Emission specifications in Europe and the US – Limit values (TVOC, LCI, CREL, ...) in critical discussion

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SUMMARY
Indoor air limit values for VOC emissions in Germany, France and California are compared. Significant differences do not correspond to differences in health risks in the respective population, but to different scientific opinions and approaches. As both industry and testing laboratories require clear and sound VOC limit values for reliable testing and stable emission requirements, these limit values urgently need harmonization throughout industrial countries.

KEYWORDS
VOC emissions, Limit value, LCI, CREL, Indoor air

INTRODUCTION

Emission into indoor air of volatile organic compounds (VOC) and its sum (TVOC) is subject of restriction by voluntary ecolabels and specifications, and by legal regulation.

The correlation between elevated VOC concentration in indoor air, and the number of occupants' complaints of bad health or bad comfort, is subject to controversial discussion. The conclusion will depend on which mixture of VOC is present in the actual situation under investigation. A correlation between bad odour and low comfort is obvious, but the significance of elevated VOC concentration on occurrence of bad odour again depends strongly on the actual VOC mixture, as well as on the presence of other contaminants, especially of ozone, in the air. Anyhow, there are several attempts for reducing emission of volatile organic chemicals (VOC) in general, and of formaldehyde, into indoor air. The rationale is that the lower the total VOC (TVOC) concentration in indoor air, the lower is the risk that any of these compounds will contribute to uncomfortable situation. Other approaches are setting limit values for specific VOC besides the TVOC.

In Germany there is a legislative regulation on chemical emissions of VOC from construction products into indoor air: the restriction of emissions from floor coverings and related products. In general, floor coverings may enter the European market when carrying a CE mark, after having shown compliance with the requirements of low inflammability, pentachlorophenol contents, formaldehyde emission, and some more as defined in the European Standards EN 14041 for resilient floor coverings and laminates, and EN 14342 for wood flooring.

But this is not good enough for Germany. There you need the additional "Ü" mark if any resilient or laminate flooring shall be marketed for locations where people stay longer than transiently. The "Ü" mark may be placed on the flooring after German DIBt authority approved its conformity with AgBB requirements, and a monitoring contract with a "ÜZ" certification body was signed. It is planned to apply that procedure also to wooden floorings that refer to EN 14342. The same procedure is also used by several ecolabels in Germany and

in Austria, just with more stringent limit values. Emission testing follows DIBt testing protocol which is a refined adaptation of ISO 16000 standard series. VOC limit values are defined in a list of German LCI values (Lowest concentration of interest, NIK in German).

French authorities are in favour of a similar approach. Information on emission shall be part of the health and environment section of the French Technical Specifications, but this is still voluntary and not used very frequently. Emission testing follows ISO 16000 standard series, namely parts 3, 6, 9 and 11. VOC limit values are defined in a list of French LCI values (Lowest concentration of interest, CLI in French).

In the US, California developed the so-called CHPS system as a tool for building "Healthy schools". These include an emission test method, and limitation of TVOC, formaldehyde, other volatile aldehydes, and individual VOCs. VOC limit values are defined in a list of CREL values (Chronic inhalation reference exposure levels). These criteria are used more and more throughout the United States by voluntary quality labels and are becoming a kind of unofficial US national standard for VOC emission control.

Neuhaus and Oppl (2008) compared the underlying testing methods, model room calculation procedures etc. This paper is analysing the limit values for single volatile organic compounds (VOC) long-term indoor air exposure.

SURVEY OF LIMIT VALUES

German LCI values

German AgBB is publishing a list every 1 - 2 years, containing German LCI values for 164 VOCs (as in 2008) under the responsibility of German health administrations. The LCI values shall serve as criterion for acceptance of emission into indoor air. German LCI values are derived from European and German occupational exposure limit values (OEL) by division with safety factors:

- A factor 10 for more sensitive population in indoor setting than at workplaces (e.g. children, old persons, sick persons)
- Another factor 10 for longer exposure duration indoors than at workplace (up tp 24 hours all days, whole life) compared to 40 h 5 days a week and only during working life time,
- A third factor 10 for suspected carcinogens.
- Proven carcinogens are limited very sharply and should not be emitted into indoor air at all.

