Alternatives to German and French approach for regulating VOC emissions

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Summary:

A seminar for industry resulted in suggestions for how to approach VOC emissions in Europe. An appropriate health-related evaluation scheme for VOC emissions into indoor air should make use of the exposure scenario as defined in ISO 16000-9, and as used by German regulators. Typical intended use and typical age of material when facing the end-user need thorough consideration when defining a testing procedure.

Emission chamber testing as defined in the standard ISO 16000 parts 3, 6, 9, 10 and 11 are the reference method because these simulate actual exposure of occupants during intended use of the material in a model room. But before any chamber testing, it should be evaluated whether emissions are relevant, and which VOC are involved, first by experience or by calculations based on formula, or by simpler testing without test chamber. In case of chamber testing, 28 days chamber testing should be necessary only if 3 days chamber test results do not already indicate sufficiently low emissions. The precision-related limitations of the testing method need to be reflected in setting reasonable lowest reporting limits for single VOC, and in the way of reporting and of setting limit values.

An alternative procedure for deriving the limit values for VOC emissions, and general limit values are also suggested.

Background

Volatile organic compounds (VOC) and its total concentration (TVOC) in indoor air are 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), 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.

At present, the only legislative regulation on chemical emissions of VOC from construction products into indoor air is the German restriction of emissions from floor coverings and related products. 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. This has not yet been established for wood floorings that refer to EN 14342.

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.

There are some initiatives to generate a European regulation of emissions from construction products, on the basis of the same approach. Several countries and many industries are not happy with this idea. Other industries are accepting the basic idea but feeling that the existing regulations are far too sophisticated and costly.

There was a very productive discussion in a seminar held for industry by Eurofins, and this paper is summarising some main suggestions on how to approach VOC emissions on a European level. This may be an inspiration for further discussion. But it should be pointed out that the following does not represent at all any industry position, and it is not an official position of Eurofins Environment A/S.

Emissions into indoor air - exposure scenario

The basic scenario of end-user exposure to indoor air contamination emitted from construction products is defined in International Standard ISO 16000-9. A person is exposed to emissions in a European model room with following parameters:

- Temperature: 23 °C
- Relative humidity: 50%
- Dimensions:
  - Area of floor and ceiling, each = 7 m^2
  - Wall area = 24 m^2
  - Sealant area = 0.2 m^2
  - The air volume in that model room is defined as: V = 17.4 m^3.
  - Resulting height = 2.5 m
- The loading factor then is
  - 0.4 m^2/m^3 for all floor covered
  - 1.4 m^2/m^3 for all walls painted
  - 0.012 m^3/m^2h for sealants
- Ventilation: ½ air exchange rate per hour
- The resulting area specific flow rate then is
  - 1.25 m^3/m^2h for floor coverings
  - 0.4 m^3/m^2h for wall paints
  - 44 m^3/m^2h for sealants

Typically it is accepted that early emissions shortly after insertion / application of a product in a building may be higher than the long-term emissions. Both are tested by monitoring the emissions after 3 and 28 days. If emissions decrease rapidly, the long-term emissions may be determined already earlier.

There are not many controversies on the significance of this exposure scenario, which can be simulated by placing a test piece into a ventilated test chamber made of stainless steel or glass.

Emissions testing

The emission testing methodology behind the German and French approach had been developed for textile floor coverings. Therefore they do not sufficiently take into account characteristics of other product groups. But even for most textile floor coverings the method may be less sophisticated without significant loss of information quality.

- **Ageing and coverage**

Any testing should be related to real use. If the product as fresh never would face the end-user of the building, such as cement sub-flooring, then a storage period may be considered before testing. Or, if typical reduction factors over time are known from representative studies, the fresh product could be tested but the result be converted by use of such ageing factors.

Many products are used behind other products that may form a barrier and reduce or even prevent actual emission into indoor air. Examples are insulation materials or adhesives for floor coverings. Normally there will not be available a representative standardised covering to be used for testing. Here again, if typical reduction factors for coverage are known from representative studies, the naked product could be tested but the result be converted by use of such coverage factors.

If these conversing factors are not known then an early test or a test with the uncovered product may be performed first, if this is faster and cheaper than simulation of a realistic scenario. If criteria are respected already under these worst-case conditions, further testing may be cancelled; else final evaluation may rely on a more realistic testing.

