Ausschuss zur gesundheitlichen Bewertung von Bauprodukten

Committee for Health-related Evaluation of Building Products

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Updated List of LCI values 2015 in Part 3

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This version applies from the date it is published. The version it replaces will continue to be valid for one more year. This also applies to updated lists of LCI values. However, old and new versions must each be applied as a complete document; they may not be mingled.

A contribution to the Construction Products Regulation:

Health-related Evaluation Procedure for Volatile Organic Compounds Emissions (VVOC, VOC and SVOC) from Building Products

1 Introduction

The health and comfort of the occupants of indoor spaces is influenced by the indoor climate in a room (in particular temperature, air exchange rate and relative humidity) and by potential indoor air pollutants. Such pollutants may be emitted by a variety of sources. Among these sources building products are of particular importance here since their selection is often not within the occupants' discretion and many of them cover large surface areas in a room.

Renovation and construction measures carried out in the context of statutory requirements on the energy efficiency of building (Energy Saving Ordinance, EnEV 2014) must ensure at the same time that a healthy indoor air quality is guaranteed for room occupants during the use phase. To prevent air infiltration and heat losses, the shell of energy-efficient buildings is often so air-tight that the air change necessary for reasons of hygiene is not achieved. The result is humidity and indoor air pollution by volatile organic compounds. Unless sufficient airing takes place, room users face avoidable risks to their comfort, health and performance. Therefore, in building construction and extensive building renovation, the development of a ventilation concept (provided, most commonly, by airing several times a day by opening windows wide and/or the use of technical ventilation systems) by architects or planners should be a mandatory requirement and building operators should be required to implement this concept.

In Germany the use of building products is subject to the provisions of the building codes of the Federal States (Länder). These provisions require that built structures shall be designed, built, and maintained in such a way that life, health or the natural environment are not endangered (Article 3, Standard Building Code (Musterbauordnung) [MBO, 2002]). Building products used in the construction or integrated in the building have to satisfy these

requirements so that chemical, physical or biological influences do not result in any hazard or unacceptable nuisance (Article 13 MBO).

In the European Union, the importance of building products was accounted for by the European Construction Products Directive (CPD) which came into force in 1989 [Council of the European Communities, 1989]. An important objective of this Directive, in addition to eliminating barriers to trade, was the integration of health concerns. In 1992, the European Construction Products Directive was transposed into German national legislation by the Building Products Act (Bauproduktengesetz, [BauPG 1992]) and by amendments to the building codes of the Federal States (Länder).

On 4 April 2011, Regulation (EU) No 305/2011of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of building products was published in the European Official Journal L 88/5. On 1 July 2013 it fully superseded the Construction Products Directive. Implementation of the new Construction Products Regulation (BauPVO) into national law is not required as European regulations take effect immediately in all Member States.

One of the objectives of the building codes of the Federal States (Länder) and of the the EU Construction Products Regulation is to protect the building users' health. "Hygiene, Health and Environment" are among the basic requirements for construction works and the building products incorporated therein. The Regulation allows EU Member States to require in their national regulations that building products must not endanger the health of room users and that their essential characteristics in that respect be proven in performance tests. This explicitly covers the prevention and control of indoor pollutants, e.g. volatile organic compounds (VOC) (Annex I, Construction Products Regulation (No 305/2011)).

The European Union has recognised the insufficient implementation of the essential requirements for building products regarding health protection and issued a mandate to CEN. The mandate[1] envisaged the development of horizontal assessment methods for dangerous substances in and their emission from building products. For this purpose, CEN has established the technical committee CEN TC 351. The horizontal assessment methods to be developed by this committee will form the basis for the technical specifications for building products in standardisation activities, European Technical Assessments and national technical approvals. As a result of the standardization work, the CEN/TS standard 16517:2013, Construction products – Assessment of release of dangerous substances – Determination of emissions into indoor air, was published. This Technical Specification (CEN/TS) is expected to be given the status of a European Standard (EN).

National and international bodies, in particular the European Collaborative Action (ECA) "Indoor Air Quality and its Impact on Man", already dealt with the evaluation of VOC emissions from building products in the 1990s. Within ECA, which now works under the title "Urban Air, Indoor Environment and Human Exposure", experts from the EU Member States and from Switzerland and Norway are thoroughly examining the specific knowledge available in Europe on a wide range of indoor issues. The results of their work are published in reports which contain sufficiently detailed information to be considered as 'pre-normative' documents. One of them is Report No 18 "Evaluation of VOC Emissions from Building

[1] Mandate M366 "Development of horizontal standardised assessment methods for harmonised approaches relating to dangerous substances under the Construction Products Directive (CPD)". European Commission, DG Enterprise, Brussels, 16 March 2005.

Products" in which a flow chart describing the procedure for evaluation of emissions from floor coverings is given as an example [ECA, 1997a].

The Committee for Health-related Evaluation of Building Products, *AgBB*[2] *(Ausschuss für die gesundheitliche Bewertung von Bauprodukten)* considers it to be one of its main tasks to establish in Germany the fundamentals for a uniform health-related assessment of building products which satisfies the requirements specified in the building codes of the Federal States (Länder) and the European Construction Products Regulation, is traceable and objective. The AgBB also supports efforts to harmonise the health assessment of emissions from building products in Europe [ECA 2012, 2013].

The Committee has presented a scheme for health-related evaluation of VOC emissions from building products used for application indoors [AgBB, 2000]. Within this scheme, volatile organic compounds include compounds within the retention range of C_6 to C_{16}, which are considered both as individual substances and as a sum parameter following the TVOC concept (TVOC = Total Volatile Organic Compounds), as well as very volatile (VVOC) and semi volatile (SVOC) organic compounds within the retention range below C_6 and from C_{16} up to C_{22}, respectively.

The scheme was extensively discussed with representatives of manufacturers and professionals after having been published first in 2000 and at the end of its introductory phase from 2002 to 2004 [Proceedings of the technical dialogues in 2001 and 2004; International Conference, 2007]. As a result of these processes, the scheme was revised [AgBB, 2005] and the German Institute for Building Technology (Deutsche Institut für Bautechnik (DIBt)) incorporated the evaluation scheme into its approval guidelines for the health-related evaluation of building products [DIBt, 2004, current version 2010]. Some of the new knowledge gained in the meantime, is taken into account in the current version [Däumling, 2012]. For other issues, further research is needed, e. g. for inclusion of certain VVOCs that have proven to be relevant for emissions from building products [e.g. Salthammer, 2014; Pech et al., 2013; Gellert and Horn, 2005]. The VOC measurement methods currently in use are not suitable enough to allow these substances to be included, with the exception of cabonyl compounds (measurement according to DIN ISO 16000-3).

By adhering to the test values set in the scheme, the minimum requirements of the aforementioned building codes for health protection with regard to VOC emissions can be met. Nevertheless, the scheme endorses initiatives of manufacturers to produce products with lower emissions. Manufacturers can therefore declare better performance parameters (VOC emissions) for their products, e. g. by means of labels [ECA, 2005; ECA 2012].

