Formaldehyde emissions from mineral wool in building constructions into indoor air

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SUMMARY
One stone wool insulation product containing phenol-urea-formaldehyde binder was tested for the emissions of formaldehyde and volatile organic compounds (VOC) simulating real use in roof constructions. Results are compared with earlier published results from tests with wall constructions and to international indoor air limit values. Possible future handling by using reductions factors when testing pure mineral wool products without constructions is discussed.

KEYWORDS
Formaldehyde, VOC, Emissions, Indoor air, Mineral wool

INTRODUCTION

Mineral wool insulation products containing phenol-urea-formaldehyde binder could emit formaldehyde and could therefore influence the indoor air quality. Insulation products are normally not directly exposed to indoor air, but they are covered by wall, roof or floor constructions.

Tests were performed simulating real use in roof constructions and the results are compared with earlier published results from tests with wall constructions and to international indoor air limit values.

METHODS

One stone wool insulation product containing phenol-urea-formaldehyde binder was tested for emissions of formaldehyde and VOC. The sample was a commercial high-density roof insulation product with a thickness of 120 mm and a density of 140 kg/m^3. The product had been selected as being representative for a roof construction in this test.

The emission tests were performed for the non-covered material and for the material in two roof constructions that simulated a typical use in a factory building or a warehouse. For practical reasons, the construction assembly was tested upside down as shown in Figure 1.

One construction was realised by covering the insulation material with two overlapping corrugated steel deck plates, and the other construction with an additional PE foil between material and steel plate. In real corrugated steel deck constructions, the steel deck and the vapour membrane are perforated by the fixing screws. Accordingly the samples were perforated with two screws.

The samples were placed upside down at the bottom of the chambers and open edges and slits were sealed with aluminium foil and VOC- and formaldehyde free aluminium tape.

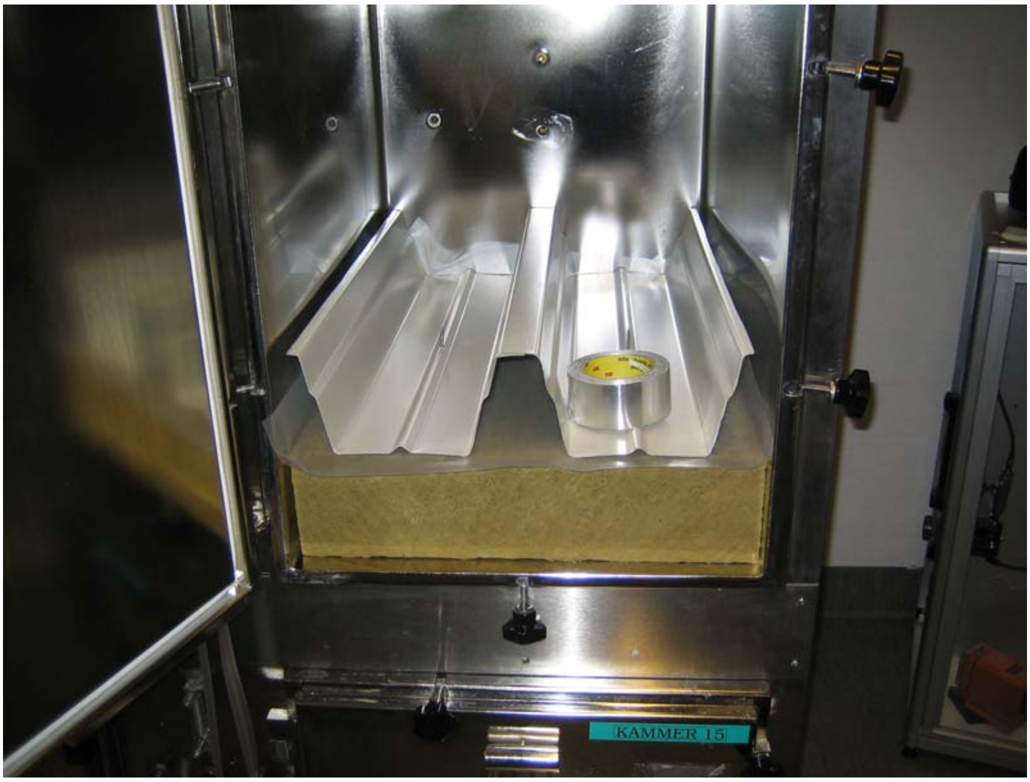

Figure 1. Sample with roof construction in test chamber, yet without sealing edges and slits.

