones to ensure that benefits already achieved are maintained.

Some of the schemes have received government support for their development, but only a few schemes are endorsed by authorities or have a mandatory status like the AgBB via DIBt approval requirements in Germany. This may be attributed in part to the difficulties in the risk assessment (i.e. the lack of data on the exposure or dose-response relationships for several of the compounds of interest especially under low and mixed exposure conditions) and to unresolved political factors. In Europe there is, however, increasing interest in mandatory labelling from some MS authorities, in addition to the harmonised testing of dangerous substances driven by mandate 366 and carried out by CEN TC351.

In Germany, the mandatory implementation of emission tests since October 2004 resulted in 260 approval licenses (based on 350 emission tests) for about 3000 different products in the broad variety of floor coverings. There was a rapid increase in 2009 as old approval licences expired. The mandatory 'emissions test' has been announced in hearings since 2001, some producers had taken advantage of the old approval procedure (licence valid for 5 years) before the start in October 2004. Other producers used the new option of emission based approval positively as a marketing instrument. Emission requirements for other product groups such as wall coverings, lacquers and

other coatings for parquets, adhesives and underlays are being implemented during 2009/2010 in Germany. As long as European harmonised standards for products with known indoor air relevance are being updated or developed without defined health criteria, the German authorities for construction surveillance can define national health criteria via approval procedures.

In France, voluntary actions, as planned in the NEHAP 2004-2008, failed to provide reliable information on VOC emissions from building products. In 2007, the French Government launched a concerted action (so-called *Le Grenelle Environnement*) for the identification and improvement of key issues regarding environment and health. *Le Grenelle Environnement* (2007) defined very ambitious objectives for the building sector in terms of energy saving. As this objective should not be achieved without taking into account IAQ in building design, *Le Grenelle Environnement* also defined three actions aimed at improving IAQ:

- Mandatory labelling of VOC emissions from building and decoration products,
- Ban of carcinogenic, mutagenic and toxic for reproduction substances category 1 and 2 (according to 67/548/CEE directive classification)
- Setting IAQ monitoring and providing corresponding information in some public buildings (e.g. schools, kindergartens, hospitals, etc.).

Transposition of those actions into French regulation is under progress, but the mandatory labelling of VOC emissions from building and decoration products will be based on four emissions classes from TVOC and a short list of 11 compounds selected because of their dangerous substance classification and because of their occurrence indoors and in product emissions. (http://ec.europa.eu/enterprise/tris/pisa/app/search/index.cfm?iYear=2009&sCountry=F&FUSEACTION=pisa_search_results&STYPE=STRUCTURED&lang=en)

Several countries do not have any schemes or policy on the topic while others have well functioning policies. Therefore, the harmonised European labelling scheme should be a framework describing the common principles for material emission labelling in EU. The harmonised framework proposes the key parameters to be assessed (in the form of either common core requirements or optional ones) and makes reference to the relevant measurement and evaluation methods.

The results of emission testing can be expressed in different ways (see Figure 1), the most frequently used are 'Pass/Fail' systems or quality related classes. This issue has become a point of discussion with regard to CE-labelling under the Construction Products Directive (CPD); there is a need for an agreed convention for labelling based on the results of testing according to the harmonised test standard currently under preparation. One proposal under discussion by the Expert Group on Dangerous Substances (EGDS) defines 3 emission classes and this type of approach (although not necessarily particular limit values) is consistent with the consensus of the preparatory group. This issue of results reporting is an issue for further discussion in the proposed enlarged working group.

2.2 Risk management strategies

The purpose of building material emission labelling schemes is to protect building users (occupants) from negative health and comfort effects by source control strategies. The need for this protection

has been demonstrated in several epidemiological studies and problem cases, (e.g. Mølhave, 2003, Heinzow et al, 2009).

Unfortunately, science has not yet been able to elucidate all substances and mechanisms causing the negative health and comfort effects. A lot of data is available on substances in the workplace environment (see chapter 4) but sufficient data in the sense of a full risk assessment chain exists only for a few substances as pointed out by INDEX (2005) and EnVIE (2008). As health is not just lack of illnesses, it will not be enough just to reduce the exposure to these known problem substances, the risks from other substances need to be reduced as well. This poses a problem for traditional risk management as the causalities and risk probabilities are not exactly known. Therefore it is also difficult to compare the effectiveness of mitigation methods.

Currently, at least the following risk management and communication strategies are in use in existing policies or in voluntary labelling schemes:

- Ban of dangerous substances (content)
- Ban of dangerous emissions
  - Carcinogenic substances
- Restriction of emissions
  - LCI-approach (Evaluation by comparison with 'Lowest concentration of Interest')
  - LCI + limits for ”non assessable substances”
  - TVOC-approach
- Sensory evaluation
- Information dissemination.

Banning substances from building materials is an effective measure to prevent unwanted emissions. This has been applied to some category 1 carcinogens (e.g. asbestos). Nevertheless, considering a total ban of dangerous substances or materials goes beyond the scope of labelling schemes.

A strategy used to assess material emissions from a health point of view is a single compound evaluation through comparing with the LCI “Lowest Concentration of Interest” values. The background of the LCI-approach was presented in ECA Report no. 18 on "Evaluation of VOC Emissions from Building Products – Solid Flooring Material" (1997). The report presented key elements of a strategy to assess chemical emissions and proposed as an example a procedure that applies the strategy to the labelling of flooring materials. The procedure is intended for the classification of these materials and serves as a basis for both, voluntary or mandatory purposes.

In addition to well known substances for which risk assessment dossiers are available, there are other substances that may cause negative health and comfort effects not yet assessed. Therefore, some labelling schemes have also set restrictions to these “not-yet assessed compounds”. This is justified as an analogy to REACH legislation (2006), companies should know what substances are emitted from their products. Furthermore, this directs the companies to using “assessed” compounds with known risks.

One of the strategies to manage the risks of chemical emissions was to set an overall indicator of the emissions. The TVOC (total amount of VOC emissions) has been used in some schemes as a limit value for emissions. While it is known that TVOC *per se* is not linked with health outcomes, a low limit value for TVOC of *e.g.* 0.2 mg/m^3 indicates that the risk for any harmful emissions is

presumably low. This approach needs to be complemented with checking the absence of carcinogens and other known dangerous substances (Andersson et al, 1997).

The indoor air (and material emissions) consists of thousands of substances and for many of them there is only limited data on their related health impact. The situation is further complicated by the chemical reactions indoors and it is obvious that current chemical measurement methods can only reveal a part of the whole picture. Humans are very sensitive to odours and irritants and our sensory system is a warning mechanism for health hazards. Results have shown that chemical characterization of emissions is not a good predictor of sensory effects. Therefore it is important to complement the chemical assessment of material emissions with sensory evaluation (Salthammer et al, 2009).

The ECA report no. 20 "Sensory Evaluation of Indoor Air Quality" published by JRC in 1999, describes different methodologies for the sensory evaluation of indoor environmental quality. The report presents the background and gives advice on methodologies, especially for sensory evaluation of indoor air quality (IAQ). Currently, ISO TC 146/SC 6 is developing a standard on sensory evaluation (2007).

2.3 Proposal for a harmonised framework for a European indoor material emissions labelling scheme

In January 2009, the group agreed upon a roadmap that foresees the development of harmonisation through two phases. A ***preparatory phase*** in which the initiator group consisting of representatives of AgBB/UBA (DE), DICL (DK) and M1 (FI) labelling systems, IEH (UK), CSTB/ AFSSET (FR) and the JRC (EC) will describe in a concise report their consensus achieved through this phase in establishing common criteria for an EU wide framework for labelling schemes. This framework will include **common core criteria** on testing and evaluation methodologies to be accepted by consensus and **optional criteria** to be applied locally for those substances/factors for which no consensus exist. However, participating labelling schemes should follow the commonly agreed measurement methods for the optional criteria. In this perspective, the first step of the preparatory WG is to complete work on identifying the existing overlap of the schemes and to achieve consensus on a common way forward to address differences. This process is supported by comparing the results of round robin testing of products performed according to the individual schemes involved in this phase. The group is also giving consideration to the on-going work within the European standards organization (CEN) to prepare a harmonised test method to determine the emission of dangerous substances from construction products in support of requirements for health safety and environment under the Construction Products Directive (CPD, 1989).

An ***expanded working group / committee / Forum***, in which other parties and stakeholders interested in the topic will be invited to join, will be established in 2010. The task of this expanded WG /committee / Forum will be to finalise the details and achieve broader consensus on the harmonised framework of the European labelling scheme through open consultation. The broader consensus would enable the efficient implementation of the harmonised framework of indoor labelling schemes in a wider and integrated context of safe, healthy, energy efficient and sustainable buildings within the EU and outside. This could be implemented by the aforementioned Forum to potentially operate over a long term basis to underpin incentives and policy measures for the sustainable labelling of products and buildings under a common 'umbrella' involving as many strategic partners affected as possible.

The intention is to align the harmonised framework across various legislative mandates, such as, Construction Products Directive (89/106/EEC), Energy Performance of Buildings Directive – EPBD (2002/91/EC), EC Lead Market Initiative (COM(2007)860), Integrated Product Policy (IPP), Chemicals Policy (REACH), Green Public Procurement, Thematic Strategy on Urban Environment (COM(2004)60), Integration of Environmental Aspects into European Standardisation (COM(2004)206), etc. The harmonised framework once finalised will be then forwarded for adoption by the EC policy process.

Table 1. *An example of the use of core and optional criteria during the transition period for the existing labelling schemes*

	Current criteria	**→Step I (1 to 2 years)**	**→Step II (ca. 5 years)**
AFSSET	R-value (based on LCI)	**Core criteria: R-value, Carcinogens, TVOC**	Harmonised criteria
	Carcinogens		
	TVOC		
	Sum of "not-yet-assessed" VOC	Optional: Sum of "not-yet-assessed" VOC	
AgBB	R-value (based on LCI)	**Core criteria: R-value, Carcinogens, TVOC**	Harmonised criteria
	Carcinogens		
	TVOC		
	Sum of "not-yet-assessed" VOC	Optional: Sum of "not-yet-assessed" VOC	
	TSVOC	Optional: TSVOC	
DICL	Irritation	**Core criteria: R-value, Carcinogens, TVOC**	Harmonised criteria
	Odour acceptability	Optional: Odour acceptability	
M1	TVOC	**Core criteria: R-value, Carcinogens, TVOC**	Harmonised criteria
	FA		
	Ammonia		
	Carcinogens		
	Odour acceptability	Optional: Odour acceptability	

In order to take into account the different levels of public awareness and political aspects in European countries as well as to synchronise the transition with the existing labelling schemes, the European labelling scheme should consist of a framework including common core criteria and testing methodologies and optional criteria. The core criteria consist of the requirements (and measurement methods) for which a broad consensus can be reached in the next phase of the process. These core criteria should then be implemented in all participating labelling schemes. It may be appropriate that there are some complementary optional requirements in particular member states e.g. an odour test. These optional criteria can be applied only for those contaminants/factors

for which no consensus (=core criteria) exist. The participating schemes should follow the commonly agreed measurement and evaluation methods for both, the core and the optional criteria.

