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

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Updated list of LCI values 2022 in the annex

This version applies from the date it is published. The version it replaces will continue to be valid for one additional 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 combined.

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 many of them cover large surface areas of a room. Volatile organic compounds (VOCs) can be emitted from building products, and their concentrations must therefore be evaluated with regard to the health assessment of indoor air quality.

In addition, 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 contamination of the indoor air with volatile organic compounds. This is particularly true in new buildings and after extensive building renovations. Without sufficient ventilation (via windows and/or via mechanical ventilation systems), avoidable risks arise for the health and comfort as well as for performance of room occupants.

1.1 Healthy indoor air as an objective in building regulations

Healthy indoor air in buildings must be ensured by limiting the substance loads from building products. Significant health hazards can be avoided or reduced if the building product emissions, both individually and collectively, are checked and assessed in terms of health. 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]). In particular, built structures must be constructed in such a way that chemical, physical or biological influences do not result in any hazard or unacceptable nuisance (Article 13, MBO). This is only possible if the building products used meet the corresponding requirements. In

addition, types of construction that are created by assembling building products to form built structures must be suitable for their intended use (Article 16a, MBO). This means, for example, that healthy air that generally corresponds to the quality of the outdoor air must be available in workplaces and substance loads that impair indoor air quality - such as VOC emissions from building products - must be eliminated by avoiding the load (ArbStättV, ASR A3.6).

The Model Administrative Provisions - Technical Building Rules (MVV TB) (Article 85a, MBO) or the corresponding Administrative Provisions - Technical Building Rules of the Federal States indicate the level of requirement to not endanger the health of room occupants.

Annex I No 3 of Regulation (EU) No 305/2011 setting out harmonised conditions for marketing building products (Construction Products Regulation, [CPR]) reflects the national requirements for construction works for hygiene, health and the environment of the EU Member States. This includes the prevention and limitation of indoor pollutants, e.g. VOCs. The basic requirements for construction works listed in Annex I are the basis for the preparation of standardisation mandates (Article 3, Paragraph 1, CPR).

In 2005 the European Commission issued a mandate to CEN (European Committee for Standardisation; French *Comité Européen de Normalisation*) to develop horizontal assessment methods for dangerous substances incorporated in and emitted from building products in accordance with the Construction Products Regulation. For this purpose, CEN established the technical committee CEN TC 351. The result of the standardisation work is the EN 16516: Construction products - Assessment of the release of dangerous substances - Determination of emissions into indoor air. The horizontal assessment methods are intended to form the basis for the technical specifications for building products in the standardisation work and in the European Technical Assessment under the CPR.

According to the CPR, harmonised rules are established for the declaration of performance of building products in relation to their essential characteristics (Article 1 CPR). When placing a building product on the market the manufacturer has to declare the performance of the building product in a declaration of performance (Article 4, Paragraph 1, CPR) on the basis of the "essential characteristics", procedures and criteria set out in the respective product standard (Article 17, Paragraph 3, CPR). If the building product performances declared according to the harmonised rules meet the requirements for this use in the respective Member State, the building product may be used (Article 16c, Paragraph 2, MBO or corresponding provisions of the Federal States building regulations, Article 8, Paragraph 4, CPR).

Whether the current level of requirements in Germany has been met has to be therefore verified before use of the building product in indoor spaces.

EN 16516 is already used in the verification processes for the assessment of emissions of volatile organic compounds by the building inspection authorities.

EN 16798-1 for the energy performance of buildings standardises low-emission or very low-emission buildings if predominantly low-emission or very low-emission building products are used. EN 16798-1 recommends identifying emission sources and specifies testing of building

product emissions according to e.g. EN 16516 to ensure acceptable indoor air quality from the start of usage of the building.

