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Comparison of Formaldehyde Concentrations in Emission Test Chambers Using EN 717-1 and EN 16516

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SUMMARY
For more than 25 years EN 717-1 (Wood-based panels - Determination of formaldehyde release - Part 1: Formaldehyde emission by the chamber method) is the standard for formaldehyde emission testing of wooden boards. In 2017 EN 16516 (Construction products - Assessment of release of dangerous substances - Determination of emissions into indoor air) was published as a new harmonised standard for the emission testing of construction products. Because test chamber conditions are different, both standards give different concentrations for formaldehyde. To determine a conversion factor four test series were set up with different wooden boards. For a loading of 1 m²/m³ the conversion factor is 1.6. This means that the formaldehyde concentration measured under the conditions of EN 16516 is a factor of 1.6 higher compared to EN 717-1.

KEYWORDS
Construction products; European standard; air exchange rate; loading factor.

1 INTRODUCTION

In 2016 the German Committee on Indoor Guide Values derived a precautionary indoor air guide value (RW I) of 100 µg/m³ formaldehyde per cubic meter. Moreover, it is recommended that this guide value should not be exceeded at any interval of half an hour during a day (UBA 2016, WHO 2010). The emission of formaldehyde especially from wooden boards and wood-based construction products is still present, since formaldehyde is an important component of adhesives in wood-based materials (Salthammer, 2010; Wilke, 2016; Richter, 2017).

Modernization and an energetic optimized construction of new buildings result in increasing tightness of buildings. Low air exchange rates, lower than 0.5/h are common without a technical ventilation system. In general, the emission of wood-based materials is affected by temperature, humidity, loading factor and air exchange rate (Meyer, 2014; Salthammer, 2010).

EN 717-1 describes test conditions by using a loading of 1.0 m²/m³, an air exchange rate of 1.0/h and a relative humidity of 45 %. Especially the air exchange rate is much different from modern houses. Nowadays values of (much) lower than 0.5/h are normal (see discussion, table 2). Consequently, the EN 16516 defines an air exchange rate of 0.5/h for its model room scenario.

Whereas in EN 717-1 there is only one loading factor, in EN 16516 different loading factors are given depending on the emission surface of a specific construction product. For wooden boards loading factors between 0.4 and 1.8 m²/m³ could be realistic. Considering only the floor or the ceiling the loading factor would be 0.4 m²/m³ for the model room given in EN 16516 (4 m x 3 m x 2.5 m, 30 m³). For a wall construction the loading factor would be 1.0 m²/m³ and the use of wooden boards for floor, wall and ceiling would result in a maximum loading factor of 1.8 m²/m³ not considering any furniture. Furniture is not a construction

product but of course it is often made from wood or wooden boards and is an additional potential source for formaldehyde.

2 METHODS

Four different wooden boards (two particle boards, OSB, multiplex board) from different manufactures were obtained from local Do-it-yourself stores and investigated in 1 m^3 emission test chambers for their emissions of formaldehyde. Standard test conditions were chosen in accordance with EN 717-1 and EN 16516 (see table 1). The testing of one material was done in parallel in two identical emission test chambers made by Heraeus-Vötsch as shown in figure 1. Sampling was done with DNPH-cartridges (Supelco) for 30 min (30 L) according to ISO 16000-3. Analysis was done using a HPLC-DAD system Agilent 1100.

Table 1. Emission test conditions of standards EN 717-1 and EN 16516

Parameter	EN 717-1	EN 16516
Temperature (°C)	23 ± 0.5	23 ± 1
Relative humidity (%)	45 ± 3	50 ± 5
Loading factor L (m^3/m^2)	1.0 ± 0.02	variable (0.4-1.8)
Air exchange rate N(1/h)	1.0 ± 0.05	0.5 ± 0.025

Figure 1. 1 m³ emission test chamber with samples.

