DOKUMENTATION

05/2021

Final report

Harmonised VOC Emission Classes for Construction Products

A Tool to Achieve Healthy Buildings

by:

Reihlen Antonia, Jepsen Dirk
Ökopol GmbH, Hamburg

publisher:
German Environment Agency

German Environment Agency

Umwelt Bundesamt

DOKUMENTATION 05/2021

Ressortforschungsplan of the Federal Ministry for the
Environment, Nature Conservation and Nuclear Safety

Project No. (FKZ) 3720 61 201 0

Report No. FB000640/ENG

Final report

Harmonised VOC Emission Classes for Construction Products

A Tool to Achieve Healthy Buildings

by

Reihlen Antonia, Jepsen Dirk
Ökopol GmbH, Hamburg

On behalf of the German Environment Agency

Imprint

Publisher
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
buergerservice@uba.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt

Report performed by:
Ökopol GmbH
Nernstweg 32-34
22765 Hamburg

Report completed in:
September 2021

Edited by:
Section II 1.3 Indoor hygiene, health-related environmental impacts
Scutaru Ana Maria
Section III 1.4 Substance-related Product Issues
Outi Ilvonen

Publication as pdf:
http://www.umweltbundesamt.de/publikationen

ISSN 2199-6571

Dessau-Roßlau, November 2021

Abstract: Harmonised VOC Emission Classes for Construction Products

The current documentation summarises the presentations and discussions of an international online conference organised by the German Environment Agency in April 2021 on emission classes for volatile organic compounds (VOCs) in construction products.

Construction products are an important source of VOC emissions into indoor air. A chamber test was standardised under the Construction Products Regulation to enable harmonised measurement results of VOC emissions from construction products. If required by the product standards, the VOC emissions must be reported as part of the performance declaration. To provide understandable information to the product users, a class system was proposed by some of the Member States to differentiate the VOC emission performance into five levels. According to the proposal, four performance characteristics are evaluated to allocate a product to a VOC emission class. The overall feedback to the proposal was positive.

Kurzbeschreibung: Harmonisierte VOC-Emissionsklassen für Bauprodukte

Die vorliegende Dokumentation fasst die Vorträge und Diskussionen einer vom Umweltbundesamt im April 2021 organisierten internationalen Online-Konferenz zu Emissionsklassen für flüchtige organische Verbindungen (VOC) in Bauprodukten zusammen.

Bauprodukte sind eine wichtige Quelle für VOC-Emissionen in die Innenraumluft. Im Rahmen der Bauproduktenverordnung wurde ein Kammertest genormt, damit die Ergebnisse von Messungen der VOC-Emissionen aus Bauprodukten harmonisierter erhoben und dokumentiert werden. Wenn Produktnormen Angaben über VOC-Emissionen fordern, müssen diese als Teil der Leistungserklärung angegeben werden. Um den Produktnutzer*innen verständliche Informationen zur Verfügung zu stellen, wurde von einigen Mitgliedstaaten ein Klassensystem vorgeschlagen, um die Leistung eines Produktes bzgl. der VOC-Emissionen in fünf Stufen zu unterteilen. Dem Vorschlag zufolge werden vier Leistungsmerkmale bewertet, um ein Produkt einer VOC-Emissionsklasse zuzuordnen. Die Resonanz auf diesen Vorschlag war insgesamt positiv.

Table of content

List of figures

List of tables

List of abbreviations

BIM	Building Information Modelling
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BREEAM	Certification system for sustainable buildings
C	Carbon
Cat.	Category
CE	Conformité Européenne
CEN	European committee for standardization
CLP	Regulation on the classification, labelling and packaging of substances and mixtures
CMR	Carcinogenic, mutagenic, reprotoxic
CPR	Construction Products Regulation
CSS	Chemicals Strategy for Sustainability
DoP	Declaration of performance
ECHA	European Chemicals Agency
EN	European norm
EPD	Environmental product declaration
EU	European Union
K	Kelvin
kPA	Kilo pascal
LCI	Lowest concentration of interest
LEED	Certification system for sustainable buildings
MAF	Mixture assessment factor
NGO	Non-governmental organisation
NPD	No performance declared
REACH	Regulation on the registration, evaluation, authorisation and restriction of chemicals
R-Value	Risk value
SVOC	Semi-volatile organic compounds
TVOC	Total volatile organic compounds
UBA	German Environment Agency (Umweltbundesamt)
VOC	Volatile organic compound

Summary

The German Environment Agency (UBA) organised an international conference about VOC emissions from construction products in April 2021. The aims of the conference were to revitalise the discussions about a class system to communicate VOC emissions from construction products, to make stakeholders aware of the work already completed as a precondition to this class system, and to provide a platform for experience and information exchange. This documentation summarises the presentations and discussions of that conference in form of an informative brochure about VOC emissions from construction products. In addition, it introduces the VOC emission class proposal discussed at the conference and the stakeholders' reactions to it .

Most people spend more than 90% of their time indoors. Therefore, the quality of indoor air, i.e. the concentration of pollutants in the indoor air, has a significant impact on human health. VOCs emitting from construction products are an important source of indoor air pollution. Due to the wide range of VOCs used in construction products the associated health effects range from "headaches" to "cancer". In the evaluation of VOC concentrations in indoor air, mixture effects must be considered, as exposure occurs to many and not only individual pollutants.

The Construction Products Regulation requires producers/placers on the market of construction products to declare their performance in accordance with the characteristics specified in the product specific standard. The essential characteristic "VOC emissions" is currently not included in the relevant product standards. The horizontal standard EN 16516 provides the methodology to determine the VOC emission of construction products and how to present the measurement results in the Declaration of Performance.

The EU-LCI Working Group was mandated by the EU Commission to develop a methodology to derive substance specific and health-based threshold values to evaluate VOC concentrations emitted from construction products into indoor air. The "lowest concentration of interest" (LCI) is the concentrations of a VOC measured in an emission test below which no adverse health effects are expected. The Working Group developed EU-LCIs for a large number of VOCs.

For many years, the German Environment Agency (UBA) has participated in the development of a VOC class system to communicate the VOC emission performance of construction products in an easily understandable way to the product users. After the EU Commission's first proposal of a respective implementing regulation in 2017 failed to get the green light from the stakeholders, related discussions and activities faded at EU level. In 2020 and within the framework of the European Green Deal and the EU Renovation Wave, the discussions were restarted. Some Member States developed a new common VOC emission class concept proposal based on the feedback received from a respective survey on how such a system should be structured and put it up for discussion at the conference.

The proposed emission class concept uses four performance characteristics, which can be derived from the chamber test measurements (the last three are related to a reference room):

- The sum of all relevant EU-LCI ratios (R-value);
- The concentration of carcinogenic, mutagenic and reprotoxic VOCs (Category 1A/B)
- The formaldehyde concentration and

► The total VOC concentration (with indication of the share of VOCs without an EU-LCI).

For each performance characteristic, categories are defined by numeric values. The combination of the performance levels (categories) of the four performance characteristics defines the indoor air quality class regarding VOC emissions.

Overall, the conference discussions indicated support for the concept in general, while some details of the parameters were criticised. Most stakeholders saw an urgent need for implementing a VOC emission class system to end the discussions and provide for clarity and guidance to both industries and authorities.

Zusammenfassung

Das Umweltbundesamt veranstaltete im April 2021 eine internationale Konferenz über VOC-Emissionen aus Bauprodukten. Ziel der Konferenz war es, die Diskussion über ein Klassensystem zur Kommunikation von VOC-Emissionen aus Bauprodukten neu zu beleben, die Akteur*innen auf die bereits geleistete Arbeit als Voraussetzung für dieses Klassensystem aufmerksam zu machen und eine Plattform für den Erfahrungs- und Informationsaustausch zu bieten. Die vorliegende Dokumentation fasst die Präsentationen und Diskussionen dieser Konferenz in Form einer informativen Broschüre über VOC-Emissionen aus Bauprodukten zusammen. Darüber hinaus wird der auf der Konferenz diskutierte Vorschlag für VOC-Emissionsklassen sowie die Reaktionen der Beteiligten darauf vorgestellt.