French Health and Environmental Protection Agency AFSSET published a list in 2006, containing French LCI values for some 190 VOCs. The LCI values shall serve as criterion for acceptance of emission into indoor air. French LCI values are derived from European and French occupational exposure limit values (OEL) in a similar manner as in Germany, but AFSSET additionally used indoor air limit values as published anywhere in Europe, in the USA and in Canada.

Californian CREL values are defined by toxicology based health risk assessment studies with respect to indoor air exposure, under the responsibility of Californian Environmental Protection Agency. Present CREL list is containing some 80 substances, some 30 of which are volatile enough to be relevant for emission into indoor air studies. Requirement is that in an emission test, no VOC must exceed ½ of its CREL. Special regulation was established for formaldehyde and acetaldehyde where the CREL values were judged to be unrealistically low

because they were lower than ubiquitous air concentrations. Substitute values were derived from acute reference exposure levels.

The different references and the different assessment methods are leading to sometimes very different limit values in these three countries, see Table 1. Most times, French LCI values are the lowest ones, but there are exceptions. To be remembered that CREL is for indoor air, while CHPS regulation defines ½ CREL as limit value for emission into indoor air.

Table 1. Selected VOC limit values in Germany (D), France (F) and California (CA).

(all in µg/m³)	LCI (D 2008)	LCI (F)	CREL (CA)
Toluene	1900	300	300
Xylenes	2200	200	700
n-Hexane	72	700	7000
Terpenes, e.g. Limonene	1500	450	-
1-Butanol	3100	1500	-
2-Ethoxyethanol	19	70	70
Crotonaldehyde	1	1	-
Formaldehyde	120	10	33

A comprehensive list of all these limit values and a comparison of these may be obtained from the authors.

DISCUSSION

Having in mind that all these limit values are addressing the same exposure of similar population, the reasonability of these differences may be questioned. Some example shall illustrate this issue.

While German scientists in BfR institute are seeing good reasons for keeping the formaldehyde emissions limit value at 120 µg/m³, France and California are using limit values of some 10% or 20% of the German limit value.

Critical questions are also raised in the case of crotonaldehyde - the underlying OEL value has been lowered for suspected carcinogeneity, and then the LCI has been reduced another time for the same reason, while other suspected carcinogens have been reduced only in the LCI procedure. Meanwhile, the underlying OEL value has been withdrawn from German OEL list, but not correspondingly from LCI lists. And a LCI value of 1 µg/m³ is lower than the detection limit. This is just one example of non-logic elements of LCI calculation that need revision.

Waiting on indoor air related scientific health risk assessments might mean that in near future only very few VOC can be assigned an LCI value. Latest findings of indoor exposure project EXPOLIS indicate that not much more is needed, but nevertheless in some countries there is a request for as many VOC limit values as possible. If that approach is followed, an improved procedure for LCI calculation could be:

- Start with a uniform data set of occupational exposure limit values, harmonised at least within EU, and for calculation of indoor air related LCI values,
- Apply a safety factor of 10 for more sensitive population to all substances with most critical health effect being a local and immediate reaction (odour, irritation, allergy), not depending on dose but on local concentration.

- Apply a safety factor of 10 for more sensitive population and an additional safety factor of 10 (in total: 100) to all substances with dose depending effects, e.g. all systemic effects
- Apply an additional safety factor of 10 (in total: 1000) to all suspected carcinogens if this had not already been considered in a lower OEL value.
- Let an international group of scientists have a plausibility check before an LCI value is issued.

CONCLUSIONS

VOC limit values for emission into indoor air have to protect population, but also have to avoid exaggerated requirements towards manufacturers. The partly very different VOC limits in different countries do not correspond to differences in health risks in the respective population, but to different scientific opinions and approaches. As both industry and testing laboratories require clear and sound VOC limit values for reliable testing and stable emission requirements, these limit values urgently need harmonization throughout industrial countries.

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