3 RESULTS

Measurements at different air exchange rates

In the beginning of the investigations the formaldehyde emission from a particle board was measured in accordance with the conditions of EN 717-1 (loading 1.0 m^2/m^3; temperature 23°C, 45 % relative humidity). Additional tests were done in parallel at two more different air exchange rates (0.5/h and 0.2/h) in 1-m^3-chambers over a period of three weeks to show the influence of the air exchange rate. The results are shown in figure 2.

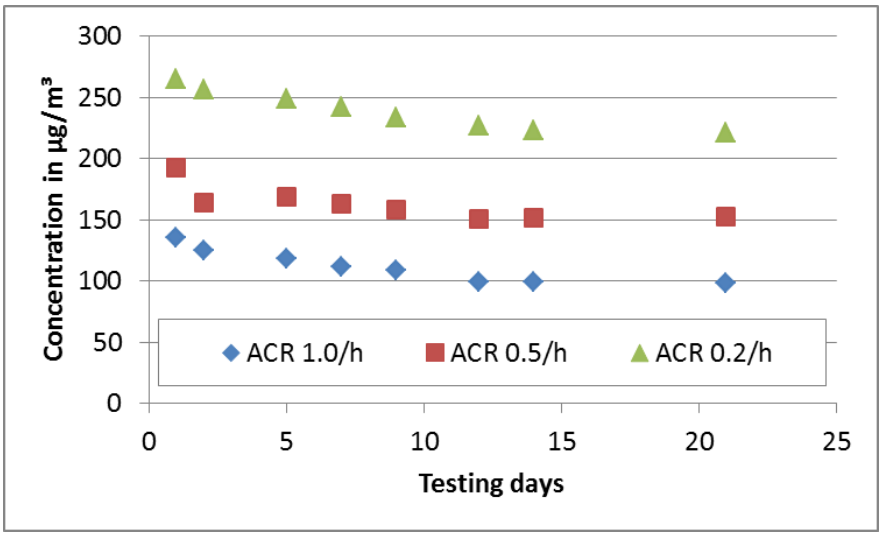

Figure 2. Formaldehyde concentration at three different air exchange rates (ACR).

Comparison of EN 717-1 and EN 16516 with a loading factor of 1.0 m²/m³

Test series with 4 wooden boards were conducted for the comparison. Two identical boards were tested simultaneously in two identical emission test chambers according to the conditions of EN 717-1 and EN 16516 as given in table 1. Results are shown in figures 3 to 6.

