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

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Committee for Health Evaluation of Building Products

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

AgBB – 2026

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.

Content

List of abbreviations

A	product surface area
AgBB	Committee for Health Evaluation of Building Products
ARGEBAU	Conference of the State Ministers and Senators for Town Building, Building and Housing Affairs
BAM	Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung)
BfR	Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung)
C	indoor air concentration
CEN	European Committee for Standardisation (Comité Européen de Normalisation)
CLP	Classification, Labelling and Packaging (Regulation EC No 1272/2008)
CMR	carcinogenic, mutagenic or reprotoxic (substances)
CPR	Construction Products Regulation
DIBt	German Institute for Building Technology (Deutsches Institut für Bautechnik)
E_{fl}	area-specific emissions rate
ECA	European Collaborative Action
ECHA	European Chemicals Agency
EN	European standard
h	hour
ISO	International Organization for Standardization
LCI	Lowest concentration of interest (Niedrigste interessierende Konzentration, NIK)
MBO	Standard Building Code (Musterbauordnung)
MVV TB	Model Administrative Provisions - Technical Building Rules
n	air change rate
pi	perceived intensity
q	area-specific air change rate
R-value	hazard index ‚R‘
SVOC	semi volatile organic compounds
TIC	total ion current
TSVOC	total semi volatile organic compounds
TVOC	total volatile organic compounds
UBA	German Environment Agency (Umweltbundesamt)
V	room volume
VOC	volatile organic compounds
VVOC	very volatile organic compounds

I. 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. The aim is to ensure a transparent and objective assessment of building products. Both the emissions of the individual substances and the cumulative effects of all detected substances are assessed. Compliance with the criteria of the AgBB evaluation scheme means that the minimum requirements of the German Federal States building regulations for the prevention of health risks to building occupants with regard to VOC emissions in indoor spaces are deemed to have been met.

1. Horizontal testing standard for chamber tests to determine VOC emissions

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. Test chamber measurements are standardised by international standards, the ISO 16000-9 to -11. Parts 9 and 10 describe the procedure when using a test chamber. Part 11 describes sampling, the storage of samples and the preparation of test specimens. EN 16516 further specifies the test conditions required to improve measurement reliability and reproducibility. The product-specific requirements for testing must be incorporated into the relevant building product standards. Tests must be carried out by laboratories accredited to EN ISO/IEC 17025 which are recognised as competent testing bodies for emission testing in accordance with EN 16516.

The test chamber method in accordance with EN 16516 is applicable to a wide range of volatile organic compounds (VOC), including semi-volatile (SVOC) and very volatile (VVOC).

2. Structural conditions and exposure scenarios

Occupants are exposed to VOC emitted from building products, i.e. released into the air. Generally, the substances are absorbed during breathing (by inhalation). Health-related evaluation of a building product is based on the indoor air concentrations of VOC 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 link between building product emissions and indoor air concentrations is formed by an exposure scenario that considers the building product emissions, the room dimensions, air change rate and the emitting surface of the building product introduced into the room.

As the majority of the building stock in Germany still consists of older, energy-inefficient buildings, the AgBB requirements must consider a wide range of building types and uses, as well as different air change rates within the buildings. In order to adequately reflect both the

energy performance and the indoor air quality characteristics of the building stock, EN 16516 specifies the air change rate in the reference room as 0.5/h. This air change rate requires regular (several times a day) ventilation, provided that no ventilation system is in place.

The AgBB evaluation scheme refers to the reference room standardised in EN 16516, which has a floor area of 3 m × 4 m and a height of 2.5 m.

Equation (1) describes the indoor air concentration C, resulting from a building product, as a function of the area-specific emissions rate Ea [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 [m^3] in quasi-steady-state equilibrium. 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.

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

To ensure that the measurement results from 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 simplistically assumes that the test chamber, the reference room and the subsequent real room have the same climatic conditions (temperature 23 °C, relative humidity 50%), and that no interactions with other building products occur.

For standard uses, the following standardised loading factors apply in accordance with EN 16516:

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

For building products and uses that deviate from the above standard uses, a loading factor as representative as possible must be calculated and the nearest standard loading factor 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 in accordance with EN 16516:

- 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 must be specified in the test report and clearly documented for the user as a criterion for assessing the test results.

3. Evaluation

The health evaluation of a building product is carried out in accordance with the flow chart in figure 1.

