Ausschuss zur gesundheitlichen Bewertung von Bauprodukten

Committee for Health-related Evaluation of Building Products

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Updated List of LCI values 2018 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.

Requirements for the Indoor Air Quality in Buildings: Health-related Evaluation Procedure for Emissions of Volatile Organic Compounds (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 change rate and relative humidity) and by potential indoor air pollutants. Such pollutants may be emitted from a variety of sources. Among these sources, building products are of particular importance since their selection is often not within the occupants' choice and many of them cover large surface areas in a room.

Renovation and construction measures carried out under the legal requirements of the energy efficiency of buildings (Energy Saving Ordinance, EnEV 2015) must ensure that a healthy indoor air quality is guaranteed for room occupants during the use phase. To prevent draught as well as heat and energy losses, the shell of energy-efficient buildings is often so airtight that the air change necessary for reasons of hygiene is not achieved. The results are humidity and pollution load of the indoor air by volatile organic compounds. Unless sufficient air exchange takes place, room occupants 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 mechanical ventilation systems) by architects or planners is a mandatory requirement and to be implemented by building operators .

Healthy indoor air as an objective in building regulations
In Germany, the use of building products is subject to the provisions of the building regulations of the Federal States (Länder). These provisions require built structures to 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, 2016]). Building products used in the construction or integrated into 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).

On 4 April 2011, Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 setting out harmonised conditions for marketing 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 German Federal States' (Länder) building regulations and the EU Construction Products Regulation is to protect the occupants health. "Hygiene, Health and Environment" are among the basic requirements for construction works that must be ensured in the form of "essential characteristics" of the installed construction products. The Regulation allows EU Member States in their national regulations to require that the health of building occupant must not be endangered. The essential characteristics of building products must be disclosed in the declaration of performance. Whether the current level of requirements in Germany has been met has to be checked before use in indoor spaces [MBO, 2016; MVV TB 2017). In this context, the prevention and control of indoor pollutants, e.g. volatile organic compounds (VOC) is explicitly covered (Annex I, Construction Products Regulation (No 305/2011)).

The European Union recognised the inadequate implementation of essential requirements for building products regarding health protection, so issued a mandate to CEN in 2005. The mandate[1] envisaged the development of horizontal assessment methods for dangerous substances incorporated in and emission from building products. For this purpose, CEN 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 and for European Technical Assessments. As a result of the standardisation work, the EN 16516:2018-01: Construction products – Assessment of the release of dangerous substances – Determination of emissions into indoor air, was published. This standard is also used in national approvals for evaluating emissions of volatile organic compounds.

AgBB tasks for ensuring a healthy indoor air quality in built structures

The Committee for Health-related Evaluation of Building Products, *AgBB*[2] *(Ausschuss für die gesundheitliche Bewertung von Bauprodukten)* was mandated by the Gesundheits- and Bauministerkonferenz to create the fundamentals for developing building regulations for protection against indoor health risks. AgBB considers the establishment of fundamentals that are traceable and objective as one of its main tasks for a uniform health-related assessment of building products which satisfies the requirements specified in the building regulations of the German Federal States (Länder) and the European Construction Products Regulation. The

[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.

[2] Composed of representatives of the health authorities of the Federal States (*Länder)*, the German 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 Bundesanstalt für Materialforschung und – prüfung (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)

AgBB also supports efforts to harmonise the health assessment of emissions from building products in Europe [ECA 27, 2012; ECA 29, 2013].

The Committee has developed a scheme for health-related evaluation of VOC emissions from building products used for indoors application [AgBB, 2000]. Within this scheme, volatile organic compounds include compounds within the retention range of C_6 to C_{16} (n-hexane up to and including n-hexadecane), which are considered both as individual substances and as a sum parameter following the TVOC concept (TVOC = Total Volatile Organic Compounds). It also includes 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 [ECA 18, 1997a; ECA 19, 1997b].

The scheme was extensively discussed with representatives of manufacturers and professionals after having been first published 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 (Deutsches Institut für Bautechnik (DIBt)) incorporated the evaluation scheme into its approval guidelines for the health-related evaluation of building products [DIBt, 2004, 2010]. From 2017, the AgBB evaluation scheme has become the basis for the "Health protection requirements for physical structures" (German: „Anforderungen an bauliche Anlagen bezüglich des Gesundheitsschutzes (ABG)"). The ABG were published in 2017 as part of the Model Administrative Provisions - Technical Building Rules (MVV TB) and have been successively adopted by the German Federal States (Länder) (as of January 2018).