The scheme should ideally include all products emitting to the indoor air and cover VOCs and formaldehyde with consideration given to other substances such as ammonia. Existing standards and future harmonised methods of testing should be the basis wherever possible. Possible improvements to the current situation could be included such as quality assurance requirements on use of reference tubes for testing analytical performance and details for quantification and evaluation methods and use of new software tools for data handling and reporting.

The main objective of the preparatory WG is to come up with a broad definition of core and optional criteria that will be subsequently fine tuned and finalised during the second phase of this project. In Table 1, an example is given on the use of core and optional criteria during the transition period for the existing labelling schemes.

2.4 Recommendations of the preparatory Working Group

- **A harmonised framework for indoor material emissions labelling schemes in EU should comprise core and optional requirements for both the chemical characterisation and the health evaluation of material emissions.**

2.5 References

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3. EXISTING STANDARDS FOR INDOOR MATERIAL EMISSION TESTING

3.1 Overview of existing standards for indoor material emission testing

Almost all existing labelling schemes actually make use of the ISO 16000 standard series. Of particular interest are:

- ISO 16000-3 (2001) concerning active sampling of formaldehyde and other carbonyl compounds and analysis by liquid chromatography (HPLC),
- ISO 16000-6 (2004) concerning active sampling of VOC on Tenax TA and analysis by gas chromatography,
- EN ISO 16000-9 and EN ISO 16000-10 (2006) concerning conditionning of test specimen in emission test chambers and test cells,
- EN ISO 16000-11 (2006) concerning the procedures for sampling, storage and preparation of test specimen,

The comparability of results obtained with the existing emission test procedures can be checked with round robin tests where a building material (possibly showing homogeneous emissions) is selected and distributed to several laboratories for analyses. Recently organised round robin tests based on the existing ISO standards 16000-3, -6, -9 and -11 showed that typically an uncertainty of around 20% for VOCs and formaldehyde can be expected. For compounds emitted at low concentration levels (e.g. below 20 $\mu g.m^{-3}$), for polar compounds like glycols or some aldehydes or for tested materials presenting inhomogeneous emissions, uncertainties at a level of 40% can be found (BAM, 2009; Yrieix et al., 2010). Unpolar and stable compounds like alkanes or aromatics exhibit the highest reproducibility.

A test laboratory must prove the specialist competence of the institute for emission tests necessary for a reliable health-related evaluation of building products. The testing laboratories must be independent. It must be accredited according to EN ISO/IEC 17025 including test chamber analysis. The verification of experience should be proven by participation in round robin tests ("RRT") or interlaboratory studies ("ILS"). An example of an appropriate framework for a round robin test is described by BAM, 2009.

The European standards organisation (CEN) under mandate of DG ENTR is working with national standardization bodies to develop horizontal standards under the Construction Products Directive (CPD) (1989). The second generation of harmonised product standards under the CPD requires harmonised test methods for determining release or emission of dangerous substances to satisfy the requirements of Essential Requirement 3 of the CPD, Hygiene, health and the environment. Under mandate M/366 issued to CEN (2005), Work package 5 ‘horizontal standards: emission scenarios in indoor air’, states that four horizontal standards will be developed:

1. Horizontal standard on the methods for generation of emission of dangerous substances from construction products into indoor air in standardized testing facilities

2. Horizontal standard on the measurement of regulated dangerous substances in indoor air samples as generated from construction products in the standardized testing facilities
3. Horizontal standard on the measurement of radiation and radioactive emissions from construction products
4. Horizontal standard on assessment for potential growth of relevant micro-organisms on construction products in the indoor environment.

CEN established a new technical committee (TC351) in 2007 to undertake the work of developing the harmonised standards concerning release of regulated dangerous substances to soil, water and air and it established a working group (WG2) specific to indoor air. As priority for their work, CEN have addressed the first two of the four proposed standards and are proposing that these should be contained within a single harmonised European standard (hEN). The aim of this hEN is not to develop a new testing method but to combine by normative references the use of existing standards complemented, when necessary, with additional and/or modified requirements so that construction products can be evaluated according to the horizontal concept specified in mandate M/366. Therefore the proposed hEN relies strongly on the ISO 16000 series of standards concerning determination of emissions of volatile organic compounds (VOCs) from building and furnishing products.

The information about emissions produced by applying the hEN is intended to be used for CE marking of construction products and attestation of conformity. The responsibility of product specification is with the technical committees responsible for standardisation of the various product types (the 'product TCs'). The determination of emission of dangerous substances into indoor air is supposed to be made under their in use conditions. Nevertheless, the experience of existing labelling schemes is to have the products tested alone as if they were in direct contact with indoor air.

The determination of emission specified in the proposed hEN is associated with a scenario which defines the climate and ventilation conditions of the air surrounding the product in a reference room. A reference room is needed since it is not possible to evaluate emissions by testing in all possible use situations. The proposed hEN method uses a test chamber in which emissions are generated under conditions maintained constant during the test. These conditions are selected so that the results can be converted to a concentration in the reference room by calculations within the ranges that such calculations are valid.

The test chamber is specified on the basis of performance requirements. This provides the flexibility on dimensions needed for the horizontal approach required in the mandate M/366 in view of the requirements for representative samples. It also specifies the air sampling and analysis of the chamber air to determine the relevant regulated dangerous substances under mandate M/366. The measurement of the concentration of substances in the chamber air that is used to derive the emission rate must be determined 3 days and 28 days after the sample of the product under test is placed in the chamber. A method for sensory evaluation of the emissions is not included within the current hEN.

This proposed hEN also refers to a number of "indirect" methods that provide within their specific field of application a result comparable or correlated to the result of the reference chamber method. Such methods may be easier to apply and/or cheaper. They are in accordance with mandate M/366 provided that their comparability or correlation to the reference test method has been demonstrated

in their specific field of application. They may have a particular application for Factory Production Control testing (FPC).

For wood-based panels existing national regulation(s) on emissions of formaldehyde specify European standard EN 717-1 (2005) for testing emission into indoor air. EN 717-1 specifies fixed dimensions for the test chamber and different climate and ventilation conditions from the proposed hEN.

A draft hEN has been prepared by WG2 and was accepted by TC351 in early 2009. As required by mandate M/366 this is to be the subject of a robustness validation programme and amended as required before national bodies are balloted on acceptance.

3.2 Recommendations of the preparatory Working Group

- **Emission testing should be based on harmonised European standards, when available.**
- **The issues of product sampling and sample preparation are a crucial part of emission testing. Procedural details need still to be further elaborated before final recommendations can be made.**
- **Products should be tested for their emissions as they are placed in the market.**
- **The WG supports the work of CEN TC351 and recommend the usage of the validated harmonised testing standard for measurement of VOC's and formaldehyde when this will become available**
- **Until harmonised standards become available, ISO 16000-series standards should be used for measurement with the following exceptions:**
  - **Emission testing should include two chamber air sampling times (day 3 and 28).**
  - **Reference room size: use the normative proposal of CEN TC 351 instead of the ISO 16000-9 informative annex B.**

3.3 References

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ISO 16000-11:2006 Indoor air – Part 11: Determination of volatile organic compounds from building products and furnishing – Sampling, storage of samples and preparation of test specimens.

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4. HEALTH EVALUATION OF PRODUCT EMISSIONS

4.1 Carcinogenic substances

Carcinogens are of special relevance for health evaluation of materials. Thus, emission testing for carcinogens is of particular importance and can present a real challenge. Key considerations include:

- Their potential toxicity / risk to human health and associated public concerns
- The analytical challenge (where might they appear in low quantities in the chromatogram?)
- How they should be classified (i.e. according to which list – IARC or EU?) and
- How absence of carcinogens should be defined and reported in labelling schemes?

In spite of a few exceptions, there are usually no safe limit values for carcinogenic substances, even the smallest amounts of carcinogens can, in theory, cause cancer mutations in cells. Therefore the usual practice to limit the amount of carcinogens is that they should be "under the detection limit" of the analysis system. There are practical problems with this approach because the detection limit will vary depending upon the objective of the analysis, and because analytical techniques are constantly improved and can detect smaller amounts of substances.

The first inter-laboratory comparison of the preparatory WG was carried out in 2007 on an odorous sample of rubber flooring. The sample was rejected by all labelling schemes, but the reasons for rejection were different. Both the M1 and DICL rejected the floor material due to results of sensory evaluation, while the material was rejected by the AgBB for the detection of a carcinogen. In fact, the most surprising result was to find measurable quantities of a category 2 carcinogen: 1,3-Dichloro-2-propanol (CAS No. 96-23-1) (animal carcinogen; European list of carcinogens according to Directive 67/548/EEC). The substance is thought to be a degradation product of chlorinated flame retardants used in the cushion backing of the rubber flooring which is there for noise reduction. The cushion layer was made of recycled material.

This difference in results of the evaluation is considered in more detail below and this demonstrates the importance of having common criteria and reference lists of substances in a future harmonised approach:

- *M1 – Finnish labelling scheme*
  VTT carried out the test in accordance with M1 protocols, i.e. focusing on TVOC, and reported only a few individual substances. The substance 1,3-Dichloro-2-propanol was detected but it was not included in the report as it was below the reporting limit of 0.005 mg/(m²h) when quantified using toluene equivalents. NB - The Finnish requirements refer only to IARC class 1 carcinogens.

- *DICL - Danish Indoor Climate Label*
  In the test carried out according to DICL guidelines, the substance 1,3-Dichloro-2-propanol was reported with an emission rate of 18 µg/(m² h) after 3 days and 11 µg/(m² h) after 28 days. But like the Finnish scheme, DICL requirements currently refer only to

IARC class 1 carcinogens and therefore no carcinogens were recorded as being present in the final report.

- *AgBB – German evaluation scheme*
  The results of tests carried out in accordance with the AgBB protocol are not presented in a standardised test report because AgBB is not a labelling scheme as such. AgBB test results are instead summarised, aggregated and then evaluated using a so called ADAM[1] excel sheet. When these calculations were carried out in this case, the product failed to meet AgBB requirements for carcinogens both on day 3 (actual result 28 µg/m³ vs a limit of 10 µg/m³ (0.01 mg/m³) for the sum of detected carcinogens) and day 28 (actual result 9 µg/m³ vs a limit of 1 µg/m³ (0.001 mg/m³) for the sum of detected carcinogens). The presence of a carcinogen was confirmed by using the ADAM excel sheet with its integrated list of category 1 and 2 EU carcinogens: the substance 1,3-Dichloro-2-propanol is a category 2 carcinogen (EU list) - and the product was therefore rejected.

4.1.1 Recommendations of the preparatory Working Group

- **For the evaluation of indoor material emissions, this preparatory WG agreed to refer to the EU-carcinogens classification.**
- **EU carcinogens determined through the harmonised protocol are volatile compounds measurable by ISO-16000.**
- **An EU group should be established to prepare a common list of carcinogens fulfilling the above criteria.**
- **If carcinogens are detected after 3 days, the test can be stopped.**

4.2 The LCI-approach

As mentioned in chapter 2, the LCI strategy is used to assess the health effects of single VOC compounds. The ECA Report no. 18 on "Evaluation of VOC Emissions from Building Products – Solid Flooring Material" (1997) presented the key elements of a strategy. During the development of the national labelling approaches in Germany and in France emphasis was put especially on the evaluation of single substances by LCI-values. Procedures have been developed in both countries that provide a transparent system for setting these values. The procedures and the main differences between them are outlined below.