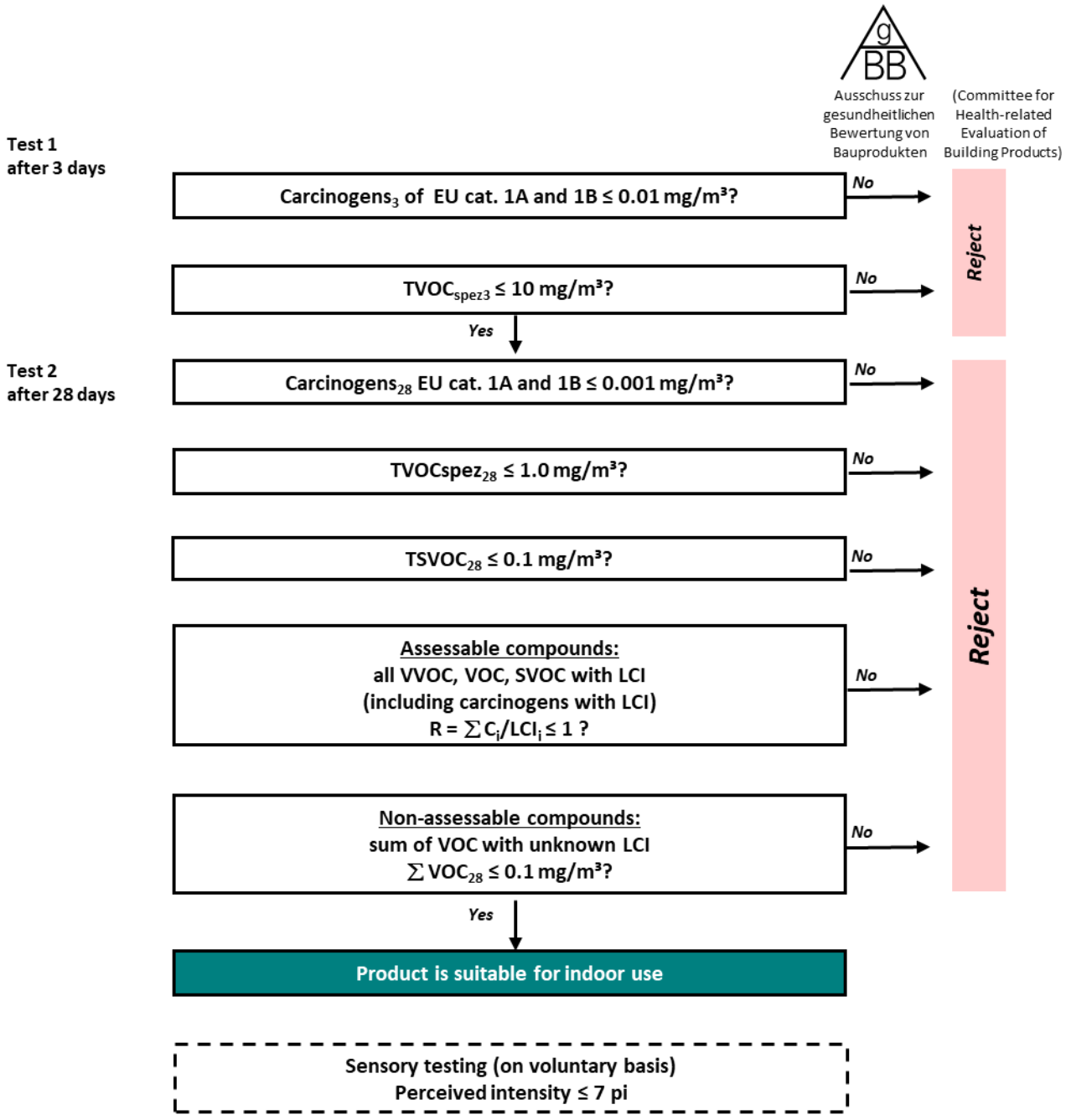

Figure 1: Flow chart for the evaluation of VVOC, VOC and SVOC emissions from building products

The start of the test (t0) is defined as the point in time at which the building product to be tested is unwrapped and placed into the test chamber. The building product remains in the test chamber for the entire duration of the test. Emissions are measured after at least three and 28 days. Criteria for anticipated termination of the emission measurement may also be defined. As a general rule: The test may be terminated no earlier than on the seventh day after the test chamber has been loaded. A prerequisite for this is that the values determined on that day are less than half of the requirements for the 28-day values and that no significant increase in the concentration of individual substances is observed compared to the measurement on the third day. Compliance with these criteria must be adequately 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 identified substances using LCI values (LCI = lowest concentration of interest, see section I 4) and that of carcinogenic substances has to be done on a substance-specific basis. The quantification of identified substances without LCI values and that of unidentified ('unknown') substances has to be carried out based on toluene equivalents (see EN 16516). The analytical method for the detection and quantification of certain specified volatile organic compounds is not sufficiently precise when using EN 16516. The determination of these substances must therefore be carried out using the analytical methods described in the notes to Chapter 4.

The following definitions apply in the AgBB evaluation scheme:
VVOC: all individual substances within the retention range below C_6
VOC: all individual substances within the retention range C_6 to C_{16} (between *n*-hexane and up to and including *n*-hexadecane)
$TVOC_{spez}$[1]: sum of all individual substances with concentrations ≥ 5 µg/m³ within the retention range C_6 to C_{16}
SVOC: all individual substances within the retention range above C_{16} to C_{22}
TSVOC: sum of all individual substances without LCI value with concentrations ≥ 5 µg/m³ within the retention range above C_{16} to 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 (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".[2]

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).

