esvoc EUROPEAN SOLVENTS DOWNSTREAM USERS COORDINATION GROUP

TECHNICAL PAPER

April 2020

VOCs and Indoor Air Quality

The European Solvents VOC Co-ordination Group (ESVOC CG[1]) supports the EU-LCI (Lowest Concentration of Interest) value concept, compared to the TVOC concept, with respect to assessing the human health aspect of indoor air quality. Individual health risk assessment of substances taking into account the EU-LCI value concept, will show best, if a product can be used safely in an indoor environment.

How shall VOCs be considered in IAQ?

Several definitions to describe "VOC" are in use.[2] Most of them are based on physical chemical properties (vapour pressure, boiling range) and/or composition (carbon number range). Definitions can also differ depending on the way VOCs are assessed, via either an in-can analysis or via an emission evaluation.

It is important to note that not all solvents are VOCs and not all VOCs are solvents.

- General VOC definition

The basic definition of VOC comes from the Directive on industrial emissions (integrated pollution prevention and control) (2010/75/EC):

"volatile organic compound' means any organic compound as well as the fraction of creosote, having at 293,15 K a vapour pressure of 0,01 kPa or more, or having a corresponding volatility under the particular conditions of use".[i]

- SVOC (Semi-VOC) definition

To further define organic compounds which can be present in indoor air, another term (SVOC) was introduced. Different definitions for SVOCs exists, and industry generally refers to the WHO definition (1989):

"semi-volatile organic compound (SVOC): are any organic compounds boiling between 240 - 260 °C up to 380 - 400 °C." [ii]

- Volatility

Volatility is indicated by a substance's vapour pressure. It characterizes the ease of a substance to vaporise, at a given temperature.

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[1] ESVOC, the European Solvents Downstream User Cooperation Group (formally the European Solvents Volatile Organic Compounds Co-ordination Group) is a unique platform that brings together manufacturers and their downstream users trade associations to facilitate the implementation of relevant existing legislation

[2] Besides the explained VOC and SVOC definitions hereunder, more generic families of VOC exist, such as Total VOC, Very VOC, LVP (Low Vapour Pressure)-VOC, etc. However, these will not be addressed in this paper as they are not generally recognized definitions.

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Substances with higher vapour pressure will vaporise more readily than substances with lower vapour pressure.

Volatility and boiling point are correlated. Therefore, the boiling point could be another indication of the volatility of a substance. Boiling points do apply more to substances and mixtures in a bulk, while vapour pressure characterizes only substances.

VOC and outdoor Air Quality in general

Air quality is an important factor impacting upon the welfare, health and climate of our planet. The subject is complex considering the emissions from many sources (natural and man-made), the atmospheric chemical reactions of these emissions and the trans- boundary air pollution between continents. One main challenge is ozone (an irritant gas to be reduced mainly in urban environment) formed by photochemical reaction between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Because ozone (in high concentrations) is responsible for human health problems, VOC's and solvent emissions have been regulated for many years now. VOCs are either man-made (transport, industry) or have a biogenic / natural (trees and plants) origin. More information can be found in the ESIG position paper "Solvent VOC emissions inventories".[3]

(S)VOC and Indoor Air Quality (IAQ)

People spend a lot of time in different indoor environments: home, office, shops, public buildings and transport vehicles. A complex set of personal, physical, biological and chemical factors impact upon the wellbeing of a person in these indoor environments. Hence an integrated and holistic approach is needed to address those factors.