2 Health-related evaluation of VOC emissions from building products

The effects of indoor air pollution have been dealt with in a large number of publications [see e.g. ECA, 1991b; WHO, 2000, 2010; Ad-hoc, 2007]. Volatile organic compounds may have effects ranging from odour perception and irritation of the mucous membranes of the eyes,

[2] Composed of representatives of the health authorities of the *Länder*, the Federal Environment Agency (UBA) with the AgBB Secretariat, the German Institute for Building Technology (DIBt), the Conference of the *Länder* Ministers and Senators responsible for urban development, construction and housing (ARGEBAU), the Federal Institute for Materials Research and Testing (BAM), the Federal Institute for Risk Assessment (BfR) and Coordination Committee 03 – hygiene, health and environmental protection - of the Building and Civil Engineering Standards Committee of the German Institute for Standardisation (DIN-KOA 03)

nose and throat to acute and/or systemic effects and long-term effects. This also includes effects on the nervous system, allergenic or allergy-promoting and, in particular, carcinogenic, mutagenic or reprotoxic properties.

The toxicological evaluation of substances emitted from building products is based on the determination of concentration levels below which there is no reason to expect adverse effects (LCI – lowest concentration of interest).

The most comprehensive evaluation system for chemical substances is available for the workplace area, in the form of occupational exposure limit values (OELs). However, where hazardous substances are handled at workplaces under typical conditions, much higher substance concentrations than under indoor living conditions are generally encountered. Also, much shorter exposure times occur at workplaces in comparison to indoor situations. When extrapolating to indoor living spaces, this must be accounted for by suitable factors, as must the inclusion of particularly sensitive population groups and the absence of exposure monitoring through measurements and occupational health surveillance [ECA, 1997a].In the evaluation of building products, the pragmatic approach that is based on these considerations has been applied until now to derive auxiliary parameters referred to as LCI (Lowest Concentration of Interest)[3] values.

Since 2011 a European initiative has been working to harmonise emissions assessment in Europe by means of LCI values, with the aim of ensuring that uniform quality requirements apply in cross-border trade. The working group has compiled a comprehensive list of emission-relevant substances, described the procedure it uses to derive EU-LCI values and published a first harmonised list of LCI values for some 80 substances [ECA 2013].

The evaluation criteria are based on the assessment of individual compounds although building occupants are exposed to a multitude of substances. This is accounted for by summing evaluated individual VOC concentrations in the risk index “R” and by means of the total concentration of volatile organic compounds (TVOC) [ECA, 2012; Seifert, 1999; DIN ISO 16000-6; Ad-hoc, 2007]. However, it has to be emphasized that a TVOC guideline value – due to the varying composition of the VOC mixture occurring in indoor air – cannot be based on toxicological assessment. However, there is sufficient evidence that with increasing TVOC concentration the likelihood of complaints and adverse health effects also increases [ECA, 1997b; Ad-hoc, 2007].

3 Sensory aspects

Emissions from building products are often associated with odour perception, which may result in annoyance and health impairment. Sensory testing is therefore an important element of the evaluation of emissions from building products. In the past, different measurement methods have been used for sensory testing [e. g. Fischer et al., 1998; ECA, 1999], but there was no harmonised, generally accepted procedure for odour assessment. Research projects on measurement of odour emissions from building products using test chambers [UBA Texte, 2007 and 2011] have developed a method which has now become a national [VDI 4302 Blatt 1] and an international [ISO 16000-28] standard.

[3] In the original German text the acronym NIK is used standing for Niedrigste interessierende Konzentration, which is the translation of LCI.

Based on current knowledge and the test chamber method according to DIN ISO 160000-28, it is now possible within the AgBB evaluation scheme to determine and objectively evaluate odour emissions from building products on the basis of perceived intensity and hedonic note. In order to gain further experience by applying the test method to different building products, the AgBB launched a pilot phase for sensory testing in 2012. The aim of the pilot phase is to examine different building products, test the applicability of the proposed method and carry out two round robin tests in cooperation with representatives of relevant industrial associations, manufacturers and test laboratories. The results from the pilot phase will enable a broader basis for the decision on how sensory testing can be incorporated into the AgBB evaluation scheme in future.

4 Measurement and evaluation of VOC emissions from building products

4.1 Test chamber method for VOC emissions measurement

VOC emissions from building products can be suitably measured in test chambers. Important parameters that have an influence on the result are temperature, air exchange rate, relative humidity, air velocity in the test chamber, the amount or surface area of the material in the chamber and the method of sample preparation. The influence of these and other parameters became evident in international intercomparison tests [ECA, 1993; ECA, 1995]. Based on the results of these tests and an earlier publication on the test procedure [ECA, 1991a], international standards for the determination of emissions from building products were published [ISO 16000-9 to -11]. Parts 9 and 10 describe the procedure when using a test chamber and a test cell, respectively. Part 11 covers sampling, storing of samples, and preparation of test specimens. The Technical Specification CEN/TS 16516 further specifies the test conditions in order to improve measurement reliability and reproducibility. For VOC assessment under the AgBB scheme, total volatile organic compounds (TVOC) must be determined as described in Annex H to this Technical Specification.

4.2 Exposure scenarios

Health evaluation of a building product is based on the indoor air concentrations of volatile organic compounds to which a room occupant is predicted to be exposed as a result of VOC emissions from that product. The evaluation cannot be carried out using solely the area-specific emissions rates of the building product as determined in test chamber measurements according to the AgBB scheme (see 4.1). Rather, it is necessary to additionally consider the indoor air situation likely to be encountered under practical conditions. The exposure scenario creates the link between product emission and concentration in indoor air. Thus, the evaluation must take into account the emissions from the product, the size of the room, the air exchange rate and the emitting surface area of the building product to be installed in the room.

Under current building law in Germany, the building shell of newly constructed or extensively renovated buildings is increasingly fitted with airtight insulation for energy reasons. This reduces the air exchange with outdoor air unless compensated by increased active ventilation. From the viewpoint of air quality, regular air exchange with ambient air is necessary to reliably transport humidity (produced e.g. by cooking or washing) as well as odours and emissions out of indoor spaces and create the prerequisites for a healthy indoor climate.

In order to take both energy and air quality aspects sufficiently into account, the AgBB scheme assumes an air exchange rate of 0.5/h for exposure analysis [DIN 1946-6]. Rooms equipped with modern sealed windows and doors, and located in buildings whose shell exhibits a high level of air-tightness as required by the German Energy Saving Ordinance normally have much lower air exchange rates. This, however, is insufficient from the perspective of indoor air quality. Therefore, the air exchange rate of 0.5/h assumed in the AgBB scheme presupposes increased active ventilation to prevent harmful consequences in terms of hygiene. Increased intensive airing by the occupants must be assumed in particular after introduction of new materials (e.g. during renovation). Furthermore, in low energy buildings, the aim must be to consistently use low-emission building products and other materials and products for indoor use.

The AgBB requirements also must take into account a broad range of building types and uses as possible. Since most of the building stock in Germany still consists of energy-inefficient old buildings, the requirements must consider the different air exchange rates in these buildings. From the perspective of indoor air quality an air exchange rate of 0.5/h remains the minimum air exchange rate target for all buildings, including old and new. It is therefore deemed to be an appropriate basis for the calculations in connection with evaluation of test chamber emission results.

$$C = \frac{E_a \cdot A}{n \cdot V} = \frac{E_a}{q} \qquad (1)$$

Equation (1) describes the indoor air concentration C, resulting from a building product, as a function of the area-specific emissions rate E_a [µg/(m^2 h)] of the product, the air exchange rate n [h^{-1}] in the room considered and the ratio of product surface area A [m^2] to the room volume V [m^3]. Parameters n, A and V can be combined into the new parameter q [m^3/(h m^2)] called the area-specific air exchange rate.