[1] The ABG (German: „Anforderungen an bauliche Anlagen bezüglich des Gesundheitsschutzes") states [MVV TB]: 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 the table in Section I 4 of this document are to be used as target compounds. Non-target compounds are defined as those substances without an LCI value. TIC: Total ion current.

3.1 Evaluation criteria after three days

- Carcinogenic substances
  Building products shall not emit any carcinogenic, mutagenic or reprotoxic substances (CMR substances). As part of the evaluation scheme, the emission of carcinogenic substances classified as EU category 1A and 1B (Regulation (EC) No 1272/2008, Annex VI, Table 3.1) is assessed for the first time after three days. Substances with mutagenic or reprotoxic properties, as well as substances with potential carcinogenic effects belonging to EU category 2 (Regulation (EC) No 1272/2008, Annex VI, Table 3.1), are evaluated within the framework of the LCI concept (see Section II 3). Carcinogens must 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, a LCI value is derived on that basis and they are treated in the same way as other VOC with LCI values (see individual substance assessment).

- $TVOC_{spez3}$
  A building product meets the criteria if the $TVOC_{spez3}$ concentration does not exceed 10 mg/m³ after three days.

3.2 Evaluation criteria after 28 days

- Carcinogenic substances
  With regard to the long-term behaviour of emissions, the release of carcinogenic substances classified as EU category 1A and 1B (Regulation (EC) No 1272/2008, Annex VI, Table 3.1) is measured again. After 28 days, no carcinogen belonging to EU categories 1A and 1B may exceed a concentration of 0.001 mg/m³.

  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, a LCI value is derived on that basis and they are treated in the same way as other VOC with LCI values (see individual substance assessment).

- $TVOC_{spez28}$
  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 meets the criteria if the $TVOC_{spez28}$ value is ≤ 1.0 mg/m³.

- Semi volatile organic compounds (SVOC)
  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.

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 (see Section II 2) 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)
  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.

- Evaluation of individual substances
  For the evaluation of individual volatile organic compounds 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 with LCI value
  A list of LCI values for a large number of volatile organic compounds found in indoor air is contained in Section I 4. The details of how these LCI values have been derived are documented in Section II 3. Listed substances in Section I 4, 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 Ri is established as defined in equation (2).

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

  In this equation, C*i* is the chamber concentration of compound *i*. It is assumed that no adverse health effects will occur in building occupants if R*i* is less than 1. If several compounds are detected at concentrations of ≥ 5 µg/m³, the effects are assumed to be additive (see Section II). To rule out any adverse health effects in this case as well, the hazard index 'R', i.e. the sum of all R*i*, must not exceed 1 (see equation (3)).

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

  b) VOC with unknown LCI value
  The sum of VOC with unknown LCI value, where the measured chamber concentration is ≥ 5 µg/m³, must not exceed 0.1 mg/m³.

3.3. Sensory testing

On a voluntary basis, a sensory test may be carried out after 28 days to assess the criterion of perceived intensity. The perceived intensity must be determined by a trained panel (ISO 16000-28). The sensory test is considered passed if the odour intensity does not exceed 7 pi.

4. List of LCI values

Closing date: July 2025

	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*	-			[1)]Classification as Carc. 1B in the 18th ATP of the CLP Regulation
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	**2200**	Adoption EU-LCI value
1-15*	1-Isopropyl-3-methylbenzene (*m*-cymene)	535-77-3	**2200**	Adoption EU-LCI value
1-16*	1-Isopropyl-4-methylbenzene (*p*-cymene)	99-87-6	**2200**	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*	-			[1)]

