TECHNICAL PAPER

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VOCs and Indoor Air Quality

The European Solvents VOC Co-ordination Group (ESVOC CG) supports the EU-LCI (Lowest Concentration of Interest) value 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.

Introduction

The European Solvents VOC Co-ordination Group (ESVOC CG)[1] supports the EU-LCI (Lowest Concentration of Interest) value 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.

VOC Definitions

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

In this context, it is important to note that with respect to solvents, not all solvents are VOCs and not all VOCs are solvents.

– General VOC definition

The basic definition is the one given in 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]

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[1] ESVOC, the European Solvents Downstream User Cooperation Group (originally 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, 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.

– SVOC (Semi-VOC) definition

Different definitions are in use for SVOC. 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 is a tendency of a substance to vapourize, at a given temperature. Substances with higher vapour pressure will vapourize more readily at a given temperature than substances with lower vapour pressure.

Volatility and boiling point are correlated. Therefore, the boiling point is another indication of the volatility of a substance, or its presence in an indoor environment. However, as the scope of an indoor air policy includes to a large extent products present and/or used in an indoor environment, VOC substances will not be found pure, but will often be included in a mixture (for example in a paint or a detergent). Therefore, inter-molecular forces will then play a significant role, even getting more important at lower vapour pressure (or higher boiling points) resulting in different emission profiles.

VOC and outdoor Air Quality in general

Air quality is a principal 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. VOCs are either man-made (transport, industry) or can have a biogenic / natural (trees and plants) origin. More information can be found in the ESIG position paper "emissions inventories".[3]

VOC and Indoor Air Quality (IAQ)

Despite improvements made on air quality for the outside environment, the indoor air has already been improved (ventilation). However, indoor air has some specifics.

People are spending an increased amount of time in different indoor environments like: 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. It is clear that an integrated approach is needed to address those factors. Among those, the chemical factor is just one of them.

[3] www.esig.org

VOCs 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 VOC. VOCs may be emitted in the indoor air environment by a wide array of products.4

It is important to note that ozone formation is not a problem in Indoor Air Quality, since ozone decomposes in contact with any surface such as a wall into oxygen. That is why elderly persons, young children and people suffering from asthma or other respiratory problems are asked to stay indoors during high ozone episodes. This is frequently given as advice in public announcements when there is an ozone peak.

As ozone formation is not a problem for Indoor Air Quality, VOCs as such are not an issue. Only the individual hazard profile of a substance (which could be seen as VOC) will be a potential issue. To improve Indoor Air Quality, VOCs should not be addressed as group, the individual substances should be assessed on its individual health impact.

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
Decrée 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 Products	Germany	Mandatory	Construction Products

[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)

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

Regulation / Scheme	Country	Mandatory / Voluntary	Product area
EU Ecolabel Indoor Outdoor Paints & Varnishes - (CD 2014/312/EU)	EU	Voluntary	Paints and Coatings
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 for interior use
Nordic Ecolabel	Scandinavia	Voluntary	Multiple product groups

Technical position

Various approaches exist to address (potential) exposure to (S)VOCs in an indoor environment.

- The chemical content approach in final products. Although a practical and simple solution for formulators, this may not be the correct scientific approach with respect to actual emission and exposure from the final product under use conditions.
- The emission measurement in model environments (instruments). Those are more complex and require standardization, effort and cost. However, these methods may be more realistic and will justify proper product selection and development.
- Use of mathematical models to estimate exposure in a conservative approach.

With respect to indoor air quality, VOCs can be present in the absence of solvents. Some VOCs are classified as hazardous, but the risk assessment of a VOC is, like any other substance, related to the concentration and duration of human exposure. This is regulated under REACH[6] where manufacturers, importers and downstream users should ensure that the substances will be used in such a way that that they do not adversely affect human health. As part of the REACH dossier, it is a requirement for the manufacturers and/or importers to define the level of exposure above which human should not be exposed. This is done for the uses covered by each individual registrant.[7]

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

[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)

AgBB standard), ultimately to prevent health risks from long-term exposure for the general population. If the calculated EU-LCI ratio is ≤ 1,0 for a substance, it is considered that the health risk of that specific substance is negligible. For formulated products, the R-value (sum of all individual EU-LCI ratio's) could be applied, however this is a very conservative approach from a toxicological point of view.

The EU-LCI Working Group is currently working on harmonization of the EU-LCI values across Europe, to have a list which can be used within the EU. EU-LCI values are preferably derived from the data, like the DNEL (or NOAEL) generated under REACH.[8]

Practical example:

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

When a TVOC-concept is applicable with a TVOC (total VOC) value of < 1000 µg/m^3 both situations are compliant. This is despite the fact that in situation 2, two substances have an emission level above its EU-LCI value resulting in an EU-LCI ratio > 1,0.

In other words, substances with a low EU-LCI value will contribute in a comparable way as substances with a high EU-LCI value within a TVOC-concept. This could result in a situation in which the emission concentrations of very hazardous substances could be much higher than less hazardous substances, although total emission is in line with the TVOC concept. As stated and from that point of view it is better to use an EU-LCI value concept. To avoid over regulating 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. In the end, indoor air quality will be more dependent on the concentrations of individual substances rather than (S)VOCs as group. With this individual substance approach the real issue can be tackled, rather than an artifact.

[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

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.

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."

FprEN 16516 (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 (C14H30) and n-Docosane (C22H46) for non-polar systems and diethyl adipate (C10H18O4) and methyl palmitate (C17H34O2) for polar systems"

FprEN 16516 (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)

[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.