# Emissions from adhesives and floor coverings on aggressive substrates

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## ABSTRACT
Extensive investigations have been carried out to study the emissions that can occur when flooring is adhered on a moist, alkaline substrate, such as concrete. The predominant VOCs in such cases are 1-butanol and 2-ethylhexanol.

The emission testing was carried out with the Field and Laboratory Emission Cell (FLEC) up to 3 years of exposure. Throughout the investigations, comparison has been made between substrates of concrete with or without a layer of a levelling compound that has a much lower alkalinity than the concrete.

The most important conclusion from the investigations was that a low alkali levelling compound is very effective in preventing alkali attack on adhesives and flooring, provided that the levelling layer is thick enough (minimum 5 mm) and that the moisture level in the concrete does not exceed 90% RH. The necessary moisture level in the concrete can be achieved by external drying or by using so-called self-drying concrete.

## INDEX TERMS
Alkali attack; Floor coverings; Adhesives; Concrete; Levelling compounds

## INTRODUCTION
It has been known for a long time that floor coverings are sensitive to moisture. The detrimental effects can be of different kinds, e.g. swelling of wood, debonding of adhesives etc. To prevent such effects, limits for the moisture content in a floor construction has to be set, depending on what kind of flooring that is to be used.

In the last decade, it has been observed that a too high moisture content can also result in decomposition of adhesives and flooring components, which in turn give rise to emissions of volatile organic compounds (VOC) polluting the indoor air. Such emissions are suspected to be of importance with regard to health problems, the so-called sick building syndrome. Apart from the influence of moisture, the alkalinity of the substrate is of great importance in this respect (Sjöberg, 2001).

## METHODS
In order to study the alkali attack on adhesives and floor coverings, combined specimens have been used. A stainless steel container with an inner diameter of 240 mm and an inner height of 100 mm was filled with concrete, either to the rim or leaving a space for a levelling compound (mostly 5 mm). Different regimes of one-sided drying out were used, sometimes preceded by water curing to simulate actual conditions on a building site. After the drying period, floor coverings were applied using water-based adhesives.

The combined specimens were then stored in standard climate until measurement of the emissions from the floor covering was done by the FLEC method (Field and Laboratory Emission Cell). This test method is covered by a recently presented draft European standard (prEN 13419-2, 2002). The first emission measurement was taken 26 weeks after the application of the floor covering, and successive measurements were taken in many cases, up to 3 years of exposure. The set-up is shown in Figure 1.

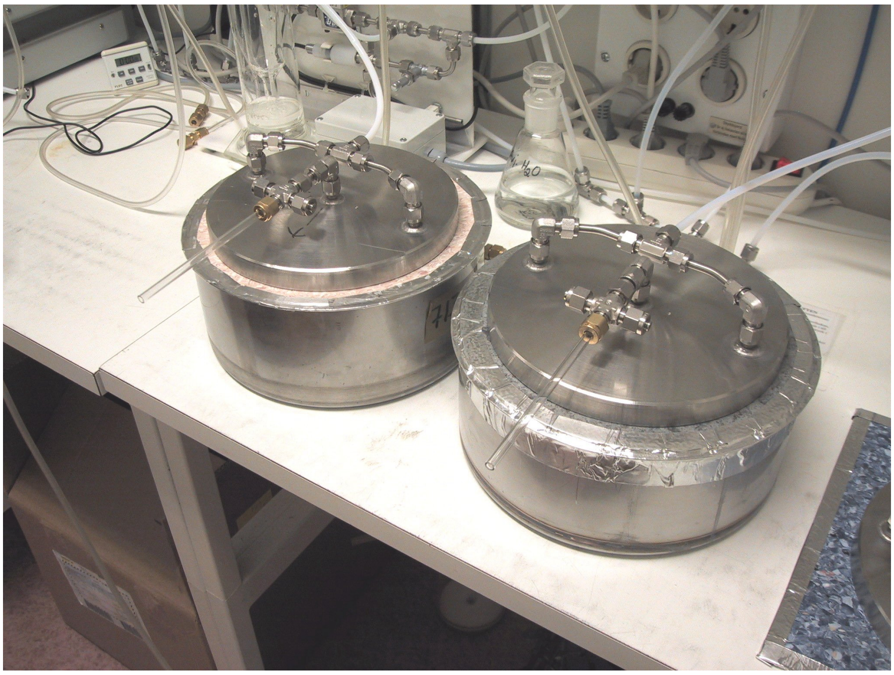

**Figure 1** Measuring the emission from combined specimens with the FLEC method.

The emission measurements registered the total VOC and the individual components. Special focus was put on the two alcohols 1-butanol and 2-etylhexanol, since emissions of these components are known to be the result of alkali attack on adhesives and floor coverings. The emissions are expressed as toluene equivalents.

Throughout the research, which has been going on for about 10 years with this methodology, comparison has always been made between substrates of concrete with and without a levelling compound. The levelling compounds used have much lower alkalinity than concrete, since they are based on calcium aluminate cement rather than ordinary Portland cement. In total, some 230 measurements have been made over the years. The following parameters have been varied:

- concrete composition,
- water curing,
- drying time,
- type of levelling compound,
- thickness of levelling layer,
- type of adhesive,
- type of flooring,
- time of exposure.

## RESULTS

Much of the results has been published in detail earlier (Alexanderson, 2001) and in different Swedish publications. The present paper attempts to summarize the most important findings.

