Comparison of emission specifications in the US and in Europe

Thomas Neuhaus* and Reinhard Oppl

Eurofins Product Testing A/S, Denmark

*Corresponding email: tne@eurofins.dk

SUMMARY
Testing methods for determination of product emissions, which are used in the European Union, are compared with US methods. These are ISO 16000-9 and the US standard ASTM D 5116-06, which were considered as generic standards in both regions, defining chamber properties, requirements and chamber handling used for product emission tests. Different specialised methods as defined by AgBB, AFSSET, GREENGUARD and the Californian CHPS specification are making use of these standards. These are compared and an outlook on potential harmonisation in the future is given.

KEYWORDS
Emissions, VOC, Test chambers, Model room

INTRODUCTION

VOC and formaldehyde emissions from interior finishing, building products and furniture, are evaluated in different manners in the United States and in member states of the European Union. Main differences are the testing time schedule, and the interpretation of test results. ISO 16000 standards series more and more are the basis for harmonisation of emission testing within Europe, while the Californian CHPS specification, also known as Section 01350, shows increasing acceptance. Main characteristics of both testing protocols approaches are compared, and an outlook on potential harmonisation in the future is given.

METHODS

Key parameters from the different testing methods for determining emissions of volatile organic compounds used in the member states of the European Union and the United States were listed and compared with each other.

The generic standards defining chamber properties, requirements and chamber handling used for product emission tests are ISO 16000-9, mostly used in Europe, and the US standard ASTM D 5116-06. Several different testing methods for various types of products are based on these two standards.

European test methods for construction products like AgBB (Germany) and AFSSET (France) are based on ISO 16000 and contain a similar approach concerning testing times, conditions and evaluation of results, also the former prEN 15052 for floor coverings. This approach was compared with the Californian CHPS specification, also known as Section 01350, which was also adapted by the Carpet and Rug Institute (CRI) and FloorScore for their environmental labels. As an example a floor-covering sample was used for comparison.

The EMICODE label, administrated by the GEV in Germany, is a well-established label for flooring installation products. The testing method was compared with the method from the US label GREENGUARD. As an example an adhesive sample was used for comparison.

RESULTS

Comparison of ISO 16000-9 and ASTM D 5116-06

Typical and important parameters for comparability of tests results from product emission testing using emission test chambers are climatic conditions, such as temperature and relative humidity, area specific ventilation rate, sampling dates.

ISO 16000-9 clearly defines chamber parameters:

- Temperature: 23°C ± 2°C
- Relative humidity: 50 ± 5 %
- Sampling date: after 3 and 28 days of storage in climate chambers
- Area specific ventilation rates defined for floor, wall and sealant scenarios

Area specific ventilation rates are derived from a model room with following properties:

- Volume: 17.4 m^3
- Air exchange rate: 0.5 h^{-1}
- Floor area: 7 m^2
- Wall area: 24 m^2
- Sealant area: 0.2 m^2

ASTM 5116 does not define these parameters, but presents examples for climatic conditions, loading and air exchange rates.

Other parameters generic, chamber material, air mixing, air tightness, recovery rate, maximum allowable background concentration are defined in both standards and show comparable requirements.

Comparison of AgBB/AFFSET method and Californian CHPS specification

Chamber and test parameters

Table 1 indicates chamber and test parameters in accordance with the AgBB/AFSSET method and the Californian CHPS specification with the example of a floor covering.

Table 1. Chamber and test parameters, AgBB/AFSSET – CHPS.

Parameter	AgBB/AFFSET	CHPS	Comparability
Temperature, °C	23 ± 2	23 ± 1	Yes
Relative humidity, %	50 ± 5	50 ± 10	Yes
Loading, m^2/m^3	0.4	0.3 - 0.7	Yes *
Air exchange rate, h^{-1}	0.5	1	Yes *
Sampling date	after 3 and 28 days	after 11, 12, 14 days **	No
TVOC definition	C_6-C_{16}	C_5-C_{17}	Partly

* When comparing area specific emission rates

** Testing 1, 2 and 4 days after a preconditioning period of 10 days

Model room concentrations and evaluation

Both methods evaluate emissions of volatile organic compounds by comparison of model room concentrations with certain limit values, but the procedure of determining these concentrations is different.