4.2.1 Defining the LCI-values in Germany

The Committee for Health-related Evaluation of Building Products, AgBB (2008) stressed the legally implemented OEL values to be the most broad and reliable basis for their ranking in LCI setting: "Occupational exposure limit values (OELVs) have been defined for many substances

[1] AgBB DIBt Assessment Mask

present in workplace air in the form of gas, vapour or suspended particulate matter. These legally binding values are set at such a level that, according to current knowledge, even repeated and long-term exposure, for up to 8 hours a day within an average 40-hour working week, is generally not expected to adversely affect workers' health over their working lives." A working group of AgBB – complemented by manufacturers' specialists - deals with the establishment of LCI values and in doing so uses existing OELVs as a starting point. The working group takes into account the basic differences between conditions in general indoor spaces (such as homes, kindergartens and schools) and those at workplaces by application of safety factors.

Since the German regulation TRGS 900 (TRGS: Technical Regulations for Hazardous Substances), does not contain values for all VOC/SVOC possibly emitted from building products, a simplified method has been developed that permits to make use, in addition to the TRGS, of similar (workplace-related) values employed by other European countries. A stepwise procedure is used that takes into account the maximum currently available toxicological evidence for each individual substance, thus enabling the assessment of as many substances as possible. Those substances that still cannot be evaluated are subjected to a strict limitation of their total amount, within the AgBB scheme.

The selection criteria are:

I. First, each individual substance is checked, whether it has been evaluated via TRGS 900 and/or an OEL (Occupational Exposure Limit) value by the European Commission. If this is the case, the lowest value is used to establish the LCI value.

II. If condition 'I' is not met, relevant lists from other countries for evaluation of substances in workplace air are examined and the lowest scientifically plausible value used to establish an LCI value.

III. As a further option, a MAK value of the German Research Association (Deutsche Forschungsgemeinschaft, DFG) and/or a TLV® value of the American Conference of Governmental Industrial Hygienists (ACGIH) or a Workplace Environmental Exposure Limit (WEEL) of AIHA (American Industrial Hygiene Association) may be used.

IV. In case a substance cannot be evaluated using conditions I., II, or III, it is checked if an individual substance assessment can be performed, preferably by referring to a substance class with similar chemical structure and comparable toxicological assessment. The lowest LCI value for a substance within this assigned substance class is then used.

V. If a substance fails to meet any of the requirements in items I. to IV, it is then assigned in the scheme to the category of the substances 'with unknown LCI value', the so-called non-assessable compounds (see flow chart). Non-identified substances fall also into this category."

In Germany (2009), 369 substances (or classes of substances) have a workplace related exposure limit (via TRGS 900). The criteria documents for these limitations including all toxicological data are available online for 65 substances. For 261 of the 369 substances reference is given to the extended compilation of criteria documents of Deutsche Forschungsgemeinschaft (DFG, 2009) Gesundheitsschädliche Arbeitsstoffe: Toxikologisch-arbeitsmedizinische Begründungen von MAK-

Werten und Einstufungen“. This broad documentation was the reason for AgBB to give priority to OELs for deriving LCI-values.

An example of LCI values and the referred basis in the LCI list (update 2010) is given in table 2.

Table 2. *Some AgBB-LCI values and the referred basis in the LCI list updated in 2010.*

	Substance	CAS No.	LCI [µg/m³]	EU-OEL** [µg/m³]	TRGS 900** [µg/m³]	Remarks**
12-1*	1.4-Dioxane	123-91-1	73	73.000	73.000	EU: Carc. Cat. 3
12-2	Caprolactam	105-60-2	240	10.000	5.000	Individ. substance evaluation
12-3*	N-Methyl-2-pyrrolidone	872-50-4	400	40.000	82.000	EU: Repr. Cat 2 (31.ATP) Individ. substance evaluation
12-4	Octamethylcyclo-tetrasiloxane (D4)	556-67-2	1 200			EU: Repr. Cat.3, Individ. substance evaluation
12-5	Hexamethylene-tetramine (Formaldehyde-release)	100-97-0	30			OELs Norway, Sweden: 3 000 µg/m^3
12-6	2-Butanonoxime	96-29-7	20			EU: Carc. Cat. 3 Individ. substance evaluation
12-7*	Tributyl phosphate	126-73-8				SVOC, EU: Carc. Cat. 3
12-8*	Triethyl phosphate	78-40-0	25			cf. Tributyl phosphate (OELs Denmark, France: 2500 µg/m³, TLV (ACGIH): 2200 µg/m³)

4.2.2 Defining the LCI-values in France

The starting basis for the AFSSET VOC WG was the approaches described in the ECA (1997) and the AgBB (2005, 2008, 2010). As the purpose was to propose a health-related evaluation procedure, the AFSSET VOC WG preferred the “ECA approach” over that used in the AgBB using first IAQ guidelines and toxicological reference values when available only for deriving LCIs. The main reason for this decision was that OELs are not established only on health-related aspects. At that time, national or international actions (as the INDEX project) provided IAQ guidelines and the AFSSET VOC WG decided that this input should be taken into consideration.

LCI values have been established for 165 single VOCs which can be emitted by building and finishing products. Therefore, in order to prioritize and explain choices made by the group for drafting LCIs, it has been decided to use the following decision tree:

1. IAQ guideline values in the following priority;
    - French national IAQ guideline value (when available)

- Guideline value from INDEX project
- WHO recommended IAQ guidelines.

2. If there is no guideline value available consideration is given to other exposure values derived from toxicological data; IRIS, ATSDR, OEHHA, Health Canada. If this provides more than one value, the lowest will normally be selected.
3. If no satisfactory value is given by 1 and 2 above, then occupational exposure limits when available will be used as a basis. A safety factor of 100 is applied to take into account time exposure difference between the general population and workers. A safety factor of 1000 is applied for carcinogens, mutagens category 3 and for substances toxic for reproduction category 1 to 3.
4. If no satisfactory value is given by 1, 2 and 3 above, the AgBB or ECA assigned substance is used to establish a LCI using conditions 1, 2 or 3. If no value available, then use the AgBB (2008) or ECA (1997) LCIs.

4.2.3 Decision tree for choice of LCI setting basis

Comparing the two approaches (Figure 2), the main difference is that France gives most credit to indoor air guidance values putting them in top of their decision tree. In Germany, priority is given to toxicological data relied upon in OEL's. AgBB emphasises the basic difference between IAQ values and the LCI-values as auxiliary values for evaluation of product emissions at day 28 in a chamber test. In AgBB, the need for taking into account also indoor air guideline values is recognised. A re-evaluation process of the ranking of priorities for LCI setting has begun.

A research project on the setting of OELs in several European countries was funded by the German Federal Environment Agency (UBA) to support the standard operational procedure for deriving NIK-values in the AgBB and also to provide a sound knowledge base for future work of the harmonization initiative. Information on limit values and criteria documents were collected in an online-database (http://www.agbb-nik.de/) and scientific and administrative aspects of limit-setting procedures were studied in detail (Sperk et al. 2010). Taking into consideration the importance of IAQ values in the AFSSET scheme, a selection of IAQ values from a number of institutions (WHO, INDEX, US EPA, Health Canada and others) was collected in order to provide a basis for the decision on the best available sources of toxicological evaluations.

4.3 Evaluation of substances without LCI value (”*non-assessable*” or *'not yet assessed'* substances)

The central goal of the LCI-concept was to assess as many of the emitting substances as possible in order to enable a real health based evaluation of emissions. This can reduce uncertainty for consumers and product manufacturers. The problem with this concept is that there are still remaining gaps in risk assessment. Also substances whose health effects are poorly known can cause problems (see appendix 5). Additional criteria are needed to tackle this problem.

Two strategies have been used to limit the potential problems with these “non-assessed” substances:

- ECA report 18, AgBB and AFSSET schemes restrict the non-assessable compounds to 10% of the TVOC amount.

- The M1-scheme in Finland has a very low allowed total amount of VOC emission (TVOC 0.2 mg/m^2.h) (including assessed and non-assessed substances). The idea behind this approach is the following: as the TVOC usually consists of several compounds, one single substance as well as the sum of non-assessed substances are assumed to be of low amount, therefore they cannot have a very high emission.

More toxicological information about the "not-yet-assessed" substances is expected in the course of the REACH process. However, degradation or reaction products – not falling under the REACH legislation- will still need to be tackled.

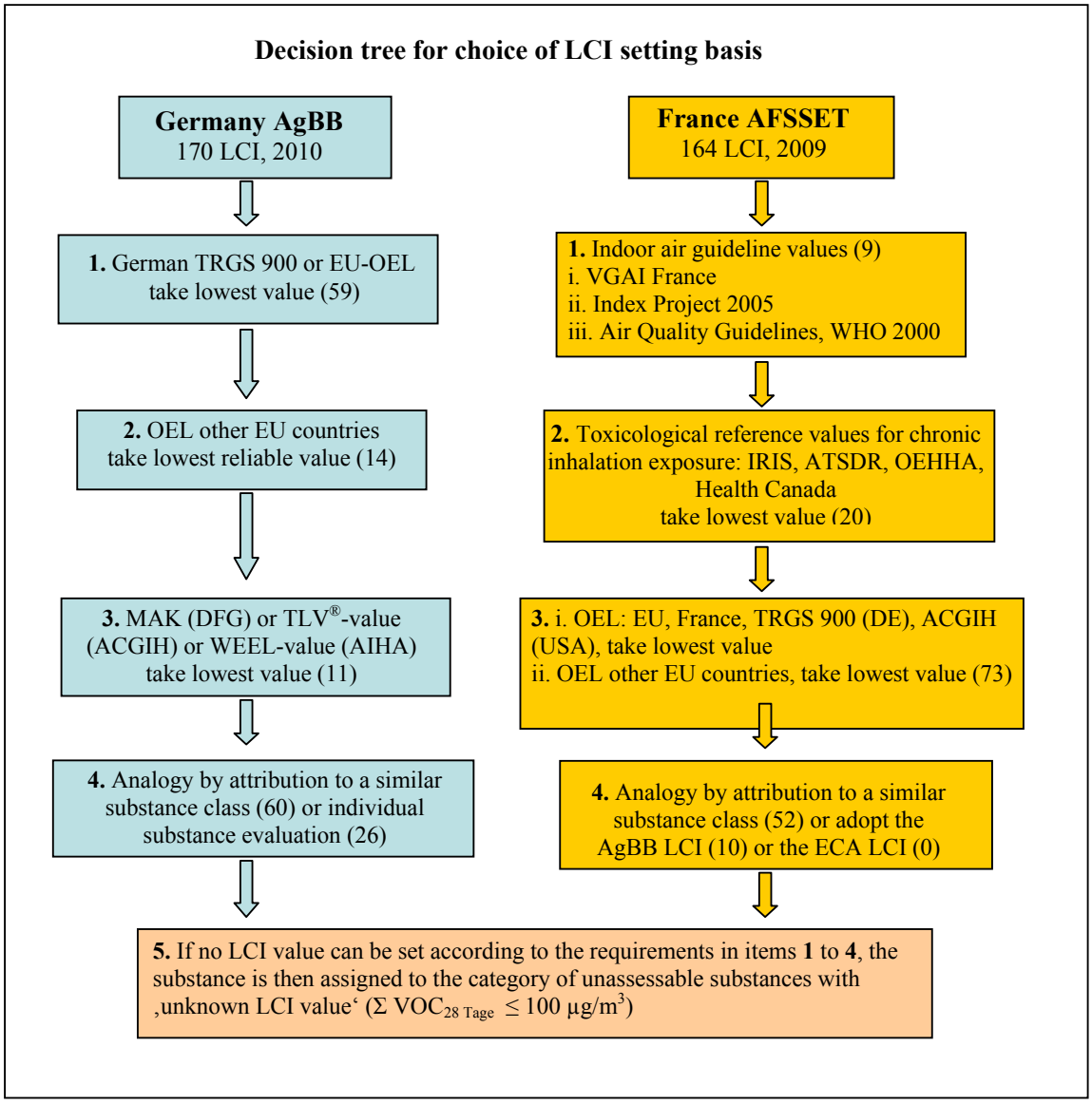

Figure 2. *Differences in the decision trees what related to the choice of the LCI setting basis.*

4.4 The TVOC-approach

The TVOC-approach is one of the strategies to manage the risks of chemical emissions was set as an overall indicator of the emissions. The TVOC (total amount of VOC emissions) has been used in some schemes as a limit value for emissions. While it is known that TVOC *per se* is not linked with health outcomes, a low limit value for TVOC of *e.g.* 0.2 mg/m^3 indicates that the risk for any harmful emissions is presumably low. This approach can be used to complement the LCI-approach to ensure that the emissions from non-LCI-assessed substances do not cause harmful health effects.