To ensure that the measurement results obtained in a test chamber are transferrable to the reference room, the AgBB scheme requires a loading factor to be set for the test chamber measurement which takes the product's intended use into account. For some standard uses, the following standardised loading factors have been defined:

- 1.0 m^2/m^3 for walls;
- 0.4 m^2/m^3 for floor or ceiling;
- 0.05 m^2/m^3 for small surfaces, e.g. a door;
- 0.007 m^2/m^3 for very small surfaces, e.g. sealants.

For building products and uses that deviate from the above standard uses, a loading factor as representative as possible must be calculated and the nearest standard loading factor be used. If the intended conditions of use suggest that a product might be used on more than one of the above surfaces, the relevant surface areas and loading factors must be summed. The standardised loading factors for such uses are:

- 0.8 m^2m^3 for walls and ceiling;
- 1.4 m^2/m^3 for walls and ceiling or walls and floor;
- 1.8 m^2/m^3 for walls, floor and ceiling.

The loading factor applied must be stated in the test report.

The reference room in the AgBB scheme has a base area of 3 m x 4 m and a height of 2.5 m.

4.3 Evaluation scheme for volatile organic compounds

For health evaluation, a product has to undergo a series of tests as shown in the flow chart in Fig. 1. The procedure starts from a product wrapped in an airtight cover. The start of the experiment (t_0) is defined as the time at which the product to be tested is unwrapped and placed into the test chamber or cell. The product remains in the test chamber or cell over the entire period of the test. For certain product groups it is necessary to define special test conditions. These specific requirements are defined separately (see Approval guidelines for the health-related evaluation of indoor construction products, Part I and Part II [DIBt, 2010]). They may also include the definition of criteria for anticipated termination of the emission measurement. In principle, anticipated termination of the test is permitted at the earliest 7

days after placing the test specimen into the chamber and under the condition that the values determined are less than half the requirements for the 28-day values and no significant increase in the concentration of individual substances is observed in comparison to the measurement on day 3. The fulfilment of these criteria has to be sufficiently demonstrated by the testing body.

In accordance with ISO 16000-6 the following definitions apply for the emission to be determined in the test chamber:
VVOC: all individual substances within the retention range < C_6
VOC: all individual substances within the retention range C_6 - C_{16}
TVOC: sum of the concentration of all individual substances with concentrations equal to or greater than 5 µg/m^3 within the retention range C_6 - C_{16}
SVOC: all individual substances within the retention range > C_{16} - C_{22}
∑SVOC: sum of the concentration of all individual substances with concentrations equal to or greater than 5 µg/m³ within the retention range > C_{16} - C_{22}

The assignment of the individual substances to the retention ranges is based on the separation on a 5 % phenyl / 95 % methyl polysiloxane capillary column. Individual substances comprise identified and non-identified compounds.

In the AgBB scheme, the identification of all individual substances is based on a presumed uniform detection limit of 1 µg/m^3 in order to cover the emission spectrum as fully as possible in a qualitative way.

All individual substances have to be quantified as required and need to be considered individually and in the summation if their concentration is equal to or greater than 5 µg/m^3. Exceptions apply to carcinogenic substances belonging to EU categories 1A and 1B according to the new GHS system (Regulation (EC) No 1272/2008 Annex VI Table 3.1) (see 4.3.1).

Identified substances with LCI values as well as carcinogens have to be quantified using their individual calibration factors. Identified substances without LCI values and non-identified ("unknown") substances are quantified on the basis of toluene equivalents [also see Annex H, CEN/TS 16516].

VOC and SVOC shall be measured using Tenax sampling and subsequent thermodesorption and analysis by GC/MSD according to DIN ISO 16000-6. Some aldehydes listed in Group 7 of the list of LCI values shall be determined using the DNPH method according to ISO 16000-3 (see Note III in the Annex).

The following explanations are given to the flow chart in Figure 1:

4.3.1 Measurement and testing after 3 days

- $\underline{TVOC_3}$

A product satisfies the criteria, if the TVOC value after 3 days ($TVOC_3$) is ≤ 10 mg/m³.

- Carcinogenic substances

Every building product has to meet the general requirement of not emitting any carcinogenic, mutagenic or reprotoxic substances. Emission of carcinogenic substances belonging to EU categories 1A and 1B is first tested at this stage of the flow chart. Substances with mutagenic or reprotoxic properties and those with potential carcinogenic effects belonging to EU

category 2 are checked within the LCI concept (see Part 3) and assigned higher safety factors if necessary. Carcinogens have to be quantified using their individual calibration factors.

No carcinogen belonging to EU categories 1A and 1B may exceed a concentration of 0.01 mg/m³ after 3 days.

Excepted from this requirement are certain substances classified as 1A or 1B carcinogens for which a threshold can be derived for the most sensitive endpoint at which a carcinogenic potential is no longer assumed. For these substances, a LCI value is derived on that basis and listed in Table 1.

- Sensory testing

The results of the research projects show that sensory testing after 3 days generates no significant additional information. Therefore, in the pilot phase, no odour measurement is performed at that time.

4.3.2 Measurement and testing after 28 days

- $TVOC_{28}$

In order to assess the long-term behaviour of the VOC emissions from a building product, the TVOC value is determined again after 28 days. This is done in the same way as described for $TVOC_3$. When calculating the $TVOC_{28}$ value, in addition to the instructions given in ISO 16000-6, it is important to be as complete as possible in the identification of compounds to permit the evaluation of individual substances.
A product satisfies the criteria, if the $TVOC_{28}$ value is ≤ 1.0 mg/m³. Products with a TVOC value higher than that are rejected.

- Semi volatile organic compounds (SVOC)

Products that satisfy the criteria for VOC emissions but instead exhibit increased emission of SVOC should not be given advantages. To prevent this from happening, the SVOC concentration in the chamber air must also be determined[4].

A product satisfies the criteria if the sum of the SVOC concentrations in the chamber air does not exceed 0.1 mg/m³. This corresponds to an additional content of 10 % of the maximum allowable $TVOC_{28}$ concentration of 1.0 mg/m³. Higher concentrations result in rejection.

For some SVOC LCI values are derived in individual cases. The SVOC for which LCI values were derived must be included in the calculation of the R-value and are not subject to the value for total SVOC of 0.1 mg/m^3 after 28 days. The sum of TVOC and the sum of all individual SVOC with LCI value may not exceed a concentration of 1.0 mg/m^3 after 28 days.

- Very volatile organic compounds (VVOC)

Products that satisfy the criteria for VOC emissions but instead exhibit increased emission of VVOC should not be given an advantage in terms of health assessment. To meet this

[4] Emission of semi volatile organic compounds with a retention time > C_{16} (hexadecane) can be quantitatively determined by chamber or cell measurements over 28 days using today's modern analysis apparatus up to a volatility comparable to that of docosane (C_{22} alcane, boiling point 369 °C). According to current knowledge, the analysis of semi volatile organic compounds with an even lower volatility will encounter increasing difficulty if the method of Tenax sampling and thermodesorption is used in chamber tests.

requirement, the VVOC concentration in the chamber air must also be determined (see Note III in the Annex).

For some VVOC LCI values are derived in individual cases. The VVOC for which LCI values were derived must be included in the calculation of the R-value but not in the TVOC value.

- Carcinogenic substances

The emission of carcinogenic substances of EU categories 1A and 1B is measured again, with an emphasis on the long-term behaviour from the user's point of view. No carcinogen of categories 1A and 1B may exceed the value of 0.001 mg/m³ after 28 days.