Die meisten Menschen verbringen mehr als 90 % ihrer Zeit in Innenräumen. Daher hat die Qualität der Innenraumluft, d. h. die Konzentration von Schadstoffen in der Innenraumluft, einen erheblichen Einfluss auf die menschliche Gesundheit. VOC, die aus Bauprodukten emittiert werden, sind eine wichtige Quelle der Innenraumluftverschmutzung. Aufgrund des breiten Spektrums der in Bauprodukten verwendeten VOC reichen die damit verbundenen gesundheitlichen Auswirkungen von "Kopfschmerzen" bis hin zu "Tumoren". Bei der Bewertung der VOC-Konzentrationen in der Innenraumluft müssen Mischungseffekte berücksichtigt werden, da im Innenraum eine gleichzeitige Exposition gegenüber vielen und nicht nur einzelnen Schadstoffen vorliegt.

Die Bauproduktenverordnung verpflichtet Unternehmen, die Bauprodukte herstellen oder in Verkehr bringen, deren Leistung gemäß den in der produktspezifischen Norm festgelegten Merkmalen zu erklären. Das wesentliche Merkmal "VOC-Emissionen" ist derzeit nicht in den einschlägigen Produktnormen enthalten. Die horizontale Norm EN 16516 enthält die Methodik zur Bestimmung der VOC-Emissionen von Bauprodukten und zur Darstellung der Messergebnisse in der Leistungserklärung.

Die EU-LCI-Arbeitsgruppe wurde von der EU-Kommission beauftragt, eine Methodik zur Ableitung stoffspezifischer und gesundheitsbezogener Schwellenwerte zu entwickeln, um die von Bauprodukten in die Innenraumluft abgegebenen VOC-Konzentrationen zu bewerten. Die "niedrigste interessierende Konzentration" (LCI) ist die in einem Emissionstest gemessene Konzentration eines bestimmten VOC, unterhalb derer keine gesundheitsschädlichen Auswirkungen zu erwarten sind. Die Arbeitsgruppe hat für eine große Anzahl von VOC EU-LCIs entwickelt.

Das Umweltbundesamt (UBA) arbeitet seit vielen Jahren an der Entwicklung eines VOC-Klassensystems, um die VOC-Emissionsleistung von Bauprodukten in leicht verständlicher Form zu vermitteln. Nachdem der erste Vorschlag der EU-Kommission für eine entsprechende Durchführungsverordnung im Jahr 2017 bei den Beteiligten keine Zustimmung fand, wurden die entsprechenden Diskussionen und Aktivitäten kontinuierlich weniger. Im Jahr 2020 und im Rahmen des Europäischen Green Deal und der EU-Renovierungswelle wurden die Diskussionen wieder aufgenommen. Einige Mitgliedstaaten entwickelten einen neuen Vorschlag für ein gemeinsames VOC-Emissionsklassenkonzept auf der Grundlage der Rückmeldungen aus einer entsprechenden Umfrage, wie ein solches System aufgebaut sein sollte, und stellten ihn auf der Konferenz zur Diskussion.

Das vorgeschlagene Emissionsklassenkonzept basiert auf vier Leistungsmerkmalen, die aus den Messungen der Kammerprüfung abgeleitet werden können (die letzten drei beziehen sich auf einen Referenzraum):

- Die Summe aller relevanten EU-LCI-Risikoquotienten (R-Wert)
- Die Konzentration krebserregender, erbgutverändernder und fortpflanzungsgefährdender VOC (Kategorie 1A/B)
- Formaldehydkonzentration und
- Die VOC-Gesamtkonzentration (mit Angabe des Anteils der VOC ohne EU-LCI).

Für jedes Leistungsmerkmal werden die Kategorien durch numerische Schwellenwerte definiert. Die Kombination der Leistungsstufen (Kategorien) der vier Leistungsmerkmale definiert die Innenraumluftqualitätsklasse hinsichtlich der VOC-Emissionen.

In den Diskussionen auf der Konferenz wurde das Konzept im Allgemeinen befürwortet, wobei einige Details der Parameter kritisiert wurden. Die meisten Beteiligten sahen die dringende Notwendigkeit, ein System von VOC-Emissionsklassen einzuführen, um die Diskussionen zu beenden und sowohl für die Industrie als auch für die Behörden Klarheit und Orientierung zu schaffen.

1 Preface

This brochure is a result of a project financed by the German Environment Ministry (BMU) and commissioned by the German Environment Agency. The project's main aim was to organise a conference to discuss the introduction of a system to indicate VOC emission classes for construction products. The conference was opened by Dr. Axel Vorwerk, the BMU's Head of the Directorate Environmental Health and Chemical Safety, with the following speech.

Ladies and Gentlemen,

I am pleased to welcome you to this international online conference "Limiting Health Impacts of Construction Products regarding Volatile Organic Compounds".

Unfortunately, we are not able to meet in person in a conference centre. But, an online conference has one advantage, time-consuming travel is not necessary. Therefore, we have a large number of attendees today. A warm welcome to all of you!

Indoor air quality is an important factor when striving for public health and a sustainable quality of life. Indoor air also affects our work productivity and cognitive abilities.

Improving indoor air quality needs an integrated approach that takes many factors into account. Construction products definitely are an important emission source for indoor air pollution. Reducing emissions from construction products is necessary and feasible.

The implementation of requirements to assess emissions of volatile organic compounds, VOC, from construction products under the Construction Products Regulation has been under discussion since 2010. In the past years we had important achievements, like the completion and publication of European harmonised analytical and assessment tools. Many European and national research projects improved our knowledge base. Many proposals were brought to the table on how to best declare the emission performance of construction products and how to define the so-called VOC classes.

Today we are able to assess the most common substances emitting from products we currently use in buildings with harmonised health-based reference values, the EU-LCI.

The Federal Ministry for the Environment has supported the harmonisation activities in many ways:

- *by sponsoring meetings of the EU-LCI Working Group, and*
- *by funding expert dossiers for the derivation of EU-LCI values.*

Furthermore, we are pleased that the German Environment Agency is strongly supporting and promoting the Europe-wide harmonisation of the health criteria for the assessment of construction products emissions.

But, here we are in 2021, still striving for consensus on this issue.

The German Government would sincerely appreciate if the European Commission puts into use the considerable knowledge gained in the past years. The time is ripe for the concrete implementation of an EU-wide harmonised declaration system to evaluate harmful emissions from construction products.

Germany is committed to ensuring that the health standards for construction products are not weakened and low-emission products come onto the market. In a fair and sustainable market, the health performance of products must be transparent for both consumers and builders. I am certain that the majority of European manufacturers look forward to the possibility of being able to compete not only by their price but also by their low VOC emissions.

Ladies and Gentlemen, this conference aims to revitalise the discussions on a harmonised communication about VOC emission classes. I wish you interesting presentations and fruitful discussions.

Thank you for your attention!

Dr. Axel Vorwerk,
German Environment Ministry (BMU)

2 Introduction

The indoor air quality is one of the important factors affecting human health as around 90% of the lifetime is spent indoors. The composition of the indoor air depends among others, on the ventilation of rooms, the behaviour of the inhabitants and users of buildings, the temperature and, not least the products used for the construction and the interiors of buildings.

Construction products may emit Volatile Organic Compounds (VOCs) to the indoor air over a very long period of time. Some of the VOCs are associated with adverse health effects, including cancer. Limiting VOC emissions from construction products is hence an important contribution to healthy indoor air. The assessment of VOC emissions from construction products and means to communicate this emission potential to the users to facilitate the selection of appropriate products have been on the EU agenda for a long time. Despite many successful national and even some European implementations, up to now no common agreement on a broadly applicable EU communication tool has been reached.

The current report aims to provide background information on why information on VOC emissions from construction products is important and how it can be obtained and evaluated with regard to the human health impacts. It aims to present and explain a concrete proposal of VOC emission classes so that this information can be communicated with construction products to end-users in order to raise awareness and support for the need and benefits of such a system.

The report is based on the presentations and discussions at the International Online Conference on Limiting Health Impacts of Construction Products regarding VOCs that took place on 20-21. April 2021.