- **Exclusions from compulsory testing**

Chamber testing of emissions is a time consuming and costly activity. Anyhow, if a product group is showing very low emissions then it should be possible to exclude these from compulsory testing regimes. An extreme example is ceramic tiles, normally not emitting any organic compounds at all. But also some coatings and some other materials are showing emissions on a very low level.

In case of doubt the low emission level can be verified by simple testing techniques such as headspace (in analogy to ISO 17895) or Microchamber testing in each actual case, or by a study covering a representative number of products with typical recipes.

- **Pre-test**

If a product group may include products both with significant and with low emissions, then a pre-test will make sense for identifying the low emission products. These could then be exempted from compulsory chamber testing on basis of the pre-test result.

Examples of such simple test methods are:

- Microchamber (ISO 16000-9, -10)
- Thermal Extraction (VDA 278, but at room temperature)
  - both techniques require the same sampling and analysis methods as chamber testing does (typically ISO 16000-3 and -6)

If these tests are performed at 23 °C then the emission rate (µg / m² x h) or (µg / kg x h) may be transformed into predicted chamber air concentration, with the appropriate factors for loading and ventilation.

Further testing may be cancelled if the results are far below (max. 1/3 of) the evaluation criteria like the TVOC. The safety factor of 2/3 is required for addressing product inhomogeneity, differences between methods, etc.).

In case of very inhomogeneous products it may be necessary to repeat the test with at least 3 or 5 test specimens from the same sample and then use either the average or the highest value (worst-case) for further evaluation.

This technique may also be relevant for monitoring conformity, e.g. for batch control testing, after good results had been testified before in a first chamber test.

- **Chamber test**

If above mentioned steps do not result in a clear decision then a chamber test may decide on acceptable or non-acceptable emission level.

The chamber test gives the emission rate (mass per surface or per volume of sample, and per hour). Typically the evaluation criteria (such as TVOC limit value) are defined as air concentration, and the emission rate is converted into air concentration by use of loading factor and ventilation rate. If emissions are reported as air concentration, then it is essential always to link these with the underlying exposure scenario (model room, loading factor, ventilation rate, climatic conditions).

The result then is the maximum possible contribution of the tested product to air pollution under standard conditions. In reality some percentage of the emitted VOC will be adsorbed on surfaces resulting in lower actual contribution to air contamination. At the same time other sources may contribute to air contamination.

All testing should follow ISO standards (ISO 16000 parts 3, 6, 9 or 10 and 11) for improving comparability of test results. Anyhow, inter-laboratory testing showed that, without prior inter-laboratory communication and cooperation, a significant variation of results from lab to lab must be expected, with ± 50% RSD and factor 1 : 10 or 1 : 15 between highest and lowest result (see CERTECH conference, proceedings 2005).

Main problem is correct identification of the VOC in a complex mixture. Absolute uncertainty is in the same order of magnitude for both low and high emissions, but relative uncertainty is increasing with low level emissions. Uncertainty is still higher for some compounds for which the analysis method is not optimised. Examples are acetic acid, glycols, and semi-volatile organic compounds (SVOC).

Further improvement is possible with training of involved laboratories. Anyhow, too high precision should not be expected. Below suggestions would help handling the limited precision:

- Report results in mg/m³, not in µg/m³, for avoiding assumption of non-realistic precision
- Reporting with maximum 2 significant figures (e.g. 120 µg, not 124.3 µg)
- No evaluation of neither SVOC (semi-volatile compounds) nor VVOC (very volatile compounds) because the ISO 16000-6 methodology is not optimised for those.
- No reporting of VOC air concentrations below 0.005 mg/m³.
  Any lower result will be of very limited reliability.
- Identification is difficult and time consuming in case of low level emissions. Therefore a satisfactory level of identification should be reached if the total area of identified VOCs corresponds to two-thirds of the total area of all the peaks in the chromatogram eluting between and including n-C6 (n-hexane) to n-C16 (n-hexadecane) (see ISO 16000-6).
  In case of very low emissions, even only 50% identification should be accepted.
- Evaluation of test results should take into account the limited precision. Any evaluation criterion (like a TVOC limit value) therefore should be handled with a ± 50% tolerance.