Excepted from this requirement are certain substances classified as 1A or 1B carcinogens for which a threshold can be derived for the most sensitive endpoint at which a carcinogenic potential is no longer assumed. For these substances, a LCI value is derived on that basis and listed in Table 1. These substances are dealt with in the same way as other VOC substances with LCI values (See Evaluation of individual substances).

- Sensory testing

In the pilot phase, sensory testing for intensity and hedonic note is performed after 28 days. Perceived intensity is determined by a trained panel (DIN ISO 16000-28, section 10.3). Hedonic note is measured by the same panel according to VDI 4302 Part 1.

- Evaluation of individual substances

In addition to evaluating the emissions of a product via the TVOC value, the evaluation of individual volatile organic compounds is also necessary. For this purpose all compounds whose concentration in the chamber air equals or exceeds 1 µg/m³ are first identified, listed with their CAS number, and quantified according to the following:

a) VVOC, VOC and SVOC assessable via LCI

For a large number of volatile organic compounds found in indoor air a list of so-called LCI values (Lowest Concentration of Interest, see footnote 3) is contained in the Annex. The details of how these LCI values have been derived are documented in the introduction to the list.

Listed substances whose concentrations in the test chamber air exceed 5 µg/m³ are evaluated based on LCI. They are quantified using their individual calibration factors.

For the evaluation of each compound *i* the ratio R_i is established as defined in equation (2).

$$R_i = C_i / LCI_i \qquad (2)$$

where C_i is the chamber concentration of compound *i*. For $R_i < 1$, it is assumed that there will be no effects. If several compounds with a concentration > 5 µg/m³ are detected, additivity of effects is assumed and it is required that R, the sum of all R_i, shall not exceed the value 1.

$$R = \text{sum of all } R_i = \text{sum of all ratios } (C_i / LCI_i) \leq 1 \qquad (3)$$

Products which do not fulfil this condition are rejected.

b) VOC not assessable via LCI

In order to avoid the risk of a positive evaluation of a product which emits larger quantities of nonassessable VOC, a limit is set for those VOC which cannot be identified or do not have an LCI value. This limit equals 10 % of the permitted TVOC value, for the sum of such substances. A product meets the criteria when the sum of such VOC determined at concentrations ≥ 5 µg/m^3 does not exceed 0.1 mg/m³. Higher concentrations result in rejection.

4.4 Conclusion

A building product which fulfils the requirements set out in the flow chart (see Figure 1) is suitable for use in enclosed building spaces from a health perspective in accordance with Articles 3 and 13 of the Standard Building Code (MBO).

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(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02008R1272-20131201&qid=1425896678438&from=EN, consolidated version including the 4th adaptation to technical progress from 2013, last retrieved on 9.03.2015).

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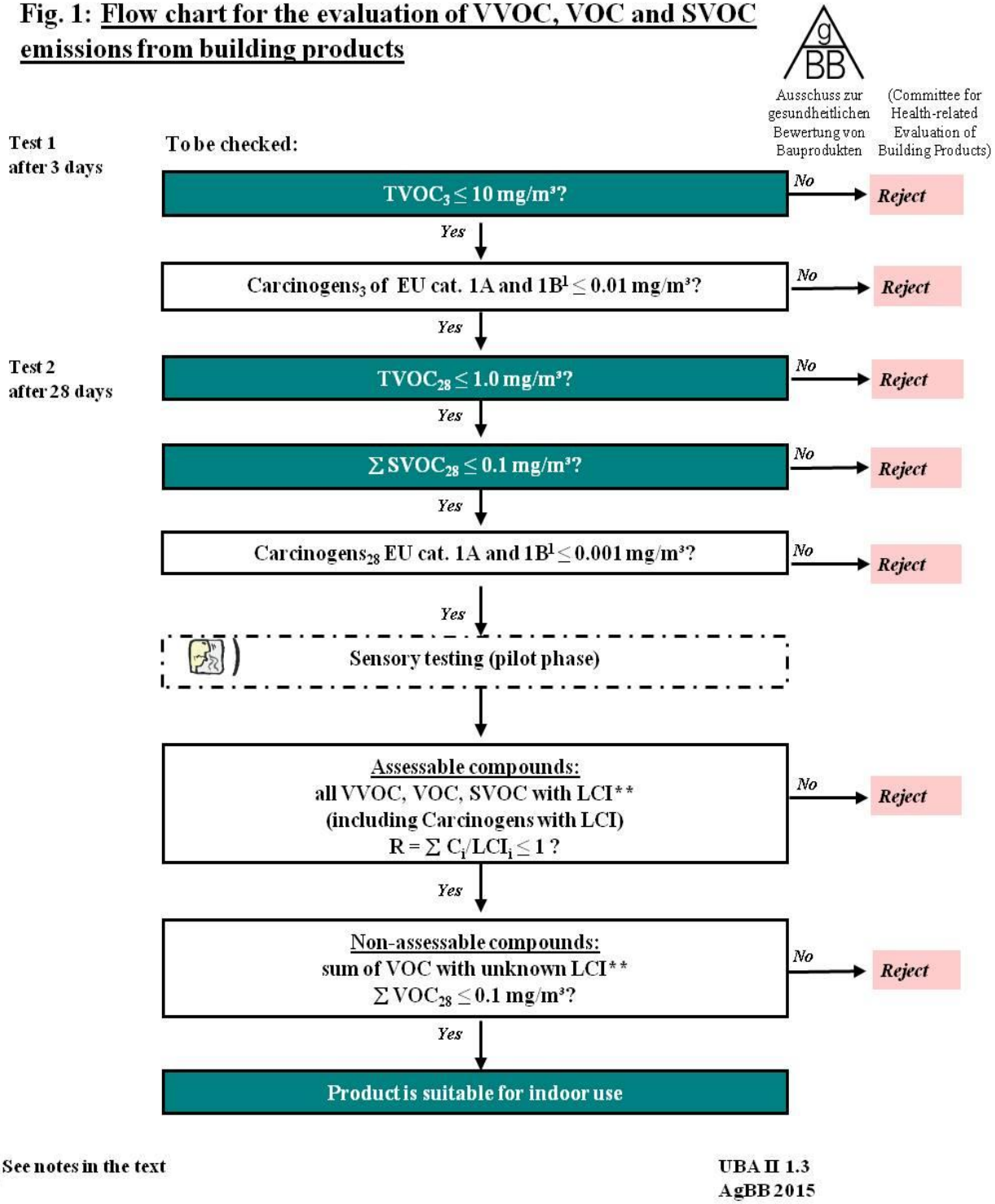
Fig. 1: Flow chart for the evaluation of VVOC, VOC and SVOC emissions from building products



* VVOC: Retention range < C6,
VOC, TVOC: Retention range C6 – C16
SVOC: Retention range C16 – C22
Emission chamber testing according to ISO 16000-9 to -11 supplemented by CEN/TS 16516: 2013

** LCI: Lowest Concentration of Interest (German: NIK)

1 Classification according to Regulation (EC) No 1272/2008 Appendix VI Table 3.1, see notes in the text

6. Annex

Establishing LCI values

6.1 Basic considerations

Volatile organic compounds belong to the most common indoor air pollutants. Building products are important potential indoor sources of volatile organic compounds. German building law requires building products to satisfy certain health-related requirements, among others. This means that their emissions must be reduced to such a level that – assuming long-term occupancy of a room - concentrations in indoor air resulting from such emissions do not pose any threat to the health of sensitive persons even under unfavourable but still realistic assumptions (concerning e.g. product loading factor, air exchange rate and indoor climate conditions). However this requires regular, proper airing (see Section 4.2). The health-related evaluation of emissions from building products is based on the derivation of substance-specific values, the so-called LCI values (Lowest Concentration of Interest). In deriving LCI values, an AgBB working group – complemented by manufacturers' specialists – has, in the past, mainly used existing health-based evaluations of substances at the workplace as a starting point, as proposed by an international expert group [ECA, 1997a].