The minimum requirements of the aforementioned building regulations for health protection with regard to VOC emissions can be met by adhering to the test values set in the scheme. Nevertheless, the scheme also endorses manufacturers' initiatives to produce products with lower emissions [Däumling, 2012]. Manufacturers can therefore declare better performance parameters (VOC emissions) for their products, e.g. by means of labels [ECA 24, 2005; ECA 27, 2012].

2 Scientific fundamentals for the health-related evaluation of volatile organic compounds emitted from building products

Literature about the effects of indoor air pollution on human health is extensive [see e.g. ECA 10, 1991b; WHO, 2000, 2010; Ad-hoc, 2007]. Acute and/or long-term effects of volatile organic compounds may range from odour perception and irritation of the mucous membranes of the eyes, nose and throat to systemic effects. This also includes effects on the nervous system, allergenic or allergy promoting and carcinogenic, mutagenic or reprotoxic properties.

National and international bodies, in particular the European Collaborative Action (ECA) "Indoor Air Quality and its Impact on Man", 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 that contain sufficiently detailed information to be considered as 'pre-normative' documents. One of them is Report No 18 "Evaluation of VOC Emissions from Building Products" in which a flow chart describing the procedure for evaluation of emissions from floor coverings is given as an example [ECA 18, 1997a].

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 from the individual substance (LCI – lowest concentration of interest for the individual substance).

The most comprehensive evaluation system for chemical substances is available for the workplace in the form of occupational exposure limit values (OELs). However, where hazardous substances are handled under typical conditions in workplaces, much higher substance concentrations than under indoor living conditions are generally encountered. In addition, 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 18, 1997a]. A pragmatic approach based on these considerations has until now been applied in the evaluation of building products as one procedure 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. 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 harmonised list of LCI values for some 115 substances [ECA 29, 2013; https://ec.europa.eu/growth/sectors/construction/eu-lci_en]. AgBB usually adopts published EU-LCI values into updates of the German LCI list (see Annex 6) in order to support the harmonisation of the health-based evaluation of building product emissions in Europe.

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) [Seifert, 1999; Ad-hoc, 2007; ECA 27, 2012; DIN ISO 16000-6, 2012; EN 16516, 2018].

The R-value is the hazard index for assessing combination effects of substances in the substance mixture formed in indoor air from VOC emitted by a building product. It is based on the recommendation of the European expert group European Collaborative Action on Man in the ECA report no. 18 and confirmed in the ECA report no. 29 [ECA 18, 1997a; ECA 29, 2013]. The Scientific Committee on Health and Environmental risks, SCHER, of the European Commission Directorate-General Health and Consumers argued for the health relevance of combination effects in its opinion on indoor air quality and for the necessity to assess them with such an additive approach in 2007 [SCHER, 2007]. The same conclusion was drawn in 2012 in the opinion on toxicity and assessment of substance mixtures by the three acknowledged scientific committees SCHER, SCCS and SCENIHR assigned by the Directorate General Health and Consumers [SCHER/SCENIHR/SCCS, 2012]

The scientific background for the TVOC concept that distinctly shows a concentration dependency for health effects caused by the sum of defined volatile organic compounds [ECA 19, 1997b; Ad-hoc, 2007] is acknowledged in controlled human studies and epidemiological research. In order to avoid an unlimited total concentration of substance emissions and thus to

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

protect against adverse health effects, the relevant ECA reports stipulate an upper limit for TVOC as a minimum requirement for adequate health protection.

3 Sensory testing

Emissions from building products are often associated with the perception of odours which may result in annoyance and health impairment. Sensory testing is therefore an important element in 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 20, 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 Part 1] and an international [ISO 16000-28] standard.

Based on current knowledge on sensory testing using the test chamber method according to ISO 160000-28, it is now possible to determine and objectively evaluate odour emissions from building products using the parameters of perceived intensity and hedonic note within the AgBB evaluation scheme. In order to gain further experience by applying the test method to different building products, the AgBB conducted a pilot phase for sensory testing between 2012 and 2015. The aim of the pilot phase was to examine different building products, test the applicability of the proposed method and carry out two interlaboratory comparisons in cooperation with representatives of relevant industrial associations, manufacturers and test laboratories. Studies by the Fraunhofer Wilhelm-Klauditz-Institute (WKI in Braunschweig) showed that the ISO 16000-28 (version December 2012) does not satisfactorily describe the measurement method [WKI, 2016]. During the pilot phase, BAM carried out two interlaboratory comparison tests, the first taking into account ISO 16000-28 and the standard VDI 4302 part 1 and in the second test, a standard operating procedure [UBA Texte 2014 and 2015]. 8 and 11 test laboratories respectively participated successfully in the interlaboratory comparisons. BAM conducted the next regular interlaboratory comparisons on VOC and sensory testing in 2016. 14 test laboratories participated successfully and the results were comparable to the previous tests.