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

The Committee on Health-related Evaluation of Building Products (AgBB) is mandated by the Conference of Health Ministers (Gesundheitskonferenz) and the Conference of Building Ministers (Bauministerkonferenz) to create the basic principles for developing building regulations for protection against indoor health risks. The AgBB is composed of representatives of the Health Authorities of the Federal States, the German Environment Agency (UBA) with the AgBB secretariat, the German Institute for Building Technology (Deutsches Institut für Bautechnik, DIBt), the Conference of the State Ministers and Senators for Town Building, Building and Housing Affairs (ARGEBAU), the Federal Institute for Materials Research and Testing (BAM) and the Federal Institute for Risk Assessment (BfR). AgBB considers the establishment of basic principles 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 Federal States and Construction Products Regulation.

The Committee developed a scheme for health-related evaluation of VOC emissions from building products used for indoors application in 2000 [AgBB, 2000]. In this evaluation 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 in accordance with 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 evaluation scheme was extensively discussed with representatives of manufacturers and professionals after first publication 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 DIBt incorporated the evaluation scheme into its approval guidelines for the health-related evaluation of building products. 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)“) of the Model Administrative Provisions - Technical Building Rules (MVV TB) [MVV TB].

The criteria of the evaluation scheme are set in such a way that they prevent indoor health risks for the general population, including children, pregnant women and elderly people. Exposure over the entire lifetime is considered.

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 evaluation scheme. Nevertheless, the scheme also endorses manufacturers’ initiatives to produce building products with lower emissions [Däumling, 2012]. Manufacturers can therefore declare better performance parameters (VOC emissions) for their building products, e.g. by means of labels like the Blue Angel [ECA 24, 2005; ECA 27, 2012].

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

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

The negative effects of indoor air pollution on human health have been extensively investigated [see e.g. ECA 10, 1991b; WHO, 2000, 2010; Doty et al., 2004; Ad-hoc, 2007; Mendell, 2007; Bernstein et al., 2008; INDEX project 2008; Alford, 2021]. Acute and/or long-term effects of volatile organic compounds may range from odour perception and local 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 [Weschler, 2006; Brightman et. al, 2008; Billionnet et. al, 2011; Takigawa et. al, 2012; Rohr, 2013; Wolkoff, 2013].

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. Experts from the EU Member States and from Switzerland and Norway within ECA 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. Particularly noteworthy 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 above which adverse effects from the individual substance are to be expected (LCI – lowest concentration of interest for the individual substance) [ECA 29, 2013]. LCI values are expressed as µg/m³ and are to be used exclusively in connection with health-related assessments of building product emissions.

Building product emissions consist of a mixture of different substances. Health effects of the mixtures have to be assessed and limited as well, since without their consideration there would be an underestimation of health risk. Ensuring an adequate and sufficient level of protection against possible adverse health effects of VOC mixtures justifies the application of a conservative assessment method. In order to estimate exposure it is essential to consider interactions between different substances. In the absence of sufficient data on interactions the toxicological convention adopted is dose addition of effects. Studies have shown that the dose addition model sufficiently predicts the toxicity of a mixture consisting of several substances [Abraham et al., 2016; Bruckner et al., 2019]. National and international committees also advocate the dose addition model for use in legislation as an acceptable conservative approach to correctly predict the effects of mixtures [European Commission, 2012; OECD, 2018; More et al., 2019; SWD, 2020; Martin et al., 2021].

For the assessment of combination effects of substances in the mixture formed in indoor air from VOC emitted by a building product, the hazard index “R” (R-value or risk index) is used in the AgBB evaluation scheme. It is based on the recommendation of the European expert

group in the ECA report no 18 and confirmed in the ECA report no 29 [ECA 18, 1997a; ECA 29, 2013]. Since the conservative approach is based only on the assumption of additive effects and all VOCs must always be considered for exposure evaluation the R-value is needed to assess health risks.

The exposure of building occupants to a wide range of substances is considered using the total concentration of volatile organic compounds (TVOC) in addition to summing up the assessed individual substance concentrations in the R-value [Hudnell, 1992; Koren, 1992; Seifert, 1999; Molhave, 1999; Ad-hoc, 2007; ECA 27, 2012; Abraham et al., 2016; ISO 16000-6; EN 16516].