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The transition period from current evaluation systems to a harmonised one may be quite long. It could be too large a step for the existing systems to not include TVOC criteria at this time and therefore pragmatic judgement would be required having collated the various current requirements. Knowledge of product performance against particular LCI values was limited and for example odour problems may be prevalent if a scheme relied only on LCIs at this time. It was unclear whether criteria for R and non-assessed compounds would be adequate with current knowledge in the absence of TVOC criteria. These limitations in knowledge would gradually be resolved as more products are tested to common criteria that involve determination of individual compounds, both assessed and non-assessed.

The TVOC-approach will also be needed at least during the transition period. During that time, the existing labelling systems will most likely use their existing criteria for the TVOC. These are in the range of 200 to 1,000 µg/m^3. A narrower range of 300 to 500 µg m-^{3} could be argued for, but such a decision would be premature as more knowledge on the effect of the LCI-approach is needed.

4.5 Recommendations of the preparatory Working Group

Considering the results of the comparison tests and all/ recent experiences of the different labels, the WG has come to the following recommendations:

- **The evaluation criteria should cover all contaminants of concern to health and comfort and be based on scientific evidence when available.**
- **The LCI-approach is currently the most feasible strategy to assess the health effects of compounds from buildings materials.**
- **An expert group should be initiated to propose common European LCI-criteria.**
- **Criteria should be set also for substances not having LCI values ("non-assessable" substances)**
- **TVOC should not be used alone as an indicator for evaluating health effects from indoor material emissions**
- **A common approach for TVOC definition along with an upper limit for TVOC should be established.**

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5. SENSORY EVALUATION PART

5.1 Overview and comparison of sensory evaluation methodologies in EU

The ECA report no. 20 "Sensory Evaluation of Indoor Air Quality", published by JRC in 1999, describes different methodologies for the sensory evaluation of indoor environmental quality. The report presents the background and gives advice on methodologies, especially for sensory evaluation of indoor air quality (IAQ).

Human subjects are indispensable in the measurement of perceived indoor air quality. Chemical and physical methods of characterization often have difficulties in taking into account the combinations of different pollutants in a meaningful way. There is, however, on-going work aiming at developing electronic sensor-based systems for the evaluation of IAQ, e.g. the SYSPAQ project (ending August 2009).

A continuous visual scale has been used for rating of acceptability of IAQ (Gunnarsen and Fanger, 1992). The scale end-points are labeled 'clearly acceptable' (often assigned the value of +1) and 'clearly unacceptable' (often assigned the value of -1). The middle of the scale is indicated as the transition between 'just acceptable' and 'just not acceptable'. Votes may therefore be interpreted both as binary votes and as votes on a continuous visual scale. This allows for a conversion of the votes on the continuous scale to an estimate of the percentage of dissatisfied. This can be done with reduced standard deviation compared to direct binary votes. A slightly modified version of the scale with a gap between 'just acceptable' and 'just not acceptable' has been developed. This version is now most commonly used.

A five point intensity scale, originally introduced by Yaglou, was initially used as a category scale and later modified to be continuous (Yaglou et al, 1936). The scale ranges from 'no odour' to 'overpowering odour'. An additional intensity scale was developed by Bluyssen (1990) and developed further by Müller (2008) based on the comparison of the odour with a comparative standard (different acetone concentrations). With this procedure the number of test participants can be reduced to 8-10 trained panelists.

The ECA report no. 20 does not give any description of methods including description of odours, using descriptors e.g. 'pleasant', 'unpleasant', 'woody', 'metallic', 'heavy', 'stale' or 'fresh'.

The result of the sensory evaluation depends on several factors, e.g. the number of subjects in the panel performing the evaluation; trained or untrained panel, etc.

In the M1 and DICL labelling schemes, the CLIMPAQ or a similar test chamber is used for the sensory evaluations (Figure 3). For the AgBB evaluation a direct use of emission test chambers according to ISO-16000-9 is proposed.

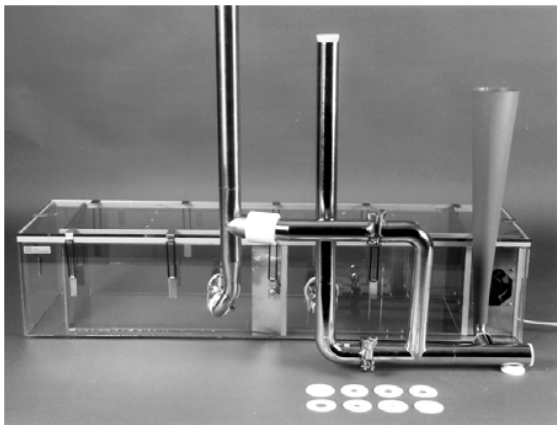

Figure 3. *CLIMPAQ (Nordtest 482, 1998)*

Examples of the scales used by M1 and DICL are shown in Appendix 1.

The differences and similarities of the methods used by the Danish Indoor Climate Labelling (DICL, 2005; 2007), the Finnish M1 (M1, 2001) classification and the AgBB (at proposal stage) are listed in Table 3.

As can be seen in Table 3 the common features in these three evaluation procedures cover only a part of the basic variables such as chamber type, air flow in the presenting cone and selection and instruction of the panel members. Important factors including the chamber loading, panel size and the evaluation procedure differ considerably in the current procedures.

Table 3. *Comparison of sensory evaluation among DICL, M1 and AgBB*

	M1	**DICL**	**AgBB (proposal)**
Test chamber	CLIMPAQ	CLIMPAQ or similar	CLIMPAQ or 16000-9 + sampling bags
Air flow in presenting cone	0.9 l/s	0.9 l/s	0.9 l/s
Panel type (trained/untrained)	Untrained	Untrained	Trained
No. of panel members	5 (+10 in certain cases)	Minimum 20	8 – 10
Criteria for inclusion in panel		Age: 18 to 50 years Smoking habits: recorded Olfactory sense: normal (equal distribution of both sexes and max. 40% smokers in the panel is preferred)	The panel members shall not be anosmic and shall not be too sensitive.
Instruction of panel members	Panel members should: - refrain from eating garlic on the day before sensory assessments	Panel members should: - refrain from eating garlic or spicy food on the day or the day before the	Similar instructions to the panel members. See ISO draft

	- take a shower in the morning of the assessment day and refrain from using strong-smelling cosmetic products - wear odourless clothes (no leather jackets etc.) - abstain from drinking coffee and smoking between sensory assessments and an hour before they begin	evaluation - refrain from eating or smoking during the last hour prior to evaluation - have a high personal hygiene and refrain from using strong-smelling cosmetics - wear clothes washed in a neutral detergent	
Evaluation include the use of: **- acceptability scale** **- odour intensity scale** **- descriptors**	Yes No Yes	Yes Yes No	No Yes No
Evaluation based on	2 evaluations (2 min. interval)	First impression (1 inhalation)	Evaluation with comparative scale
Accept criteria	Mean value of votes: Acceptability >0.1 ('just acceptable') If the mean value of acceptability falls within the range [-0.4; +0.4] the evaluation procedure is repeated with 5 more subjects	Median of votes: Acceptability >0 ('acceptable') Odour intensity <2 (2='moderate odour')	None (at the moment)
Model room conditions: - **model room** - **material loading** - **air change rate** **Relative material loading factor (based on air change rate)**	17 m^3 (DS90) According to DS90 2 per hour 1	17 m^3 (DS90) According to DS90 0.5 per hour 4	17 m^3 (DS90) ISO 16000-9 varied Depend on type of product (ISO 16000-9)

The methods have recently been compared and discussed (Müller et al., 2008). This discussion includes aspects of accuracy of the methods. The factor which affects the accuracy most is the standard deviation (s) of the evaluations, followed by the panel size. In general the panel size shall be large enough to meet the requirements of the accuracy of the odour evaluation. The standard deviation of an untrained panel can be estimated to 0.4 on the acceptability scale. From the acceptability, the percentage of dissatisfied can be calculated. The two graphs below show the 90%

confidence interval of the acceptability mean value, dependent on the panel size (Figure 4). The accuracy requirement set for the labelling acceptance criteria thus determines the panel size both when using untrained and trained panels.

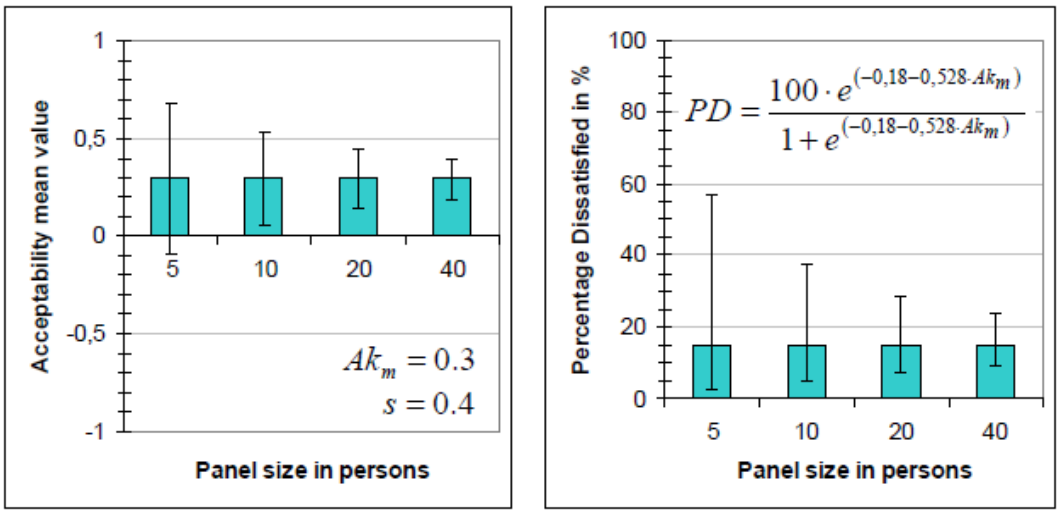

Figure 4. *Impact of panel size on 90% confidence interval of the acceptability mean value (Ak_m) and percentage of dissatisfied (PD) (Müller et al., 2008)*

5.2 ISO/CD 16000-28 Determination of odour emissions from building products using test chambers

The ISO standard draft "Determination of odour emissions from building products using test chambers" has undergone a balloting and voting, and accepted as ISO/CD 16000-28.