When looking at (S)VOCs, they include a broad variety of substances, some of which may have short- and long-term adverse health effects, while others are non-hazardous. Impact on human health is linked to the indoor concentration, time spent indoors and hazardousness of the individual substance, classed as (S)VOC. (S)VOCs may be emitted in the indoor air environment by a wide array of products.[4]

What is the real problem indoors when looking at VOCs specific? It is not ozone as in outdoor air, because in indoor air, NOx and UV light are normally not present, so the formation of ozone will not be a problem. Moreover, ozone chemically decomposes when it hits an object like a wall or ceiling. Indoors however, human health could be impacted by the intrinsic properties of certain chemical substances. Therefore, it is clear that to improve the indoor air quality the long-term exposure to these chemical

[3] www.esig.org

[4] VOCs from living environments are only one aspect of indoor air quality and although relevant, it may not necessarily be the main source of concern, thinking of: inadequate ventilation, tobacco smoke, mould, fungus, heating system, smoke from cooking stoves, ozone from copying machines. For instance, over half of all benzene in indoor air may come from cigarette smoke (IPCS Environmental Health Criteria on Benzene)

substances has to be controlled and reduced. To achieve this, **the individual substances should be assessed on their individual health impact. The EU-LCI value concept suits well for this approach.**

In this respect, the characterisation of a substance as SVOC or VOC is not important, but the substance emission should have an LCI ratio below 1 to demonstrate a safe situation.

Today there are several regulations and voluntary schemes in place which already address the volatile chemical substances as groups and not as individual substances. However, in the context of Indoor Air Quality, using a method which eliminates certain volatile substances based on their actual LCI, rather than focusing on the group of volatile substances as a whole (TVOC) is seen as preferable.

Regulatory instruments and voluntary schedules addressing IAQ[5]

Regulation / Scheme	Country	Mandatory / Voluntary	Product area
Construction Product Regulation - EU 2011/305	EU	Mandatory	Construction Products
Decree 2011/321 and related Arrêté of 19/04/2011	France	Mandatory	Construction & decorative products
Royal Decree of 8 May 2014 establishing the threshold levels of emissions into the indoor environment of building products for specific intended uses	Belgium	Mandatory	Flooring (including Coatings, (tiles) adhesives and screeds)
AgBB Health-related Evaluation of Emissions of Volatile Organic Compounds (VVOC, VOC and SVOC) from Building Product	Germany	Mandatory	Construction Products
EU Ecolabel addressing Solvents VOC	EU	Voluntary	Multiple product groups
Danish Indoor Climate Label	Denmark	Voluntary	Construction Products
GUT	Germany	Voluntary	Flooring / carpets
Blue Angel	Germany	Voluntary	Multiple product groups
M1	Finland	Voluntary	Construction products
Nordic Ecolabel	Scandinavia	Voluntary	Multiple product groups

[5] This is a non-exhaustive overview, not claiming to be complete.

Technical position

To predict the indoor air quality as a formulator of mixtures used indoors, various approaches exist to assess (potential) exposure to (S)VOCs.

- The composition approach in final products (% of individual substances in the product), combined with the use of mathematical models to estimate exposure of each substance in a conservative way.
- The emission measurement in model environments (for instance European reference room defined in EN 16516).

Both approaches are used to determine the human exposure to a substance in a context of a risk assessment. As there are pro's and cons for both approaches it will depend on the situation, which approach would suit best for a proper risk assessment.

(S)VOCs can be present in absence of solvents. Some (S)VOCs are classified as hazardous, but the risk assessment of a (S)VOC is (like for any other substance) related to the concentration and duration of human exposure. For instance, under REACH[6] manufacturers, importers and downstream users have to ensure that substances are used in such a way that they do not adversely affect human health. As part of the REACH dossier, the registrant has to define the exposure level (as part of the exposure scenarios) to which human beings should not be exposed. This is done for the uses covered by each individual registrant and visible in the annex of the SDS (exposure scenario) of each product[7].

This information from REACH could also be used to improve indoor air quality for instance in the EU LCI value concept. EU-LCI values (usually expressed as µg/m^3) are health-based values used to evaluate emissions after 28 days from a single product during a laboratory test chamber procedure to approximate the long-term indoor VOC emission scenarios. They can be applied in product safety assessments (like in the German AgBB standard), ultimately to prevent health risks from long-term exposure for the general population. If the calculated EU-LCI ratio (Conc. i / EU-LCI$_i$) is ≤ 1,0 for a substance, it is considered that the health risk of that specific substance is negligible. For formulated products, the R-values (sum of all individual EU-LCI ratio's) can be calculated, however this is from a toxicological point of view, a very conservative approach (see practical example situation 1 below; individual EU-LCI values are below 1, while the R-value is over 1).