The findings of the pilot phase can be used to specify the ISO 16000-28 through additional measurement requirements. With these additional specifications, the measurement procedure is suitable for assessing the perceived intensity. The necessary revision of the ISO 16000-28 is currently in progress.

Use of low-odour building products is a prerequisite for low-odour indoor spaces. According to Article 13 of the MBO, buildings must be designed and be fit for use in such a way that due to (…) chemical, physical or biological impacts hazards or unacceptable nuisance shall not result. The AgBB considers it an unacceptable nuisance when more than 30% of an untrained, large group of people interviewed rate the odour of building products as unacceptable. Based on such interviews [UBA Texte, 2011] and from health and hygiene perspectives, the AgBB sets the perceived intensity of 7 pi as a preliminary assessment criterion for the sensory testing of a building product. So far, only a few studies have investigated odour emissions from building products and odour intensity of the indoor air resulting from the installation of various building products [UBA Texte, 2011 and 2017].

For the time being, the AgBB recommends sensory testing of building products to be conducted on voluntary basis. The AgBB also recommends continuing the investigation of the effects of odour-intensive building products on the odour load of indoor spaces.

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 standardised test chambers. Important parameters that have an influence on the result are temperature, air change 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 interlaboratory comparisons [ECA 13, 1993; ECA 16, 1995]. Based on the results of these tests and an earlier publication on the test procedure [ECA 8, 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, sample storage and preparation of test specimens. The EN 16516:2018-01 further specifies the test conditions in order to improve measurement reliability and reproducibility. Within the evaluation of volatile organic compounds emissions under the AgBB scheme, the total volatile organic compounds (TVOC) must be determined as described in chapter 8.2.6.1 paragraph 2: sum of all volatile organic compounds (target compounds[4] and non-target compounds[4], identified and non-identified compounds), $TVOC_{spez}$.

4.2 Structural conditions and exposure scenarios

Room occupants are exposed to volatile organic compounds in buildings due to emissions from building products. Generally, the substances are absorbed during breathing (by inhalation). Health-related evaluation of a building product is based on the indoor air concentrations of volatile organic compounds emitted from that product. The evaluation cannot be carried out using only 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 change rate and the emitting surface area of the building product to be installed in the room.

Under current German building regulations, 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 (e.g. produced by cooking or washing) as well as odours and emissions out of indoor spaces and create the prerequisites for a healthy indoor climate.

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[4] Target compounds are the substances listed in the LCI list in Table 1 of this document.
Non-target compounds are substances without LCI values.

In order to take both energy and air quality aspects sufficiently into account, the health-related assessment in the AgBB scheme applies for a minimum air change rate of 0.5/h [DIN 1946-6]. This air change rate also applies for the reference room according to the EN 16516:2018-01. The air change rate of 0.5/h defined in the AgBB scheme presupposes regular (several times during the day) ventilation if no ventilation system exists. This is necessary to prevent harmful consequences in terms of hygiene. Increased intensive airing by the occupants is necessary and especially after the 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 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 change rates in these buildings. From the perspective of indoor air quality, an air change rate of 0.5/h remains the minimum air change rate target for all buildings, both 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 change 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 change 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 that 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.

These loading factors correspond to the specifications in the EN 16516:2018-01.

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 use suggests 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 and documented clearly for the user.

The reference room in the AgBB scheme and EN 16516:2018-01 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 "Health protection requirements for physical structures" (German: „Anforderungen an bauliche Anlagen bezüglich des Gesundheitsschutzes (ABG)", Model Administrative Provisions - Technical Building Rules (MVV TB), [MVV TB, 2017]). They may also include criteria definition for anticipated termination of the emission measurement. In principle, anticipated termination of the test is allowed no earlier than 7 days after placing the test specimen into the chamber. The prerequisite for this is 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.

The determination of organic compounds in the vapour phase of the test chamber air shall be carried out in accordance with EN 16516. Quantification of the identified substances with LCI values and carcinogenic substances has to be done using their individual calibration factors. The quantification of the identified substances without LCI values and non-identified ("unknown") substances has to be carried out based on toluene equivalents (see EN 16516).