In almost all cases emissions are decreasing after 3 days. If the required long-term emission level is already reached after 3 days, no further 28 days testing should be required.

Evaluation, acceptable emission level

Carcinogenic compounds shall not be found in indoor air. They are therefore required not to be detectable, or restricted with very low limit values that shall be near the detection limit. Besides this, any decision on acceptance of the emission level is for restricting emissions that may cause discomfort or health injury, or bad odour which again may induce symptoms. At present, three approaches are used.

1. Limitation of any problematic emission just by restricting the total emissions, the TVOC
   - if total emissions are low then the probability is low that any individual VOC may cause problems.

2. Limitation of all VOC with low irritation threshold and odour threshold
   - this approach assumes that present indoor pollution may only cause discomfort by irritation and odour, and that most of these can be determined by VOC testing.

3. Limitation of VOC emissions by setting limit values depending on their specific toxicological properties. This approach is becoming more and more popular.

At present, the limit values for VOC emissions, the so-called LCI values (Lowest concentration of interest) are derived from the Occupational Exposure Limit values (OEL) by dividing with safety factors. This is done by CESAT and by AgBB in a very schematic manner, and as a result many wood-based panels, and many linoleum floorings, should be rated as a risk to human health. Plausibility from public health experience tells us that this health risk is not real, but just by calculation.

A more differentiated approach to derive LCI values may serve as an alternative and is characterised as follows.

	WHEN	**LCI**	**WHY**
1)	If DNEL (Derived No Effect Level) is available	DNEL for inhalation, long-term, consumer from REACH assessment	REACH legislation will require DNEL levels for many VOC in indoor air
2)	If C3 <u>but only if</u> C3 was not already considered in setting the OEL	OEL/1000	Safety factors for long exposure, and sensitive population, and possible carcinogenic effect; but no double consideration of C3 classification in both OEL and LCI setting
3)	If OEL was set for irritation or etching or odour (immediate effects)	OEL/10	Safety factor for sensitive population, but not for longer exposure (which does not affect this type of health effect)
4)	Else	OEL/100	Safety factors for long exposure, and sensitive population
5)	Or, if sufficient specific are data available	Different LCI	Specific knowledge should always overrule schematic calculation

OEL: Occupational Exposure Limit, applied to workplace atmospheres, assuming exposure only of healthy workforce, and only at maximum 8 hours per 5 days a week.

In above scheme, a factor of 10 was assumed for all the safety factors for
- exposure longer than 8 hours / 5 days a week,
- more sensitive population may be affected,
- possible carcinogenic effect (C3).
It may be subject to discussion whether the safety factor 10 is an appropriate figure for these purposes.

In above scheme, OEL are used as one of the starting points. In a pan-European setting, with many different national lists of OEL available, in first priority the European SCOEL list should be taken into account (SCOEL = European Scientific Committee on Occupational Exposure Limits). For a VOC without such European OEL an average of the OELs available in EU member states could be selected.

Today both AgBB and CESAT are reporting LCI values with very specific figures, such as 220 or 360 µg/m³. It is doubtable whether toxicology is precise enough to justify such differences. More easy to handle would be to group the LCI values into only few grades: 0.01 - 0.05 - 0.1 - 0.5 - 1 - 5 - 10 mg/m³, and to define the LCI with only 1 significant figure - not as 0.14 but as 0.1.

Today both AgBB and CESAT are reporting slightly different LCI values for very similar chemical compounds. It is doubtable whether toxicology is precise enough to justify such differences. More easy to handle would be to assign one LCI value to whole groups of similar chemicals, as long as not specific exceptions are necessary. Examples are most aliphatic hydrocarbons (except n-hexane), most aromatic hydrocarbons (except benzene and toluene), and the terpenes and sesquiterpenes. This may reduce work burden for analytical differentiation between isomers without impairing the quality of health-related information.

There is not much controversy about the additive evaluation of the involved VOC by calculating the R value: For each VOC the test result is divided by its LCI, and the sum of these expressions (the R value) may not exceed 1 (which corresponds to 100% of the allowed).

LCI values need to be defined and adapted continuously at one official place. In Germany, AgBB established a toxicology task force with participation of industry. On a European level, a European task force would be needed.