Scientifically controlled, recognised human studies and epidemiological research show a clear concentration dependency for health effects caused by the sum of defined volatile organic compounds [ECA 19, 1997b; Ad-hoc, 2007]. Totalling the different volatile organic compounds in a mixture in indoor air and setting an upper limit for the total concentration against long-term exposure is an accepted and necessary method to address health risks [see e.g. ECA 18, 1997a; Seifert, 1999; Järnström et al., 2006; Brelih et al., 2012; Hormigos-Jimenez et al., 2017]. ECA reports no. 18 and 19 of the European expert groups state that the TVOC criterion is necessary for adequate health protection. Accordingly, a TVOC limit of 1 mg/m³ is stipulated in the AgBB evaluation scheme. This ensures that the total emissions of VOCs are restricted by means of an upper limit and remain within a range that is not harmful to health. The TVOC criterion is therefore necessary to ensure the basic requirement in the building regulations of the Federal States with regard to health protection in indoor spaces in the long term and to exclude risks with sufficient probability.

The TVOC measurement has been standardised as a test criterion in the ISO 16000-6 since the 1990s and in EN 16516 since 2017.

3 Sensory testing

Emissions from building products are often associated with the perception of odours which may result in annoyance and health impairment of the room occupants. 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 16/07 and UBA Texte 35/2011] 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 considering ISO 16000-28 and the standard VDI 4302 part 1 and in the second test, a standard operating procedure [UBA Texte 88/2014 and UBA Texte 79/2015]. Eight and 11 test laboratories, respectively participated successfully in the interlaboratory comparisons. The regular interlaboratory comparisons on VOC and sensory testing took place in 2016 and 2018. The results were comparable to the previous tests.

These findings can be used to specify and revise the ISO 16000-28 through additional measurement requirements. The measurement procedure is suitable for assessing the perceived intensity with these additional specifications. The English version of the revised standard was published at the end of 2020.

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 35/2011] and from health and hygiene perspectives, the AgBB sets the perceived intensity of 7 pi (pi: perceived intensity) 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 35/2011 and UBA Texte 36/2016].

For the time being, the AgBB recommends that sensory testing of building products be conducted on a 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

The criteria of the AgBB evaluation scheme are used for the uniform assessment of the released (emitted) VOCs from a building product on the basis of a defined reference room, irrespective of the type of building product. Both the emissions of the individual substances and the cumulative effects of all detected substances are assessed.

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 developed [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. EN 16516 further specifies the test conditions required to improve measurement reliability and reproducibility. The intended use, purpose, location and circumstances of typical use of a building product are not specified in EN 16516 but need to be defined on a product-related basis and anchored in the corresponding product standard.

4.2 Structural conditions and exposure scenarios

Room occupants are exposed to VOC 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 building 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 evaluation scheme. It is necessary to additionally consider the indoor air situation likely to be encountered under practical conditions. The exposure scenario creates the link between building product emission and concentration in indoor air. Thus, the evaluation must consider the emissions from the building 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.

In order to take sufficient account of both the energy properties of a building and the air quality aspects, the health-related assessment in the AgBB evaluation scheme applies for a minimum air change rate of 0.5/h. This air change rate also applies for the reference room according to EN 16516. The air change rate of 0.5/h defined in the AgBB evaluation 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 consider as broad a 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 and is an appropriate basis for the calculations in connection with an evaluation of test chamber emission results.

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 building 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 [m³]. Parameters n, A and V can be combined into the new parameter q [m³/(h m²)] called the area-specific air change rate.

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

To ensure that the measurement results obtained in a test chamber are transferrable to the reference room, a loading factor has to be set for the test chamber measurement that takes the building product's intended use into account. EN 16516 assumes that the climatic conditions of the test chamber (temperature at 23°C, relative humidity at 50%), the reference room and later the real room are the same and that no interactions with other building products occur.

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 EN 16516.

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 used. If the intended use suggests that a building 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^2/m^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 evaluation scheme and in EN 16516 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 building product has to undergo a series of tests as shown in the flow chart in figure 1.