The tests were performed with stainless steel test chambers that were ventilated with clean air of 50% RH at a temperature of 23°C. ISO 16000 standards were applied. Loading was 1.38 m^2/m^3, air exchange rate was 0.5 per hour and area specific ventilation rate was 0.36 m^3/m^2h. ISO 16000 standards were applied in order to achieve a better detection limit.
For formaldehyde determination, air samples were drawn through DNPH tubes, which were analysed by HPLC as described in ISO 16000-3.

VOC emissions were analysed by sampling air on Tenax TA® tubes following GC/MS analyses in accordance with ISO 16000-6. Test duration was 28 days with 4 testing times: 1, 3, 7 and 28 days after loading the test chambers.

RESULTS

Emissions of volatile organic compounds (VOC)

VOC emission tests on the non-covered stone wool showed no emissions of any volatile organic compounds above a detection limit of 2 µg/m^2h.

VOC emission tests on the material used for the roof construction (steel plate and PE foil) showed an area specific emission rate of 220 µg/m^2h (TVOC in accordance with ISO 16000-6) after 24 hours, which was decreasing below the detection limit of 2 µg/m^2h during 28 days. Possible source could be the PE foil, which had a strong odour.

As the stone wool was proven to be free of VOC emissions, this parameter was not considered for further discussions or tests within this project.

Emissions of formaldehyde

Table 1. Formaldehyde emission rates, µg/m^{2}h.

Stone wool	1 day	3 days	7 days	28 days
non-covered stone wool	72	72	65	50
Covered with steel plate	23	23	22	20
Covered with steel plate + PE foil	14	13	10	10
steel plate + PE foil (without stone wool)	12	11	8.3	8.3

Emissions from construction element without mineral wool are almost identical with the emissions of the construction including mineral wool. Possible source of formaldehyde emissions from the construction elements could be the coated steel plate.

The results were plotted against time for the non-covered stone wool with one surface exposed to the test chamber, then with this surface covered with the corrugated steel deck, and finally with an additional PE foil between material and the corrugated steel deck. The steel deck was fastened with two screws. Finally the construction (PE foil and steel plate) without stone wool was tested alone. The results are given in Figure 2, expressed as emission rates per surface area and hour. The error bars represent the ± 20% within-laboratory uncertainty (expressed as relative standard deviation).