The objective of the standard is to provide a cost effective method for evaluation of the odour of the material emissions even from big building products. It uses EN ISO 16000-9 type test facilities and test conditions. Odour determination is done using a defined funnel or other equipment validated to perform equally.

The standard also sets requirements for the testing environment.

ISO/CD 16000-28 has two alternative assessing methods, the acceptability of the odour emission and the intensity of the odour emission. The methods can be used separately. The acceptability method uses a discontinuous scale ranging from "clearly acceptable to just acceptable" and from "just unacceptable to clearly unacceptable".

The perceived intensity Π is determined by comparing the intensity of the sample with different specified intensities of the reference substance (e.g. acetone). The smelling capability varies from human to human. The use of comparative sources reduces the inter-individual variance of the test result since all panel members evaluate air quality based on the same reference scale.

The unit of Π is [pi]. The comparative scale consists of reference substance-air mixtures. The comparative scale of intensity is defined by the following points:

0 pi = odour threshold concentration of the acetone-air mixtures (e.g. 20 mg acetone/m³ air) at which 50% of the panel can perceive the odour.

Concentrations for 1 to n pi follow a linear gradation of the acetone concentrations. The objective of further development is a linear scale with regard to perceived intensity

The requirements, testing of panel members, tasks and behaviour of the odour panel are defined. The minimum size of the acceptability panel is 15 panelists and of the intensity panel 10 panelists.

5.3 Recommendations of the preparatory Working Group

Considering the experiences of the different labelling schemes and the results of the comparison test, the WG has come to the following recommendations:

- **Sensory evaluation is considered to be an important part of the assessment of material emissions. Results have shown that chemical characterization of emissions is not a good predictor of sensory effects. Therefore it is important to complement the chemical assessment of material emissions with sensory evaluation.**
- **This WG supports the work of ISO TC146/SC6 in creating a standard for sensory evaluation. A draft standard ISO/CD 16000-28 on "Determination of odour emissions from building products using test chambers" has been developed in early 2010. It includes both acceptability evaluation using an untrained panel and perceived intensity measurement with a trained panel. It also combines the odour evaluation chamber technique with the harmonised testing standard (model room) prepared by CEN TC351.**
- **The practical implication of the implementation of the ISO standard should be discussed and clarified at a later stage.**

5.4 References

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Gunnarsen, L. and Fanger, P.O. (1992) Adaptation to indoor air pollution. *Environment International*, **18**, 43-54.

M1 (2004) Emission Classification of Building Materials: Protocol for Chemical and Sensory Testing of Building Materials.

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Nordtest method NT Build 482 (1998). Building materials: Emissions testing using the CLIMPAQ. ISSN0283-7153, Espoo.

Yaglou, C.P., Riley, E.C. and Coggings, D.I. (1936). Ventilation requirements. *ASHRAE Transactions*, **42**, 133-162.

6. DATA HANDLING, EVALUATION AND REPORTING

6.1 Introduction

In the existing labelling schemes M1 and DICL the testing report is based on ISO 16000-6. The reporting of test results includes information on the measurement, starting from the point of air sampling from the test chamber and the analytical details and results. In addition to the sampling and analytical details the test report shall also include information about product sampling and test specimen preparation. The latter topics are included in the harmonized standard method for determining the emissions of dangerous substances from construction products under development in CEN TC351. In addition to the technical details to be reported, data handling and evaluation procedures must be specified by the harmonized European labelling scheme. It was agreed within this working group to use the LCI approach for assessing the health effects of the emissions.

According to the draft horizontal test standard it is required to report:

- identified target compounds, provided with CAS number
- identified non-target compounds, provided with CAS number
- non identified compounds
- carcinogenic substances
- TVOC
- TSVOC

6.2 Tools for data handling and evaluation

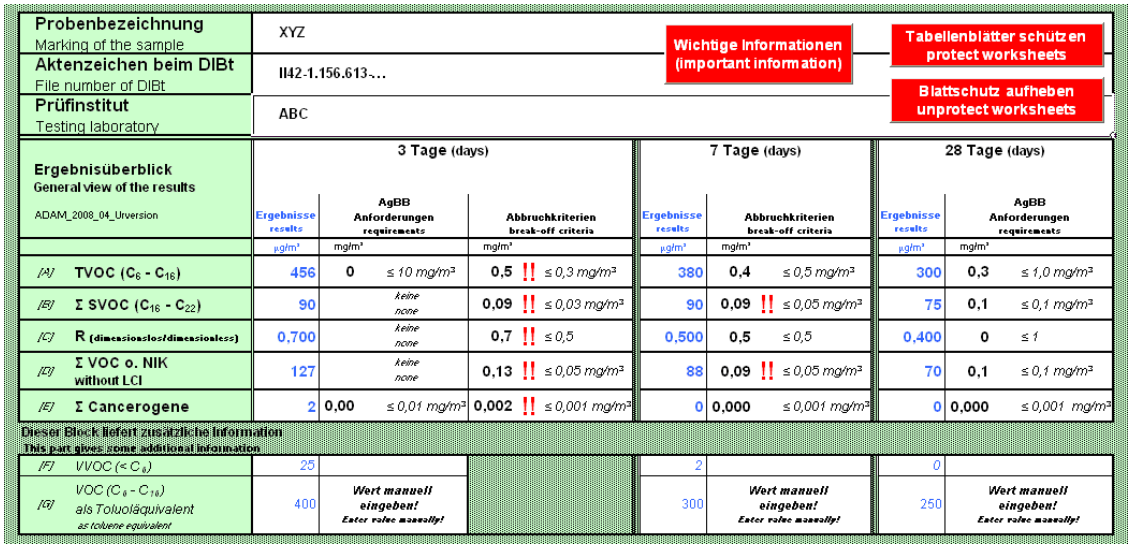
6.2.1 The ADAM tool for aggregation and reporting of results

The Excel calculation mask ADAM has been developed for use in the approval procedure in DIBt:

1. to allow a quick overview of test results in the evaluation sheet
2. to allow better comparability by standardised layout of parameters and results
3. to screen single contributions of LCI-quotients to the final result
4. to allow the use of different updated or former LCI-lists
5. to help in the identification of carcinogens.

The ADAM excel sheet has proven its suitability in DIBt and AgBB. As its application is obligatory in the approval procedure it can be purchased for a nominal fee through DIBt. For the purpose of statistical analysis of the data a research programme has been set up by DIBt to improve different features. The import of data from different laboratories is not facilitated yet; here an automatic transfer of data into the software would be suitable.

The ADAM excel sheet (Figure 5) may be adapted also to other LCI-Lists e.g. the French CLI list could be included as an option for evaluation of results: either according to AgBB-list or according to AFSSET list of LCI-values.



Probenbezeichnung Marking of the sample	XYZ										
Aktenzeichen beim DIBt File number of DIBt	II42-1.156.613-...										
Prüfinstitut Testing laboratory	ABC										
Ergebnisüberblick General view of the results ADAM_2008_04_Urversion	3 Tage (days)					7 Tage (days)			28 Tage (days)		
	Ergebnisse results	AgBB Anforderungen requirements		Abbruchkriterien break-off criteria		Ergebnisse results	Abbruchkriterien break-off criteria		Ergebnisse results	AgBB Anforderungen requirements	
	µg/m³	mg/m³		mg/m³		µg/m³	mg/m³		µg/m³	mg/m³	
[A] TVOC (C_6 - C_{16})	456	0	≤ 10 mg/m³	0,5 !!	≤ 0,3 mg/m³	380	0,4	≤ 0,5 mg/m³	300	0,3	≤ 1,0 mg/m³
[B] Σ SVOC (C_{16} - C_{22})	90		keine none	0,09 !!	≤ 0,03 mg/m³	90	0,09 !!	≤ 0,05 mg/m³	75	0,1	≤ 0,1 mg/m³
[C] R (dimensionslos/dimensionless)	0,700		keine none	0,7 !!	≤ 0,5	0,500	0,5	≤ 0,5	0,400	0	≤ 1
[D] Σ VOC o. NIK without LCI	127		keine none	0,13 !!	≤ 0,05 mg/m³	88	0,09 !!	≤ 0,05 mg/m³	70	0,1	≤ 0,1 mg/m³
[E] Σ Cancerogene	2	0,00	≤ 0,01 mg/m³	0,002 !!	≤ 0,001 mg/m³	0	0,000	≤ 0,001 mg/m³	0	0,000	≤ 0,001 mg/m³
Dieser Block liefert zusätzliche Information This part gives some additional information											
[F] VVOC (< C_6)	25					2			0		
[G] VOC (C_6 - C_{16}) als Toluoläquivalent as toluene equivalent	400	Wert manuell eingeben! Enter value manually!				300	Wert manuell eingeben! Enter value manually!		250	Wert manuell eingeben! Enter value manually!	

Wichtige Informationen (important information)

Tabellenblätter schützen protect worksheets

Blattschutz aufheben unprotect worksheets

Figure 5. *ADAM-excel sheet as it is currently used by DIBt for submission of emission tests in the approval procedure. This example shows the ADAM evaluation sheet for a floor covering tested after 3, 7 and 28 days. The exclamation marks mean that the criteria for a break-off of the test are not fulfilled.*

6.3 Recommendations of the preparatory Working Group

- **A shared data handling and reporting tool (e.g. as the ADAM Excel sheet) could be used as a basis for a future harmonized European system for documentation and evaluation of data.**
- **Additional features like an import tool and integration of alternative LCI-lists are feasible improvement options.**

6.4 References

ADAM: AgBB DIBt Assessment Mask. http://www.dibt.de/en/service.html

7. GENERAL CONCLUSIONS AND RECOMMENDATIONS

The preparatory working group co-ordinated by EC-JRC and composed of representatives of AFSSET, AgBB, DICL and M1 labelling systems, CSTB and IEH, elaborated a harmonised framework for a European labelling scheme featuring the following:

- ➔ The framework should include common core criteria and testing methodologies, and optional criteria;
- ➔ The criteria should cover all volatile substances of concern to health and comfort. Risk assessment data should be used, when available.
  - Single volatile compounds (using the LCI values and EU carcinogenicity data)
  - Total amount of volatile compounds (TVOC).
- ➔ The LCI-approach will not be able to cover all the contaminants of interest for the health and comfort of consumers.
  - Additional strategies (e.g. sensory evaluation) will be needed
  - The application of these strategies could be optional.
- ➔ Testing should be based on harmonised European standards (CEN TC351), when they are available.

This concept is graphically represented in figure 6.