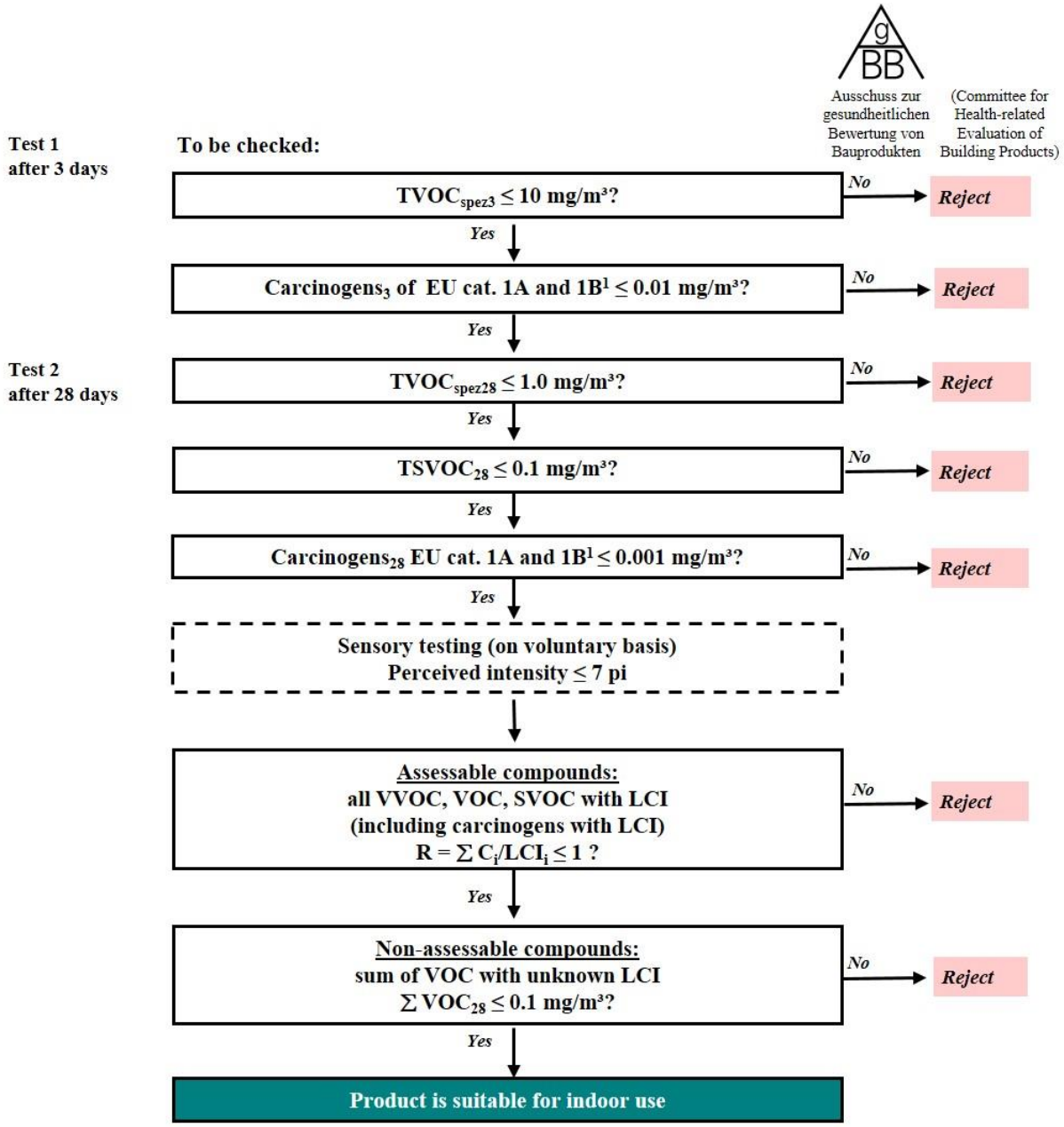

Fig. 1: Flow chart for the evaluation of VVOC, VOC and SVOC emissions from building products

Explanations: VVOC: retention range < C6; VOC and TVOC: retention range C6 – C16; SVOC: retention range C16 – C22. LCI: Lowest Concentration of Interest (German: NIK), [1]Classification according to Regulation (EC) No 1272/2008 Appendix VI Table 3.1. For further details see chapter 4.3.

