Eurofins Product Testing A/S
Smedeskovvej 38
8464 Galten
Denmark
(Address for dispatch of samples)

Phone **+45 7022 4276**
Fax **+45 7022 4275**

- US office:
2200 Rittenhouse St., Suite 150
Des Moines, IA 50321
Phone **515-362-5937**

More offices in France, Germany, the Netherlands, China

voc@eurofins.com
www.product-testing.eurofins.com

Date
Nov 4th, 2010

Our ref.
ROP

Inspirations for further development of low VOC emissions specification for products for interior use

Based on LEED® 2009, HQE, and other specifications

About this paper

Sustainable buildings certification programs contain several sustainability criteria. A certified sustainable building has to collect points by fulfilling a certain percentage of these specifications.

One part of those sustainability criteria can require the use of products that promote good indoor air quality by emitting no or only low amounts of Volatile Organic Compounds (VOC) into surrounding indoor air.

Eurofins Product Testing A/S is asked frequently what could be meaningful VOC limitations for products intended to be used in interior of sustainable buildings.

This document contains suggestions, meant as inspiration for development of low VOC emissions limit values for products for interior use, within the frame of sustainable building specification and certification.

This document also contains an annex 1 with a list of existing low VOC emissions limitations. All of these have inspired the suggestions in this paper.

And this document contains an annex 2 with a description of basic technical background that may be important for handling this issue in an appropriate manner.

Below will you find an explanation of the basic approach, and then 2 alternatives for defining more detailed specifications. All these are trying to improve knowledge and to promote low VOC emitting products without setting up any complicated procedure with many calculations. It was also tried to allow several pathways for achieving high flexibility both in Europe and in the USA. That approach will increase the number of available low VOC labeled products.

Background and assumptions

Background of these specifications are numerous technical and conceptual discussions about low VOC requirements in several countries, where Eurofins specialists are or have been involved.

Limitation of VOC content in the products with respect to protection of outside atmosphere is another important issue, but not within the scope of this paper.

Basic philosophy behind the approach presented here is to reduce emissions of formaldehyde, VOCs etc into indoor air, as to improve indoor air quality. The intention is to establish an advantage if products with lower VOC emissions are used instead of products with higher VOC emissions, or with unknown VOC emissions level.

At the same time it is intended to allow maximum flexibility by accepting several pathways for showing compliance, without re-inventing new sets of limit values and new methodologies. Existing methodology was used to maximum possible extent.

Another basic assumption is that the different existing low VOC rating schemes, even though different in detail, they all exclude high VOC emissions products and promote low VOC emissions products. The differences between the different existing VOC scales are relevant only for a very small gray zone where products just comply of just fail, depending on which VOC rating was applied. As long as main goal is to reduce use of high VOC emitting products, this grey zone is considered of minor interest, and products falling into this grey zone also should have some advantage.

Basic approach

The suggestion is to grant points to a building for sustainability certification as follows:

- 20% of maximum points for knowledge of VOC emissions for products used on at least 65% of interior surfaces
  (this already is significant progress in many cases)
- 60 % of maximum points for use of low VOC emissions products on at least 65% of interior surfaces
- 100 % of maximum points for very low VOC emissions products on at least 65% of interior surfaces

This can apply to all products used indoors, including lower structures such as insulation material behind a gypsum plate, or an adhesive beneath a flooring. All products in a structure (e.g. cement + adhesive + flooring) have to comply for considering the surface (here: the flooring) as low emitting.

The 65% rule is meant for allowing exceptions for surfaces that may need special treatment for security reasons, such as anti-slip properties of hallways and staircases, or technical devices such as elevators and HVAC systems. The figure "65%" still can be subject of discussion.

No points are assigned for low VOC *content* of liquid products, because for very most products no correlation exists between VOC content and long-term VOC emissions. Any limitation of VOC content may make sense only for protection of urban outdoor air against generation of ozone and summer smog. On the other hand, legal VOC content limits are already established in Europe and in several US States, and there is no need to add on such limits to sustainable building specifications.

Suggestion 1: Flexible approach

- Assign 20% of maximum points if VOC emissions are known for products used on at least 65% of all interior surfaces

- Assign 60% of points if products used on at least 65% of interior surfaces are low emitting products, meaning:

    - TVOC is below 1000 µg/m³ in the reference room at the latest after 28 days

    - Formaldehyde is below 60 µg/m³ in the reference room at the latest after 28 days

    - This can be shown a.o. by compliance with AgBB limit values if formaldehyde value complies with above limit value.

- Assign 100 % of maximum points if products used on at least 65% of interior surfaces are very low emitting products, meaning:

    - TVOC is below 250 µg/m³ in the reference room at the latest after 28 days

    - Formaldehyde is below 10 µg/m³ in the reference room at the latest after 28 days

    - This can be shown a.o. by compliance with any of the above cited low VOC ranking schemes - if formaldehyde emission value complies with above limit value.