Figure 1: There are many emisssion sources in a room

Source: archideaphot/Fotolia.com

3 The Policy Context

3.1 Legal background and history

The EU Construction Products Regulation (CPR) defines basic requirements for buildings including one specifying that buildings shall not cause harm to human health or the environment. Amongst other aspects, this basic requirement addresses the release of VOCs to the indoor air. If a Member State wishes to define requirements on how buildings in their territory should be constructed – e.g., limit the concentration of VOCs in indoor air – the CPR provides the tools for choosing products with matching performances.

For various types of construction products, harmonised European standards exist that define performance parameters which can be assessed and declared for all products of that product type. These parameters are called essential (product) characteristics and are relevant to check and decide whether it is possible to use a product in a particular building, i.e., if it would not endanger the fulfilment of the basic requirements required by the provisions in any Member State.

To ensure compliance with the basic requirement of human health protection, it is important to know the VOC emission characteristics of a construction product. Therefore, harmonised standards of products that are used indoors and are likely to release VOCs should include a possibility to determine the VOC emission. The essential characteristic "VOC emissions" can be added once these have been included in formal standardisation requests for the specific harmonised product standards.

All essential characteristics specified in a harmonised standard must be declared in the declaration of performance (DoP) by the producers/placers on the market of the construction products. Horizontal harmonised standards define the test methods to determine the performance of essential characteristics. If a performance is not determined, a "no performance declared" (NPD) option is also available.

The DoP includes all technical, safety and health information that is necessary to select a product for use in a building. Products with a complete and compliant DoP may carry the CE marking, which is a precondition for placing a product on the EU market if a harmonised standard exists. If national provisions exist for buildings, information in the DoP can be used to check conformity with the national requirements. The DoP is hence an important information source about the product.

The standardisation request (mandate) M/366 to CEN covers the assessment methods for releases of dangerous substances from construction products. The mandate covers methods for all construction products with the exception of paints, which are generally excluded from the CPR's scope. As the uptake of a respective essential characteristic into a product standard takes time and as there are many product standards, the requirement to identify the VOC emission has still not been included in all relevant standardisation requests and standards of the currently 36 product groups covered by the CPR.

The development of a horizontal method to test the VOC emissions from construction products under M/366 was a pre-condition to the inclusion of the VOC emissions as an essential characteristic into standardisation requests and the corresponding product standards. The harmonised European standard EN 16516 "Construction products: Assessment of release of dangerous substances – Determination of emissions to indoor air", was published in 2017. Some more information about the standard is provided in Section 4.4.

Figure 2: Assessment methods and guidance are developed at EU level

Source: Photo by Guillaume Périgois on Unsplash

A second milestone for the assessment of VOC emissions was the development of a methodology for and the derivation of reference values: the "lowest concentrations of interest" (LCIs). The LCIs are derived from toxicological data and indicate "the lowest concentration above which, according to best professional judgment, the pollutant may have some effect on people in the indoor environment."[1] The LCIs indicate if the occurrence of a VOC in indoor air may adversely affect human health (concentration above the LCI) or is unlikely to cause harm (concentration below the LCI value), when the particular substance is the only pollutant present. The EU Commission DG Grow mandated an expert group on dangerous substances (EU-LCI Working Group) to derive respective values for the relevant VOCs in indoor air in 2015. This is further described in Section 4.2.

In discussions about the evaluation of the health impacts of VOCs in indoor air, the characterisation of potential harm from a construction product with the help of LCI alone was seen as insufficient, due to demonstrated simultaneous presence of several VOCs in the indoor air. Therefore, discussions started on which set of evaluation parameters adequately reflects the potential risks from construction products releasing VOCs to the indoor air and how these could best be communicated.

The German authorities were among the drivers of the discussions on how to design an evaluation and communication system for the VOC emission performance of construction products. A "lunch briefing" in Brussels was held to **propose and discuss criteria** for VOC emission classes in 2017. Under the German EU Council Presidency in autumn 2020, a **report** concerning the further development of the CPR was prepared and discussed at an informal virtual meeting of the Working Party Technical Harmonisation (Construction Products) and at the conference "**Construction Products – Fit for the Future**". With the International Conference on Limiting Health Impacts of Construction Products regarding VOC, the German authorities aimed to revive the discussion on the VOC emission classes.

[1] ECA report no 18 (1997)

3.2 Current political context

In the frame of the EU Green Deal, a number of policies have been developed that aim at an ecological transformation of the European society and economy. Some of these policies are also relevant for the design and use of buildings and construction products.

In relation to the 'Zero Pollution Ambition for a Toxic-Free Environment', the **Chemicals Strategy for Sustainability** (CSS) was launched, which is expected to trigger the replacement of hazardous substances in any type of product, including construction products, thereby reducing the exposure levels outdoors as well as indoors. Due to envisaged changes to the REACH regulation and the Classification and Labelling Regulation (CLP), the availability and accessibility of information on the content of hazardous substances in the raw materials of construction products will change with time. In addition, the requirements towards the human health and environmental performance of products are likely to increase due to the generally higher level of ambition as well as a focus on making products more suitable for a circular economy, and the transparency requirements on the content of hazardous substances (including VOCs) in products may become stricter.

Figure 3: Insulation material

Source: Photo by Patryk_Kosmider on iStock

The **EU Renovation Wave Strategy** will also affect the quality of indoor air and influence developments on the VOC emission performance of construction products. The Renovation Wave Strategy aims to initiate extensive renovation works of existing buildings across the EU to reduce the energy consumption of buildings, and thereby contributing to the achievement of the goal of climate neutrality. To ensure all renovation activities also contribute to a healthy indoor environment, high health and environmental standards must be guaranteed in the implementation of all activities. If VOC emissions from construction products are considered on a regular basis in the selection of renovation products, the demand for (easily understandable) information on the VOC emission performance will increase and may generate a market push towards low emission products in general.

Overall, the decision makers at EU level give high priority to the protection of human health and the environment, which is a good opportunity and incentive to further proceed on the evaluation and communication of VOC emissions from construction products into indoor air.

4 Evaluating VOC Emissions from Construction Products

4.1 Health hazards of VOCs

Volatile organic compounds are a diverse group of chemical substances, which share the characteristic that they are carbon-based molecules with a vapour pressure of 0.01 kPa or more at room temperature (i.e. 293 K) or a corresponding volatility under the particular conditions of use[2]. Some VOCs are associated with adverse effects on human health, including respiratory irritation, impaired development of unborn life, cardio-vascular diseases, neurological and renal diseases as well as cancer.

Most VOCs that are intentionally used in construction products are registered under REACH. Therefore, data on their hazardous properties should be available in **ECHA's database** of registered substances. The extent to which this information is generated and provided depends on the registration volume of a VOC. In addition, all chemicals placed on the market must be classified and labelled using available information. The classification and labelling information is publicly accessible through ECHA's **classification and labelling inventory**.

Currently, information is missing especially for substances that are used in low volumes or that are not actively used, but form when using the product through reactions with the surrounding air (e.g., oxygen, ozone, VOC from other sources, humidity).

Apart from the toxicological effects, odours are also associated with the occurrence of VOCs. While odours apparently have no immediate toxic effect, they are correlated with a decreased well-being of the inhabitants.

Figure 4: The ECHA database provides substance information

Source: © European Chemicals Agency, 2013

[2] DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control); Art. 3(45)

4.2 Reference values to assess impacts of emissions from construction products - EU-LCIs

To evaluate a given VOC exposure level regarding its potential health impacts, a reference is needed about the toxicity of that VOC. At EU level the threshold concentration below which no adverse effect is expected of a VOC in the context of the CPR is called "Lowest Concentration of Interest" (LCIs).

The ECA report no 29[3] defines an LCI as "health-based values used to evaluate emissions after 28 days from a single product during a laboratory test chamber procedure" (as defined in EN 16516).

An expert group started developing a common methodology for deriving EU-LCI values and was officially mandated to do so by DG Grow in 2015. The methodology is documented in the above mentioned ECA report no 29. The application of the LCI concept is closely bound to the test procedure laid down in the EN 16516 standard.