The criteria for derivation of European LCI values (EU-LCI) are more elaborate and based on a comprehensible rationale. This includes an extensive consideration of current original scientific literature. The reasons for the selection of reference studies are stated and applied safety factors are documented in line with guidance provided by ECHA [ECA 2013; Däumling and Scutaru, 2013]. In order to support the harmonisation of the health-based evaluation of construction product emissions in Europe, AgBB adopts published EU-LCI values into updates of the German LCI list.

LCI values are used solely for evaluating emissions from building products on the basis of test chamber measurements. The derivation methodology and the way LCI values are applied make such values an adequate expression of the criteria required in building regulations to safeguard against health risk caused by volatile organic compounds, bearing in mind that the emissions from building products into indoor air result in multi-compound mixtures.

6.2 Derivation procedure

The derivation procedure of the EU-LCI Working Group is described in detail in ECA Report 29. This procedure and published EU-LCI values will be gradually adopted into the German LCI list.

Should substances have to be newly evaluated for which such values do not yet exist, provisional German LCI values may be defined on the basis of the EU-LCI derivation procedure, stating the reasons for any deviations from this procedure.

Until a list of substances consisting completely of evaluations based on the EU-LCI procedure is in place, the German LCI list will continue to include values which are based on existing assessment values for substances at the workplace, including in particular:

- indicative occupational exposure limit values (EU-IOELV) and binding occupational exposure limit values (EU-BOELV), set by the European Commission,
- occupational exposure limit values (AGW) according to TRGS 900,
- MAK values (maximum concentrations at the workplace), set by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG),
- SCOEL-values or SCOEL-recommendations to the European Commission (SCOEL: Scientific Committee on Occupational Exposure Limits),
- occupational exposure limit values applied in other EU Member States,
- DNEL (derived no-effect level) determined for inhalative occupational exposure under the REACH Regulation,
- TLVs® (threshold limit values) of the American Conference of Governmental Industrial Hygienists (ACGIH),
- WEEL (workplace environmental exposure limit) values of the American Industrial Hygiene Association (AIHA).

Factors are applied to these assessment values to account for the following basic differences between conditions in indoor spaces like homes, kindergartens and schools and those at workplaces:

- continuous exposure in contrast to a changing and regularly interrupted workplace exposure,
- existence of risk groups which are not present at the workplace at all (children, senior citizens) or are particularly protected by occupational health regulations (pregnant women, allergic persons),
- absence of exposure measurements and medical checks, and a generally undefined overall indoor exposure.

A factor of 100 is normally applied to the assessment values for the workplace. A smaller safety factor may be chosen in the case of substances whose irritative effects are predominantly local. An additional factor of 10 should be considered in the case of potential carcinogens classified into EU category 2. Reprotoxic and mutagenic substances are evaluated on a case-by-case basis with regard to the additional factor. For defined carcinogens which are assumed to have a carcinogenicity threshold above that for non-carcinogenic endpoints, LCI values can be established on the basis of the criteria given here. No LCI values are derived for all other substances with demonstrated carcinogenic properties according to EU categories 1A and 1B; these substances are dealt with separately within the AgBB scheme (see Figure 1).

The German LCI list can also continue to include, in justified individual cases, LCI values which are based on:

- indoor air guideline values set by the Ad-hoc working group of the Federal Environment Agency's Indoor Hygiene Commission and the supreme health authorities of the Federal States (in future: Committee for Indoor Air Guideline Values),
- WHO indoor air quality guidelines
- DNELs (derived no-effect levels) determined for long-term inhalative consumer exposure under the REACH Regulation.

If no LCI value can be derived for a substance on the basis of such values, the Working Group considers whether an individual substance assessment can be performed by referring to a substance class with similar chemical structure and comparable toxicological assessment. This "read-across" corresponds to the procedure described in ECA Report 29 [ECA 2013].

Substances which cannot be evaluated are subjected to a strict limitation of their total amount, within the AgBB scheme ("VOC with unknown LCI", see Figure 1).

6.3 Publication

LCI values are exclusively determined by the AgBB's LCI Working Group, whose members also include representatives of industrial associations. The working group meets regularly to discuss LCI values to be added or revised. Its work priorities are determined by need, urgency and data availability. An updated version of the list of LCI values is published[5] at regular intervals and is provided in Table 1 along with brief notes on how the values were derived. Furthermore, at the same internet address[5], currently discussed or agreed changes of LCI values and new substances under consideration are given in the list of prospective LCI value changes for information before the next update. The list of EU-LCIs along with the documents on which they are based as well as a list with the members of the EU-LCI Working Group is available on the internet at www.eu-lci.org.

For substances not yet included in the list of LCI values, manufacturers have the possibility to apply for LCI values to be established by submitting available data to the AgBB. They may also submit substantiated requests for revision of an existing LCI value. An application form is available for download on the Federal Environment Agency's website[5].

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[5] http://www.umweltbundesamt.de/themen/gesundheit/kommissionen-arbeitsgruppen/ausschuss-zur-gesundheitlichen-bewertung-von, last consulted on 19.03.15