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
1-30*	Naphthalene	91-20-3	**15**	Adoption EU-LCI value
1-31	Indene	95-13-6	**450**	Adoption EU-LCI value
2	**Aliphatic hydrocarbons (n-, iso- and cyclo-)**			
2-1*	-			[1)]
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*	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	**2500**	Adoption EU-LCI value
3-2	α-Pinene	80-56-8	**2500**	Adoption EU-LCI value
3-3*	-			[1)]
3-4	Limonene	138-86-3	**5000**	Adoption EU-LCI value
3-5*	-			[1)]
4	**Aliphatic mono alcohols (n-, iso- and cyclo) and dialcohols**			
4-1*	-			[1)]
4-2*	-			[1)]
4-3*	-			[1)]
4-4*	*tert*-Butanol (2-methyl-2-propanol)	75-65-0	**2100**	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	**11000**	Adoption EU-LCI value Read across from 2-methyl-1-propanol
4-7*	Pentanol (all isomers)	71-41-0 30899-19-5 94624-12-1 6032-29-7 584-02-1 137-32-6 123-51-3 598-75-4 75-85-4 75-84-3	**900**	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	**800**	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*	-			[1)]
4-14*	-			[1)]
4-15	1,4-Cyclohexanedimethanol	105-08-8	**8300**	Adoption EU-LCI value
4-16*	Other saturated *n*-alcohols, C7 to C13			[1)]Revaluation, see 4-18
4-17*	Other saturated *iso*-alcohols, C6 to C13			[1)]Revaluation, see 4-18
4-18*	Other saturated n- and iso-alcohols, C6 to C13		**800**	Adoption EU-LCI value 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	**900**	Adoption EU-LCI value
5-3*	Benzyl alcohol	100-51-6	**450**	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	**4400**	Adoption EU-LCI value
6-13	2-Methoxyethanol	109-86-4	**100**	Adoption EU-LCI value
6-14*	2-Ethoxyethanol	110-80-5	**30**	Adoption EU-LCI value
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	**50**	Adoption EU-LCI value
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	**4000**	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	**500**	Adoption EU-LCI value
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
6-45	Diethylene glycol phenylether	104-68-7	**80**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
6-46	Neopentyl glycol (2,2-dimethylpropane-1,3-diol)	126-30-7	**8700**	Adoption EU-LCI value
6-47*	Propylene glycol phenyl ether	770-35-4	**2000**	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 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	**5**	Adoption EU-LCI value
7-10*	2-Pentenal	1576-87-0 764-39-6 31424-04-1	**7**	Adoption EU-LCI value Read across from 2-butenal
7-11*	2-Hexenal	16635-54-4 6728-26-3 505-57-7 1335-39-3 73543-95-0	**7**	Adoption EU-LCI value Read across from 2-butenal
7-12*	2-Heptenal	2463-63-0 18829-55-5 29381-66-6 57266-86-1	**7**	Adoption EU-LCI value Read across from 2-butenal
7-13*	2-Octenal	2363-89-5 25447-69-2 20664-46-4 2548-87-0	**7**	Adoption EU-LCI value Read across from 2-butenal
7-14*	2-Nonenal	2463-53-8 30551-15-6 18829-56-6 60784-31-8	**7**	Adoption EU-LCI value Read across from 2-butenal
7-15*	2-Decenal	3913-71-1 2497-25-8 3913-81-3	**7**	Adoption EU-LCI value Read across from 2-butenal
7-16*	2-Undecenal	2463-77-6 53448-07-0	**7**	Adoption EU-LCI value Read across from 2-butenal
7-17	Furfural	98-01-1	**10**	Adoption EU-LCI value

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
7-18	Glutaraldehyde	111-30-8	**1**[**]	Adoption EU-LCI value
7-19	Benzaldehyde	100-52-7	**90**	WEEL (AIHA): 8 800 µg/m^3
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 Formaldehyde limit values according to entry 77 of Annex XVII to Regulation (EC) No 1907/2006 (the REACH Regulation) must be complied with from 6 August 2026.
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

	Substance	**CAS No.**	**LCI [µg/m³]**	**Remarks**
9-10	2-Ethylhexanoic acid	149-57-5	**150**	Adoption EU-LCI value
9-11	Neodecanoic acid	26896-20-8	**750**	Individual substance evaluation
10	**Esters and Lactones**			
10-1*	-			[1)]
10-2*	-			[1)]
10-3*	-			[1)]
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*	-			[1)]
10-10	Isobutyl acetate	110-19-0	**4800**	Adoption EU-LCI value
10-11*	1-Butyl acetate	123-86-4	**8500**	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	**200**	Adoption EU-LCI value
10-16*	2-Ethylhexyl acrylate	103-11-7	**250**	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
10-28*	Butyl methacrylate	97-88-1	**2200**	Adoption EU-LCI value
10-29*	2-Ethylhexyl methacrylate	688-84-6	**2100**	Adoption EU-LCI value
10-30*	1,3-Bis(acetyloxy)propan-2-yl acetate	102-76-1	**5800**	Individual substance evaluation
11	**Chlorinated hydrocarbons**			
	currently not occupied			
12	**Others**			

	Substance	CAS No.	LCI [µg/m³]	Remarks
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
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)	26172-55-4	**1****	Adoption EU-LCI value
12-10*	2-Methyl-4-isothiazoline-3-on (MIT)	2682-20-4	**1****	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	**50**	Adoption EU-LCI value
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 2025

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

† Until further notice, propenal cannot be quantified using the analytical methods specified in the AgBB evaluation scheme. No assessment is carried out under the LCI value concept.

‡ analysis of acetic acid according to VDI 4301, Part 7

VVOC very volatile organic compounds

SVOC semi volatile organic compounds

1) To ensure compatibility during evaluation, assigned numbers in the LCI list can not be reallocated when a substance or a group of substances has been deleted or moved to another place.

Additional remarks

I) Note on current lists of carcinogenic substances (EU Category 1):

The lists of substances classified as category 1A and 1B carcinogens under EU Regulation 1272/2008, and for which restrictions are required under the AgBB evaluation scheme, can be found here:
https://chem.echa.europa.eu/obligation-lists/clhList (please ensure the information is up to date – availability of the link last checked on 26.05.26)

II) Analysis of carbonyl compounds:

The carbonyl compounds formaldehyde (LCI 7-22), acetaldehyde (LCI 7-20), propanal (LCI 7-21), butanal (LCI 7-1) and acetone (LCI 8-10) shall be determined using the method described in ISO 16000-3 that is in accordance with the specifications of EN 16516.