For each LCI a factsheet is prepared with general information, documenting what data were compiled for the specific substance, how they were evaluated and what considerations finally underpin the derived LCI. No LCIs are derived if relevant data is not available. New values are continuously included in the **list of LCIs** by the EU Subgroup on EU-LCI Values.

4.3 Combination effects of VOCs

The existence of combination effects and options of their assessment have been discussed for a long time in the context of chemicals management and policies. It seemed generally accepted in the regulatory context that the assessment of combination effects is neither necessary nor possible.

The lack of a necessity to assess combination effects was based on the false assumption that no adverse effects would occur if the concentrations of all individual components of a mixture remained below their individual effect thresholds. Over time this assumption has been disproved by several scientific studies and the existence of combination effects is now commonly accepted.

The complexity that an assessment of combination effects has to tackle remains a challenge due to the large number of possible substance combinations. However, at least one very simple solution is currently being discussed under the Chemicals Strategy for Sustainability, consisting of the implementation of an (additional) Mixture Assessment Factor (MAF) in chemical risk assessments.

The scientific studies showing that adverse effects occur even when the exposure to individual substances remains below the effect thresholds also proved that the approach of "concentration addition" can predict the toxicity of a mixture. Concentration addition is the process of summing up risk quotients of all components of a mixture that cause the same type of adverse effect[4].

[3] European Collaborative Action Urban Air, Indoor Environment and Human Exposure (2013): Harmonisation framework for health-based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept. Report No. 29

[4] The application of the dose additivity approach is limited if hazardous components of a mixture may cause different adverse effects, i.e. one is a respiratory sensitiser and another impairs fertility. At the moment it is not feasible to use health endpoint specific risk quotients.

In the context of chemicals risk assessment, this is expressed by the following equation:

$$Hazard\ Index = \sum \frac{Exposure}{Effect\ threshold}$$

Equation 1: Determining the hazard index of a mixture

If the sum of all risk quotients exceeds the value of 1, the adverse effects which the assessment is made for is predicted to occur. The assessment parameter "R-value" in the context of the CPR is analogous to the concentration addition method and appropriate to predict the risks from VOC emissions in indoor air.

The calculated exposure concentration of a particular VOC is divided by its EU-LCI and an EU-LCI ratio is obtained. If the sum of all EU-LCI ratios (the R-Value) exceeds the value of "1" harm may occur. The size of the R-value gives an indication of the level of risk, i.e. the larger the R-value, the more likely are adverse effects on human health from the co-exposure to several VOCs.

$$R - value = \sum \frac{Exposure}{LCI}$$

Equation 2: Determining the R-value of the VOC emissions from a construction product

4.4 Determining VOC exposures in indoor air

4.4.1 Measuring VOC releases from construction products

To define a common approach across the EU to determine VOC emission from construction products, the harmonised standard EN 16516[5] was developed. Amongst others, the standard defines relevant terms and describes how products should be sampled, transported and handled, what conditions to ensure in the test chamber and how to measure VOCs in the test chamber air. The standard also defines how to calculate the VOC emission rate based on the measured data and how to derive and report an exposure concentration in a standard reference room as well as how to report the test results.

The EN 16516 is applicable to any construction product used indoors and all therein contained regulated dangerous substances, which are either volatile or semi-volatile or very volatile aldehydes. The VOCs are allocated into the three groups based on their retention time in the gas chromatography.

As a result of the measurements, the chamber test allows determining the reference room concentration of:

- Identified target compounds
- Identified non-target compounds
- Unidentified compounds
- Volatile carcinogens
- Total Volatile Organic Compounds (TVOC)
- Total Semi-Volatile Organic Compounds (TSVOC)

[5] EN 16516:2017 Constructions products – Assessment of release of dangerous substances – Determination of emissions into indoor air

Figure 5: Testing VOC emissions in the chamber test

Source: Federal Institute for Materials Research and Testing (BAM) 4.2

The information obtained via the chamber test is used in the health assessment of the construction product emission.

The scenario defined in the EN 16516 of a reference room is considered a moderate and simplified scenario, due to the (comparably short) time scale of 28 days and the absence of conditions in the chamber tests that may reduce VOC concentrations in real life indoor environments. The chosen room size, temperature, air change, humidity and product loading factors represent typical conditions in a small room.

4.4.2 Predicting VOC occurrence in indoor air

The Building Information Modelling (BIM) is a tool to predict the performance of a building regarding several parameters, including the quality of indoor air. It allows an integrated view of the building performance by facilitating the combination of various types of technical information.

In their research, D'Amico et al.[6] aimed to link data on measured VOC emissions (e.g., from the application of the EN 16516) to the actual indoor air quality under "real life conditions". The model they developed should support building designers to check the impact of various construction products on the indoor air quality in the design stage of buildings. It assumes a complete mixing of VOCs in indoor air and considers both multiple sources of VOCs and various conditions influencing the VOC concentrations, such as the ventilation. Factors which are not

[6] D'Amico et al. 2021): Modelling VOC Emissions from Building Materials for Healthy Building Design. Sustainability 2021, 13, 184.

related to the building itself, such as the use of cleaning products or the user behaviour are not considered in the model.

Figure 6: Building information modelling aims to predict VOC concentrations indoors

Source: Photo by Jarek Ceborski on Unsplash

The authors conclude that the currently applied VOC limit values, e.g., under the BREEAM[7] or LEED[8] protocol, do not necessarily correlate with a high indoor air quality. They derived indications on the influence of VOCs released from construction products on the indoor air quality that were considered helpful for the building design process. Another research finding points to the fact that the producers of construction products frequently provide either incomplete VOC emission information or do not specify under which conditions the VOC emission data were obtained. Availability of standardised information on VOC emissions of construction products would be a prerequisite for integrating indoor air quality data in BIM.

4.4.3 Measuring VOC occurrence in indoor air

In Germany, a database exists[9] on VOC concentrations in indoor air. The database contains more than 7500 data sets on more than 500 individual substances collected from indoor air measurements. The data include background documentation on the reasons for the measurement, the conditions in the indoor environment, sampling etc.

Evaluations of this data, which were collected from 2002 to 2012, show that some substances are almost always present in indoor air, such as acetaldehyde and formaldehyde. In contrast, a large majority of the 500 identified substances was not detected at relevant concentrations, i.e., above the detection limit. Some (aromatic) solvents were found to occur in very high concentrations. The total VOCs concentrations (TVOC) reported to this database range between 25 µg/m^3 and 27 500 µg/m^3.

[7] https://www.breeam.com/

[8] https://www.usgbc.org/leed

[9] The database is operated by the AGÖF (Association of ecological research institutes) and was originally established with funding from the German Environment Agency. https://www.agoef.de/orientierungswerte/agoef-voc-datenbank.html

Figure 7: Indoor air samples are analysed regarding their VOC content

Source: Bremer Umweltinstitut GmbH

Overall, from 2002 to 2012 the occurrence of halogenated compounds decreased, while the measured TVOC concentrations increased, and the formaldehyde concentrations appear to have been stable in the German indoor air environments. According to the database, the time trends indicate that the number of individual VOCs in indoor air is currently higher than when the database was set up and that a higher diversity of VOCs are used in construction products. The data show that it is possible to reach a very low pollutant level in indoor air with the construction products currently on the market, but elevated pollutant levels can also occur.

5 VOC Emission Classes

5.1 VOC emission classes as a communication instrument

At present, the performance of construction products and safety information is mainly communicated via the DoP and, where relevant, a label according to the CLP regulation (hazard information and safety advice according to chemicals classification). The CE marking indicates conformity with the performances declared in the DoP, but this meaning is frequently not known to the consumers. Complementing the CE marking and the DoP with information on a VOC emission class would add important, directly available health information to the existing communication.

VOC emission classes are not only a mere communication instrument but, by defining minimum and maximum values for the classes, they are an evaluation system which distinguishes products with better performance (lower VOC emissions) from those with a lower performance (higher VOC emissions). The emissivity of construction products is only one among many essential characteristics that determine the product performance. Regarding the health impacts it is the most important one for many construction products.