The following definitions apply in the AgBB scheme:
VVOC: all individual substances within the retention range < C_6
VOC: all individual substances within the retention range C_6 - C_{16}
$TVOC_{spez}$[5]: sum of the concentration of all individual substances with concentrations equal to or greater than 5 µg/m³ within the retention range C_6 - C_{16} (between n-hexane and up to and including n-hexadecane)
SVOC: all individual substances within the retention range > C_{16} - C_{22}
TSVOC: 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}.

Determination of the $TVOC_{spez}$ has to be carried out as described in chapter 8.2.6.1 paragraph 2 of the EN 16516: "the sum of all identified target compounds (quantified using authentic standards) plus all identified non-target compounds and non-identified compounds (quantified using the TIC response factor for toluene) eluting in a defined section of the chromatogram, after correcting for blank values of the respective compounds quantified in the same way".

In the AgBB scheme, the identification of all individual substances is based on a presumed uniform detection limit of 1 µg/m³ in order to qualitatively cover the emission spectrum as fully as possible. It is desirable to aim for a high degree of identification in order to enable an individual substance evaluation.

All individual substances have to be quantified as required and need to be considered individually and in summation if their concentration is equal to or greater than 5 µg/m³.

[5] The ABG states (p. 261 of the MVV TB, 2017): $TVOC_{spez}$ (total volatile organic compounds) is the total concentrations of substance-specific target compounds (LCI substances) and non-identified concentrations quantified using the toluene equivalent and non-target compounds with individual concentrations of 5 µg/m³ and above.

Exceptions apply to carcinogenic substances belonging to EU categories 1A and 1B according to the GHS system (Regulation (EC) No 1272/2008 Annex VI Table 3.1) (see 4.3.1).

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

4.3.1 Measurement and testing after 3 days

- $TVOC_{spez3}$

A product satisfies the criteria if the $TVOC_{spez}$ value after 3 days ($TVOC_{spez3}$) 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 tested at this initial 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.

4.3.2 Measurement and testing after 28 days

- $TVOC_{spez28}$

In order to assess the long-term behaviour of the VOC emissions from a building product, the $TVOC_{spez}$ value is determined again after 28 days. A product satisfies the criteria if the $TVOC_{spez28}$ value is ≤ 1.0 mg/m³. Products with a $TVOC_{spez28}$ value higher than that are rejected.

- Semi volatile organic compounds (SVOC)

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

A product satisfies the criteria if the sum of the SVOC (TSVOC) concentrations in the chamber air does not exceed 0.1 mg/m³. This corresponds to an additional content of 10 % of the maximum allowable $TVOC_{spez28}$ concentration of 1.0 mg/m³. Higher concentrations result in rejection.

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 total value for SVOC of 0.1 mg/m^3 after 28 days. The sum of $TVOC_{spez28}$ 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

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

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 $TVOC_{spez28}$ value.

- Carcinogenic substances

The emission of carcinogenic substances in EU categories 1A and 1B is measured again with an emphasis on the long-term behaviour from the occupant'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

Sensory testing for perceived intensity is firstly performed after 28 days on a voluntary basis. The perceived intensity is determined by a trained panel (ISO 16000-28:2012 chapter 10.3 and additional specifications in accordance with VDI 4302 Part 1). Sensory testing is considered passed if an odour intensity of 7 pi is not exceeded.

- Evaluation of individual substances

In addition to evaluating the emissions of a product via the $TVOC_{spez}$ 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 LCI values 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, additive effects are assumed and then 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 non-assessable VOC, a limit is set for those VOC which cannot be identified or do not have a LCI value. This limit equals 10 % of the permitted $TVOC_{spez28}$ 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). Irrespective of this, if the building product has passed the sensory testing, this must be documented additionally and separately.