The evaluation scheme starts from a building product wrapped in an airtight cover. The start of the experiment (t_0) is defined as the time at which the building product to be tested is unwrapped and placed into the test chamber or cell. The building product remains in the test chamber or cell over the entire period of the test. For certain building product groups it is necessary to define special test conditions. These specific requirements are defined separately. Emissions are usually measured after three and 28 days. They may also include a definition of criteria for the anticipated termination of the emission measurement. In principle, anticipated termination of the test is allowed no earlier than seven 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 compared to the measurement on day three. 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 (see table 1) 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}
$TVOC_{spez}$[1]: 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 EN 16516: "The sum of all identified target compounds[2] (quantified using authentic standards) plus all identified non-target compounds[3] and non-identified compounds (quantified using the TIC[4] 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 evaluation 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. Exceptions apply to carcinogenic substances belonging to EU categories 1A and 1B according to the CLP system (Regulation (EC) No 1272/2008 Annex VI Table 3.1).

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[1] The ABG (German: „Anforderungen an bauliche Anlagen bezüglich des Gesundheitsschutzes") states [MVV TB]:
Sum of volatile organic compounds. Sum of the concentrations of identified and unidentified volatile organic compounds calculated by summing the concentrations of all substances (target and non-target, identified and unidentified compounds) in the air of the reference room; these are substances eluting between n-hexane up to and including n-hexadecane using a specified analytical column, each with a concentration equal to or greater than 5 µg/m³. Target compounds are to be quantified using their individual calibration factors while non-target, identified and unidentified compounds are to be quantified via the toluene equivalent.

[2] The substances listed in the LCI value list in table 1 in chapter 6 of this document are to be used as target compounds.

[3] Non-target compounds are defined as those substances without an LCI value.

[4] TIC: Total ion current

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

4.3.1 Measurement and testing after three days

- $TVOC_{spez3}$

A building product satisfies the criteria if the $TVOC_{spez}$ value after three 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 (CMR substances). Emission of carcinogenic substances belonging to EU categories 1A and 1B (Regulation (EC) No 1272/2008 Annex VI Table 3.1) 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 (Regulation (EC) No 1272/2008 Annex VI Table 3.1) are checked according to the LCI concept (see Chapter 6) 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 three days.

Exempt 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, an LCI value is derived on that basis and listed in Table 1 (see chapter 6).

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 building product satisfies the criteria if the $TVOC_{spez28}$ value is ≤ 1.0 mg/m³. Building products with a higher $TVOC_{spez28}$ value are rejected.

- Semi volatile organic compounds (SVOC)

Building products that exhibit increased SVOC emissions are additionally considered with regard to the SVOC concentrations in the chamber air.

A building 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/m³ 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/m³ after 28 days.

- Very volatile organic compounds (VVOC)

Building products that exhibit increased emission of VVOC are additionally considered with regard to the VVOC concentrations in the chamber air.

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 (Regulation (EC) No 1272/2008 Annex VI Table 3.1) is measured again with an emphasis on their long-term behaviour from the occupant's perspective. No carcinogen of categories 1A and 1B may exceed the value of 0.001 mg/m³ after 28 days.

Exempt 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, an LCI value is derived on that basis and listed in Table 1 (see chapter 6). 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 performed after 28 days on a voluntary basis. The perceived intensity is determined by a trained panel according to ISO 16000-28. Sensory testing is considered passed if odour intensity does not exceed 7 pi.

- Evaluation of individual substances

In addition to evaluating the emissions of a building 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

A list of LCI values for a large number of volatile organic compounds found in indoor air is contained in the Annex (chapter 6). 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).

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

In this equation C_i is the chamber concentration of compound *i*. For $R_i < 1$, it is assumed that there will be no health 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 (see equation 3).

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

Building products which do not fulfil this condition are rejected.

b) VOC not assessable via LCI

For reasons of health, substances that cannot be identified analytically (EN 16516) or substances that can be identified but do not have an LCI value, i.e. have not been assessed toxicologically, must also be considered. Consequently, quantitative limitation of substance emissions with unknown properties is imperative. The use of new substances would otherwise undermine health protection in practice, since a substance-related assessment is not possible due to the current lack of LCI values.