Any communication approach should be clear about the target group and what instruments via what communication channels are appropriate. Several target groups can be discerned, amongst others:

- National authorities defining and authorising construction products for use in specific buildings
- Building planners, such as architects and main contractors in the construction sector
- SME construction companies
- Privat consumers, do-it-yourself market
- Investment and insurance companies
- Enforcement authorities
- Product certification bodies (state or non-governmental)

Figure 8: The CE marking indicates conformity with the product standards

Source: European Commission

The existing and already established information tool under the CPR is the DoP. The DoP may contain information on all essential characteristics included in the harmonised standard of the product group. The inclusion of VOC emissions as an essential characteristic into all relevant product standards is one of the preconditions for a comprehensive communication. The DoP is an important information source for all actors. While most actors are familiar with the technical specifications, they have difficulties in interpreting the environmental and health information. Only the authorities are likely to understand the VOC emission information well enough, for example.

The proposal of VOC emission classes aims to support communication to the end-users (private consumers and construction companies, architects, building-owners, housing societies, awarding authorities, public procurers etc.) with an assumed low expertise in VOC issues. The system should be as simple as possible but complex enough to distinguish products with a better performance from those with a lower one. Additionally, it could be useful to stimulate the development of less emissive construction products. Potential users of detailed VOC information are expected to use the DoPs directly whenever it is accessible, which may not always be the case at their decision-making stages where several products should be compared.

Existing information instruments, such as Environmental Product Declarations (EPD) are flexible and can integrate (additional) information, such as a VOC emission class. Similarly, product labels like the Blue Angel are likely to adapt to an additional type of information on VOC emissions (e.g., refer to the best class as a minimum criterion). EPDs and ecolabels already rely on detailed information about the product composition and/or VOC emission data (separate test reports can be substituted through the DoP). Access to the detailed information is essential for these tools. Similarly, the national authorities should be able to use the detailed DoPs to assess compliance with national regulations and/or enforce them.

The discussion on VOC emission classes has been going on since 2010. Some Member States have implemented legislation with requirements on VOC emissions, such as Belgium, France and Germany, however with slightly differing approaches regarding the evaluation parameters. Industry stakeholders have participated in the discussions and favoured an EU harmonised approach to save resources and implement a clear and transparent communication. Despite an expressed need for such classes and the long discussion periods, up to now no agreement has been reached on the concept or design of VOC emission classes that could be applied across the EU.

A survey among the Member States in autumn 2020 resulted in a list of issues that they today consider important for such a harmonised VOC emission class system:

- The declaration of VOC emissions under the CPR should be ensured
- VOC classes should be compatible with a high level of protection for all building users
- VOC classes with at least three performance levels should be developed
- An informative assessment in the form of a pictogram with colour scale for consumers should be used
- At least the following criteria should be used to determine the classes:
    - EU-LCI,
    - R-value,
    - Carcinogenic, Mutagenic and Reprotoxic substances (CMR)

- TVOC
- Formaldehyde

► VOC emission classes should be implemented very soon.

Figure 9: A class system must be applicable to various construction product types

Source: Photo by Life Of Pix on Pexels

5.2 Introduction to the current proposal

Experts from national authorities upon initiative of the German Environment Agency proposed a harmonised class system for VOC emissions based on the feedback received during consultation of the Member States (see above). The proposal was introduced and discussed at the International Conference on Limiting Health Impacts of Construction Products Regarding VOCs on April 20 and 21, 2021. It is briefly explained here and provided as Annex 1 to this report.

The VOC emission class proposal refers to the horizontal standard EN 16516 as a testing method. Its performance parameters are already used in existing binding and voluntary evaluation schemes and the system covers any product on the market intended for indoor use regardless of its VOC emission performance.

The four suggested performance characteristics, which are divided into up to four performance levels are:

- The R-value[10] of a construction product, which is the sum of all relevant EU-LCI ratios;
- The concentration of VOCs with carcinogenic, mutagenic and reprotoxic (CMR) properties[11] of the categories 1A and 1B in a reference room which do not have an EU-LCI;
- The formaldehyde concentration in a reference room and
- The total VOC concentration in a reference room in combination with an indicator of the share of compounds without an EU-LCI therein.

Table 1 shows the performance characteristics, how they are abbreviated and the minimum and maximum values that determine the categories (levels of performance). Grey shaded fields indicate that a category is not defined for the performance characteristic.

Table 1: Performance characteristics, performance levels and their minimum and maximum values

Category **Performance characteristic**	**Abbr.**	**Cat. 0**	**Cat. 1**	**Cat. 2**	**Cat. 3**
Sum of EU-LCI ratios (R-value)	VOC	≤ 1.0	≤ 2.0	> 2	
CMR_{VOC}	CMR[12]	≤ 1µg/m³	> 1 µg/m³		
Formaldehyde	F	≤ 10 µg/m³	≤ 30 µg/m³	Limit of REACH Regulation	
TVOC	SUM	≤ 200 µg/m³	≤ 500 µg/m³	≤ 1000 µg/m³	> 1000 µg/m³
Index for TVOC (SUM)					
Sum of VOC without an LCI (incl. substances from C6 to C22)	Index A, B or C	≤ 100 µg/m³	≤ 200 µg/m³	> 200 µg/m³	

The combination of the assessment results for all four performance characteristics determines the overall Indoor Air Class of a product.[13]

[10] An EU-LCI ratio is calculated by dividing the measured and modelled concentration of a substance in the reference room by the EU-LCI of this substance. The R-value is the sum of the EU-LCI ratios of all relevant VOCs in the reference room. See also Section 4.3.

[11] VOCs with CMR properties for which an EU-LCI exists, and which are included in the EU-LCI list are NOT part of this performance characteristic but covered by performance characteristic "R-value". All CMRs, which are not detected by measurements according to the standard EN 16516 are not covered by the parameter.

[12] The threshold value of 1 µg/m³ is factually the detection limit. Hence, whenever at least one VOC is detected that is a CMR, the product falls into category 1. There is no further differentiation of the category.

[13] The figure shows the proposal after modification due to the discussions at the conference; the option to classify products where no performance is declared was deleted after the discussions. In the initial proposal, the "NPD" was assigned to the worst performance category.

Figure 10: Combining performance levels and deriving indoor air classes (IA).

Performance characteristic	VOC			CMR_{VOC}		Formaldehyde				TVOC			
Category Indoor air	0	1	2	0	1	0	1	2	3	0	1	2	3
IA 0													
IA 1													
IA 2													
IA 3													
IA 4													

Source: own illustration, Ökopol

The CPR allows two options in the declaration of performance:

- A product is tested and hence, the performance level is available in the DoP or
- A product is not tested and the DoP specifies: "no performance determined".

The emission class proposal does not allow classifying a product if any of the performances is not determined.

The sum of the EU-LCI ratios (performance characteristic "VOC") addresses combination effects of VOCs in the indoor air from the construction product.[14] The justification for using this performance characteristic in the classification system is provided in Section 4.3.

VOCs with CMR properties of the categories 1A and 1B are to be separately assessed and evaluated according to the proposal. This corresponds to current practice in national evaluation schemes and is justified due to the very severe health effects as well as the lack of a clear effect threshold, below which no adverse effects are expected. CMR substances, for which an effect threshold and hence an EU-LCI exists, are not to be included in the assessment of this performance.

Formaldehyde is independently addressed as a separate performance characteristic because of two reasons: it is frequently found in indoor air, and it is included in most of the existing assessment schemes (compatibility). The lowest value of 10 µg/m^3 was derived from the French system, where this threshold demarks the A+ category. It is estimated that around 90% of the labelled products in France meet this value. The upper limit of the formaldehyde performance characteristic is based on the limit value that will be set by an ongoing REACH restriction of formaldehyde and formaldehyde releasing substances in articles for consumer use (including construction products).