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- 1. Fachgespräch zur Vorgehensweise bei der gesundheitlichen Bewertung der Emissionen von flüchtigen organischen Verbindungen aus Bauprodukten (1st technical dialogue on the procedure for the health-related evaluation of emissions of volatile organic compounds from building products). Umweltbundesamt 2001. (http://www.umweltbundesamt.de/service/termine/agbb-fachgespraech-zur-emissionsmessung-von, last retrieved on 9.02.2018).
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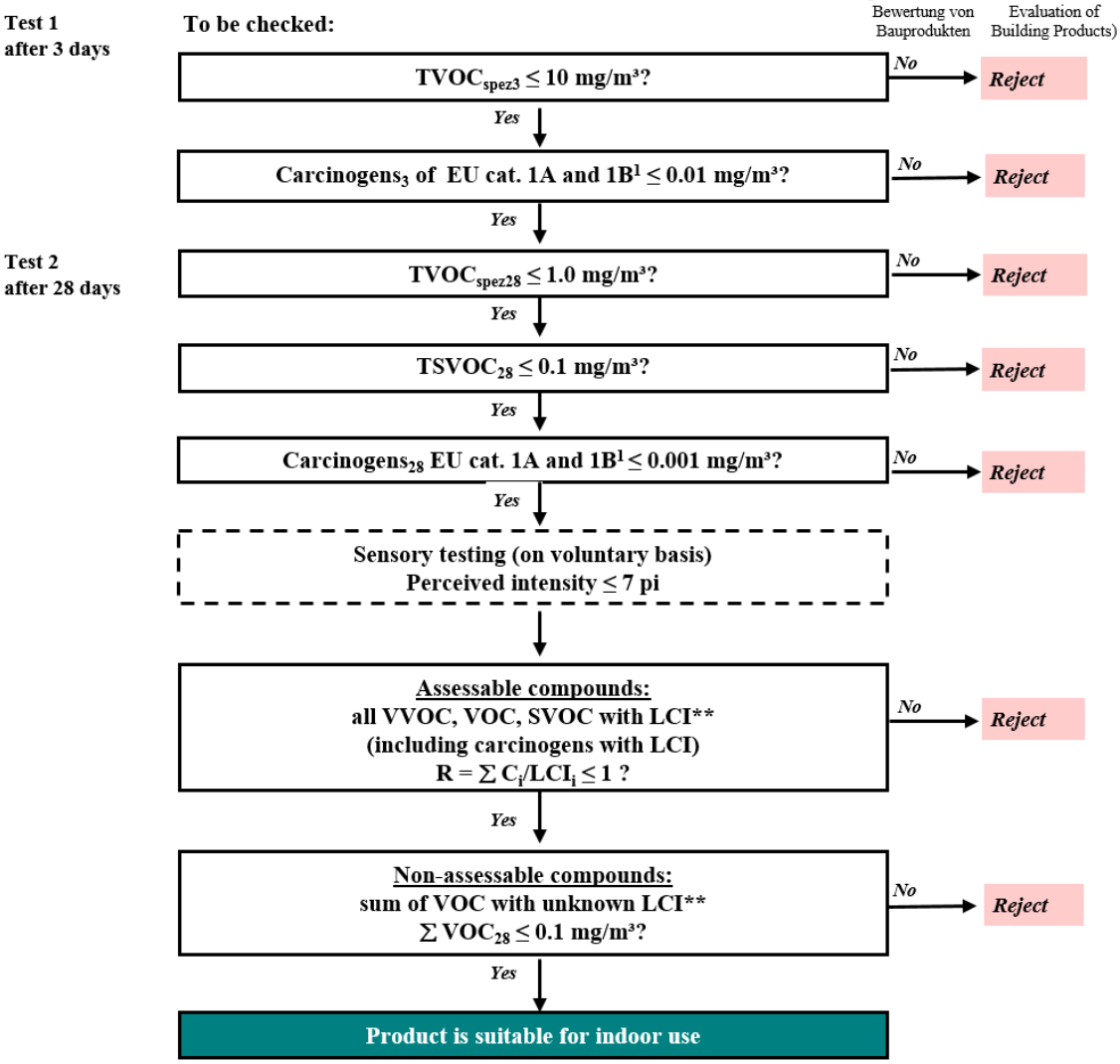
Fig. 1: Flow chart for the evaluation of VVOC, VOC and SVOC emissions from building products

Ausschuss zur gesundheitlichen Bewertung von Bauprodukten (Committee for Health-related Evaluation of Building Products)



* VVOC: retention range < C6, VOC, TVOC: retention range C6 – C16, SVOC: retention range C16 – C22 Emission chamber testing according to EN 16516:2018-01 — UBA II 1.3 AgBB 2018

** 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 https://www.umweltbundesamt.de/en/topics/health/commissions-working-groups/committee-for-health-related-evaluation-of-building

6. Annex

Establishing LCI values

6.1 Basic considerations

Volatile organic compounds are significant indoor air pollutants. German building regulations requires building products, which are important potential indoor sources of volatile organic compounds, to satisfy certain health-related requirements. 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 change rate and indoor climate conditions). Here it is a precondition that regular ventilation is carried out (see Section 4.2). The health-related evaluation of emissions from building products is based on the derivation of substance-specific values, the LCI values (Lowest Concentration of Interest).

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

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 proposed by an international expert group [ECA 18, 1997a] as a starting point.

At present, the criteria used for derivation of European LCI values (EU-LCI) require 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 29, 2013; Däumling and Scutaru, 2013; https://ec.europa.eu/growth/sectors/construction/eu-lci_en]. In order to support the harmonisation of the health-based evaluation of building product emissions in Europe, AgBB usually adopts published EU-LCI values into updates of the German LCI list. Deviations are justified.