AFSSET method is simulating a model room in the test chambers by using the same area specific ventilation rate in the chambers as defined for the model room in ISO 16000-9. AgBB uses another size of model room, with a floor area of 12 m^2, but also the same area

specific ventilation rates for floor and walls as defined in ISO 16000-9. This means that measured chamber concentrations are equal to the desired model room concentrations.

Californian CHPS specification requires calculation of emission rates and recalculations into two different model room concentrations (classroom and office building).

For AgBB/AFSSET method evaluation of TVOC is done after 3 and 28 days and evaluation of single VOC is done after 28 days, while the CHPS method is only evaluating results after 14 days (including 10 days preconditioning). The sum parameters like TVOC are directly being compared to limit values, but evaluation of single compounds is different.

AgBB/AFSSET is using a list of up to 255 single VOC including values called lowest concentrations of interest LCI for each compound. The concentrations of all VOC substances are divided by their respective LCI value (if given). The sum of the quotients gives the R-value, see equation (1).

$$R = \sum_{i}^{n} \left({}^{C_i}\!/\!_{LCI_I} + \ldots + {}^{C_n}\!/\!_{LCI_n} \right) \quad (1)$$

The R-value should not exceed the limit value of 1.

Californian CHPS specification is comparing the model room concentrations directly with a list of chronic inhalation Reference Exposure Levels (ChRel). No single compound should exceed one-half of the individual ChRel (or the specific indoor Rel for formaldehyde).

Table 2 shows the differences in the properties of the model rooms and some selected limit values. The limit values were given as concentrations and were then calculated into area specific emission rates for better comparison.

Table 2. Model room and limit values, AgBB/AFSSET – CHPS.

	AgBB	AFSSET	CHPS, CRI, FloorScore	
			Classroom	Office building
Model room				
Volume, m^3		17.4	231	30.6
Floor area, m2		7	89.2	11.1
Air exchange rate, h^{-1}		0.5	0.9	0.75
Loading m^2/m^3 (flooring)		0.4	0.39	0.36
Area specific ventilation rate, m^3/m^2h (flooring)		1.25	2.1	1.86
Limit values, concentration, µg/m^3				
TVOC	1000	1000	500*	500*
Formaldehyde	120	10**	16.5	16.5
Styrene	860**	250**	450	450
Phenol	78**	200**	100	100
Limit values, emission rates, µg/m^2h				
TVOC	1250	1250	1050*	930*
Formaldehyde	150	12.5**	35	31
Styrene	1075**	312.5**	945	837
Phenol	97.5**	250**	210	186

* CRI and FloorScore limit values

** NIK or LCI limit value

Comparison of GEV/EMICODE method and GREENGUARD method

Chamber and test parameters

Table 1 indicates chamber and test parameters in accordance with the GEV method and the GREENGUARD method with the example of an adhesive.

Table 3. Chamber and test parameters, GEV/EMICODE – GREENGUARD.

Parameter	GEV/EMICODE	GREENGUARD	Comparability
Temperature, °C	23 ± 2	23 ± 1	Yes
Relative humidity, %	50 ± 5	50 ± 5	Yes
Loading, m^2/m^3 (adhesive)	0.4	0.41	Yes
Air exchange rate, h^{-1}	0.5	1	Yes *
Sampling date	after 1 and 10 days	after 6, 24, 48, 72, 96 (or 120) and 168 hours	partly
TVOC definition	C_6-C_{16}	C_6-C_{16}	Yes

* When comparing area specific emission rates

Model room concentrations and evaluation

Both methods evaluate emissions of volatile organic compounds by comparison of model room concentrations with certain limit values, but the procedure of determining these concentrations is different.