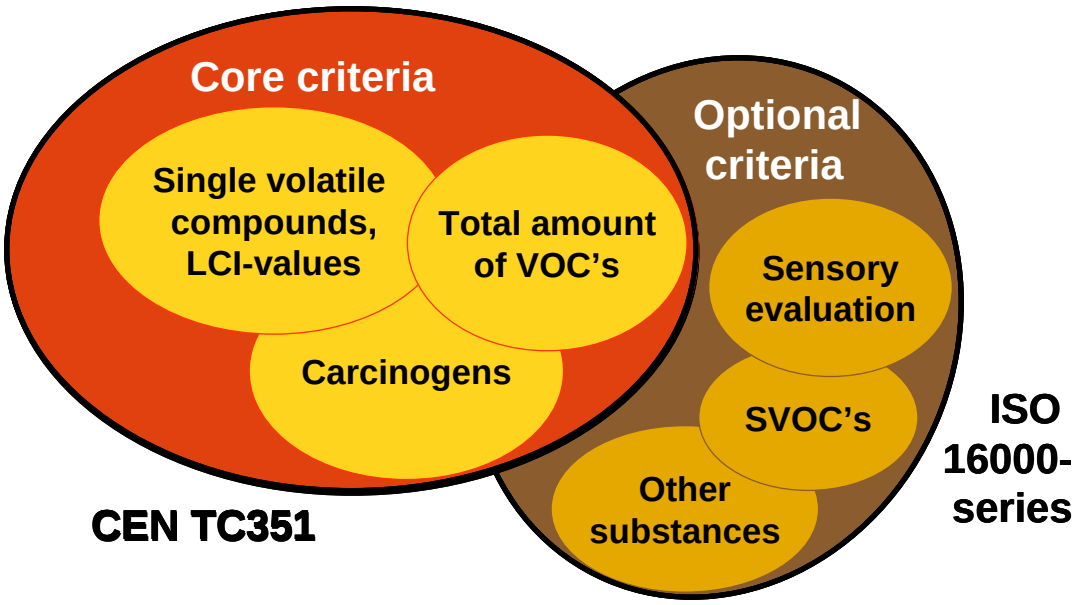


Figure 6: *The concept of the harmonised framework for indoor labelling schemes in EU*

The consensus so far reached for the measurement methods, the core and the optional criteria the harmonised framework should be composed of is summarised in Table 4.

Table 4. *Consensus reached for the measurement methods, the core and the optional criteria*

Requirements / Parameter	M1 Finland	DICL Denmark	AgBB Germany	AFSSET France	Consensus
Measuring method / Chamber	ISO 16000 series	ISO 16000 series	ISO 16000 series	ISO 16000 series	**Harmonised CEN Standard (based on ISO 16000 series)**
Measuring points (days)	28	3, 10 and 28	3 and 28	3 and 28	**3 and 28**
Core criteria					
Single VOCs evaluated (R = ∑ Ci/LCI <1))	No	comparison with irritation threshold	R < 1 165 LCIs (2010)	R < 1 164 LCIs (2009)	**R < 1 Harmonised list of LCIs**
Carcinogens evaluated according to **Concentration admitted**	IARC class 1 SERa < 5 µg/m²h	IARC class 1	EU classes 1 and 2 56 listed compounds Sum < 1 µg/m³	EU classes 1 and 2 2 listed compounds < 1 µg/m³	**Harmonised list of EU carcinogens classes 1 and 2 compounds to be checked**
TVOC measured	SERa < 200 µg/m²h	No	1000 µg/m³	1000 µg/m³	**200-1000 µg/m³**
Formaldehyde measured	SERa < 50 µg/m²h	75 µg/m³ (after 60 days)	No[1]	10 µg/m³ (LCI)	**Value to be discussed**
Optional criteria					
Compounds without LCI assessment	No	No	Sum < 100 µg/m³	Sum < 100 µg/m³	**Sum < 100 µg/m³**
Other compounds evaluated	Ammonia				
TSVOC measured	No	No	< 100 µg/m³	No	**Await validation TC 351**
Sensory evaluation	Acceptability untrained panel 15 persons	Acceptability and intensity;untrained panel 20 persons	No (Draft for intensity measurement developed)	No	**Await ISO 16000-28**

[1] Fomaldehyde measurement required for approval application at DIBt

Considering the experiences of the different labelling schemes and the results of the comparison tests undertaken so far, this preparatory WG has come to the following conclusions and recommendations.

GENERAL FRAMEWORK:

- A harmonised framework for indoor material emissions labelling schemes in EU should comprise core and optional requirements for both the chemical characterisation and the health evaluation of material emissions.

EMISSION TESTING OF INDOOR MATERIALS:

- Emission testing should be based on harmonised European standards, when available.
- The issues of product sampling and sample preparation are a crucial part of emission testing. Procedural details need still to be further elaborated before final recommendations can be made.
- Products should be tested for their emissions as they are placed in the market.
- The WG supports the work of CEN TC351 and recommend the usage of the validated harmonised testing standard for measurement of VOC's and formaldehyde when this will become available.
- Until harmonised standards become available, ISO 16000-series standards should be used for measurement with the following exceptions:
    - Emission testing should include two chamber air sampling times (day 3 and 28),
    - Reference room size: use the normative proposal of CEN TC 351 instead of the ISO 16000-9 informative annex B.
- The WG proposes the development of a detailed protocol for calibration of all target compounds (LCIs) suitable for efficient, and as far as possible automated analysis with appropriate sensitivity, including for carcinogens.

EVALUATION OF INDOOR MATERIAL EMISSIONS:

- For the evaluation of indoor material emissions, this preparatory WG agreed to refer to the EU-carcinogens classification.
- EU carcinogens determined through the harmonised protocol are volatile compounds measurable by ISO-16000.
- An EU group should be established to prepare a common list of carcinogens fulfilling the above criteria.
- If carcinogens are detected after 3 days, the test can be stopped.
- The evaluation criteria should cover all contaminants of concern to health and comfort and be based on scientific evidence when available.

- The LCI-approach is currently the most feasible strategy to assess the health effects of compounds from buildings materials.
- An expert group should be initiated to propose common European LCI-criteria.
- Criteria should be set also for substances not having LCI values ("non-assessable" substances)
- TVOC should not be used alone as an indicator for evaluating health effects from indoor material emissions
- A common approach for TVOC definition along with an upper limit for TVOC should be established.
- Sensory evaluation is considered to be an important part in the assessment of material emissions. Results have shown that chemical characterization of emissions is not a good predictor of sensory effects. Therefore it is important to complement the chemical assessment of material emissions with sensory evaluation.
- This WG supports the work of ISO TC146/SC6 in creating a standard for sensory evaluation. A draft standard ISO/CD 16000-28 on "Determination of odour emissions from building products using test chambers" has been developed early 2010. It includes both acceptability evaluation using an untrained panel and perceived intensity measurement with a trained panel. It also combines the odour evaluation chamber technique with the harmonised testing standard (model room) prepared by CEN TC351.
- The practical implication of the implementation of the ISO standard should be discussed and clarified at a later stage.

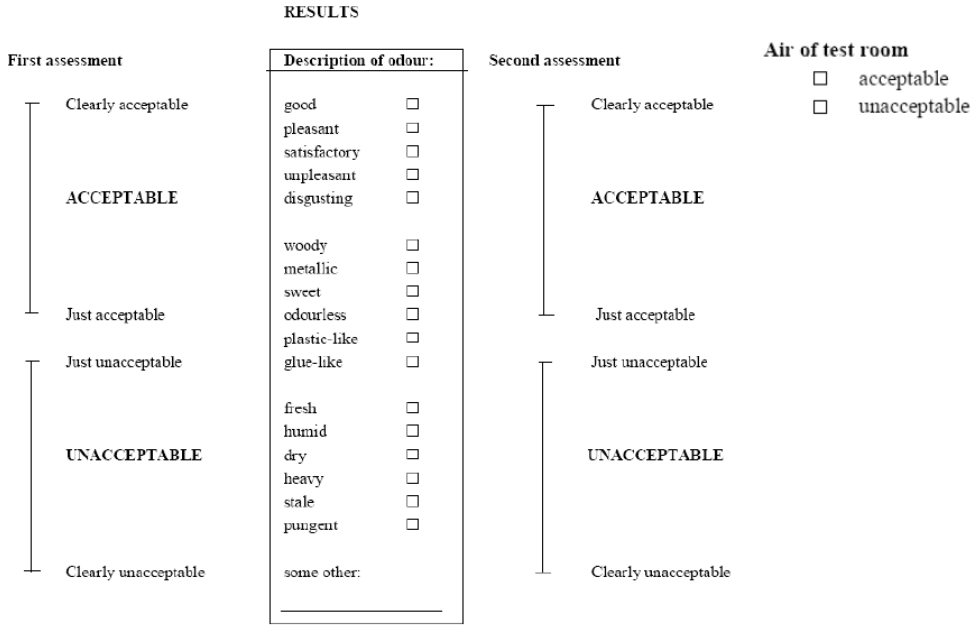
DATA HANDLING AND REPORTING:

- A shared data handling and reporting tool (e.g. as the ADAM Excel sheet) could be used as a basis for a future harmonised European system for documentation and evaluation of data.
- Additional features like an import tool and integration of alternative LCI-lists are feasible improvement options.

It is planned to continue the harmonisation work under the umbrella of an expanded group representing a broad range of stakeholders concerned with the labelling of construction products on the basis of the emissions to indoor air. This work will take account of developments in standardisation (CEN and ISO) and regulations at European and national level. The aim is for a harmonised basis for emission testing and evaluation that can be applied in voluntary and mandatory schemes that provide a cost effective method for identifying and promoting low emitting products in Europe with consequential benefits for concerned consumers and the quality of air in buildings.

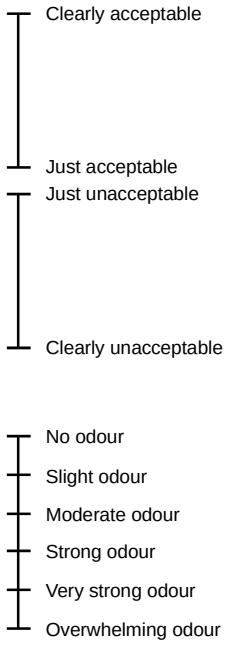
APPENDIX 1: Examples of scales for sensory evaluation

1a. Example of scales used for sensory evaluation of acceptability and odour intensity by M1



1b. Example of scales used for sensory evaluation of acceptability and odour intensity by DICL.

Imagine that you during your work day are exposed to this air quality. How do you rate the air quality?



APPENDIX 2: Short summaries of evaluation procedures in AFSSET, AgBB, DICL and M1

A: AFSSET protocol for evaluating indoor material emissions

The first National Environment and Health Action Plan (NEHAP) 2004–2008 was presented in France in June 2004. It was composed of 45 actions (including 12 high priority ranked actions) aimed at providing good quality air and water, preventing environmentally based pathologies (including cancer), providing better public information and protecting sensitive populations. In order to improve indoor air quality, high priority action n° 15 of the Plan wanted to promote the use of building products with low VOC emissions and a limited aptitude for growth of micro organisms. For this purpose, the 2004–2008 NEHAP asked for the development of a health-related protocol for the evaluation of VOC and formaldehyde emissions from building products. It also fixed the ambitious objective to have 50% of labelled products according to this protocol in 2010, on a voluntary basis.