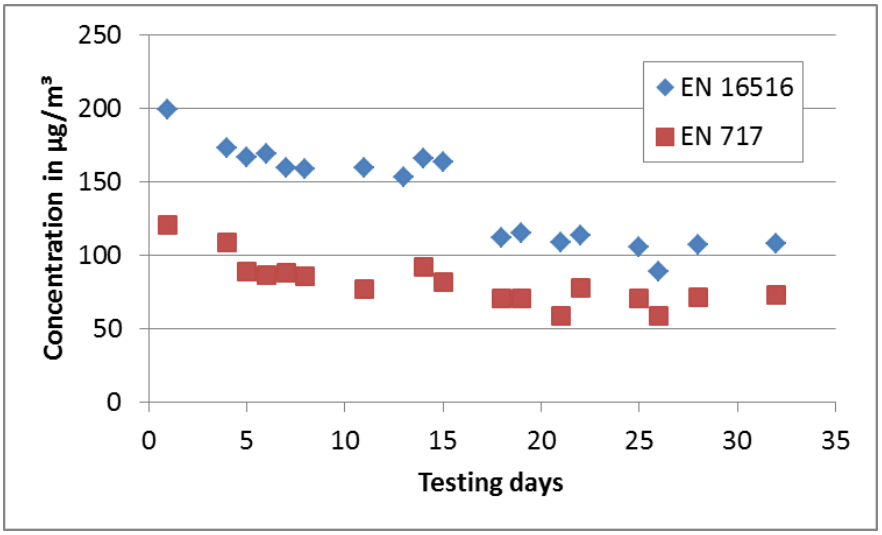

Figure 3. Formaldehyde concentrations from particle board 1

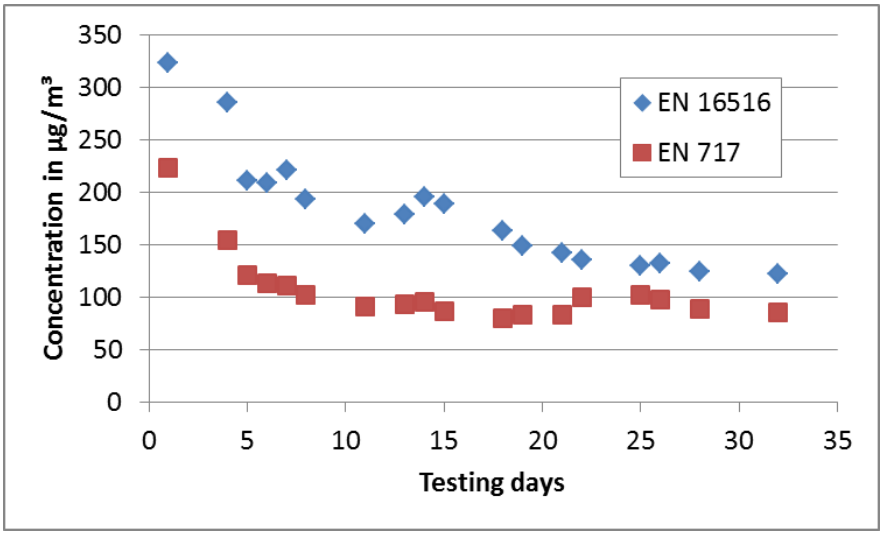

Figure 4. Formaldehyde concentrations from a “multiplex” board

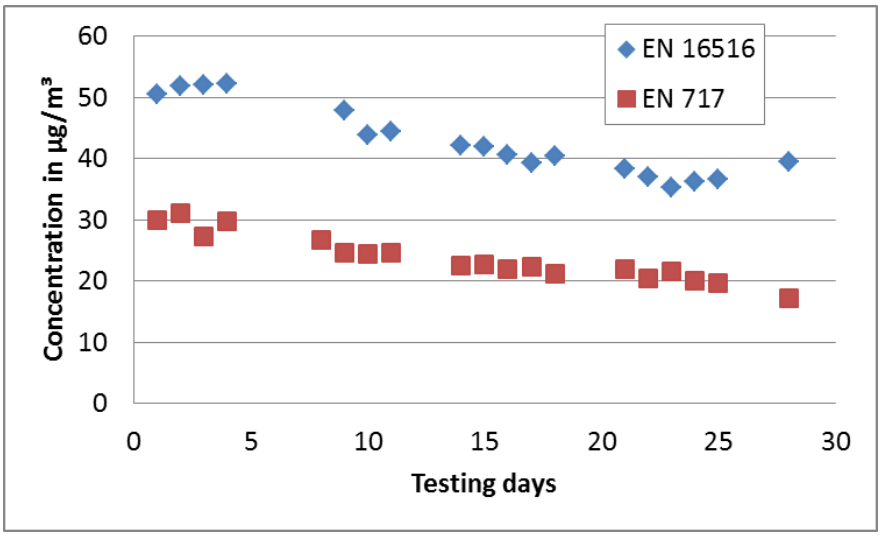

Figure 5. Formaldehyde concentrations from an OSB

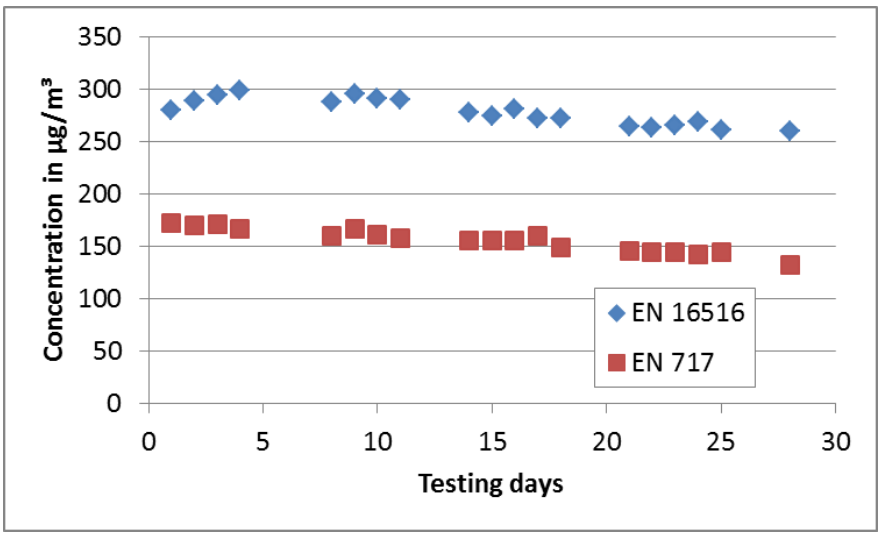

Figure 6. Formaldehyde concentrations from particle board 2

As expected the formaldehyde concentrations are higher at the conditions of EN 16516. The comparison of all measured concentrations is shown in figure 7. The trend line gives a slope of 1.7, which is the average factor for a conversion of results from EN 717-1 into EN 16516.