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 that are based on existing assessment values for substances in the workplace or on individual substance evaluations (see AgBB evaluation scheme until 2015[6]).

Should substances for which EU-LCI values do not yet exist have to be newly evaluated, German LCI values may be set on the basis of the EU-LCI derivation procedure, stating the reasons for any deviations from this procedure. If necessary, a revision of German LCI values can be carried out according to the EU-LCI derivation procedure.

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6 https://www.umweltbundesamt.de/en/topics/health/commissions-working-groups/committee-for-health-related-evaluation-of-building

If no LCI value can be derived for a substance due to insufficient data, 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 29, 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).

For substances not yet included in the list of LCI values, manufacturers can 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 German Environment Agency's website[6].

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[6] 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[6], 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-LCI values 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 at https://ec.europa.eu/growth/sectors/construction/eu-lci_en.

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(http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000L0039&rid=5, last retrieved on 2.08.2018).

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Table 1

List of LCI values

Closing date: July 2018

	Substance	CAS No.	LCI [µg/m³]	Remarks
1	**Aromatic hydrocarbons**			
1-1	Toluene	108-88-3	**2900**	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	**1700**	Adoption EU-LCI value
1-8	n-Propyl benzene	103-65-1	**950**	Adoption EU-LCI value
1-9	1-Propenyl benzene (ß-methyl styrene)	637-50-3	**2400**	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	**1000**	Adoption EU-LCI value
1-15	1-Isopropyl-3-methylbenzene (m-cymene)	535-77-3	**1000**	Adoption EU-LCI value
1-16	1-Isopropyl-4-methylbenzene (p-cymene)	99-87-6	**1000**	Adoption EU-LCI value
1-17*	1,2,4,5-Tetramethylbenzene	95-93-2	**250**	Adoption EU-LCI value
1-18	n-Butylbenzene	104-51-8	**1100**	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	**1100**	Adoption EU-LCI value
1-22	1-Phenyldecane and isomers	104-72-3	**1100**	Read across from ethylbenzene
1-23	1-Phenylundecane and isomers	6742-54-7	**1100**	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	**1200**	Adoption EU-LCI value
1-28*	Vinyl toluene (all isomers: o-, m-, p-methylstyrenes)	25013-15-4	**1200**	Adoption EU-LCI value
1-29	Other alkylbenzenes, unless individual isomers have to be evaluated otherwise		**450**	Read across from trimethylbenzenes
1-30*	Naphthalene	91-20-3	**10**	Adoption EU-LCI value
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	**4300**	Adoption EU-LCI value
2-3	Cyclohexane	110-82-7	**6000**	Adoption EU-LCI value
2-4	Methylcyclohexane	108-87-2	**8100**	Adoption EU-LCI value
2-5	--			[1)]
2-6	--			[1)]
2-7	--			[1)]
2-8*	n-Heptane	142-82-5	**15000**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
2-9*	Other saturated aliphatic hydrocarbons, C6-C8		**14000**	Adoption EU-LCI value
2-10	Other saturated aliphatic hydrocarbons, C9-C16		**6000**	Adoption EU-LCI value
2-11	Other saturated aliphatic hydrocarbons, C17-C22		**1000**	SVOC Individual substance evaluation
2-12*	1-Dodecene	112-41-4	**750**	Individual substance evaluation
3	**Terpenes**			
3-1	3-Carene	498-15-7	**1500**	Adoption EU-LCI value
3-2	α-Pinene	80-56-8	**2500**	Adoption EU-LCI value
3-3	ß-Pinene	127-91-3	**1400**	Adoption EU-LCI value
3-4	Limonene	138-86-3	**5000**	Adoption EU-LCI value
3-5	Other terpene hydrocarbons		**1500**	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	**11000**	Adoption EU-LCI value
4-6	1-Butanol	71-36-3	**3000**	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	**2100**	Adoption EU-LCI value
4-9	Cyclohexanol	108-93-0	**2000**	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	**1700**	Adoption EU-LCI value
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			Revaluation, see 4-16 and 4-17
4-14*	Other saturated n- and iso-alcohols, C11 to C13			Revaluation, see 4-16 and 4-17
4-15	1,4-Cyclohexanedimethanol	105-08-8	**1600**	Individual substance evaluation
4-16*	Other saturated n-alcohols, C7 to C13		**1700**	Read across from 1-octanol, saturated cyclic alcohols are excluded
4-17*	Other saturated iso-alcohols, C6 to C13		**300**	Read across from 2-ethyl-1-hexanol, saturated cyclic alcohols are excluded