In order to avoid a building product being classified as harmless even though it emits larger quantities of non-assessable 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 $TVOC_{spez28}$ value for the sum of such substances. A building product meets the criteria when the sum of such VOC determined at concentrations ≥ 5 µg/m³ does not exceed 0.1 mg/m³. Higher concentrations result in rejection.

4.4 Conclusion

The adverse health effects of VOCs are scientifically proven and are adequately demonstrated in the technical literature. VOCs not only have an effect on room occupants on their own, they also always do in the sum of several simultaneously occurring substances. In addition to the analysis of individual substances, sum concentrations (TVOC, TSVOC, VOC without LCI) also play a central role in the assessment of health hazards.

The criteria of the AgBB assessment scheme are selected in such a way that they prevent indoor health risks for the general population. When assessing the emissions of building products, the exceedance of a hazard limit is averted similar to other technical requirements (e.g. fire protection; stability). The interaction of harmful VOCs and the summation of individual emissions from the various building products used indoors to depict the total exposure is also considered.

A building product which fulfils the requirements set out in the evaluation scheme (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). If the building product has passed the (currently voluntary) sensory testing, this must be documented separately.

5 References

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6. Annex

Derivation of LCI values

6.1 Basic considerations

Volatile organic compounds are significant indoor air pollutants. German building regulations require 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). In this context, 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

A working group within the AgBB (LCI Working Group) which includes experts from the manufacturer side is responsible for the derivation of LCI values. Between the years 2000 and 2010, the derivation of LCI values was based mainly on existing health-based evaluations of substances at the workplace in accordance with the ECA report no 18. However, where hazardous substances are handled under typical conditions in workplaces, much higher substance concentrations than under indoor living conditions are generally encountered. 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].

Since 2011, a European initiative has been working to harmonise emissions assessment in Europe by means of LCI values (EU-LCI values). The criteria used for derivation of the EU-LCI values 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; 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, the LCI working group reviews the published EU-LCI values and usually adopts them into updates of the German LCI list. Deviations are justified. German LCI values may be set on the basis of the EU-LCI derivation procedure for substances to be newly assessed for which EU-LCI values

do not yet exist (EU LCI concept according to ECA 29, 2013). The derivation procedure is based on the guidance of the European Chemicals Agency ECHA (Guidance on information requirements and chemical safety assessment - Chapter R.8: Characterisation of dose [concentration]-response for human health). If necessary, a revision of German LCI values can be carried out according to the EU-LCI derivation 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 that are based on existing assessment values for substances in the workplace or on individual substance evaluations (see AgBB evaluation scheme until 2015).

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 no 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 in chapter 4.3).

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[5].

6.3 Publication

LCI values are exclusively determined by the AgBB's LCI working group which 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 by the AgBB[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-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. Please also refer to remark V in table 1.

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Table 1

List of LCI values

Closing date: October 2020

	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-Propylbenzene	103-65-1	**950**	Adoption EU-LCI value Read across from ethylbenzene
1-9	1-Propenylbenzene (ß-methylstyrene)	637-50-3	**1200**	Adoption EU-LCI value Read across from 2-phenylpropene
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 Read across from xylene
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 Read across from trimethylbenzene
1-18	n-Butylbenzene	104-51-8	**1100**	Adoption EU-LCI value Read across from ethylbenzene
1-19	1,3-Diisopropylbenzene	99-62-7	**750**	Adoption EU-LCI value Read across from xylene
1-20	1,4-Diisopropylbenzene	100-18-5	**750**	Adoption EU-LCI value Read across from xylene
1-21	Phenyloctane and isomers	2189-60-8	**1100**	Adoption EU-LCI value Read across from ethylbenzene
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-Phenylcyclohexene (4-PCH)	4994-16-5	**300**	Read across from styrene
1-25	Styrene	100-42-5	**250**	Adoption EU-LCI value
1-26	Phenylacetylene	536-74-3	**200**	Read across from styrene
1-27	2-Phenylpropene (α-methylstyrene)	98-83-9	**1200**	Adoption EU-LCI value
1-28	Vinyltoluene (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