GEV method is simulating a model room in the test chambers by using the same parameters (loading and air exchange rate) in the chambers as defined for the model room in ISO 16000-9. Measured chamber concentrations are equal to the desired model room concentrations. Seven carcinogenic compounds will be evaluated after 1 day and the sum parameter TVOC will be evaluated after 10 days. Other single VOC compounds will not be evaluated.

GREENGUARD method requires calculation of emission rates and recalculations into two different model room concentrations (classroom and office building). Only the results after 168 hours will be compared with limit values. No single compound should exceed 0.1 TLV (Threshold Limit Value, occupational exposure limit) for GREENGUARD Certification (office building). GREENGUARD Children and Schools (classrooms) requires no concentrations of single compounds above 0.01 TLV or one-half of the individual ChRel.

Table 4 shows the differences in the properties of the model rooms and some selected limit values. The limit values were given as concentrations and were then calculated into area specific emission rates for better comparison.

Table 4. Model room and limit values, GEV/EMICODE – GREENGUARD.

	GEV/EMICODE	GREENGUARD	
		Classroom	Office
Model room			
Volume, m^3	17.4	229	32
Floor area, m^2	7	84	13.1
Air exchange rate, h^{-1}	0.5	0.9	0.72
Loading m^2/m^3 (adhesive)	0.4	0.37	0.41
area specific ventilation rate, m^3/m^2h (adhesive)	1.25	2.3	1.76
Limit values, concentration, µg/m³			
TVOC	500	220	500
Formaldehyde	50	16	60
Acetaldehyde	50	9	4500
Benzene	2	16	160
Limit values, emission rates, µg/m²h			
TVOC	625	510	880
Formaldehyde	63	37	106
Acetaldehyde	63	21	7920
Benzene	3	37	282

DISCUSSION

The main differences between European and US testing methods for determination of emissions of volatile compounds from materials are testing duration, sampling times and the way of calculating model room concentrations and evaluation.

US methods are using several sampling times, but are only evaluating the results from the last testing date. This makes testing very extensive and costly, especially GREENGUARD method, where results from six testing dates should be analysed, but only the last one is used.

Testing duration for European methods is 10 up to 28 days and for US methods 7 to 14 days. This makes a comparison of results difficult, not only between Europe and the United States, also within the single methods of each continent. In general European methods have longer test durations than US methods, which represents better long-term emission, but on the other hand, shorter tests are faster and less costly.

While all European methods use the same area specific ventilation rates for evaluation as defined in the model room in ISO 16000-9, US methods use two kinds of model rooms (classroom and office), which are not harmonised within the different methods. This results in different sizes and properties for classrooms and offices for CHPS and GREENGUARD. The area specific ventilation rates for CHPS are 2.1 m^3/m^2h (classroom) and 1.86 m^3/m^2h (office building), this means, that the deviation between these two model rooms is about 13%. Calculation of concentrations for these two model rooms with rather close properties seems to be redundant, when considering an uncertainty ± 20% (relative standard deviation) of the test method itself.

GREENGUARD method is using model rooms with higher differences concerning properties and also different limit values, which results partly in very different limit vales, as shown for acetaldehyde (presented as emission rates).

Due to very different limit values for single compounds, it is difficult to compare European and US methods. In both continents, different limit values for the TVOC are used, but also different area specific ventilation rates of the model rooms, which result in quite close limit values when expressed in emission rates.

CONCLUSIONS

For better comparison of US methods among each other, there is a need to harmonize model room properties and it should be discussed to use only one model room, because calculated model room concentrations in classrooms and offices could be very similar regarding an uncertainty of ± 20% (relative standard deviation) of the test method itself. The area specific ventilation rates as defined for the model room in ISO 16000-9 could be used, like European methods do. This would result in a better international comparability, but also in higher model room concentrations, because the ventilation rate will be lower.

When harmonising testing durations it should be considered that longer testing durations represent a more precise long-term emission, but on the other hand, shorter tests are faster and less costly.

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