III) Analysis of substance groups

The quantification of substances from the substance groups LCI 2-9, LCI 2-10, LCI 4-18 and LCI 10-17 is carried out as toluene equivalents, i.e. following calibration with toluene.
The subdivision of the substance groups (2-9/2-10) required due to the different LCI values is determined by the appearance of an 'alkane peak' in the gas chromatogram at the retention time of n-nonane. For aliphatic hydrocarbons with a retention time shorter than that of *n*-nonane, the LCI value of 14000 µg/m³ applies, and for aliphatic hydrocarbons with a retention time equal to or exceeding that of n-nonane, the LCI value of 6000 µg/m³ applies. The retention time of n-nonane shall also be used for the classification of individual peaks of saturated aliphatic hydrocarbons that cannot be identified more precisely.

IV) Analysis of acetic acid (LCI 9-1)

The analytical method described in VDI 4301, Part 7, shall be used for the determination of acetic acid.

V) Adoption of EU-LCI values

At present, discrepancies may arise between a EU-LCI value included in the LCI list and the current EU-LCI value in the EU-LCI list. This is primarily due to delays in publication by the relevant bodies. The assessment lists must be used in their entirety; they must not be mixed. The supporting documents for the adopted EU-LCI values are published at https://single-market-economy.ec.europa.eu/sectors/construction/eu-lci-subgroup_en (availability of the link last checked on 26.05.26).

II. Rationale

1. Introduction

Indoor environmental conditions, particularly room and surface temperature, air change rates and relative humidity, as well as volatile organic compounds (VOC) in indoor air, influence human health and well-being in indoor spaces. VOC can be released from a wide variety of sources and are usually present as mixtures. As they often cover large surface areas of a room, building products have a significant influence on the indoor air quality [Hodgson, 2000; Park, 2013; Paciencia, 2013; Derbez et al., 2018; Harb, 2018; Richter, 2021]. To ensure adequate indoor air quality in buildings during use, it is therefore essential to assess the health impacts of emissions from building products.

The use of low-emission building products is particularly important in low-energy buildings with a low air change rate to avoid health risks caused by emissions from building products.

1.1 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]). 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.

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 – the minimum level of protection. Irrespective of this, other areas of law (e.g. occupational safety, pollution control, waste legislation) may impose different requirements.

Indoor air quality in buildings must be safe for health and, as a rule, equivalent to outdoor air quality; this must be ensured by limiting emissions from building products. Before using building products indoors, it is therefore necessary to check whether the applicable requirements regarding their emissions are met.

Regulation (EU) No 2024/3110 laying down harmonised rules for the marketing of building products (Construction Products Regulation, [CPR]) sets out in Annex I No 3 essential requirements for construction works, including those relating to hygiene and health. These include, amongst other things, the prevention and limitation of indoor pollutants, e.g. VOC. The basic requirements for construction works listed in Annex I form the basis for the development of standardisation mandates (Article 5(2) of the CPR).
In 2005, on the basis of the CPR, the European Commission issued a mandate to CEN (European Committee for Standardisation) to develop horizontal assessment methods for dangerous substances incorporated in and emitted from building products. For this purpose, CEN established the technical committee CEN TC 351. The result of this standardisation work

is the EN 16516: Construction products – Assessment of the release of dangerous substances – Determination of emissions into indoor air.
Horizontal assessment methods form the basis for technical specifications of building products in the standardisation work and in the European Technical Assessment under the CPR. The horizontal standard EN 16516 is now used throughout Europe in building control verification procedures for assessing VOC emissions from building products.

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 product (Article 6 CPR) on the basis of the "essential characteristics", procedures and criteria set out in the respective product standard. If the building product performances declared according to the harmonised rules meet the requirements for the 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 17, Paragraph 3, CPR).

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. EN 16798-1 has not been implemented by the building authorities.

1.2 Healthy indoor air quality in built structures - AgBB tasks

The Committee on Health-related Evaluation of Building Products (AgBB) is mandated by the Conference of Health Ministers (Gesundheitsministerkonferenz) and the Conference of Building Ministers (Bauministerkonferenz) to create the basic principles for a uniform assessment of building products for protection against indoor health risks, and to update these principles in line with the current state of knowledge. This fulfils, on the one hand, the requirements specified in the building regulations of the German Federal States and the European CPR and, on the other hand, enables a comprehensible and objective product evaluation. With the aim of achieving healthy indoor air quality, all emissions from building products are assessed according to the same health criteria, regardless of their source.

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).