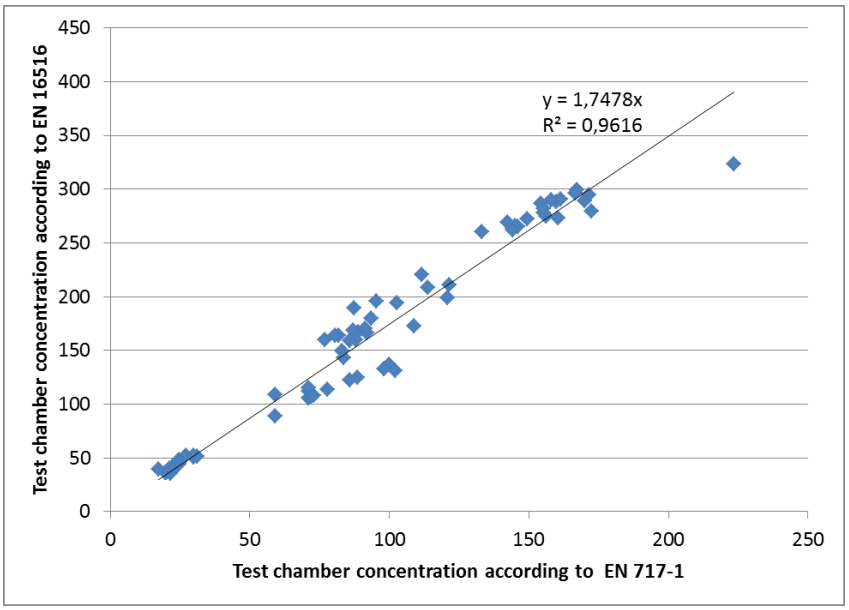

Figure 7: Correlation of EN 717-1 and EN 16516 (single values)

According to EN 717-1 there is the calculation of the equilibrium-concentration of formaldehyde. Comparison of this equilibrium-concentration with the end-concentration of EN 16516 after 28 days is given in figure 8. In this case the trend line gives a slope of 1.6 as conversion factor. A factor of 1.6 is also calculated when using the WKI formula (Meyer et al., 2014) for the calculation of formaldehyde concentrations under conditions different from EN 717-1.