Harmonisation of EU-LCI values across Europe is managed under the responsibility of the EU-LCI working group. EU-LCI values are preferably derived from the data, like the DNEL (or NOAEL) generated under REACH[8]. Agreed EU-LCI values are published on the website of the EU-LCI WG (link: https://ec.europa.eu/growth/sectors/construction/eu-lci_en).

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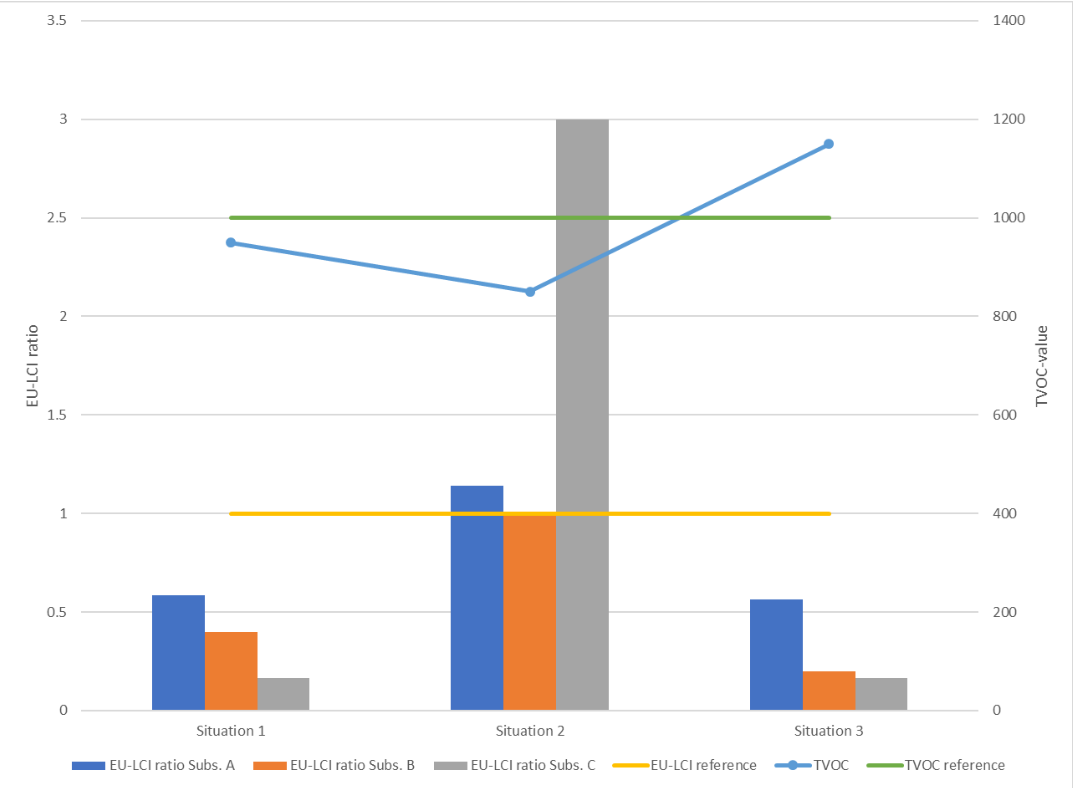
[6] REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals REGULATION (EC) No 1907/2006),

[7] ECHA Guidance on information requirements and chemical safety assessment, Chapter R.8: Characterisation of dose [concentration]-response for human health – V2.1 November 2012)

[8] See also JRC report no 29, Harmonisation framework for health-based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept

Practical example:

		Emission (µg/m³)	EU-LCI value (µg/m³)	EU-LCI ratio
Situation 1	Substance A	700	1200	≤ 1,0
	Substance B	200	500	≤ 1,0
	Substance C	50	300	≤ 1,0
	TVOC	**950**		
	R-value			**1.15**
Situation 2	Substance A	400	350	> 1,0
	Substance B	300	300	≤ 1,0
	Substance C	150	50	> 1,0
	TVOC	**850**		
	R-value			**5.14**
Situation 3	Substance A	900	1600	≤ 1,0
	Substance B	100	500	≤ 1,0
	Substance C	150	900	≤ 1,0
	TVOC	**1150**		
	R-value			**0.93**



It can be noted that situations 1 and 2 with a TVOC (total VOC) value of < 1000 µg/m^3 seem compliant. This despite the fact that in situation 1 and 2 the R-value limit (1.0) is exceeded and in situation 2, two substances even have an emission level above their EU-LCI value resulting in an EU-LCI ratio > 1,0. In situation 3 the TVOC limit is exceeded, while both individual EU-LCI ratio's and R-value are below 1,0.

In other words, the EU-LCI concept will value each individual compound on its contribution to the indoor air quality, while the TVOC-concept will not distinguish between the properties of the various contributing substances. Therefore, it is better to use an EU-LCI value concept. To avoid overregulating in safety level and to make sure substances used are chosen on its health effect, an EU-LCI value concept should prevail over a TVOC concept. The indoor air quality is dependent on the exposure to and risk from individual substances rather than (S)VOCs as a group. With an individual substance approach, the real risk can be managed, rather than an artefact.

When available, the REACH and EU-LCI values assessment routes should prevail above a generic VOC content or emission number. Substances with an intrinsic higher safety level and thus a higher EU-LCI value will be in a disproportionate way impacted by a regulated TVOC concept than substances with a lower EU-LCI value, and having thus an intrinsic lower safety level, under the same TVOC concept[9].

ESVOC therefore supports the development of the relevant data sets, to derive (EU) LCI values for those individual substances, which are considered as "(S)VOCs", in order to be able to perform a risk-based evaluation of the indoor air environment.

[9] TVOC is a simple parameter that summarizes adsorbed VOCs. TVOC is used as a pragmatic approach, however it is more a general parameter, rather than a health-based indicator.

Endnotes

[i] **For specific products/markets there could be other definitions in use for VOC's**

For example, in the Deco Paints Directive 2004/42/EC (in-can analysis):
"Volatile Organic Compounds with boiling point below 250°C at a standard atmospheric pressure of 101,3 kPa."

EN 16516:2017 (emission evaluation)
"Volatile organic compound (VOC): organic compound eluting between and including n-hexane and n-hexadecane on the gas chromatographic column specified as a 5 % phenyl / 95 % methyl polysiloxane capillary column, including all compounds listed in Annex G, which are considered to be VOCs even if they elute after n-hexadecane or before n-hexane under the specific test conditions"

[ii] **Other definitions for SVOCs as examples**

EU Ecolabel for indoor and outdoor paints and varnishes (2014/312/EU; in-can analysis)
"Semi volatile organic compounds' (SVOCs) means any organic compound having a boiling point of greater than 250 °C and which, in a capillary column (1) are eluting with a retention range between n-Tetradecane ($C_{14}H_{30}$) and n-Docosane ($C_{22}H_{46}$) for non-polar systems and diethyl adipate ($C_{10}H_{18}O_4$) and methyl palmitate ($C_{17}H_{34}O_2$) for polar systems"

EN 16516:2017 (emission evaluation)
"Semi-volatile organic compound (SVOC): organic compounds which elute after n-hexadecane and up to and including n-docosane, on the gas chromatographic column specified as a 5 % phenyl / 95 % methyl polysiloxane capillary column minus all compounds listed in Annex G, which are considered to be VOCs and not SVOCs even if they elute after n-hexadecane under the specific test conditions"

ISO 16000
"Organic compound whose boiling point is in the range from (240 °C to 260 °C) to (380 °C to 400 °C)"
(note: this classification has been defined by the World Health Organization)