AgBB is restricting the sum of VOC without LCI to a very low level of 0.1 mg/m³. This may have non-plausible consequences. As an example, use of Texanol in many formulations may exceed limitation of VOC without LCI when testing the emissions. The AgBB toxicology task force withdrew an earlier LCI and does not see enough data available for establishing a new LCI. If a new LCI were higher than 0.1 mg/m³ (which can be expected) then Texanol is treated today too badly not because of its properties, but because of lack of toxicological knowledge and decision. Therefore it may be a better idea to assign an "average" LCI of 1 or 0.5 mg/m³ to all VOC without LCI.

German AgBB is also restricting non-identified VOC because these are handled as part of the sum of the VOC without LCI. This means that the capability of the laboratory to identify complex mixtures may decide on acceptance of the product, rather than the health-related properties. Therefore it may be better to specify the required degree of identification (see above) and to keep non-identified VOC out of scope, or to assign an "average" LCI of 1 or 0.5 mg/m³ to all non-identified VOC.

When acceptance of a product on European or national market is concerned, the AgBB criteria look quite reasonable if the limits for carcinogenic VOC are adapted to the capabilities of the testing method, and SVOC criterion is skipped because testing method is not sufficiently reliable for those. A suggestion for evaluation criteria can be found below:

Date of test	**TVOC**	**Carcinogenic VOC (C1 + C2)**	**R (total LCI evaluation)**	**Formaldehyde**
3 days	10 mg/m³	0.005 mg/m³	-	-
28 days test	1 mg/m³	0.005 mg/m³	R = 1	0.12 mg/m³

This is for acceptance on the market. Lower criteria may be applied for voluntary labelling of low emission products.

For further reading:

German scheme for authorisation of floor coverings by DIBt for German market with the so-called "Ü"-mark in addition to the CE mark, see http://europa.eu.int/comm/enterprise/tris/pisa/app/search/index.cfm?fuseaction=pisa_notif_overview&iYear=2005&inum=255&lang=EN&sNLang=EN

AgBB publication, see www.umweltbundesamt.de/building-products/agbb.htm

Basic publication used as starting point for both CESAT and AgBB: EU research report ECA no 18 (EUR 17334) "Evaluation of VOC Emissions from Building Products – Solid Flooring Materials", 1997. www.jrc.cec.eu.int/pce/modnoiseca_ecareports.htm

Publication of new French LCI like values may be expected by end December at: www.afsset.fr/index.php?pageid=714&parentid=424

European OEL are published by SCOEL = European Scientific Committee on Occupational Exposure Limits, see http://europa.eu.int/comm/employment_social/health_safety/scoel_en.htm

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Regulation of VOC emissions

Alternative to current
German and French approaches

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www.eurofins.com/product-testing

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VOC emissions and health / well-being

- Correlation between elevated VOC concentration and complaints of bad health or of bad comfort
  - Still not unambiguous
  - Depending on actual compounds in VOC mixture and on ozone concentration
- Correlation between elevated VOC concentration and bad odour (leading to reduced well-being)
  - Depending on actual compounds in VOC mixture and on ozone concentration

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Reduction of VOC emissions

- Rationale: Prevention
  - Lower VOC = lower potential of discomfort
- Safety and CE marking
  - EN 14041 for resilient floorings and laminates
  - EN 14342 for wooden floorings
  - Both not dealing with VOC emissions
- Not good enough for Germany
- Developments in Europe

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VOC emissions in Europe

- European Commission goes for Regulation of VOC in consumer products, in paints, …
- REACH legislation will deal a.o. with exposure of users indoors
- CEN TC 351 working on on emission testing under Construction Products Directive CPD
- EN standards for CE marking without VOC requirements
- Supplemental German requirement for non-wooden floor coverings (CE mark / EN 14041):
  - Ü conformity mark
  - ÜZ conformity certification bodies
- EU: Notified, suggested for Europe-wide use

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Emissions testing

- Emissions may be tested for
  - Compliance with legislative requirements
  - REACH documentation
  - Application for voluntary labels (like EMICODE, M1, CHPS, Blue Angel)
  - Compliance with customer requirements (clean rooms, car and aircraft industry)
  - Internal purposes