        - Even though some of the low VOC ranking schemes are having slightly different VOC limit values, they all make an effective distinction between low VOC emitting and high VOC emitting products in the market.

          But many of the low VOC ranking schemes are having a higher formaldehyde limit value; therefore the formaldehyde emission value needs to comply with above limit value in addition to compliance with the respective low VOC ranking scheme.

- Exemptions:

    - Products that are inherently non-emitting sources of VOCs can be considered fully compliant with very low emissions limit values without any VOC emission testing requirements,

        - specifically stone and ceramic products, powder-coated, plated or anodized metals, and glass without integral organic-based surface coatings, binders, or sealants.

Suggestion 2: Limit value approach

As above, but with setting more detailed limits based on a compilation of limit values from the different VOC rating schemes.

Below tables are examples for how such limit values could look like:

Low VOC emissions	After 3 days	After 14 days	Or after 28 days	Unit
TVOC	10 000	2000	1000	µg/m³
R_D value (based on German NIK values)	-	1.5	1	-
Each VOC with California CREL	-	< ½ CREL	< ½ CREL	µg/m³
TSVOC	-	100	100	-
Any individual carcinogens (C1, C2)*	5	5	5	µg/m³
Formaldehyde	-	120	60	µg/m³

* If detectable with ISO 16000-3/-6 test methods

Very low VOC emissions	After 3 days	After 14 days	Or after 28 days	Unit
TVOC	2000	500	250	µg/m³
R_D value (based on German NIK values)	-	1	1	-
R_F value (based on French CLI values)	-	1	1	-
Each VOC with California CREL	-	< ½ CREL	< ½ CREL	µg/m³
TSVOC	-	50	50	µg/m³
Any individual carcinogen (C1, C2)*	5	5	5	µg/m³
Formaldehyde	-	20	10	µg/m³

* If detectable with ISO 16000-3/-6 test methods; 5 µg/m³ has shown to be the lowest reasonable limit value; any lower limit value cannot be monitored by testing in a reliable manner.

In this case the 14 days and 28 days limit values could be seen as alternatives; compliance with any of both has to be shown. This will allow to use both existing European and North American low VOC emissions programs.

Regarding loading factors for testing and calculation, European Reference Room (see Annex 2) should be applied, as well as chapter 7.6.1/7.6.2 in BIFMA e3 standard for office furniture, and loading factors for other furniture should be developed from the BIFMA model. This approach will be a realistic worst-case assumption for characterization of products with low VOC emissions.

Exemption from testing: As above.

Conclusion

The team of Eurofins Product Testing A/S is in favor of the flexible approach but considers the limit value approach as a meaningful alternative solution.

We are sure that different teams will come to different conclusions. This paper shall not serve for anything more than inspiring any team developing low VOC emissions specifications.

ANNEX 1:

Some Green Building certification schemes with existing low VOC specifications

- LEED by US GBC, USA
- LEED by GBC Italia
- HQE, France
- BREEAM, United Kingdom
- Green Star Australia

For more information, please see:
www.product-testing.eurofins.com/green-buildings.aspx

Most relevant programs and labels that include low VOC rating schemes

Europe:

- AgBB, Germany
- AFSSET, France
- Blue Angel, Germany
- Building Materials Assessment, Sweden
- CertiPUR, Europe
- GUT / Prodis, Europe
- EMICODE, Europe
- European ecolabel, Europe
- Indoor Air Comfort, Europe
- M1, Finland
- Natureplus, Europe
- Umweltzeichen, Austria

USA:

- ANSI/BIFMA X71./M7.1
- BIFMA e3 (level certification)
- Carpet and Rug Green Label Plus
- CertiPUR US
- FloorScore
- Green Seal
- Greenguard
- Indoor Advantage

For more information, please see:
www.product-testing.eurofins.com/ecolabels-en.aspx

ANNEX 2:

Technical background

Low VOC emissions evaluation will evaluate early and long-term VOC emissions from a product. The tested emission rate (per hour and surface, or per hour and product) then is transformed by calculation into an air concentration in an exposure scenario, consisting of a typical reference room, typical ventilation, and typical room climate.

Here is an example calculation of air concentration C at a given testing time:
C = Area specific emission rate (µg/m²h) x loading factor (m²/m³) / air change rate (h^{-1}).

There are three reasons for doing this. Normal users would rather understand the meaning of an air concentration, but not the meaning of an emission rate. Any limit values also are expressed as air concentrations. And this approach allows lower emission rate from large surfaces and higher emission rate from less relevant small surfaces, still achieving good indoor air quality.

Dimensions of reference room and loading factors

The different reference rooms in use differ by their dimensions. A small room is the worst-case assumption leading to relatively high test results. Any larger room would show better results.

In Europe, this is the European reference room[1]:

Table 1: European reference room (CEN TC 351)

	Dimensions
Length x width x height	4 m x 3 m x 2.5 m
Surface floor or ceiling	12 m²
Surface walls	31.4 m²
Surface window	2 m²
Surface door	1.6 m²
Volume	30 m³

The typical relation of surface to air volume gives the loading factor (m²/m³), e.g. for walls, floor etc.