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Table 1

List of LCI values

Closing date: December 2014

	Substance	CAS No.	LCI [µg/m³]	Remarks
1	**Aromatic hydrocarbons**			
1-1*	Toluene	108-88-3	**2 900**	Adoption EU-LCI value
1-2*	Ethylbenzene	100-41-4	**850**	Adoption EU-LCI value
1-3*	Xylene, mix of o-, m- and p-xylene isomers	1330-20-7	**500**	Adoption EU-LCI value
1-4*	p-Xylene	106-42-3	**500**	Adoption EU-LCI value
1-5*	m-Xylene	108-38-3	**500**	Adoption EU-LCI value
1-6*	o-Xylene	95-47-6	**500**	Adoption EU-LCI value
1-7*	Isopropylbenzene (cumene)	98-82-8	**500**	MAK: 50 000 µg/m³
1-8*	n-Propyl benzene	103-65-1	**950**	Adoption EU-LCI value
1-9	1-Propenyl benzene (ß-methyl styrene)	637-50-3	**2 400**	Read across from α-methyl styrene
1-10*	1,3,5-Trimethylbenzene	108-67-8	**450**	Adoption EU-LCI value
1-11*	1,2,4-Trimethylbenzene	95-63-6	**450**	Adoption EU-LCI value
1-12*	1,2,3-Trimethylbenzene	526-73-8	**450**	Adoption EU-LCI value
1-13*	2-Ethyltoluene	611-14-3	**550**	Adoption EU-LCI value
1-14*	1-Isopropyl-2-methylbenzene (o-cymene)	527-84-4	**1 000**	Adoption EU-LCI value
1-15*	1-Isopropyl-3-methylbenzene (m-cymene)	535-77-3	**1 000**	Adoption EU-LCI value
1-16*	1-Isopropyl-4-methylbenzene (p-cymene)	99-87-6	**1 000**	Adoption EU-LCI value
1-17*	1,2,4,5-Tetramethylbenzene	95-93-2	**500**	Adoption EU-LCI value
1-18*	n-Butylbenzene	104-51-8	**1 100**	Adoption EU-LCI value
1-19*	1,3-Diisopropylbenzene	99-62-7	**750**	Adoption EU-LCI value
1-20*	1,4-Diisopropylbenzene	100-18-5	**750**	Adoption EU-LCI value
1-21*	Phenyloctane and isomers	2189-60-8	**1 100**	Adoption EU-LCI value
1-22*	1-Phenyldecane and isomers	104-72-3	**1 100**	Read across from ethylbenzene
1-23*	1-Phenylundecane and isomers	6742-54-7	**1 100**	Read across from ethylbenzene
1-24*	4-Phenyl cyclohexene (4-PCH)	4994-16-5	**300**	Read across from styrene
1-25*	Styrene	100-42-5	**250**	Adoption EU-LCI value
1-26*	Phenyl acetylene	536-74-3	**200**	Read across from styrene
1-27	2-Phenylpropene (α-Methylstyrene)	98-83-9	**2 500**	EU-OEL: 246 000 µg/m³
1-28	Vinyl toluene (all isomers: o-, m-, p-methyl styrenes)	25013-15-4	**4 900**	AGW: 490 000 µg/m³
1-29*	Other alkylbenzenes, unless individual isomers have to be evaluated otherwise		**450**	Read across from trimethylbenzenes
1-30	Naphthalene	91-20-3	**5**	AGW: 500 µg/m³
1-31*	Indene	95-13-6	**450**	Adoption EU-LCI value
2	**Aliphatic hydrocarbons (n-, iso- and cyclo-)**			
2-1	3-Methylpentane	96-14-0		VVOC
2-2	n-Hexane	110-54-3	**72**	EU-OEL: 72 000 µg/m³
2-3*	Cyclohexane	110-82-7	**6 000**	Adoption EU-LCI value
2-4*	Methylcyclohexane	108-87-2	**8 100**	Adoption EU-LCI value
2-5	--			[1)]
2-6	--			[1)]
2-7	--			[1)]
2-8	n-Heptane	142-82-5	**21 000**	EU-OEL: 2 085 000 µg/m³
2-9	Other saturated aliphatic		**15 000**	AGW: 1 500 000 µg/m³

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
	hydrocarbons, C6-C8			
2-10*	Other saturated aliphatic hydrocarbons, C9-C16		**6 000**	Adoption EU-LCI value
2-11*	Other saturated aliphatic hydrocarbons, C17-C22		**1 000**	SVOC Individual substance evaluation
3	**Terpenes**			
3-1*	3-Carene	498-15-7	**1 500**	Adoption EU-LCI value
3-2*	α-Pinene	80-56-8	**2 500**	Adoption EU-LCI value
3-3*	ß-Pinene	127-91-3	**1 400**	Adoption EU-LCI value
3-4*	Limonene	138-86-3	**5 000**	Adoption EU-LCI value
3-5*	Other terpene hydrocarbons		**1 500**	Adoption EU-LCI value (This group includes all mono-terpenes, sesquiterpenes and their oxygen containing derivatives)
4*	**Aliphatic mono alcohols (n-, iso- and cyclo) and dialcohols**			
4-1	Ethanol	64-17-5		VVOC
4-2	1-Propanol	71-23-8		VVOC
4-3	2-Propanol	67-63-0		VVOC
4-4*	tert-Butanol (2-methyl-2-propanol)	75-65-0	**620**	Adoption EU-LCI value
4-5	2-Methyl-1-propanol	78-83-1	**3 100**	AGW: 310 000 µg/m³
4-6*	1-Butanol	71-36-3	**3 000**	Adoption EU-LCI value
4-7*	Pentanol (all isomers)	71-41-0 30899-19-5 94624-12-1 6032-29-7 548-02-1 137-32-6 123-51-3 598-75-4 75-85-4 75-84-3	**730**	Adoption EU-LCI value
4-8*	1-Hexanol	111-27-3	**2 100**	Adoption EU-LCI value
4-9*	Cyclohexanol	108-93-0	**2 000**	Adoption EU-LCI value
4-10*	2-Ethyl-1-hexanol	104-76-7	**300**	Adoption EU-LCI value
4-11	1-Octanol	111-87-5	**500**	Individual substance evaluation
4-12*	4-Hydroxy-4-methyl-pentane-2-one (diacetone alcohol)	123-42-2	**960**	Adoption EU-LCI value
4-13	Other saturated n- and iso-alcohols, C4 to C10		**500**	Read across from 1-octanol, saturated cyclic alcohols are excluded
4-14	Other saturated n- and iso-alcohols, C11 to C13		**500**	Read across from 1-octanol, saturated cyclic alcohols are excluded
4-15*	1,4-Cyclohexanedimethanol	105-08-8	**1 600**	Individual substance evaluation
5	**Aromatic alcohols**			
5-1	Phenol	108-95-2	**10**	Individual substance evaluation
5-2*	BHT (2,6-di-tert-butyl-4-methylphenol)	128-37-0	**100**	Adoption EU-LCI value
5-3*	Benzyl alcohol	100-51-6	**440**	Adoption EU-LCI value
6	**Glycols, Glycol ethers, Glycol esters**			
6-1	Propylene glycol (1,2-Dihydroxypropane)	57-55-6	**2 500**	Individual substance evaluation
6-2	Ethanediol (ethylene glycol)	107-21-1	**260**	AGW: 26 000 µg/m³
6-3*	Ethylene glycol monobutylether	111-76-2	**1 100**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
6-4*	Diethylene glycol	111-46-6	**440**	Adoption EU-LCI value
6-5*	Diethylene glycol monobutylether	112-34-5	**670**	Adoption EU-LCI value
6-6*	2-Phenoxyethanol	122-99-6	**1 100**	Adoption EU-LCI value
6-7	Ethylene carbonate	96-49-1	**370**	Read across from ethanediol
6-8	1-Methoxy-2-propanol	107-98-2	**3 700**	AGW: 370 000 µg/m³
6-9*	2,2,4-Trimethyl-1,3-pentane diol monoisobutyrate	25265-77-4	**600**	Adoption EU-LCI value
6-10	Butyl glycolate	7397-62-8	**550**	Read across from ethanediol
6-11*	Diethylene glycol monomethyl ether acetate (BDGA)	124-17-4	**850**	Adoption EU-LCI value
6-12*	Dipropylene glycol monomethyl ether	34590-94-8	**3 100**	Adoption EU-LCI value
6-13	2-Methoxyethanol	109-86-4	**3**[#]	EU-OEL: 3 110 µg/m³
6-14	2-Ethoxyethanol	110-80-5	**8**	EU-OEL: 8 000 µg/m³
6-15*	2-Propoxyethanol	2807-30-9	**860**	Adoption EU-LCI value
6-16*	2-Methylethoxyethanol	109-59-1	**220**	Adoption EU-LCI value
6-17*	2-Hexoxyethanol	112-25-4	**1 400**	Read across from ethylene glycol monobutylether
6-18	1,2-Dimethoxyethane	110-71-4	**4**[#]	Read across from 2-methoxyethanol
6-19	1,2-Diethoxyethane	629-14-1	**10**	Read across from 2-ethoxyethanol
6-20	2-Methoxyethyl acetate	110-49-6	**5**	AGW: 4 900 µg/m³
6-21	2-Ethoxyethyl acetate	111-15-9	**11**	EU-OEL: 11 000 µg/m³
6-22	2-Butoxyethyl acetate	112-07-2	**1 300**	AGW: 130 000 µg/m³
6-23	2-(2-Hexoxyethoxy)-ethanol	112-59-4	**740**	Read across from diethylene glycol-monobutyl ether
6-24*	1-Methoxy-2-(2-methoxy-ethoxy) ethane	111-96-6	**28**	Adoption EU-LCI value
6-25*	2-Methoxy-1-propanol	1589-47-5	**19**	Adoption EU-LCI value
6-26*	2-Methoxy-1-propyl acetate	70657-70-4	**28**	Adoption EU-LCI value
6-27	Propylene glycol diacetate	623-84-7	**5 300**	Read across from propylene glycol
6-28*	Dipropylene glycol	110-98-5 25265-71-8	**670**	Adoption EU-LCI value
6-29	Dipropylene glycol monomethyl ether acetate	88917-22-0	**3 900**	Read across from dipropylene glycol monomethyl ether
6-30	Dipropylene glycol mono-n-propylether	29911-27-1	**740**	Read across from diethylene glycol-monobutyl ether
6-31	Dipropylene glycol mono-n-butylether	29911-28-2 35884-42-5	**810**	Read across from diethylene glycol-monobutyl ether
6-32	Dipropylene glycol mono-t-butylether	132739-31-2 (Mixture)	**810**	Read across from diethylene glycol-monobutyl ether
6-33*	1,4-Butanediol	110-63-4	**2 000**	Adoption EU-LCI value
6-34	Tripropylene glycol monomethyl ether	20324-33-8 25498-49-1	**2 000**	Individual substance evaluation
6-35	Triethylene glycol dimethyl ether	112-49-2	**7**	Read across from 2-methoxy-ethanol
6-36	1,2-Propylene glycol dimethyl ether	7778-85-0	**25**	Read across from 2-methoxy-1-propanol
6-37*	2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	6846-50-0	**450**	Adoption EU-LCI value
6-38*	Ethyldiglycol	111-90-0	**350**	Adoption EU-LCI value
6-39*	Dipropylene glycol dimethyl ether	63019-84-1 89399-28-0 111109-77-4	**1 300**	Adoption EU-LCI value
6-40	Propylene carbonate	108-32-7	**250**	Individual substance evaluation