	Substance	CAS No.	LCI [µg/m³]	Remarks
5	**Aromatic alcohols**			
5-1*	Phenol	108-95-2	**70**	Adoption EU-LCI value
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	**2100**	Adoption EU-LCI value
6-2*	Ethanediol (ethylene glycol)	107-21-1	**3400**	Adoption EU-LCI value
6-3*	Ethylene glycol monobutylether	111-76-2	**1600**	Adoption EU-LCI value
6-4*	Diethylene glycol	111-46-6	**5700**	Adoption EU-LCI value
6-5	Diethylene glycol monobutylether	112-34-5	**670**	Adoption EU-LCI value
6-6*	2-Phenoxyethanol	122-99-6	**60**	Adoption EU-LCI value
6-7*	Ethylene carbonate	96-49-1	**4800**	Read across from ethanediol
6-8*	1-Methoxy-2-propanol	107-98-2	**7900**	Adoption EU-LCI value
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		Reevaluation
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	**3100**	Adoption EU-LCI value
6-13	2-Methoxyethanol	109-86-4	**3**[#]	EU-OEL: 3 110 µg/m³; Adoption of EU-LCI value is under discussion
6-14	2-Ethoxyethanol	110-80-5	**8**	EU-OEL: 8 000 µg/m³; Adoption of EU-LCI value is under discussion
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	**2000**	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; Adoption of EU-LCI value is under discussion
6-22*	2-Butoxyethyl acetate	112-07-2	**2200**	Adoption EU-LCI value
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	**1600**	Adoption EU-LCI value
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	**3900**	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

[#] 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**
6-31	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	**2000**	Adoption EU-LCI value
6-34*	Tripropylene glycol monomethyl ether	20324-33-8 25498-49-1	**1200**	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	Ethyl diglycol	111-90-0	**350**	Adoption EU-LCI value
6-39	Dipropylene glycol dimethyl ether	63019-84-1 89399-28-0 111109-77-4	**1300**	Adoption EU-LCI value
6-40*	Propylene carbonate	108-32-7	**1000**	Individual substance evaluation
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	**1400**	Individual substance evaluation
6-44	1,2-Propylene glycol n-butylether	5131-66-8 29387-86-8 15821-83-7 63716-40-5	**1600**	Individual substance evaluation
6-45*	Diethylene glycol phenylether	104-68-7	**80**	Read across from 2-phenoxyethanol
6-46	Neopentyl glycol (2,2-dimethylpropane-1,3-diol)	126-30-7	**1000**	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; Adoption of EU-LCI value is under discussion
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; Adoption of EU-LCI value is under discussion
7-11	2-Hexenal	16635-54-4 6728-26-3 505-57-7 1335-39-3	**14**	Read across from 2-pentenal; Adoption of EU-LCI value is under discussion
7-12	2-Heptenal	2463-63-0 18829-55-5 29381-66-6	**16**	Read across from 2-pentenal; Adoption of EU-LCI value is under discussion
7-13	2-Octenal	2363-89-5	**18**	Read across from 2-pentenal;

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
		25447-69-2 20664-46-4 2548-87-0		Adoption of EU-LCI value is under discussion
7-14	2-Nonenal	2463-53-8 30551-15-6 18829-56-6 60784-31-8	**20**	Read across from 2-pentenal; Adoption of EU-LCI value is under discussion
7-15	2-Decenal	3913-71-1 2497-25-8 3913-81-3	**22**	Read across from 2-pentenal; Adoption of EU-LCI value is under discussion
7-16	2-Undecenal	2463-77-6 53448-07-0	**24**	Read across from 2-pentenal; Adoption of EU-LCI value is under discussion
7-17*	Furfural	98-01-1	**10**	Adoption EU-LCI value
7-18*	Glutaraldehyde	111-30-8	**1**[#]	Adoption EU-LCI value
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	**750**	VVOC Individual substance evaluation
7-22	Formaldehyde	50-00-0	**100**	VVOC Adoption EU-LCI value
7-23*	Propenal	107-02-8	**14**	VVOC Adoption EU-LCI value
8	**Ketones**			
8-1*	Ethyl methyl ketone	78-93-3	**20000**	Adoption EU-LCI value
8-2	3-Methylbutanone-2	563-80-4	**7000**	Adoption EU-LCI value
8-3*	Methyl isobutyl ketone	108-10-1	**1000**	Adoption EU-LCI value
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	**1000**	Read across from cyclopentanone
8-7	2-Methylcyclohexanone	583-60-8	**2300**	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	**2100**	Read across from propylene glycol
8-10	Acetone	67-64-1	**1200**	VVOC AGW: 1 200 000 µg/m³
9	**Acids**			
9-1*	Acetic acid	64-19-7	**1200**	Adoption EU-LCI value
9-2*	Propionic acid	79-09-4	**1500**	Adoption EU-LCI value
9-3*	Isobutyric acid	79-31-2	**1800**	Adoption EU-LCI value
9-4*	Butyric acid	107-92-6	**1800**	Adoption EU-LCI value
9-5*	Pivalic acid	75-98-9	**2100**	Adoption EU-LCI value
9-6*	n-Valeric acid	109-52-4	**2100**	Adoption EU-LCI value
9-7*	n-Caproic acid	142-62-1	**2100**	Adoption EU-LCI value
9-8*	n-Heptanoic acid	111-14-8	**2100**	Adoption EU-LCI value
9-9*	n-Octanoic acid	124-07-2	**2100**	Adoption EU-LCI value
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