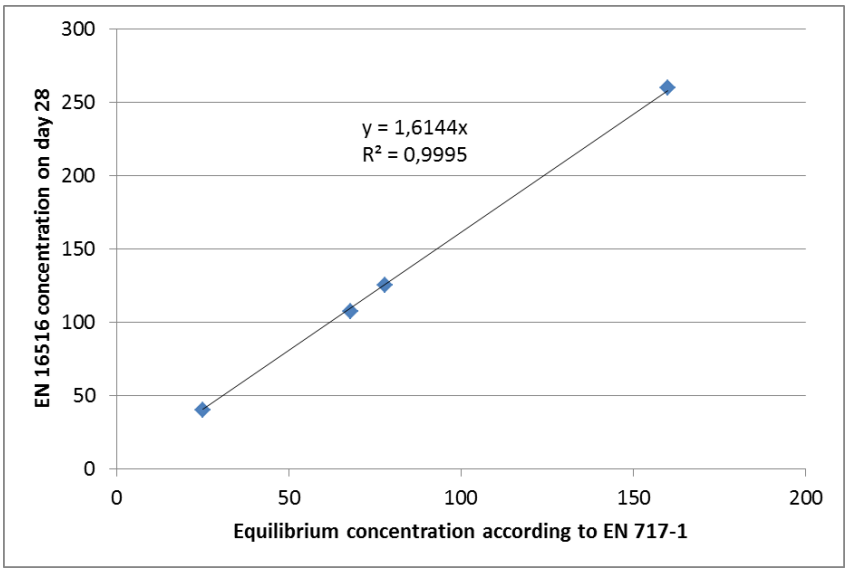

Figure 8: Correlation of EN 717-1 and EN 16516 (equilibrium vs. end concentration)

4 DISCUSSION

All four test series show a very good consistency for the difference of the formaldehyde concentration when comparing EN 717-1 and EN 16516 conditions. The differences in the conditions are humidity and air exchange rate. Table 2 shows values of indoor air exchange rates as given in the literature. It can be seen that real indoor air exchange rates can be much lower than 0.5/h, especially when there is no mechanical ventilation.

Table 2. Indoor air exchange rates in literature

Literature	Average/h	Remark
Hofmann, 2014	0.13 ± 0.099	Window ventilation
	0.629 ± 0.514	Mechanical ventilation
	0.40 ± 0.61	Living rooms
	0.38 ± 0.31	School rooms
Kah, 2005	0.22	Controlled ventilation
	0.03	Without controlled ventilation
Grams, 2002 und 2005	0.1-0.4	School rooms
Coutalides, 2008	< 0.3	Low energy houses
Münzenberg, 2003	0.26	Houses

The test series were set up with a loading factor of 1.0 m^2/m^3. According to EN 16516 higher loading factors of 1.4 or 1.8 m^2/m^3 are possible leading to even higher formaldehyde concentrations and consequently higher conversation factors.

It was very surprising that one out of four tested particle boards (board 2, figure 6) did not fulfill the German requirements of 0.1 ppm (124 µg/m^3) for the test chamber measurement according to EN 717-1.

5 CONCLUSIONS

Using an air exchange rate of 1.0/h for a test method is not representing real indoor conditions and is not up to date. This is proved by actual air exchange measurements in modern flats and houses. Literature (table 2) gives average air exchange rates of less than 0.5/h. Therefore the use of wooden boards with test values of 100 µg/m^3 determined by EN 717-1 (air exchange rate 1.0/h) might lead to indoor formaldehyde concentrations of more than 100 µg/m^3.
For the further use of EN 717-1 as official test method it is recommended to change the air exchange rate to 0.5/h in accordance with EN 16516 and ISO 16000-9 to establish a more realistic test scenario. Alternative to the change of conditions a conversion factor of 1.6 could be used to calculate a formaldehyde concentration in accordance to EN 16516 from a test done in accordance to EN 717-1.

ACKNOWLEDGEMENT

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