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AgBB assessment scheme - I

- AgBB = Task force of German authorities: Health-related evaluation of construction products
- Developed from ECA report # 18
- Voluntary basic concept
- Binding use by DIBt for authorisation before entry into German market
  - Floor coverings with CE mark (EN 14041) for use in locations where prolonged stay of humans may occur
  - Planned: More products
- Voluntary use of this approach by several ecolabels

AgBB scheme - II

- After 3 days:
  Restriction of emission of TVOC, carcinogenic VOC
- After 28 days:
  "Health-related evaluation": Restriction of emission of
  - TVOC, Aldehydes
  - Carcinogenic VOC
  - LCI/NIK values, R value, VOC without LCI
  - TSVOC
- (planned:) Odour testing

AgBB scheme - III

- Evaluation criteria for single VOC
- LCI / NIK yearly update (except of 2006)
  - LCI derived from OEL by division with 100, or with 1000 in case of C3 substances
- R value (Σ ($conc_{(i)}$ / $LCI_{(i)}$)) < 1 (< 100% of all LCI)
- VOC without published LCI are restricted
  - Non-identified compounds are included into restriction of VOC without LCI
- Similar approaches:
  - CESAT (France)
  - CHPS (California): C-REL as evaluation criteria

DIBt authorisation procedure

- Contact DIBt
- Report formulation (recipe)
- Negotiate group authorisation for reducing costs
- 28 days emission chamber test
- Application, authorisation for 5 year period
- Contract with certification body, "ÜZ-Stelle"
  - In-factory production monitoring
- Spot tests after ÜZ body took samples on-site, 1 x / year
  - Now: 3 days emission chamber test
  - In future: Thermal extraction / micro chamber test

German AgBB / DIBt approach - The "Golden Hen" ?

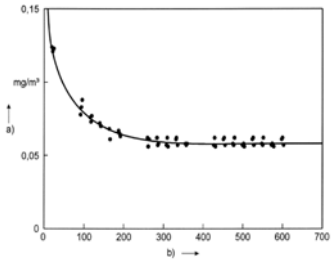
- Industries - different positions:
  - Not liking too many additional work and costs
  - Being happy with protecting their brand
  - Responsible Care policy
- Criticism:
  - AgBB too sophisticated, too detailed, too costly
  - Not enough scientific reasoning

Emission into Indoor Air - Exposure scenario - I

- Model room
  - Floor area 7 m², Height 2.5 m, 1 window, 1 door
  - Wall area 24 m², Sealant area 0.2 m²
  - 1/2 air exchange per hour, 23 °C (Asia: 25°C/28°C), 50% relative humidity
  - 24 hours exposure (conservative approach)
- Emissions tested after 3 days (early exposure) and 28 days (long-term exposure)

Emission decay over time

Volatile compound as example



Exposure scenario - II

- Loading factor m^2/m^3
- Area specific ventilation rate m^3/m^2h (air exchange, divided by loading)
  - Flooring: 0.4 m^2/m^3 / 1.25 m^3/m^2h
  - All walls: 1.4 m^2/m^3 / 0.4 m^3/m^2h
  - Sealants: 0.012 m^2/m^3 / 44 m^3/m^2h
- Scenario widely accepted, just the small size of the room is discussed (and the temperature is different in Asia)

Emission test and reality

- Test chamber and real room
  - Adsorption on walls reduces effective emission
  - Other sources will contribute
- Ageing (airing out during storage, transport, construction process)
- Coverage (e.g. adhesive by carpet, or wall by paint)
- Either find conversion factors, or
  - First do worst-case test, and
  - if not clear then simulate reality

Exceptions from compulsory testing

- Product Groups with known no (or very low) emissions
  - Such as ceramic tiles, or stones: No testing
- Products with known correlation between contents and emission
  - Find formula and estimate by calculation

Allowing simpler testing

- Products known or suspected to be of low emission
  - Allow stopping test after first test in chamber after 3 days (instead of full 28 days test period)
  - Allow simpler test methods, instead of test chambers
    - More or less simulating the test chamber
    - Use safety factor 1/3 for estimating chamber result