The Committee first published the AgBB evaluation scheme for the health assessment of VOC emissions from building products intended for use in indoor spaces in 2000 [AgBB, 2000]. The AgBB evaluation scheme covers VOC in the retention range from C_6 to C_{16} (*n*-hexane up to and including *n*-hexadecane), which are considered as individual substances and as sum parameters, as well as very volatile (VVOC) and semi volatile organic compounds

(SVOC) in the retention range below C_6 and from C_{16} to C_{22}, respectively [ECA 18, 1997a; ECA 19, 1997b].

The AgBB evaluation scheme was extensively discussed with representatives of manufacturers and professionals both upon its publication and during its introductory phase from 2002 to 2004 [Proceedings of the technical dialogues in 2001 and 2004; International Conference, 2007]. The result was adopted by the AgBB [AgBB, 2005] and implemented by the DIBt in the approval guidelines for the health-related evaluation of building products. Since 2017, the AgBB evaluation scheme has become the basis for the assessment of building products according to the 'Requirements for buildings regarding health protection (ABG)', Annex 8 of the Model Administrative Provisions - Technical Building Rules [MVV TB].

The criteria of the AgBB evaluation scheme are set to protect the general public, including children, pregnant women and the elderly, from indoor health risks. Exposure over the entire lifetime is considered. However, groups with particular individual sensitivities, such as people with allergies and those with pre-existing medical conditions, cannot be taken into account when establishing the assessment criteria.

Compliance with the criteria of the AgBB evaluation scheme ensures that the minimum requirements for protecting the health of building occupants from VOC emissions are met. Manufacturers can declare performance levels that go beyond these requirements as a precautionary measure by using voluntary quality labels, such as the Blue Angel [ECA 24, 2005; ECA 27, 2012; Däumling, 2012].

The AgBB actively supports efforts to harmonise the health assessment of emissions from building products in Europe [ECA 27, 2012; ECA 29, 2013; European Commission, 2023].

2. Scientific fundamentals for the health-related evaluation of VOC emitted from building products

The negative effects of indoor air pollution on human health have been extensively investigated and proven [see, for example ECA 10, 1991b; WHO, 2000, 2010, 2021; Doty, 2004; Billionnet, 2011; Cakmak, 2014; Halios, 2022]. Acute and/or long-term effects of VOC can range from odour perception, discomfort and local irritation of the mucous membranes of the eyes, nose and upper respiratory tract, to impaired lung function, effects on the nervous system and systemic effects [Mendell, 2007; Brightman, 2008; Nakaoka, 2014; Allen, 2015; Kleinbeck, 2024]. Health effects of substances also include carcinogenic (cancer-causing), mutagenic (genotoxic) and reprotoxic (reproductive and/or developmental) effects, as well as endocrine-disrupting (disruption of the endocrine system and resulting impairments or damage) properties [Sarigiannis, 2011; EFSA Scientific Committee, 2013; Radke, 2018; Chupeau, 2020; Zhang, 2020]. This may also include allergenic or allergy-aggravating properties of substances [Nurmatov, 2015].

As early as the 1990s, national and international bodies, in particular the European Collaborative Action (ECA) 'Indoor Air Quality and its Impact on Man', were specifically addressing issues related to the assessment of VOC emissions from building products. The ECA comprised experts from countries of the European Union. Coordinated by the European Union's Joint Research Centre, it compiled the specific knowledge available in Europe on a

wide range of indoor environment-related topics in the following years and summarised this in reports. These reports contained such detailed information that they can be described as "pre-normative". Particularly noteworthy is ECA Report 18, 'Evaluation of VOC Emissions from Building Products', which provides an example of an assessment scheme for emissions from floor coverings [ECA 18, 1997a].

For the health assessment of substances emitted from building products, concentration levels are determined above which the individual substance is expected to have adverse effects on health (LCI values; lowest concentration of interest for the individual substance; see Section II 3) [ECA 29, 2013].

However, building products generally emit not just individual substances, but mixtures of a wide variety of substances. To ensure that adverse health effects arising from VOC mixtures are kept to a minimum, an appropriately conservative assessment method is therefore required, one that also takes into account interactions between different substances. As there is insufficient data on interactions, the dose addition of effects is assumed as a toxicological convention. Studies have shown that the dose addition model adequately predicts the toxicity of a mixture consisting of several substances [Wolkoff, 1997; Nielsen, 2007; Abraham, 2016; Bruckner, 2019]. National and international committees and studies advocate the additive model as a suitable approach for adequately accounting for the effects of mixtures in regulatory requirements [European Commission, 2012; OECD, 2018; More, 2019; SWD, 2020; Martin, 2021]. The assessment of mixtures of substances in the workplace also follows an additive approach [TRGS 402, 2023]. Against this background, the AgBB uses the additive model in accordance with scientific convention as a practical approach.

Combinatorial effects of individual substances with LCI values within a mixture of substances emitted by a building product are assessed in the AgBB evaluation scheme using the hazard index 'R' (R-value) criterion. This is based on the recommendation of the European expert panel in ECA Report 18 and was reconfirmed in ECA Report 29 [ECA 18, 1997a; ECA 29, 2013; Azuma, 2016; Pelletier, 2018].