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
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
2-9	Other saturated aliphatic hydrocarbons, C6-C8		**14000**	Adoption EU-LCI value Read across from 2-methylpentane
2-10	Other saturated aliphatic hydrocarbons, C9-C16		**6000**	Adoption EU-LCI value
2-11*	-			[1)]
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		**1400**	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

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
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	**8300**	Adoption EU-LCI value
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
5	**Aromatic alcohols**			
5-1	Phenol	108-95-2	**70**	Adoption EU-LCI value
5-2	2,6-di-tert-Butyl-4-methylphenol (BHT)	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	Ethylene glycol (ethanediol)	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 Read across from ethanediol
6-5	Diethylene glycol monobutylether	112-34-5	**350**	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	**850**	Adoption EU-LCI value
6-10	Butyl glycolate	7397-62-8	**900**	Adoption EU-LCI value
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	**100**	Adoption EU-LCI value
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	**900**	Adoption EU-LCI value
6-18*	1,2-Dimethoxyethane	110-71-4	**100**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
6-19*	1,2-Diethoxyethane	629-14-1	**150**	Adoption EU-LCI value
6-20	2-Methoxyethyl acetate	110-49-6	**150**	Adoption EU-LCI value Read across from 2-methoxyethanol
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	**400**	Adoption EU-LCI value Read across from diethylene glycol monobutylether
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 Read across from acetic acid
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	**950**	Adoption EU-LCI value Read across from 2-methoxy-1-methylethyl acetate
6-30	Dipropylene glycol mono-n-propylether	29911-27-1	**200**	Adoption EU-LCI value Read across from dipropylene glycol mono-n-butylether
6-31	Dipropylene glycol mono-n-butylether	29911-28-2 35884-42-5	**250**	Adoption EU-LCI value
6-32	Dipropylene glycol mono-t-butylether	132739-31-2 (Mixture)	**250**	Adoption EU-LCI value
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**	Adoption EU-LCI value
6-35	Triethylene glycol dimethyl ether	112-49-2	**150**	Adoption EU-LCI value
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	**1300**	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	**1800**	Adoption EU-LCI value
6-41	Hexylene glycol (2-methyl-2,4-pentanediol)	107-41-5	**3500**	Adoption EU-LCI value
6-42*	3-Methoxy-1-butanol	2517-43-3	**1700**	Adoption EU-LCI value
6-43*	1,2-Propylene glycol n-propylether	1569-01-3 30136-13-1	**5200**	Adoption EU-LCI value
6-44	1,2-Propylene glycol n-butylether	5131-66-8 29387-86-8 15821-83-7 63716-40-5	**650**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
6-45	Diethylene glycol phenylether	104-68-7	**80**	Adoption EU-LCI value
6-46*	Neopentyl glycol (2,2-dimethylpropane-1,3-diol)	126-30-7	**8700**	Adoption EU-LCI value
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 Read across from butanal
7-3	Hexanal	66-25-1	**900**	Adoption EU-LCI value Read across from butanal
7-4	Heptanal	111-71-7	**900**	Adoption EU-LCI value Read across from butanal
7-5	2-Ethyl-hexanal	123-05-7	**900**	Adoption EU-LCI value Read across from butanal
7-6	Octanal	124-13-0	**900**	Adoption EU-LCI value Read across from butanal
7-7	Nonanal	124-19-6	**900**	Adoption EU-LCI value Read across from butanal
7-8	Decanal	112-31-2	**900**	Adoption EU-LCI value Read across from butanal
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 73543-95-0	**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 57266-86-1	**16**	Read across from 2-pentenal; Adoption of EU-LCI value is under discussion
7-13	2-Octenal	2363-89-5 25447-69-2 20664-46-4 2548-87-0	**18**	Read across from 2-pentenal; 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