Testing techniques - emissions

- Emission test chamber or cell (ISO 16000-9/10, VDA 276) = simulation of real room = reference method
- More simple methods:
  - Extraction
  - Evaporation of formaldehyde (VDA 275), fogging (ISO 6452), headspace (VDA 277)
  - Thermal desorption / extraction (VDA 278)

  - Microchamber (ISO 16000)

Microchamber

Volume: 3 ml or 40 ml

Photo: Eurofins Environment A/S

Emission Test Chamber

Simulation of a small room of 7 m² and 2.5 m height

- Size: up to 120 - 240 litres and more
  - FLEC cell: very small, 35 ml, different air velocity
  - Microchamber: 3 or 40 ml
- Temperature: 23 °C (but Japan: 28 °C, Korea: 25 °C)
- Relative Humidity (50 %)
- Air exchange / Loading = Area Specific Flow Rate
- For flooring and adhesives (as an example):
  - Air exchange = 0.5/h
  - Loading = 0.4 m²/m³
  - Area Specific Flow Rate 1.25 m³/(m²xh) = 1.25 m/h

Test chambers

Photo: Eurofins Environment A/S

Test chamber with a floor covering in a seal box

Photo: Eurofins Environment A/S

Air sampling

2 Tenax TA tubes in series

2 tubes sets in parallel

= 4 tubes per analysis

Photo: Eurofins Environment A/S

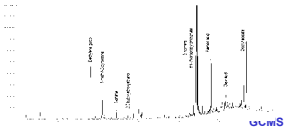
Analyses

GC/MS:

VOC, TVOC

HPLC:

Aldehydes, isocyanates



Photo, data: Markes International

Follow international standards

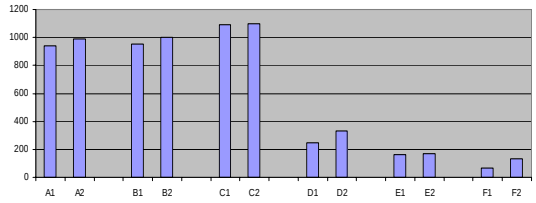
- ISO 16000:
  - Part 3 (Aldehydes)
  - Part 6 (VOC; TVOC)
  - Part 9 (chamber) (earlier: EN 13419-1)
  - Part 10 (FLEC) (earlier: EN 13419-2)
  - Part 11 (Test specimen) (earlier: EN 13419-3)
- EN 717-1 Formaldehyde testing for E1
- ASTM D5116 and more ASTM standards
- JIS A 1901

Significance of test result

- What you get is:
  Chamber air concentration at given time µg/m³
  - Calculate emission rate per area µg/m²h
    (or per mass, or per device)
  - Calculate contribution to air concentration µg/m³
    in model room or in real room (source strength)
- Consider ageing, coverage, adsorption, other sources
- Consider limited precision

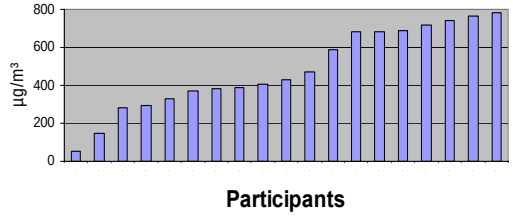
Within lab reproducibility

TVOC Reproducibility within Eurofins Laboratory:
6 Flooring Samples in 2 Test Chambers each (µg/m³)



1 adhesive tested by 20 labs

TVOC 2nd GEV Round Robin Test
TVOC GEV (Results of Participants)

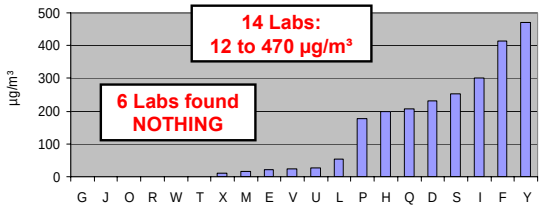


Participants

1 lab did not report a TVOC

Single substances

2. GEV Round Robin Test
Ethylene glycol: 20 labs testing ONE adhesive



Reproducibility – Round Robin Tests

- Minor contribution of
  - Sample preparation
  - Chamber device
  - Analytical device
- Main problem showed to be:
  - Correct identification, with consequence for
    - Applying correct calibration factor (RRF)
    - Calculation of single substances
    - Calculation of sum parameters like TVOC
- Core factor: Experience of the lab