As only individual substances with a LCI value are included in the hazard index 'R', this criterion does not adequately represent the assessment of building occupants' exposure to a mixture of VOC. To close this gap, emissions are additionally assessed using TVOC [cf. Hudnell, 1992; Koren, 1992; Molhave, 1999; Fromme, 2019; ECA 27, 2012; Abraham, 2016; Suzuki, 2021; ISO 16000-6; EN 16516].

Controlled exposure studies in humans using defined VOC mixtures and cross-sectional epidemiological studies on TVOC have repeatedly demonstrated concentration-dependent health effects [see ECA 19, 1997b; Tsumura, 2023]. Against this background, the summation of the various VOC in a mixture in indoor air and setting an upper limit for the total concentration in relation to long-term exposure is a proven and necessary measure to avoid health risks [see e.g. ECA 18, 1997a; Järnström, 2006; Brelih, 2012; Hormigos-Jimenez, 2017]. ECA Reports 18 and 19 from the European expert groups explain the significance of TVOC for adequate health protection in indoor spaces. Accordingly, as an assessment criterion within the AgBB concept, TVOC restricts the total emissions from the building product to an upper limit necessary for health protection.

The importance of TVOC is also evident from the fact that it has been standardised as a parameter in the international standard ISO 16000-6 since the 1990s and in the horizontal testing standard EN 16516 since 2017. Limiting TVOC at source at the level of building products has become a requirement in the European standard EN 16798-1, as well as in national and international legal regulations and voluntary requirements [Shrubsole, 2019; Tuomi, 2014; Azuma, 2020; Scutaru, 2020; Dodd, 2021].

The requirements of the two criteria, TVOC and the hazard index 'R', limit the formation of harmful secondary emissions in connection with the oxidising capacity of indoor air [Welscher, 2018; Wolkoff, 2020]. This is because emitted substances can undergo chemical reactions with other substances indoors, which take place in the indoor air, on particles or on surfaces. For certain individual substances with high LCI values, the TVOC limit may be stricter than the combination of substance-specific criteria with the hazard index 'R'. This limitation is intentional and serves to protect health from combined effects with other components of the air mixture that are not included in the hazard index 'R'.

SVOC, such as phthalates and brominated flame retardants, are often emitted from building products over much longer periods than VOC due to their lower vapour pressure [Hutter, 2013; Bradman, 2014]. According to Weschler (2009), SVOC emissions from building products can be detected over years or even throughout the entire service life of the product. As many SVOC are classified as neurotoxic, carcinogenic, mutagenic, toxic to reproduction or endocrine-disrupting (see e.g. Li, 2019; Pelletier, 2017, 2018), it is necessary to limit SVOC emissions in total.

For health protection reasons, consideration must also be given to substances that cannot be identified analytically (EN 16516), or those that can be identified but do not have a LCI value (not toxicologically assessed or not assessable). As the use of such substances in practice prevents the otherwise required level of health protection, a separate quantitative limit on substance emissions for VOC with unknown LCI value is essential.

The use of substances intended to mask disturbing emissions from building products is regarded as problematic due to the additional VOC exposure this causes for building occupants, and is therefore rejected by the AgBB.

3. Derivation of LCI values

3.1 Basic considerations

LCI values (lowest concentration of interest for the individual substance) are used for the toxicological evaluation of emissions from building products. They indicate the concentration level above which adverse health effects are expected for the individual substance [ECA 29, 2013]. LCI values are expressed in µg/m³. They are derived for the health-related evaluation of emissions from building products and should be applied in this context.

With regard to the mixture of substances emitted by building products in indoor spaces, LCI values are a necessary parameter for mitigating health risks posed by individual substances. LCI values are used to determine the hazard index 'R' (see Section I 3.2) and are not used alone as an assessment parameter.

3.2 Derivation procedure

A working group within the AgBB (the LCI Working Group) composed of experts and representatives from the manufacturing industry is responsible for the derivation of LCI values. Between 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 18. However, where hazardous substances are handled under typical conditions in workplaces, much higher substance concentrations than in public and privately used living spaces are generally encountered. Furthermore, relatively shorter exposure times are assumed in the workplace. Consequently, vulnerable population groups and the absence of exposure monitoring through measurements and occupational health surveillance are taken into account in the derivation of LCI values using appropriate factors [ECA 18, 1997a].

Since 2011, EU LCI values (European LCI values) have been developed and published by a European Commission expert group comprising experts from the Member States [ECA 29, 2013; European Commission, 2023].

The procedure for deriving EU-LCI values consists of three steps: 1. Compilation of available toxicological data; 2. Assessment of data quality; 3. Derivation of a EU-LCI value based on a standardised fact sheet. The selection of the reference study (key study) that serves as the basis for deriving the EU-LCI value is justified, and the extrapolation factors applied are documented in accordance with the guidelines 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," ECHA, 2012). The derivation procedure includes rounding rules and instructions for the application of read-across for substances with insufficient data.