Table 2: Loading factors for building materials

Intended use	Loading factor
Ceiling and flooring	0.4 m²/m³
Walls	1.0 m²/m³
Ceiling and walls	1.4 m²/m³
Ceiling, walls and flooring	1.8 m²/m³

You may deviate from these values with ± 50% of the specified value when performing the VOC emission chamber test, but maximum loading shall not exceed 2.0 m²/m³. In case of such deviations during testing, the test result shall be re-calculated to the specified value.

[1] CEN TC 351 WG 2 N0129: CEN/TC 351/WG 2 "Emissions into indoor air" - WI 351009 - Construction products - Assessment of emissions of regulated dangerous substances from construction products - Determination of emissions into indoor air (CEN internal draft as of 12 February 2010).

In the USA, a small private office with similar dimensions is the worst-case situation. Open-plan offices and school class rooms are also in use as reference rooms. Different programs use different reference rooms, but the differences of the dimensions are not very large (CDPH Section 1350, BIFMA M7.1, Greenguard).

Ventilation of reference room

In Europe, ½ air change per hour is assumed to be a good standard ventilation, meaning that all air in a room is renewed every two hours. In the USA, between ⅔ and 1 air change per hour is applied. This gives higher ventilation and thus higher dilution of any emitted substances, leading to lower air concentrations.

Climate in reference room

In Europe, USA, and China the standard climate in use for VOC emissions evaluation is 23 °C with 50% humidity. In contrast to that, Japan uses 28 °C and South Korea uses 25 °C as standard temperature.

Equipment of reference room

Only few standards are dealing with equipment inside a reference room, e.g. ANSI/BIFMA X7.1/M7.1 that specifies typical amount of furniture in US offices.

Limit values

Limit values are specified for single substances and for sum parameters.

Single substances can be individual VOCs, formaldehyde etc. Sum parameters can be the total of all VOCs (TVOC), but also parameters such as the R value (the total percentage of limit values reached by measured VOC air concentrations), and some more.

Total VOC (TVOC) sometimes is criticized because it does not have any toxicological meaning. But it is a good limitation for avoiding excessive exposure to VOCs that have not yet been assigned a limit value. This is a precautionary measure for the case that in near future, some of the today non-limited VOCs will be restricted with a limit value.

Semi-volatile VOCs (SVOC) and very volatile VOCs (VVOC) are restricted only by very few evaluation schemes for the following reasons:

SVOCs are not volatile enough to generate high emissions and for that reason they are seldom determined by the standard testing technique. Only some of the SVOCs are volatile are stable enough for being detected and quantified. VVOCs are so volatile that they mostly disappear within few days or weeks and do not constitute any long-term exposure in very most cases.

Testing and analytical issues

A sample is taken from production or from stock such that it represents the production best possible. It is transported to the testing lab air tight packaged in short time. Testing has to start 25 days (USA) or 8 weeks (Europe) after last step in production at the latest.

A test specimen is prepared in a standardized manner, similar to typical intended use. Surfaces covered in reality will be covered during testing. The loading factor in test chamber will be similar as in the reference room, but small deviations during testing can be leveled out by calculation at the end. Large deviations should be avoided as these can falsify the result.

The test specimen is placed in a ventilated test chamber made of stainless steel or of glass at controlled climate. Typical requirements will be 23 °C inside test chamber and 50% relative humidity of inlet air. Air samples are taken from outlet air after defined elapsed time. Air samples are collected on adsorption tubes that then proceed to the laboratory for chemical analysis.

It is essential to follow exactly the relevant standards, best internationally harmonized ones, such as ISO 16000 standard series (namely parts 3, 6, 9 and 11), and the forthcoming new European standard still under development by CEN TC 351 WG2. All these go for Tenax TA / Thermal desorption / GC/MS for VOC determination and DNPH / HPL / UV for volatile aldehydes.

As emissions will decay over time during the first days and weeks, definition of testing times is essential. In Europe, most testing is performed after 3 days for early exposure and after 28 days for long-term exposure, where the test specimen stays in the test chamber between these dates. In the USA, earlier testing times are applied, typically during the first one or two weeks. 14 days is the mostly used time of emissions evaluation in North America.

Quality of testing laboratories

VOC emission testing is not trivial at all. Reliable results require high experience. It is essential that testing laboratories prove their competence by inclusion of VOC emission testing into an ISO 17025 accreditation, and by regular participation in round-robin testing showing good performance.

It should be noted that an ISO 17025 accreditation is granted not to a whole laboratory, but only to specific methods, applied to specific matrices. Therefore a laboratory being ISO 17025 accredited for other (e.g. mechanical) testing may be very inexperienced in VOC emissions testing if not the scope of accreditation covers also VOC emissions testing and evaluation methodology.

For more information on VOC emission testing please see:
www.product-testing.eurofins.com/voc-testing.aspx