The TVOC performance characteristic represents the sum of the concentrations of all individual substances, with the exception of semi-volatile organic compounds (SVOC) that can be determined by the chamber test according to EN 16516. It is used in all legally binding and many voluntary VOC assessment schemes and in state-of-the-art ventilation standards currently in

[14] The R-value does not integrate any exposures resulting from the occurrence of VOCs from other emission sources to the indoor air. Hence, the parameter does not address the cumulative exposure in a real-life indoor environment but only the combination effects of VOCs from the one construction product that is assessed.

place. In general, it is considered important to provide an overview/orientation of the occurrence of VOCs. The TVOC covers all identified and all unidentified and unknown VOCs with a defined chain length (C6 to C16) emitting from a construction product. To enable a comprehensive evaluation of the emission it is suggested to complement the core criterion with an indicator of the share of VOCs and SVOCs that do not have an EU-LCI value[15].

It is suggested that the VOC emission class (IA0 to IA4 with colour code) is communicated with/below the CE marking. The individual results of the four performance characteristics should rather be provided in the DoP.

5.3 Opinions on the proposal

In general, there appears to be a broad interest in the current proposal across the Member States. A formal consultation of the Member States was not carried out.

The consulted industry representatives expressed a general support for the proposed harmonised VOC classes. Benefits for manufacturers would arise, when a harmonised classification is implemented in all Member States making existing, overlapping systems obsolete. The TVOC as an assessment parameter is considered acceptable when it is only used in connection with the health-related parameters and not on its own.

Some aspects of criticism concern:

- Consistency of terminology with the CPR[16]
- Mixing of threshold values and the lack of information (NPD) in categories of the system (worst performance)[17]
- Sum of the compounds without an EU-LCI as an assessment parameter
- The list of VOCs with CMR properties requires comparably quick updating because new data becomes available on these properties and poses challenges for the updating process as well as the implementing industries

The colour coding suggested for communication in conjunction with the CE marking is a main point of criticism, amongst others because of:

- Additional costs to the industry as printers for CE markings are black and white and coloured printing would require change of equipment
- The colour coding (and the grouping as well) is considered a task of the Member States and depending on national requirements for construction products
- Colour coding could be mistaken as an evaluation of the entire product rather than only one of its essential characteristics

From the NGOs' perspective, the proposed system is criticised amongst others because it seems unclear to what extent it ensures safety of the inhabitants of a building. This relates to the fact that the test results do not necessarily reflect the actual exposure conditions in real life, which could be worse than the conditions in the reference room. It would be important to avoid

[15] This gives an indication of the VOC amounts that do not have an EU-LCI and of VOCs that are not identified in the measurement, and of which it is hence not known whether or not they pose health hazards.

[16] This concerns the term "health" vs "hygienic" assessment

[17] Cf above, this was changed in the proposal after the Conference.

communication with the colour codes that gives the impression of no risks, where risks may remain. An emission class of e.g., IA 2 could be interpreted as meaning that there are no risks. In addition, a higher level of ambition is requested.

From the EU Commission's perspective, the harmonised VOC emission classes should be an instrument to support the end-users (professional and private) to decide what applications a particular construction product can be used for, therefore the information to be conveyed should be simple. Hence the combination of several performance characteristics into one class is generally supported. Concerns from the Commission side relate to the inclusion of "no performance declared (NPD)" into the class system, as the lack of information is not considered information that can be included into a class[18].

A concern was also expressed about consistency of such class system with existing legislation, in particular REACH as both higher as well as lower values would have to be justified[19]. Overly high ambitions of the classes could endanger support for the communication proposal.

[18] This point has been corrected in the annex. The NPD option should not be part of a classification and classification is not possible, when information is missing.

[19] The lower categories of the formaldehyde performance characteristic set values stricter than expected under the REACH – restriction.

6 Conclusions and Outlook

The International Conference on Limiting Health Impacts of Construction Products regarding VOC was a milestone in the discussion on VOC emission classes. It confirmed the need for information on VOC emissions of construction products by several different types of actors, including architects, construction companies, professional users and consumers but also researchers, product certification bodies and NGOs, national authorities and enforcement institutions.

The accessibility of information on the product performance regarding VOC emissions is important for all these target groups, but the type of information they need, and the communication channels largely vary.

The basic information on VOC emissions obtained by the standardised chamber test EN 16516 is/will be available in the form of DoPs with time, when product standards are amended respectively. While serving the detailed data needs of e.g., national authorities and expert staff in larger construction companies, it should be translated into understandable information for the less experienced users, including private consumers, professional users or architects. The "translation" of information into one VOC emission class, which is communicated in conjunction with the CE marking, is generally considered a viable option. There is a broad consensus on most issues related to the VOC emission class proposal and the conditions for concluding the work with a delegated act specifying a VOC emission class system appear to be favourable. A formal draft proposal may become available in 2022 for further discussion and adoption.

In the future, data storage and distribution on the performance of construction products, including on VOC emissions, are likely to progress another step with the digitalisation of DoPs ("smart DoPs"). Such smart DoPs could automatically aggregate data according to any information need or output format. The implementation of such systems will take time and hence, intermediate systems like the VOC emission classes are needed.

7 References

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, *OJ L 396, 30.12.2006*

Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. *OJ L 353, 31.12.2008*

Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC. *OJ L 88, 4.4.2011*

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). *OJ L 334, 17.12.2010*

EU Commission (2020) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Chemicals Strategy for Sustainability Towards a Toxic-Free Environment. Brussels, 14.10.2020 COM(2020) 667 final ; accessed 05.07.2021 https://ec.europa.eu/environment/pdf/chemicals/2020/10/Strategy.pdf

EU Commission (2020): COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. Brussels, 14.10.2020 COM(2020) 662 final ; accessed 05.07.2021 https://ec.europa.eu/energy/sites/ener/files/eu_renovation_wave_strategy.pdf

Umweltbundesamt (2018): Roadmap for Healthy Buildings – 1st step: Harmonisation of Health Criteria for Construction Products. Discussion Report. Dokumentationen 02/2018. Dessau; accessed 28.05.2021
https://www.umweltbundesamt.de/publikationen/roadmap-for-healthy-buildings-1st-step

EN 16516: 2020 Construction products: Assessment of release of dangerous substances. Determination of emissions into indoor air

ECHA's registration database: https://echa.europa.eu/information-on-chemicals/registered-substances

Classification and labelling inventory: https://echa.europa.eu/information-on-chemicals/cl-inventory-database

ECA (2013). Harmonisation framework for health based evaluation of building products indoor emissions in Europe (EU-LCI). European Collaborative Action Urban air, indoor environment and human exposure, Report No. 29, EUR EN 26168.

D'Amico et al. (2021): Modelling VOC Emissions from Building Materials for Healthy Building Design. Sustainability 2021, 13, 184

A Draft Proposal: VOC Emission Classes

A concept to assign and communicate VOC emission classes was developed prior to the International Conference on Limiting Health Impacts from Construction Products regarding VOC Emissions. The proposed approach was discussed at the conference.

The version of the emission class proposal **as amended after the conference** is presented below. Among the changes due to the conference discussion are

- The wording of the proposal was slightly modified in order to better match the terms in the CPR.
- If the performance characteristic in a particular category is not declared (NPD), this category cannot be assigned and hence, the class system cannot be applied.
- The highest (worst) category of all performance characteristics but "formaldehyde" has no upper limit, which is expressed by a "greater than". Formaldehyde is limited by the EU restriction on the content in products.

  The terms used in the proposal were changed to better align them with the construction products regulation and to avoid the use of the word "class" for both a performance level of a performance characteristic and the overall VOC emission class.

Informal discussion proposals on the basis of feedback received in the Council Working Group Technical Harmonisation (Construction Products)[20]:

PERFORMANCE DECLARATION FOR VOC EMISSIONS DETERMINED ACCORDING TO EN 16516

The given limit values for each characteristic (performance) are determined after a test duration of 28 days with a product loading factor reflecting the representative maximum use area of the product in the reference room.