[#] An evaluation within the framework of the LCI-concept will take place only from a measured concentration of 5 µg/m³.

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
6-41	Hexylene glycol (2-methyl-2,4-pentanediol)	107-41-5	**490**	MAK: 49 000 µg/m³
6-42	3-Methoxy-1-butanol	2517-43-3	**500**	Individual substance evaluation
6-43	1,2-Propylene glycol n-propylether	1569-01-3 30136-13-1	**1 400**	Individual substance evaluation
6-44	1,2-Propylene glycol n-butylether	5131-66-8 29387-86-8 15821-83-7 63716-40-5	**1 600**	Individual substance evaluation
6-45	Diethylene glycol phenylether	104-68-7	**1 450**	Read across from 2-phenoxyethanol
6-46	Neopentyl glycol (2,2-dimethylpropane-1,3-diol)	126-30-7	**1 000**	Individual substance evaluation
7	**Aldehydes**			
7-1*	Butanal	123-72-8	**650**	VVOC Adoption EU-LCI value
7-2*	Pentanal	110-62-3	**800**	Adoption EU-LCI value
7-3*	Hexanal	66-25-1	**900**	Adoption EU-LCI value
7-4*	Heptanal	111-71-7	**900**	Adoption EU-LCI value
7-5*	2-Ethyl-hexanal	123-05-7	**900**	Adoption EU-LCI value
7-6*	Octanal	124-13-0	**900**	Adoption EU-LCI value
7-7*	Nonanal	124-19-6	**900**	Adoption EU-LCI value
7-8*	Decanal	112-31-2	**900**	Adoption EU-LCI value
7-9	2-Butenal (crotonaldehyde, cis-trans-mix)	4170-30-3 123-73-9 15798-64-8	**1**[#]	Individual substance evaluation
7-10	2-Pentenal	1576-87-0 764-39-6 31424-04-1	**12**	Read across from 2-butenal, but no EU classification as mutagen
7-11	2-Hexenal	16635-54-4 6728-26-3 505-57-7 1335-39-3	**14**	Read across from 2-pentenal
7-12	2-Heptenal	2463-63-0 18829-55-5 29381-66-6	**16**	Read across from 2-pentenal
7-13	2-Octenal	2363-89-5 25447-69-2 20664-46-4 2548-87-0	**18**	Read across from 2-pentenal
7-14	2-Nonenal	2463-53-8 30551-15-6 18829-56-6 60784-31-8	**20**	Read across from 2-pentenal
7-15	2-Decenal	3913-71-1 2497-25-8 3913-81-3	**22**	Read across from 2-pentenal
7-16	2-Undecenal	2463-77-6 53448-07-0	**24**	Read across from 2-pentenal
7-17	Furfural	98-01-1	**20**	Individual substance evaluation
7-18	Glutaraldehyde	111-30-8	**2**[#]	AGW: 200 µg/m³
7-19	Benzaldehyde	100-52-7	**90**	WEEL (AIHA): 8 800 µg/m³
7-20*	Acetaldehyde	75-07-0	**1 200**	VVOC Adoption EU-LCI value
7-21	Propanal	123-38-6		VVOC
7-22*	Formaldehyde	50-00-0	**100**	VVOC Individual substance evaluation