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
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	**300**	VVOC Adoption EU-LCI value
7-21	Propanal	123-38-6	**650**	VVOC Adoption EU-LCI value
7-22	Formaldehyde	50-00-0	**100**	VVOC Adoption EU-LCI value
7-23	Propenal	107-02-8	**14**[†]	VVOC Individual substance evaluation
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	**1200**	Adoption EU-LCI value
8-5*	Cyclohexanone	108-94-1	**1400**	Adoption EU-LCI value
8-6*	2-Methylcyclopentanone	1120-72-5	**1400**	Adoption EU-LCI value 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**	Adoption EU-LCI value Read across from propylene glycol
8-10	Acetone	67-64-1	**120000**	VVOC Adoption EU-LCI value
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 Read across from propionic acid
9-4	Butyric acid	107-92-6	**1800**	Adoption EU-LCI value Read across from propionic acid
9-5	Pivalic acid	75-98-9	**2100**	Adoption EU-LCI value Read across from propionic acid
9-6	n-Valeric acid	109-52-4	**2100**	Adoption EU-LCI value Read across from propionic acid
9-7	n-Caproic acid	142-62-1	**2100**	Adoption EU-LCI value Read across from propionic acid
9-8	n-Heptanoic acid	111-14-8	**2100**	Adoption EU-LCI value Read across from propionic acid
9-9	n-Octanoic acid	124-07-2	**2100**	Adoption EU-LCI value Read across from propionic acid
9-10	2-Ethylhexanoic acid	149-57-5	**150**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
9-11	Neodecanoic acid	26896-20-8	**750**	Individual substance evaluation
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	**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	**650**	Adoption EU-LCI value
10-7*	n-Butyl formate	592-84-7	**4900**	Adoption EU-LCI value Read across from methyl formate
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**	Adoption EU-LCI value 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	**25**	Individual substance evaluation
10-19	Dibutyl fumarate	105-75-9	**50**	Adoption EU-LCI value
10-20*	Dimethyl succinate	106-65-0	**20**	Adoption EU-LCI value
10-21*	Dimethyl glutarate	1119-40-0	**25**	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**	Adoption EU-LCI value
10-25*	Diisobutyl glutarate	71195-64-7	**35**	Adoption EU-LCI value Read across from dimethyl glutarate
10-26*	Diisobutyl succinate	925-06-4	**35**	Adoption EU-LCI value Read across from dimethyl succinate
10-27*	(5-Ethyl-1,3-dioxan-5-yl)methyl acrylate	66492-51-1	**80**	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 (D4)	556-67-2	**1200**	Adoption EU-LCI value
12-5	Hexamethylenetetramine	100-97-00	**30**	Adoption EU-LCI value

	Substance	CAS No.	LCI [µg/m³]	Remarks
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	**500**	Adoption EU-LCI value
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
12-18	N-Butyl-2-pyrrolidone	3470-98-2	**500**	Individual substance evaluation Read across from N-ethyl-2-pyrrolidone
12-19*	5-Ethyl-1,3-dioxane-5-methanol	5187-23-5	**850**	Individual substance evaluation

*: new or altered in 2022

[#]: An evaluation within the framework of the LCI concept will take place only at and above a measured concentration of 5 µg/m³.

†: For the time being, propenal cannot be quantified using the analytical methods mentioned in the AgBB assessment scheme. An evaluation within the framework of the LCI value concept does not take place.

VVOC very volatile organic compounds

SVOC semi volatile organic compounds

1) In order to ensure compatibility during the evaluation, 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 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) can be found here: https://echa.europa.eu/information-on-chemicals/cl-inventory-database

II) Analysis of aldehydes

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

III) Analysis of VVOC

Determination of the VVOC formaldehyde, acetaldehyde, propanal and acetone shall be done using the method described in the ISO 16000-3. For the other VVOC 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).

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 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.

V) Adoption of EU LCI values

Currently, differences between an adopted EU LCI value in the NIK list and the current EU LCI value in the EU LCI list may occur. This is mainly due to delays in publication by the committees involved. The assessment lists must be used in their entirety; they must not be mixed. The rationale documents for the adopted EU LCI values are published at https://ec.europa.eu/growth/sectors/construction/eu-lci/documents-glossary_en.