Essential characteristics for health assessment (EU-LCI ratio, CMR_{VOC}, formaldehyde)

Emissions of individual VOC into a reference room (EU-LCI ratio)

Performance characteristic	VOC 0	VOC 1	VOC 2
Sum of EU-LCI ratios	sum ≤ 1.0	sum ≤ 2.0	sum > 2.0

An EU-LCI ratio is calculated by dividing the measured concentration of a substance in the reference room by the EU-LCI of this substance. The EU-LCI list will be updated every 36 months. When declaring this performance characteristic, the reference to the version of the EU-LCI list used as basis shall be given in brackets: e.g. VOC 0 (EU-LCI 2021). After an update, test laboratories shall use the new list for all tests beginning at the latest 90 days after its publication. The list can be consulted at: https://ec.europa.eu/docsroom/documents/44905/attachments/1/translations/en/renditions/native

CMR_{VOC} emissions into a reference room:

Performance characteristic	CMR 0	CMR 1
CMR_{voc}	≤ 1 µg/m³	no performance limit

CMR_{VOC} include substances with the following harmonised classifications under the CLP Regulation (Regulation (EC) No 1272/2008): CARC 1A, CARC 1B, MUTA 1A, MUTA 1B, REPR 1A or REPR 1B. Only substances that can be determined using EN 16516 (length of carbon chain C1 – C22) are addressed. In addition to formaldehyde the following CMR_{VOC} that do not show CMR effects below a threshold and are covered under EU-LCI are excluded from the CMR_{VOC} category and assessed with their EU-LCI:

No	CAS No	Substance	EU-LCI (µg/m³)	Harmonised classification
6-12	109-86-4	Ethylene glycol monomethyl ether	100	Repr. 1B
6-13	110-49-6	2-Methoxyethyl acetate	150	Repr. 1B
6-14	110-71-4	1,2-Dimethoxyethane	100	Repr. 1B
6-15	111-96-6	Diethylene glycol dimethyl ether	28	Repr. 1B
6-18	112-49-2	Triethylene glycol-dimethyl ether	150	Repr. 1B
6-19	110-80-5	Ethylene glycol monoethyl ether	600	Repr. 1B
6-20	111-15-9	2-Ethoxyethyl acetate	900	Repr. 1B
6-21	629-14-1	1,2-Diethoxyethane	150	Repr. 1B
6-32	1589-47-5	1-Propylene glycol 2-methyl ether	19	Repr. 1B
6-33	70657-70-4	1-Propylene glycol 2-methyl ether acetate	28	Repr. 1B
7-2	75-07-0	Acetaldehyde	300	Carc. 1B
12-3	872-50-4	N-Methyl-2-pyrrolidone	1800	Repr. 1B

[20] https://data.consilium.europa.eu/doc/document/ST-13596-2020-INIT/en/pdf

In future, if an EULCI value can be derived for further CMR_{VOC}, these substances will also be excluded from the CMR_{VOC} category. CMR_{VOC} are listed in the annex for information.

Formaldehyde emissions into a reference room

Performance characteristic	**F0**	**F1**	**F221**
Formaldehyde	≤ 10 µg/m³	≤ 30 µg/m³	Limit of REACH-Regulation

Essential characteristics for hygienic assessment

Quantity of VOC emissions into a reference room:

Performance characteristic	**SUM 0**	**SUM 1**	**SUM 2**	**SUM 3**
TVOC	≤ 200 µg/m³	≤ 500 µg/m³	≤ 1000 µg/m³	> 1000 µg/m³

Index for SUM performance characteristic	**A**	**B**	**C**
∑compounds without EU-LCI (C6-C22)	≤ 100 µg/m³	≤ 200 µg/m³	> 200 µg/m³

The letters A and B can be used as addition to any SUM performance characteristic; e.g. SUM 1^{B}

Colour code for essential characteristic indoor air emissions

IA0 VOC 0 + CMR 0 + F0 + SUM 0

IA1 not higher than VOC 0 + CMR 0 + F1 + SUM 1

IA2 not higher than VOC 0 + CMR 0 + F2 + SUM 2

IA3 not higher than VOC 1 + CMR 0 + F2 + SUM 2

IA4 any other result

In addition to the indoor air class with colour code the individual essential characteristics shall be declared in the declaration of performance for transparency.

[21] EU-LCI value for formaldehyde: 100 µg/m³. The value under the REACH regulation is expected to become available during 2021 (current proposals include 50, 62, 80 and 124 µg/m³).

Example of a performance declaration

Indication in CE marking: indoor air emissions IA1

Indication in the declaration of performance (DoP):

Essential characteristic	Test method	Class
Indoor air emissions	EN 16516	IA1 | VOC 0 (EU-LCI 2021) | CMR 0 | F1 | SUM 0[B]

Annex: informative list of harmonised CMR_{VOC} without EU-LCI based on ECHA C&L inventory

Chemical name	CAS No	CMR 1 property
sulfallate (ISO); 2-chloroallyl N,N-dimethyldithiocarbamate	95-06-7	Carc. 1B
dimethylcarbamoyl chloride	79-44-7	Carc. 1B
N,N-dimethylhydrazine	57-14-7	Carc. 1B
1,2-dimethylhydrazine	540-73-8	Carc. 1B
isobutyl nitrite	542-56-3	Carc. 1B
tris(2-chloroethyl)phosphate	115-96-8	Repr. 1B
hexamethylphosphoric triamide; hexamethylphosphoramide	680-31-9	Carc. 1B Muta. 1B
1,3-propanesultone; 1,2-oxathiolane 2,2-dioxide	1120-71-4	Carc. 1B
isoprene (stabilised); 2-methyl-1,3-butadiene	78-79-5	Carc. 1B
benzene	71-43-2	Carc. 1A Muta. 1B
benz[a]anthracene	56-55-3	Carc. 1B
chrysene	218-01-9	Carc. 1B
1,2-dibromoethane	106-93-4	Carc. 1B
1,2-dichloroethane; ethylene dichloride	107-06-2	Carc. 1B
1-bromopropane; n-propyl bromide	106-94-5	Repr. 1B
1,2-dichloropropane; propylene dichloride	78-87-5	Carc. 1B
1,2-dibromo-3-chloropropane	96-12-8	Carc. 1B Muta. 1B Repr. 1A
trichloroethylene; trichloroethene	79-01-6	Carc. 1B
chloroprene (stabilised); 2-chlorobuta-1,3-diene (stabilised)	126-99-8	Carc. 1B
α-chlorotoluene; benzyl chloride	100-44-7	Carc. 1B
α,α,α-trichlorotoluene; benzotrichloride	98-07-7	Carc. 1B
1,2,3-trichloropropane	96-18-4	Carc. 1B Repr. 1B
1,3-dichloro-2-propanol	96-23-1	Carc. 1B
hexachlorobenzene	118-74-1	Carc. 1B
1,4-dichlorobut-2-ene	764-41-0	Carc. 1B
2-bromopropane	75-26-3	Repr. 1A
2,3-dibromopropan-1-ol; 2,3-dibromo-1-propanol	96-13-9	Carc. 1B
α, α,α,4-tetrachlorotoluene; p-chlorobenzotrichloride	5216-25-1	Carc. 1B
1-chloro-2,3-epoxypropane; epichlorhydrin	106-89-8	Carc. 1B
bis(chloromethyl) ether; oxybis(chloromethane)	542-88-1	Carc. 1A
propylene oxide; 1,2-epoxypropane; methyloxirane	75-56-9	Carc. 1B Muta. 1B