To support the harmonisation of health-related evaluation of emissions from building products in Europe, the published EU-LCI values are generally adopted when the LCI list is updated. Only a few substances remain on the LCI list that are based on workplace exposure limits. These, too, will soon be replaced by EU-LCI values derived from current data.

For substances to be newly evaluated for which no EU-LCI values yet exist, LCI values are derived analogously to EU-LCI values. These are identified in the LCI list as 'individual substance evaluation'.

If the data available is insufficient to derive a LCI value, an assessment is conducted to determine whether an individual substance evaluation can be performed based on assignment to a substance class with a similar chemical structure and comparable toxicological assessment. This 'read-across' approach is consistent with the methodology described in ECA Report 29 [ECA 29, 2013].

Substances that cannot be evaluated are subjected to a strict limitation of their total amount within the AgBB evaluation scheme using the parameter "VOC with unknown LCI' (see also Section I 3.2 and Figure 1 'VOC with unknown LCI').

Manufacturers can apply to the AgBB for the derivation of a LCI value by submitting appropriate data. The same applies to substantiated requests to change existing LCI values,

provided these do not represent EU LCI values. An application form can be downloaded from the website of the German Environment Agency. A corresponding procedure at the EU level is desirable but has not yet been established.

3.3 Publication

An updated version of the LCI list is published regularly and is included in Section I 4, along with brief notes on how it was derived. The EU-LCI list, including supporting documents is available on the European Commission's website.

4. Voluntary sensory evaluation

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.

As a result of two research projects on odour emission measurements of building products in test chambers [UBA Texts 21/2007 and UBA Texts 61/2011], a nationally standardised [VDI 4302 Part 1] and an internationally standardised [ISO 16000-28] methodology are now available.

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 within the AgBB evaluation scheme using the parameter of perceived intensity.

During a pilot phase from 2012 to 2015, extensive experience was gained with the test methodology for various building products. The pilot phase aimed to examine different building products in collaboration with interested parties from industry associations, manufacturers, and testing institutes, to check the applicability of the proposed methodology, and to conduct two interlaboratory comparisons. Studies by the Fraunhofer Wilhelm-Klauditz Institute (WKI in Braunschweig) showed that ISO 16000-28 (December 2012 edition, withdrawn) does not sufficiently describe the measurement procedure [Salthammer, 2016]. During the pilot phase, BAM offered two interlaboratory tests that, in addition to ISO 16000-28, also included VDI 4302 Part 1 and, in the second interlaboratory test, a standard operating procedure [UBA Texts 88/2014 and UBA Texts 79/2015]. Eight and 11 test laboratories, respectively participated successfully in the interlaboratory comparisons.

The findings from the pilot phase made it possible to specify and revise ISO 16000-28 by adding additional measurement requirements. Taking these additional specifications into account, the measurement procedure is suitable for determining perceived intensity (ISO 16000-28:2021-11).

From the AgBB's perspective, odour nuisances constitute an unacceptable situation for the occupants of indoor spaces. An evaluation criterion is needed to identify when the intensity of an odour nuisance becomes unacceptable. Based on a survey [UBA Texts 61/2011] and from a health and hygiene perspective, the AgBB derives a preliminary standard for odour

intensity in pi (pi: perceived intensity), which can be used to determine whether a building product causes an unacceptable odour nuisance.

Low-odour building products are a prerequisite for low-odour indoor spaces [UBA Texts 73/2017] and are therefore decisive for people's well-being, performance, and long-term health when they are inside buildings.
For this reason, the AgBB recommends odour testing of building products on a voluntary basis. Furthermore, the AgBB supports further research into the effects of odour-intensive building products on odour levels in indoor spaces.

5. Conclusion

The adverse health effects of VOC are scientifically proven and documented in the technical literature. Building products emit VOC that vary in type, composition, and concentration. The criteria of the AgBB evaluation system are selected to protect the general public from health hazards in indoor spaces. These criteria are standardised and apply as generally acknowledged rules of technology. All building products are assessed according to the same health criteria, regardless of their source.

VOC always have an effect on building occupants as a mixture and as the sum of multiple substances present simultaneously. In the AgBB evaluation scheme, in addition to assessing individual substances, the combined effects of harmful VOC are taken into account through the hazard index 'R' and the summation of individual emissions (TVOC, TSVOC, VOC with unknown LCI) from the building product to determine total exposure. Since the assumption of an additive effect (hazard index 'R') underestimates the potential impact of substance mixtures, the criteria defined in the AgBB represent a minimum level of health protection. This level of protection is generally insufficient for people with pre-existing conditions and those with specific hypersensitivity to certain allergenic substances, who are considered vulnerable groups.

A building product that fulfils the criteria set out in the AgBB evaluation scheme is safe for human health and suitable for use in indoor spaces. This is a necessary prerequisite for achieving acceptable indoor air quality in accordance with generally acknowledged rules of technology. To this end, performance testing of building products with regard to the basic requirement of health protection is an indispensable prerequisite for ensuring the minimum level of protection in the long term after the installation of building products in buildings.

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