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
10-2	Ethyl acetate	141-78-6		VVOC
10-3	Vinyl acetate	108-05-4		VVOC
10-4	Isopropyl acetate	108-21-4	**4200**	Adoption EU-LCI value
10-5	Propyl acetate	109-60-4	**4200**	Adoption EU-LCI value
10-6	2-Methoxy-1-methylethyl acetate	108-65-6	**2700**	Adoption EU-LCI value
10-7	n-Butyl formate	592-84-7	**2000**	Read across from methyl formate (AGW: 120 000 µg/m³)
10-8*	Methyl methacrylate	80-62-6	**750**	Adoption EU-LCI value
10-9*	Other methacrylates		**750**	Read across from methyl methacrylate
10-10	Isobutyl acetate	110-19-0	**4800**	Adoption EU-LCI value
10-11	1-Butyl acetate	123-86-4	**4800**	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	**200**	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	**2800**	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
11	**Chlorinated hydrocarbons**			
	currently not occupied			
12	**Others**			
12-1*	1,4-Dioxane	123-91-1	**400**	Adoption EU-LCI value
12-2	Caprolactam	105-60-2	**300**	Adoption EU-LCI value
12-3*	N-Methyl-2-pyrrolidone	872-50-4	**1800**	Adoption EU-LCI value
12-4	Octamethylcyclotetrasiloxane	556-67-2	**1200**	Adoption EU-LCI value
12-5	Hexamethylenetetramine	100-97-00	**30**	Adoption EU-LCI value
12-6*	2-Butanonoxime	96-29-7	**15**	Adoption EU-LCI value
12-7*	Tributyl phosphate	126-73-8	**300**	SVOC Adoption EU-LCI value
12-8*	Triethyl phosphate	78-40-0	**80**	Individual substance evaluation
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	**60**	Adoption EU-LCI value
12-12	Decamethylcyclopentasiloxane (D5)	541-02-6	**1500**	Read across from octamethyl-cyclotetrasiloxane
12-13	Dodecamethylcyclohexasiloxane (D6)	540-97-6	**1200**	Read across from octamethyl-cyclotetrasiloxane
12-14	Tetrahydrofuran	109-99-9	**1500**	AGW: 150 000 µg/m³
12-15	Dimethylformamide	68-12-2	**15**	AGW: 15 000 µg/m³
12-16	Tetradecamethylcycloheptasiloxane (D7)	107-50-6	**1200**	Read across from octamethyl-cyclotetrasiloxane
12-17*	N-Ethyl-2-pyrrolidone	2687-91-4	**400**	Adoption EU-LCI value

	Substance	CAS No.	LCI [µg/m³]	Remarks
12-18*	N-Butyl-2-pyrrolidone	3470-98-2	**500**	Individual substance evaluation

*: new or altered in 2018

#: 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/fachinfos/kmr-liste/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

The carbonyl compounds formaldehyde, acetaldehyde, propanal, propenal, butanal and acetone shall be determined using the method described in ISO 16000-3 that is in accordance with the specifications of the EN 16516.

IV) Analysis of VVOC

Determination of the VVOC formaldehyde, acetaldehyde, propanal, propenal and acetone shall be done using the method described in the ISO 16000-3. For the other VVOCs listed in the LCI list, a suitable test method in accordance with the current state of standardisation shall be used and reported (see also EN 16516, Annex C).

V) 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 14000 µg/m³ applies to aliphatic hydrocarbons with a retention time shorter than that of n-nonane and an LCI of 6000 µg/m³ 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.