Chemical name	**CAS No**	**CMR 1 property**
2,2'-bioxirane; 1,2:3,4-diepoxybutane	1464-53-5	Carc. 1B Muta. 1B
tetrahydro-2-furylmethanol; tetrahydrofurfuryl alcohol	97-99-4	Repr. 1B
2,3-epoxypropan-1-ol; glycidol; oxiranemethanol	556-52-5	Carc. 1B Repr. 1B
phenyl glycidyl ether	122-60-1	Carc. 1B
chlormethyl methyl ether	107-30-2	Carc. 1A
styrene oxide	96-09-3	Carc. 1B
furan	110-00-9	Carc. 1B
R-2,3-epoxy-1-propanol	57044-25-4	Carc. 1B Repr. 1B
R-1-chloro-2,3-epoxypropane	51594-55-9	Carc. 1B
2-(2-aminoethylamino)ethanol; (AEEA)	111-41-1	Repr. 1B
1,2-dihydroxybenzene	120-80-9	Carc. 1B
bisphenol A; 4,4'-isopropylidenediphenol	80-05-7	Repr. 1B
safrole; 5-allyl-1,3-benzodioxole	94-59-7	Carc. 1B
chlorophacinone (ISO)	3691-35-8	Repr. 1B
anthraquinone	84-65-1	Carc. 1B
2,3-epoxypropyl methacrylate; glycidyl methacrylate	106-91-2	Carc. 1B Repr. 1B
urethane (INN); ethyl carbamate	51-79-6	Carc. 1B
bis(2-methoxyethyl) phthalate	117-82-8	Repr. 1B
vinclozolin (ISO)	50471-44-8	Repr. 1B
methoxyacetic acid	625-45-6	Repr. 1B
bis(2-ethylhexyl) phthalate; di-(2-ethylhexyl) phthalate; DEHP	117-81-7	Repr. 1B
dibutyl phthalate; DBP	84-74-2	Repr. 1B
1,2-benzenedicarboxylic acid, dipentylester, branched and linear [1] n-pentyl-isopentylphthalate [2], di-n-pentyl phthalate [3] diisopentylphthalate [4]	84777-06-0 [1] 131-18-0 [3] 605-50-5 [4]	Repr. 1B
BBP; benzyl butyl phthalate	85-68-7	Repr. 1B
diisobutyl phthalate	84-69-5	Repr. 1B
dihexyl phthalate	84-75-3	Repr. 1B
perfluorooctanoic acid	335-67-1	Repr. 1B
perfluorononan-1-oic acid [1] perfluorononan-1-oic acid sodium salts [2] perfluorononan-1-oic acid ammonium salts [3]	375-95-1 [1] 21049-39-8 [2] 4149-60-4 [3]	Repr. 1B
dicyclohexyl phthalate	84-61-7	Repr. 1B
nonadecafluorodecanoic acid	335-76-2	Repr. 1B
acrylonitrile	107-13-1	Carc. 1B
3,7-dimethylocta-2,6-dienenitrile	5146-66-7	Muta. 1B
2-nitropropane	79-46-9	Carc. 1B
nitrobenzene	98-95-3	Repr. 1B
dinocap (ISO)	39300-45-3	Repr. 1B
dinoseb (ISO); 6-sec-butyl-2,4-dinitrophenol	88-85-7	Repr. 1B
2-nitronaphthalene	581-89-5	Carc. 1B
4-nitrobiphenyl	92-93-3	Carc. 1B

Chemical name	**CAS No**	**CMR 1 property**
nitrofen (ISO); 2,4-dichlorophenyl 4-nitrophenyl ether	1836-75-5	Carc. 1B Repr. 1B
2-nitroanisole	91-23-6	Carc. 1B
2-nitrotoluene	88-72-2	Carc. 1B Muta. 1B
azobenzene	103-33-3	Carc. 1B
methyl-ONN-azoxymethyl acetate; methyl azoxy methyl acetate	592-62-1	Carc. 1B
4-aminoazobenzene; 4-phenylazoaniline	60-09-3	Carc. 1B
2-naphthylamine	91-59-8	Carc. 1A
2-methoxyaniline; o-anisidine	90-04-0	Carc. 1B
4,4'-bi-o-toluidine	119-93-7	Carc. 1B
benzidine	92-87-5	Carc. 1A
4,4'-diaminodiphenylmethane; 4,4'-methylenedianiline	101-77-9	Carc. 1B
biphenyl-4-ylamine; xenylamine; 4-aminobiphenyl	92-67-1	Carc. 1A
dimethylnitrosoamine; N-nitrosodimethylamine	62-75-9	Carc. 1B
2,2'-dichloro-4,4'-methylenedianiline; 4,4'-methylene bis(2-chloroaniline)	101-14-4	Carc. 1B
4,4'-methylenedi-o-toluidine	838-88-0	Carc. 1B
2,2'-(nitrosoimino)bisethanol	1116-54-7	Carc. 1B
o-toluidine; 2-aminotoluene	95-53-4	Carc. 1B
nitrosodipropylamine	621-64-7	Carc. 1B
4-methyl-m-phenylenediamine; 2,4-toluenediamine	95-80-7	Carc. 1B
4-chloroaniline	106-47-8	Carc. 1B
4-chloro-o-toluidine	95-69-2	Carc. 1B
2,4,5-trimethylaniline	137-17-7	Carc. 1B
N,N,N',N'-tetramethyl-4,4'-methylendianiline	101-61-1	Carc. 1B
6-methoxy-m-toluidine; p-cresidine	120-71-8	Carc. 1B
methylhydrazine	60-34-4	Carc. 1B
ethyleneimine; aziridine	151-56-4	Carc. 1B Muta. 1B
tridemorph (ISO); 2,6-dimethyl-4-tridecylmorpholine	24602-86-6	Repr. 1B
2-methylaziridine; propyleneimine	75-55-8	Carc. 1B
propiconazole (ISO)	60207-90-1	Repr. 1B
quinoline	91-22-5	Carc. 1B
imidazole	288-32-4	Repr. 1B
quinolin-8-ol; 8-hydroxyquinoline	148-24-3	Repr. 1B
1-vinylimidazole	1072-63-5	Repr. 1B
N,N-dimethylformamide; dimethyl formamide	68-12-2	Repr. 1B
acrylamide; prop-2-enamide	79-06-1	Carc. 1B Muta. 1B
N,N-dimethylacetamide	127-19-5	Repr. 1B
formamide	75-12-7	Repr. 1B
N-methylacetamide	79-16-3	Repr. 1B
N-methylformamide	123-39-7	Repr. 1B
N-ethyl-2-pyrrolidone; 1-ethylpyrrolidin-2-one	2687-91-4	Repr. 1B

B International Online Conference: Limiting Health Impacts of Construction Products Regarding VOC (20. – 21.04.2021)

Conference programme 20.04.2021

9:00 – 10:00 Registration

10:00 Opening the conference

Lilian Busse, German Environment Agency

Axel Vorwerk, German Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

10:15 The policy context– Setting the scene

The EU policy context and needs for action
Lilian Busse, German Environment Agency (UBA)

Health impact assessment of indoor air quality
Katleen de Brouwere, Vito

11:05 Stakeholder inputs on the need to declare VOC emissions from construction products

Michael Neaves, ECOS
Pekka Vuorinen, CFCI
Birgit Müller, HTW Berlin
Andrea Klinge, ZRS Architekten
Alexander Röder, Institut Bauen und Umwelt e.V.

Discussion

12:00 Lunch break

13:00 VOC in indoor air – Health hazards determination and assessment

Combination effects of chemicals–the importance of summing up risk quotients
Andreas Kortenkamp, Brunel University London

Harmonised test standard: EN 16516 – common approach for all building products for interiors
Olaf Wilke, Bundesanstalt für Materialforschung und -prüfung (BAM)

Progress with the establishment of harmonised health-based reference values, EU-LCIs
Derrick Crump, Indoor Air Quality (IAQ) Consulting Limited & Associate

Current data on the occurrence of VOCs in indoor air and emissions from building products: What do we know and what should we know?
Heidrun Hofmann, Bremer Umweltinstitut

Discussion

15:00 Closing the day

Conference programme 21.04.2021

8:00 – 9:00 Registration

9:00 Opening of the second day
Welcome
Recap of the first day

9:10 BIM for healthy buildings: integrating VOC requirements for assessing IAQ
Alessandro D'Amico, University of Rome

9:35 Towards a common proposal for VOC emission classes

Proposal for harmonised VOC emission classes
François Maupetit, CSTB

Comments to the proposal for harmonised emission classes
Martin Glöckner, Deutsche Bauchemie e.V.
Manfred Fuchs, European Commission, DG Grow

10:20 Panel discussion about the VOC emission class proposal

Sara Elfving, Boverket – National Board of Housing, Building and Planning
Thomas Lützkendorf, Karlsuher Institut für Technologie
Edmund Vankann, GUT
Manfred Fuchs, European Commission, DG Grow

11:00 Final discussion
Opening the panel discussion to questions from the audience

11:20 Closing the conference