In this framework, the French Agency for Environmental and Occupational Health Safety (AFSSET) has been mandated for establishing the health-related protocol for the evaluation of VOC and formaldehyde emissions from building products. A working group established by AFSSET and co-chaired by CSTB started its work in 2004. In October 2006, a first protocol for the evaluation of VOC and formaldehyde emissions from solid building products, based on similar approaches developed previously (ECA, 1997; AgBB, 2005), proposed by the working group and approved by the AFSSET Air experts group and by AFSSET has been presented. This protocol has been updated and was expanded to liquid and finishing products in 2009 (AFSSET, 2009). The protocol is based on the ISO 16000 standards series and on VOC and formaldehyde sampling and analysis after 3 and 28 days of emission testing in emission test chambers or cells. The protocol has been presented in detail elsewhere (AFSSET, 2009; Rousselle et al., 2008). Criteria for the health-related evaluation of emissions from building products according to the AFSSET protocol are:

- TVOC
- Carcinogenic and mutagenic compounds category 1 and 2 (according to 67/548/CEE Directive classification): 2 listed compounds -benzene and trichloroethylene
- Identification of respiratory sensitizer: information on product requirements
- R (risk index) calculated as the sum of ratio of individual VOC concentrations above 5 $\mu g.m^{-3}$ to their respective Lowest Concentrations of Interest (LCI): $R = \Sigma (Ci / LCI)$
- Sum of non-assessable compounds with concentrations above 5 $\mu g.m^{-3}$ (unidentified compounds or VOC without LCI): Σ Cni.

For individual VOC evaluation through the R ratio, AFSSET established a list of 164 LCIs in 2009. Limit values of exposure concentrations according to the AFSSET protocol are presented in Table A2.1.

So far, the AFSSET protocol has not been endorsed by voluntary labelling schemes in France and promotion of low emission products as proposed in action n° 15 of the 2004–2008 NEHAP remained extremely limited.

Table A2.1. *Limit values of exposure concentrations according to the AFSSET protocol (µg.m^{-3})*

Limit values (µg.m^{-3})	**Day 3**	**Day 28**
TVOC	10000	1000
Carcinogens (C1, C2)	10	1
R = Σ (Ci / LCI)	-	1
Σ Cni	-	100

B: AgBB protocol for evaluating indoor material emissions

To establish the fundamentals for a uniform and reproducible health-related evaluation of building products in Germany, the Committee for Health-related Evaluation of Building Products (Ausschuss zur gesundheitlichen Bewertung von Bauprodukten - AgBB) has developed criteria for testing and evaluating VOC emissions from building products. The evaluation scheme sets quality standards relevant to health for future production of building products for use indoors and thus stimulates the development of particularly low-emission products. It is not aimed at subsequent evaluation of products already installed.

German authorities published the first version of AgBB-scheme in 2000. Basically, until 2002 it was a set of criteria for limiting emissions from products for two different levels:

1. The main level is a mandatory VOC emission scheme. It contains limitations for building products proving their 'fitness to use' under the Essential Requirement No. 3 of the European Regulation for Building Products.
2. The second level was a proposal for voluntary use. This level is to show very low emission profiles for particular products.

The AgBB scheme has been integrated into the approval procedure for selected construction products (so far for a big variety of floor coverings and related adhesives) in Germany by DIBt since 2004. In this context it is a mandatory scheme. It was notified to the European Commission in 2005 (and 2008 in an updated version).

According to the AgBB-scheme VOC and SVOC emissions are measured after 28 days ventilated storage in a test chamber, following the test methods of ISO 16000 series. The three fundamentals of the evaluation are:

1. limits for the total amount of emissions,
2. assessment of toxicological relevance of detected single substances and
3. limits for non-assessable substances.

The basis for the evaluation of single substances in (2) is a list of about 165 LCI-values (Lowest Concentration of Interest), which are updated periodically based on current toxicological knowledge (updated LCI-list May 2010).

Table A2.2 presents the limit values for the emissions according to the AgBB-scheme.

Table A2.2. *Limit values for the emissions according to the AgBB-scheme*

Limit values for	Day 3 (µg/m^3)	Day 28 (µg/m^3)
TVOC	10000	1000
Carc. Cat. 1 and 2	10	1
SVOC	-	100
R = Σ (Ci / LCI)	-	1
Σ Cni	-	100

- R calculated as the sum of ratio of individual VOC concentrations above 5 µg/m^3 to their respective LCI
- Σ Cni: sum of non assessable compounds with concentrations above 5 µg/m^3 (unidentified compounds or VOC without LCI.

C: DICL (The Danish Indoor Climate Label)

The Indoor Climate Label was initiated in 1993 by the Danish Ministry of Housing and Urban Affairs. It was originally introduced in Denmark to reduce emissions from building materials and products used in the indoor environment.

The main principle of the Indoor Climate Label is the determination of the indoor-relevant time value. The time value is based on chemical analysis of the emission of single volatile organic compounds (VOCs) and aldehydes. These are evaluated in relation to sensory irritation (eye and upper airways) combined with a sensory evaluation of air acceptability and intensity of odour. The emission test is carried out on a newly manufactured product.

The indoor-relevant time value is the time (in days) from when the product is first released for sale until the concentration (converted into a standard room) of all individual compounds is below half the threshold value for irritation of mucous membranes. The threshold values for irritation of mucous membranes are those given in VOCBASE (Jensen and Wolkoff, 1996). Analysis is carried out on at least two occasions. According to the General Labelling Criteria common to all product areas (DICL, 2007) and Standard Test Method (DICL, 2005), which is based on the ISO 16000-series standards, testing times of 72 hours and 28 days should as a principal rule be included.

At the same time the product must fulfil the requirements for the sensory evaluation of the air quality. The sensory evaluation criteria for an acceptable air quality is: 1) the air quality shall be perceived as “acceptable” (median of minimum 20 persons’ evaluations) using the acceptability scale, and 2) the odour intensity shall be below 2 (“moderate odour”) using a 6-point continuous scale for odour intensity.

For all product areas a maximum allowed time-value is set in the criteria.

In addition to the chemical analysis and sensory evaluation, ceiling products are also tested for the release of fibres and particles. The method is based on the Nordtest method NT Build 347 (Nordtest, 1989), in which test specimens are installed in a test chamber and vibrated with sound from a loudspeaker.

The Indoor Climate Label also requires the product to be accompanied by instructions or storage, installation, application, use, cleaning and maintenance etc. to ensure a low impact on the indoor air quality throughout the normal lifetime of the product.

D: M1 Emission classification of Building Materials (Finland)

The first version of the emission classification was developed by the Finnish Society of Indoor Air Quality and Climate (FiSIAQ) in 1995 as part of Classification of Indoor Climate, Construction, and Finishing Materials. The first emission classifications were granted in 1996. In May 2000 the system changed its name into emission classification of building materials.

The goal of the classification is to enhance the development and use of low-emitting building materials so that material emissions do not increase the requirement for ventilation. The classification presents requirements for the materials used in ordinary work spaces and residences. The classification does not overrule official building codes or interpretations of them.

The emission classification of building materials has three emission classes. Emission class M1 corresponds to the best quality and emission class M3 includes materials with the highest emission rates. Classified materials have to fulfil the following criteria at the age of 28 days.

Table A2.3. *Criteria for the M1 and M2 emission classes*

Examined qualities	M1 [mg/m^{2}h]	M2 [mg/m^{2}h]
The emission of total volatile organic compounds (TVOC). A minimum of 70% of the compounds shall be identified.	< 0,2	< 0,4
The emission of formaldehyde (HCOH)	< 0,05	< 0,125
The emission of ammonia (NH_3)	< 0,03	< 0,06
The emission of carcinogenic compounds belonging to category 1 of the IARC monographs (IARC 1987)[1*]	< 0,005	< 0,005
Odour (dissatisfaction with odour shall be below 15 %)[2*]	Is not odorous	Is not significantly odorous

1* IARC 1987, does not apply to formaldehyde (IARC 2004)
2* The result of sensory evaluation shall be > + 0,1

- Plasters and tiling products, levelling agents, putty, mastics, fillers, screeds and renders shall not contain casein.

- Emission class M3 includes materials whose emissions exceed the values specified for materials in category M2.
- Materials that have not been tested shall not be granted a classification label. However, design guidance provided in the Classification of Indoor Climate places no restrictions on the use of uncoated brick, stone, ceramic tile, glass and metal surfaces as well as board and log surfaces made of wood (Finnish wood) may be used as M1 classified materials. The VOC emissions of fresh wood may nevertheless exceed the limit value of emission class M1.

Sample selection, analysis and measurements of material emissions are to be conducted as stipulated documents based on the ISO 16000-series standards.

- Protocol for the Chemical and Sensory Testing of Building Materials for the Emission Classification of Building Materials.
- Protocol for the Sensory Testing of Building Materials for the Emission Classification of Building Materials.

Applications for an emission classification for a building material are submitted to the Building Information Foundation RTS on an application form. Additional information can be found at www.rts.fi.

A more detailed description of the whole testing and acceptance method can be seen on the Web site of RTS (Building Information Foundation) (Saarela et al., 2004).

The reliability of the whole procedure rests on the chemical and sensory tests done by well-known, skilled and certified or officially accredited laboratories. Today, seven laboratories from Finland, Denmark, Germany and Sweden are accepted for M1-testing. The system is open to any laboratory with the capacity to carry out ISO 16000-series testing, a reliable quality assurance system and performance demonstrated by e.g. participation in European round-robin tests.

According to references and experience, the general accuracy of the chemical tests is about 20%. The probable error of the sensory tests (the classification used small untrained two step panels (5/15)) is 10%. In every case the overall risk of wrong conclusions in accepting and classifying materials seems to be sufficiently low and functional for this purpose (Saarela, 2003).

An essential part of the classification is product quality control, which makes the system more reliable. The quality of classified products is verified also through sample testing. The products to be tested are selected annually by the committee developing and supervising classification work

Emission Classified Products

Today there are over 1500 classified products from over 110 manufacturers or importers. The largest product groups among classified products are:

- plaster, rendering, putties, fillers etc.
- flooring
- paints and varnishes
- building boards
- mineral wool.

Classification requires that the product has been tested by an approved testing laboratory in accordance with the required methods. Sample selection, analysis and measurements of material emissions must be performed at a competent and impartial laboratory approved by the classification working group.

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Saarela K. (2003). Emissions from construction materials. Results from the National Healthy Building Programme. Proceedings of Healthy Buildings 2003 Conference, Singapore.