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
8	**Ketones**			
8-1*	Ethylmethylketone	78-93-3	**5 000**	Adoption EU-LCI value
8-2*	3-Methylbutanone-2	563-80-4	**7 000**	Adoption EU-LCI value
8-3	Methylisobutylketone	108-10-1	**830**	AGW: 83 000 µg/m³
8-4*	Cyclopentanone	120-92-3	**900**	Adoption EU-LCI value
8-5*	Cyclohexanone	108-94-1	**410**	Adoption EU-LCI value
8-6	2-Methylcyclopentanone	1120-72-5	**1 000**	Read across from cyclopentanone
8-7*	2-Methylcyclohexanone	583-60-8	**2 300**	Adoption EU-LCI value
8-8*	Acetophenone	98-86-2	**490**	Adoption EU-LCI value
8-9	1-Hydroxyacetone (1-Hydroxy-2-propanone)	116-09-6	**2 400**	Read across from propylene glycol
8-10*	Acetone	67-64-1	**1 200**	VVOC AGW: 1 200 000 µg/m³
9	**Acids**			
9-1	Acetic acid	64-19-7	**1 250**	Individual substance evaluation
9-2*	Propionic acid	79-09-4	**310**	Adoption EU-LCI value
9-3	Isobutyric acid	79-31-2	**370**	Read across from propionic acid
9-4	Butyric acid	107-92-6	**370**	Read across from propionic acid
9-5	Pivalic acid	75-98-9	**420**	Read across from propionic acid
9-6	n-Valeric acid	109-52-4	**420**	Read across from propionic acid
9-7	n-Caproic acid	142-62-1	**490**	Read across from propionic acid
9-8	n-Heptanoic acid	111-14-8	**550**	Read across from propionic acid
9-9	n-Octanoic acid	124-07-2	**600**	Read across from propionic acid
9-10*	2-Ethylhexanoic acid	149-57-5	**150**	Adoption EU-LCI value
10	**Esters and Lactones**			
10-1	Methyl acetate	79-20-9		VVOC
10-2	Ethyl acetate	141-78-6		VVOC
10-3*	Vinyl acetate	108-05-4		VVOC
10-4*	Isopropyl acetate	108-21-4	**4 200**	Adoption EU-LCI value
10-5*	Propyl acetate	109-60-4	**4 200**	Adoption EU-LCI value
10-6*	2-Methoxy-1-methylethyl acetate	108-65-6	**2 700**	Adoption EU-LCI value
10-7	n-Butyl formiate	592-84-7	**2 000**	Read across from methyl formiate (AGW: 120 000 µg/m³)
10-8	Methyl methacrylate	80-62-6	**2 100**	AGW: 210 000 µg/m³
10-9	Other methacrylates		**2 100**	Read across from methyl methacrylate
10-10*	Isobutyl acetate	110-19-0	**4 800**	Adoption EU-LCI value
10-11*	1-Butyl acetate	123-86-4	**4 800**	Adoption EU-LCI value
10-12*	2-Ethylhexyl acetate	103-09-3	**350**	Read across from 2-ethyl-1-hexanol
10-13*	Methyl acrylate	96-33-3	**180**	Adoption EU-LCI value
10-14*	Ethyl acrylate	140-88-5	**210**	Adoption EU-LCI value
10-15*	n-Butyl acrylate	141-32-2	**110**	Adoption EU-LCI value
10-16*	2-Ethylhexyl acrylate	103-11-7	**380**	Adoption EU-LCI value
10-17*	Other acrylates (acrylic acid ester)		**110**	Adoption EU-LCI value
10-18*	Dimethyl adipate	627-93-0	**50**	Adoption EU-LCI value
10-19*	Dibutyl fumarate	105-75-9	**50**	Adoption EU-LCI value
10-20*	Dimethyl succinate	106-65-0	**50**	Adoption EU-LCI value
10-21*	Dimethyl glutarate	1119-40-0	**50**	Adoption EU-LCI value
10-22*	Hexamethylene diacrylate	13048-33-4	**10**	Adoption EU-LCI value
10-23*	Maleic acid dibutylester	105-76-0	**50**	Adoption EU-LCI value
10-24	Butyrolactone	96-48-0	**2 700**	Individual substance evaluation
10-25	Diisobutyl glutarate	71195-64-7	**100**	Individual substance evaluation
10-26	Diisobutyl succinate	925-06-4	**100**	Individual substance evaluation

	Substance	CAS No.	LCI [µg/m³]	Remarks
11	**Chlorinated hydrocarbons**			
	currently not occupied			
12	**Others**			
12-1	1,4-Dioxane	123-91-1	**73**	AGW: 73 000 µg/m³
12-2*	Caprolactam	105-60-2	**300**	Adoption EU-LCI value
12-3*	N-Methyl-2-pyrrolidone	872-50-4	**400**	EU-OEL: 40 000 µg/m³
12-4*	Octamethylcyclotetrasiloxane	556-67-2	**1 200**	Adoption EU-LCI value
12-5*	Hexamethylenetetramine	100-97-00	**30**	Adoption EU-LCI value
12-6	2-Butanonoxime	96-29-7	**20**	Individual substance evaluation
12-7	Tributyl phosphate	126-73-8		SVOC
12-8	Triethyl phosphate	78-40-0	**75**	Read across from tributyl phosphate (MAK: 11 000 µg/m^3)
12-9*	5-Chloro-2-methyl-2H-isothiazol-3-one (CIT)	26172-554	**1**$^{\#}$	Adoption EU-LCI value
12-10*	2-Methyl-4-isothiazoline-3-on (MIT)	2682-20-4	**100**	Adoption EU-LCI value
12-11	Triethylamine	121-44-8	**42**	AGW: 4 200 µg/m³
12-12	Decamethylcyclopentasiloxane (D5)	541-02-6	**1 500**	Read across from octamethyl-cyclotetrasiloxane
12-13	Dodecamethylcyclohexasiloxane (D6)	540-97-6	**1 200**	Read across from octamethyl-cyclotetrasiloxane
12-14	Tetrahydrofuran	109-99-9	**1 500**	AGW: 150 000 µg/m³
12-15*	Dimethylformamide	68-12-2	**15**	AGW: 15 000 µg/m³
12-16*	Tetradecamethylcycloheptasiloxane (D7)	107-50-6	**1 200**	Read across from octamethyl-cyclotetrasiloxane
12-17*	N-Ethyl-2-pyrrolidone	2687-91-4	**430**	Individual substance evaluation

*: new or altered in 2015

$^{\#}$: An evaluation within the framework of the LCI-concept will take place only at and above a measured concentration of 5 µg/m³.

VVOC very volatile organic compounds

SVOC semi volatile organic compounds

1) In order to maintain compatibility with the ADAM template, assigned numbers in the LCI list cannot be reassigned when a substance or a group of substances has been deleted or moved to another place.

Additional remarks:

I) Links to current lists of carcinogenic substances (EU category 1):

The links below lead to lists of substances which are classified as Category 1A or 1B carcinogens under EU Regulation 1272/2008 and have to be evaluated under the AgBB scheme (please make sure lists are up to date):.

- Institute for Occupational Safety and Health of the German Social Accident Insurance http://www.dguv.de/ifa/de/fac/kmr/index.jsp
- ECHA, European Chemicals Agency http://echa.europa.eu/web/guest/information-on-chemicals/cl-inventory-database

II. Data treatment

A software tool (ADAM, AgBB-DIBt-Auswerte-Maske) has been developed for the collection and storage of emissions data and the calculation of the test result. This software can be obtained from the DIBt (contact DIBt, Kolonnenstr. 30B, 10829 Berlin, phone +49(0)30 78730-353, fax +49(0)30 78730-11353).

III. Analysis of aldehydes

Determination of the emission of some saturated and unsaturated aldehydes of Group 7 of the LCI list by gas chromatography poses problems in the concentration range of interest. For example, in the case of butenal and glutaraldehyde, the ratio of the limit of quantification and the LCI value is very small if the GC/MS method with Tenax thermodesorption (DIN ISO 16000-6) is applied, and the method is only suitable to a limited extent for quantitative determination of butenal. Therefore, the DNPH method with HPLC analysis (DIN ISO 16000-3) should be used for determination of butenal and glutaraldehyde; the limits of quantification are around 2 µg/m^3.

Use of the DNHP method enables the quantitative determination not only of aldehydes belonging to the class of VOC, but also of some VVOC such as formaldehyde, acetaldehyde, butyraldehyde and acetone.

IV **Analysis of saturated aliphatic hydrocarbons (LCI 2-9 and LCI 2-10)**

Subdividing this group of compounds is necessary because of their different LCI. It is based on the appearance of an "alkane hump" in the gas chromatogram at the retention time of n-nonane, i.e. an LCI of 15 000 µg/m^3 applies to aliphatic hydrocarbons with a retention time shorter than that of n-nonane and an LCI of 6 000 µg/m^3 to aliphatic hydrocarbons with a retention time equal to or exceeding that of n-nonane.

The allocation of individual peaks of saturated aliphatic hydrocarbons which cannot be identified exactly shall also be based on the retention time of n-nonane.