VOC, SVOC test reproducibility

- Reliability of test results:
  - Variation +/- 20 % (RSD) should be guaranteed within one lab (but sometimes better)
  - But: Low concentration = higher uncertainty (weaker MS signal)
  - Variation +/- 50% between different labs (RSD) Slight improvement may be possible
- SVOC, VVOC, reactive compounds (e.g. formaldehyde) cannot be measured in a reliable manner
- Air concentration below 0.005 mg/m³
  (for some compounds even already below 0.02 mg/m³) are not significant at all in many cases

Limitation of VOC emission

- 3 approaches
  - Prevention: Limit any emission - then no specific problems will occur (TVOC limitation)
  - Limit only VOC with irritating and odorous properties
  - Define limit values for VOC based on their specific properties
- Additional requirement: No carcinogens detectable (but not all carcinogens are detected with VOC test)

VOC limit values - I

- Limit values for VOC based on their specific properties
  - LCI, NIK (ECA report, AgBB, CESAT)
    - Find OEL, divide by safety factors:
      - 10 for longer exposure than 8 hours
      - 10 for sensitive population
      - 10 for suspected carcinogens (C3)
  - Additional information from WHO, UBA, AFSSET
  - California: C-REL values (Chronic inhalation reference emission limits)

VOC limit values - II

- Combined evaluation, R value
  $(\Sigma\ (conc_{(i)}\ /\ LCI_{(i)})) < 1$ (< 100% of all LCI)
- Problem:
  Comparison of VOC specific limit values with test chamber result
  - Limit values are for inhaled air
  - Test chamber result has some but limited power in predicting real room air concentration (see above)

VOC limit values - III

- Calculation of LCI / NIK, as of today:
  - Very schematic safety factors at present not sufficient differentiation
  - May exclude products emitting VOC with low LCI
  - But does plausibility support such action?

VOC evaluation - Suggestions - I

Always be aware that:

- Emission test result is NOT an expected indoor air concentration - it is a material property under test conditions
- Comparing an emission test result with health-related limit values requires transformation of test result into predicted model room concentration
- Legal requirements shall help protecting human health; voluntary low emission labels may have sharper criteria

VOC evaluation - Suggestions - II

Defining limit values, order of priority:

1. DNEL (see REACH legislation)
2. If C3 and OEL does not include this: OEL / 1000
3. If OEL was based on irritation or odour: OEL / 10
4. Else: OEL / 100
5. Or with specific knowledge: Specific limit value

OEL list used:

1. European list (SCOEL); if not found:
2. Average of European national lists, or analogy conclusion

VOC evaluation - Suggestions - III

Facilitate limit values:

- Use only few values (such as 0.05, 0.1, 0.5, … mg/m³)
- Do not differentiate too much between VOC, toxicology is not so precise
- Assign group limits to hydrocarbons and terpenes, for reducing analytical work burden

VOC evaluation - Suggestions - IV

Handling of VOC without limit value:

- Assign average limit, such as 0.5 or 1.0 mg/m³ (lack of toxicological knowledge does not mean that the VOC is toxic)

Handling of non-identified VOC:

- Assign average limit, such as 0.5 or 1.0 mg/m³ (lack of identification is a property rather of the lab than of the product in test)
- But require minimum 2/3 of TVOC to be identified

VOC evaluation - Suggestions - V

Suggestion for defining general limit values:
(for model room ISO 16000, after 3 days / 28 days)

- TVOC: 10 mg/m³ / 1 mg/m³ (based on values as suggested by Seifert and Molhave)
- Carcinogenic VOC if and as far as method can detect: 0.005 mg/m³ each
- R value for combined VOC evaluation: 1.0
- No limits for SVOC, VVOC

Formaldehyde: Still subject to discussion but probably 0.12 mg/m³ will make sense

VOC evaluation - Suggestions - VI

Procedure for defining limit values:

- Who will set the limits on European level?
- Or will we have numerous different national lists?

Open question …

At present, CEN TC 351 is working only on test methods, not on requirements and limit values

Regulation of VOC emissions

Alternative to current
German and French approaches

Reinhard Oppl
Eurofins Environment A/S

www.eurofins.com/product-testing