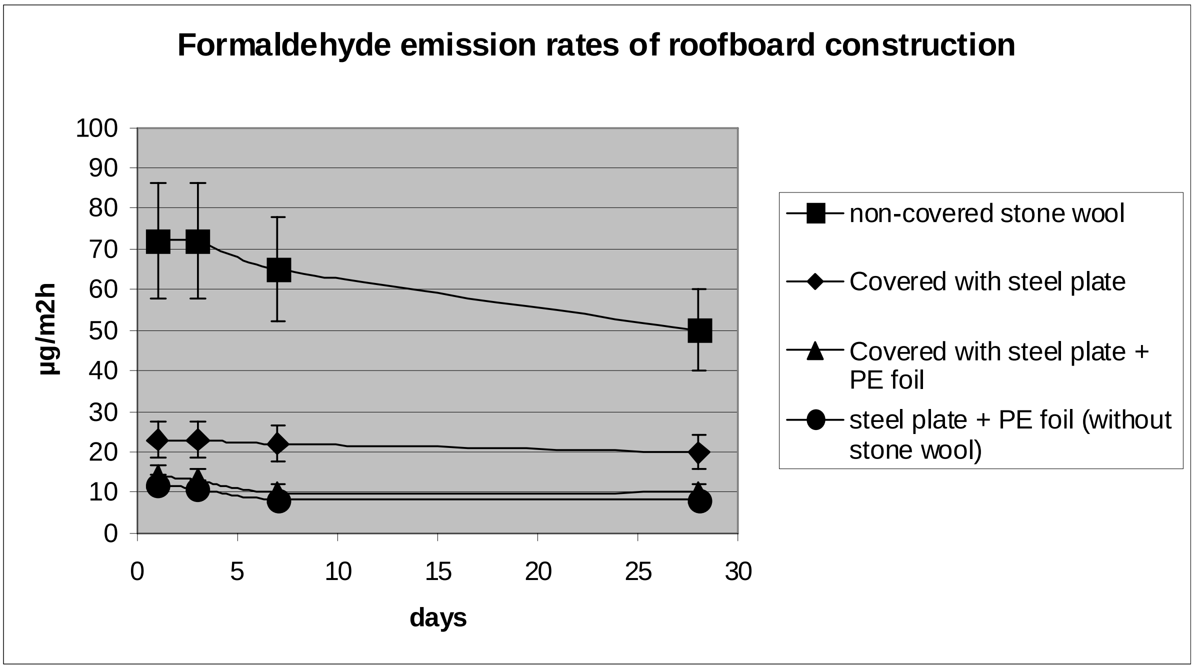

Figure 2. Emission rates stone wool.

Table 2 below shows an overview of area specific emission rates, in µg/m^{2}h, of this product and earlier published results from glass and stone wool products as emissions from non-covered mineral wool, and mineral wool covered with wall constructions (gypsum boards and PE foil) after storage of 28 days in emission test chambers.

The ratio of detected formaldehyde when testing mineral wool in building constructions in comparison to testing non-covered material was calculated. Emissions from the other construction elements (without mineral wool) were ignored in this calculation.

The area specific emission rates after 28 days from the covered mineral wool were calculated into concentrations in a model room as described in ISO 16000-9, with 24 m² wall area, a height of 2.5 meters, a volume of 17.4 m^3 and an air exchange rate of 0.5 per hour. A room height of 5 meters was used for the roof board construction with commercial and industrial use.

Table 2. Overview of formaldehyde emission in different constructions after 28 days.

	Non-covered mineral wool, $\mu g/m^2h$	Covered mineral wool, $\mu g/m^2h$	Ratio covered/non-covered mineral wool	Model room concentration (covered mineral wool), $\mu g/m^3$
Roof construction				
Stone wool 1	50	10	0.20	4.0
Wall construction				
Stone wool 2	18	3.9	0.22	11
Stone wool 3	32	9.5	0.30	27
Glass wool 1	20	4.6	0.23	13
Glass wool 2	25	4.6	0.18	13

DISCUSSION

Insulation material in simulated real use (roof and wall constructions) showed significantly lower formaldehyde emissions than non-covered material.

The results were compared with current assessment criteria in use in Europe, see Table 2.

Table 3. Formaldehyde criteria.

	Criteria
E1 for wooden products, after 28 days (EN 13986:2002)	120 $\mu g/m^3$
M1, Finland, after 28 days (The Building Information Foundation RTS)	50 $\mu g/m^2h$
CHPS, after 14 days (California Department of Health Services)	33 $\mu g/m^3$

All tested products complied with the different criteria for formaldehyde emissions when in complete construction (including PE foil) and were in most cases far below these limit values.

Several published and unpublished studies showed typical formaldehyde concentration in outdoor air in the range between 1 and 5 µg/m³ and typical ubiquitous formaldehyde concentration in indoor air always was at least 10 µg/m³. Thus the formaldehyde emission from completely covered mineral wool was in the same order of magnitude as ubiquitous formaldehyde concentration in indoor air and only slightly higher than typical formaldehyde concentration in outdoor air.

Calculations of the ratio between formaldehyde emission rates of covered and non-covered mineral wool, showed that the emission rates of covered mineral wool were 82 - 70 % lower than the emission rates of non-covered mineral wool.

CONCLUSIONS

The results implicate that testing formaldehyde emissions from non-covered mineral wools does not reflect reality, because formaldehyde emissions from mineral wool in building constructions into indoor air are significantly lower. The emissions from mineral wool in building constructions are mostly far below international indoor limit values for formaldehyde.

As a conclusion, it could be possible to use a conversion factor of 0.2 - 0.3 for evaluating the determined data, when testing formaldehyde emissions from non-covered mineral wool. Further tests would be necessary to confirm this factor.

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