APPENDIX 3: Sampling, storage and test specimen preparation - an overview on the procedure details in existing labelling schemes in EU

■ According to EN ISO 16000-11
□ See Remarks

	EN ISO 16000-11	M1	DICL	DIBt/ AgBB	AFSSET	Remarks
Sample collection						
- responsible parties	- not clearly defined	■	■	■	■	
- chain of custory/sampling report	- not required	■	□	□	■	□ DICL: yes □ DIBt: yes
- sampling at the factory	- asap after normal manufacturing process	■	■	■	■	
- other possible sampling points	- product samples from retail stores/stock	■	■	■	■	
- time interval between production and sampling	- minimise, no exact limit	□	■	□	■	□ M1: if possible within 1 hour from manufacturing □ DIBt: coatings and adhesives sell-by date still valid
Sample packaging after sampling	- inert, airtight - standard delivery package when suitable	■	■	■	■	

Product specific instructions - sampling	**EN ISO 16000-11**	**M1**	**DICL**	**DIBt*/ AgBB**	**AFSSET**	**Remarks**
Sampling from rolls (resilient products) - e.g. many insulation products, flexible frooring materials, wall coverings	- discard 1 m or at least the outer layer of the roll - cut full width - amount depends on the need - pack within 1 hour from sampling	■ □	□	■ □	■	□ M1: discard min 2 m of the roll □ DICL: shall be arranged with the test lab □ DIBt: cut 1 – 1,5 m, width ≤ 2m
Sampling rigid products - e.g. tiles, parquets, laminated floorings, wall construction products like chip- and gypsum boards, wood panels, ceiling materials, acoustic panels	- unopened standard package - if necessary: cut sample from the middle of large board	■	□	■	■	□ DICL: shall be arranged with the test lab
Liquid products - e.g. paints, varnishes, oils,	- unopened standard package	■	■	■	■	

waxes, levelling compounds, plasters, mortars, screed, concrete, adhesives, sealants, caulks, putties, surface coatings						

Sample storage and shipment		**M1**	**DICL**	**DIBt*/ AgBB**	**AFSSET**	**Remarks**
Sample storage before shipment	- protect from chemical contamination and physical exposure		■	■	■	
Shipment	- protect from chemical contamination and physical exposure	■ □	■ □	■ □	■	□ M1: asap after sampling and packing □ DICL: at the shortest transport □ DIBt: normal transport services
Storage at the laboratory before testing	- in unopened shipment package - normal indoor conditions - minimise storage time	■ □	■ □	■	■	□ M1: storage time max 3 weeks □ DICL: storage time max time 3 weeks, for concrete immediately

Test specimen preparation		**M1**	**DICL**	**DIBt*/ AgBB**	**AFSSET**	**Remarks**
Solid products						
Rolled products	- test specimen taken symmetrically from the middle of the sample, if possible 50 cm from sides - seal back side and edges	■	■	■ □	■	□ DIBt textile floorings may be blanked out, sealing of edges not required
Rigid products	- tiles, panels, etc: sample from the middle of the retail package - boards: exclude ≥ 50 cm from both ends - joints symmetrically distributed over the test specimen i.e. joint length vs. area same as in finished product - seal back side and edges *Note:* if the emissions from the backside of the material are of interest, may be left open	■	■	■ □	■	□ DIBt: sample area vs. joint length min 2,5:1 or max gap-ratio depending on the product width
Liquid products						
- paints	EN 927-1	■	■ □		■	□ DICL: wall paint on gypsum, other paints on spruce

	- substrates: glass, stainless steel, polyester - depending on the purpose of the test also other substrates may be used (combined products) - applying method not restricted					
- adhesives	- inert substrate, 300 g/m²	■		■	■	
- levelling compounds, synthetic resin floorings and plasters	- inert substrate, wet layer thickness 3 mm	■		□	■	□ DIBt: floor coatings: on inert substrate according to manufacturer's instructions, edges sealed
- screed materials, concrete	- inert substrate, wet layer thickness 50 mm	■			■	
- sealants and fillers	- inert U-profile, wet layer thickness 3 mm, width 10 mm	■			■	
- sealant foams		□				□ M1: inert U-profile height 40 mm, width min 15 mm
- putty	- inert substrate, wet layer thickness 2 mm	■			■	
-care and maintenance products			□			□ DICL: floor oil on beech according to manufacturer's instruction
Combined products	- recommended method: using controlled reference specimen		□	□	■	□ DICL: prepared in laboratory according to the relative amount of different materials □ DIBt: hard floorings surface-treatment on-site: preparation according to technical fact sheet of the surface treatment agent

It is noted that there are a number of shortcomings in the aforementioned protocols for particular product groups, for example:

- insulation materials of different types
- other adhesives than floor covering adhesives
- building blocks
- care and maintenance products

It is also recognised that in cases where the protocol allows options more detailed operating guidance is needed for enhancing the homogeneity of the test results.

APPENDIX 4: Dibasic esters as new and relevant indoor air contaminants

A case study on indoor air contamination due to dibasic esters (CAS Reg. No. 95481-62-2, DBE, DIMETHYL ADIPATE, DIMETHYL GLUTARATE, DIMETHYL SUCCINATE) is presented. Health problems of children (age 6 to 10 years) and teachers in a primary school in Germany were found to be associated with elevated indoor air concentrations in the range between 1 and 2 mg/m³ for the sum of the C4-C6 dibasic esters (Figure A5.1). These semi-volatile chemicals (Bp > 200 Cº) are novel indoor air contaminants and no reference values or guidance values exist for the mixture or the single components. Odour threshold according to DIN EN 13725 2003 was determined as 0.47 mg/m³ (95% confidence interval: 0.33 -0.67 mg/m³). Using a benchmark value of 5 mg/m³ for nasal irritation from animal experiments an indoor air guidance value of 0.5 mg/m³ is proposed. Health effects in children were assessed by means of a questionnaire with 8 sick-building-syndrome items (Figure A5.2). A statistically significant difference was found for nasal irritation, cough, headache and fatigue between exposed children and an unexposed control group and 3 weeks after the children had left the contaminated rooms. We speculate that the symptoms and complaints are most likely caused by indoor exposure to dibasic esters originating form a polyurethane floor component (barrier layer) and recommend that these semi-volatile and otherwise preferable substitutes for conventional solvents should not be used in building products, where longer lasting release could occur.

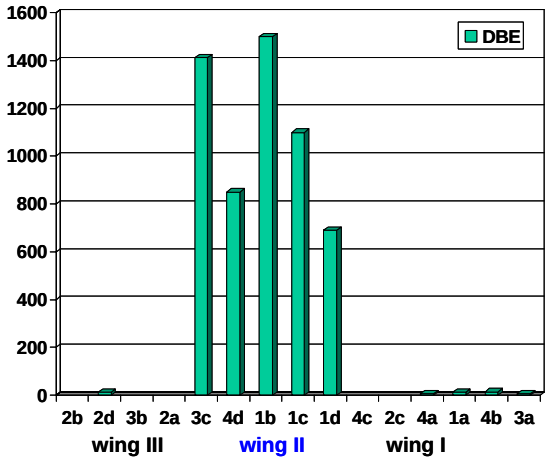

Figure A5.1**:** *Concentration of the dibasic esters in 5 class rooms in wing II renovated using a polyurethane ground coat as water barrier in the floor. Epoxide based products were used in wings I and III.*

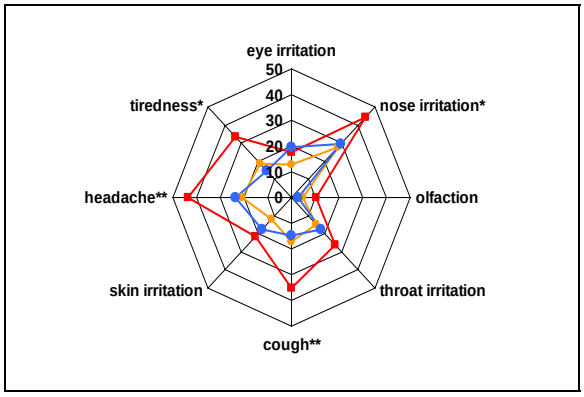

***Figure A5.2*:** *Health complaints of children Reference: Heinzow et al., Gefahrstoffe Reinhaltung der Luft, 69 (2009) No. 4 April)*

APPENDIX 5: Members of the ECA "*Urban Air, Indoor Environment & Human Exposure*" Steering Committee

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Title: *ECA-IAQ (European Collaborative Action, Urban Air, Indoor Environment and Human Exposure), 2010. Harmonisation framework for indoor material labelling schemes in the EU, Report No 27.*

Author(s): *Derrick Crump, Christine Däumling, Lis Winther-Funch, Wolfgang Horn, Marion Keirsbulck, François Maupetit, Jorma Säteri, Kristina Saarela, Ana Maria Scutaru, Tiina Tirkkonen, Thomas Witterseh, Caroline Sperk, Stylianos Kephalopoulos*

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Abstract

This report describes the outcome of recent activities and a roadmap setting out the steps being taken by a preparatory working group led by the European Commission for establishing an EU wide harmonised framework for labelling schemes (which consists of core and optional criteria) and obtaining broad consensus through open consultation. The recommendations made by the WG are:

GENERAL FRAMEWORK:

A harmonised framework for indoor material emissions labelling schemes in EU should comprise core and optional requirements for both the chemical characterisation and the health evaluation of material emissions.

EMISSION TESTING OF INDOOR MATERIALS:

Emission testing should be based on harmonised European standards, when available. The issues of product sampling and sample preparation are a crucial part of emission testing. Procedural details need still to be further elaborated before final recommendations can be made. Products should be tested for their emissions as they are placed in the market. The WG supports the work of CEN TC351 and recommends the usage of the validated harmonised testing standard for measurement of VOC's and formaldehyde when this will become available. Until harmonised standards become available, ISO 16000-series standards should be used for measurement with the following exceptions: (1) Emission testing should include two chamber air sampling times (day 3 and 28) and (2) Reference room size: use the normative proposal of CEN TC 351 instead of the ISO 16000-9 informative annex B.

The WG proposes the development of a detailed protocol for calibration of all target compounds (LCIs) suitable for efficient, and as far as possible automated analysis with appropriate sensitivity, including for carcinogens.

EVALUATION OF INDOOR MATERIAL EMISSIONS:

For the evaluation of indoor material emissions, the preparatory WG agreed to refer to the EU-carcinogens classification. EU carcinogens determined through the harmonised protocol are volatile compounds measurable by ISO-16000. An EU group should be established to prepare a common list of carcinogens fulfilling the above criteria. If carcinogens are detected after 3 days, the test can be stopped. The evaluation criteria should cover all contaminants of concern to health and comfort and be based on scientific evidence when available. The LCI-approach is currently the most feasible strategy to assess the health effects of compounds from buildings materials. An expert group should be initiated to propose common European LCI-criteria. Criteria should be set also for substances not having LCI values (i.e., "non-assessable" substances). TVOC should not be used alone as an indicator for evaluating health effects from indoor material emissions. A common approach for TVOC definition along with an upper limit for TVOC should be established. Sensory evaluation is considered to be an important part in the assessment of material emissions. Results have shown that chemical characterization of emissions is not a good predictor of sensory effects. Therefore it is important to complement the chemical assessment of material emissions with sensory evaluation. This WG supports the work of ISO TC146/SC6 in creating a standard for sensory evaluation. A draft standard ISO/CD 16000-28 on "Determination of odour emissions from building products using test chambers" has been developed early 2010. It includes both, acceptability evaluation using untrained panel and perceived intensity measurement with trained panel. It also combines the odour evaluation chamber technique with the harmonised testing standard (model room) prepared by CEN TC351. The practical implication of the implementation of the ISO standard should be discussed and clarified at a later stage.

DATA HANDLING AND REPORTING:
A shared data handling and reporting tool (e.g. as the DIBT's ADAM Excel sheet) could be used as a basis for a future harmonised European system for documentation and evaluation of data. Additional features like an import tool and integration of alternative LCI-lists are feasible improvement options.

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Mission of the JRC

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.