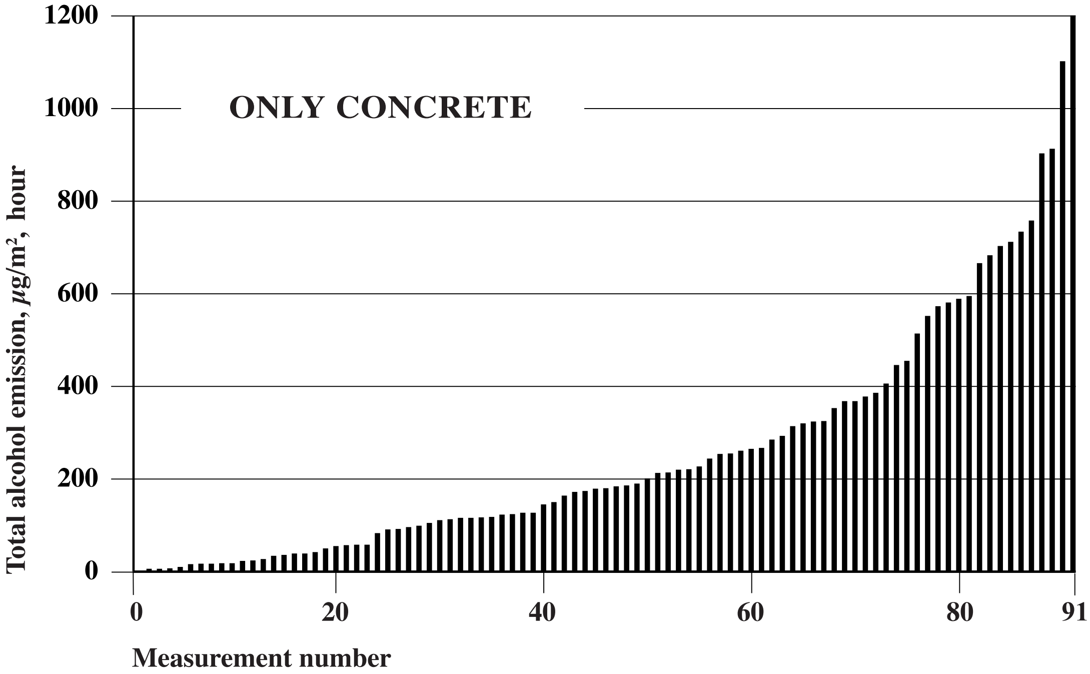


**Figure 2** Alcohol emissions from all samples with only concrete as substrate. The results are assorted with respect to increasing emissions.

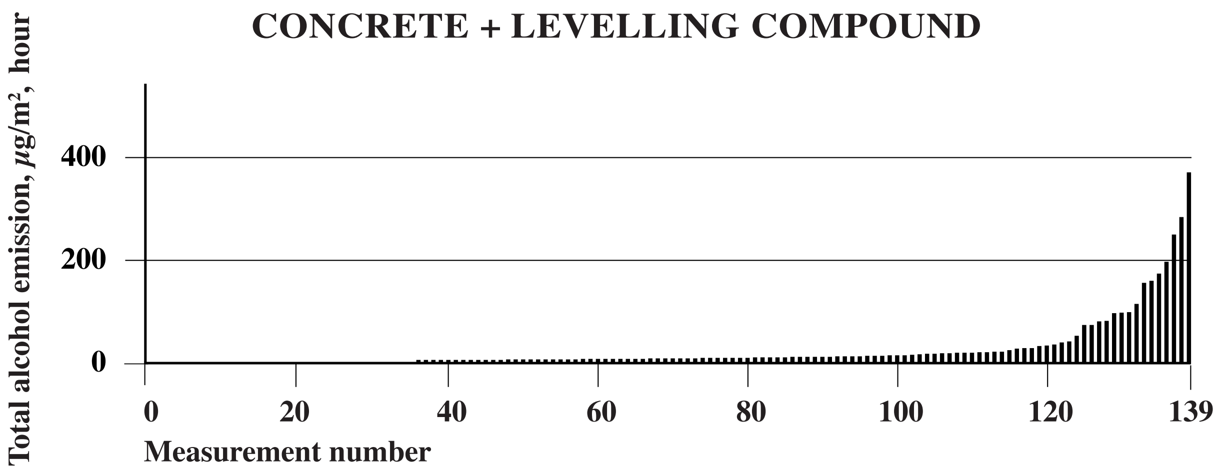


**Figure 3** Alcohol emissions from all samples with concrete and a levelling compound as substrate. The results are assorted with respect to increasing emissions.

The diagram in Figure 2 shows the emissions of 1-butanol and 2-etylhexanol from all specimens where the floor covering has been applied directly to concrete; Figure 3 shows the same thing for all specimens which had a layer of levelling compound on top of the concrete. The difference is striking. From the 91 concrete samples, only six had a total alcohol emission of less than 10 $\mu g/m^2$ h. For the 139 samples with levelling compounds, 80 were below that level.

From these results, it is obvious that the use of a low alkalinity substrate, such as a calcium aluminate based levelling compound, can act as a barrier to alkali attack from concrete when adhering a floor covering with an adhesive. However, the high-end side of Figure 3 shows that there are cases when this barrier effect is not functioning quite well. It is therefore most interesting to analyse when this is the case. It was found that the moisture level in the concrete and the time of exposure are important factors.

The crucial moisture level is that which will prevail directly under the floor covering, when the moisture in the concrete has been redistributed to equilibrium. This redistribution takes place when the floor covering hinders the drying. It was found that it normally takes about 1 month for the samples used (100 mm thick) to reach this equilibrium. The moisture was then measured under the flooring and expressed as relative humidity, RH.

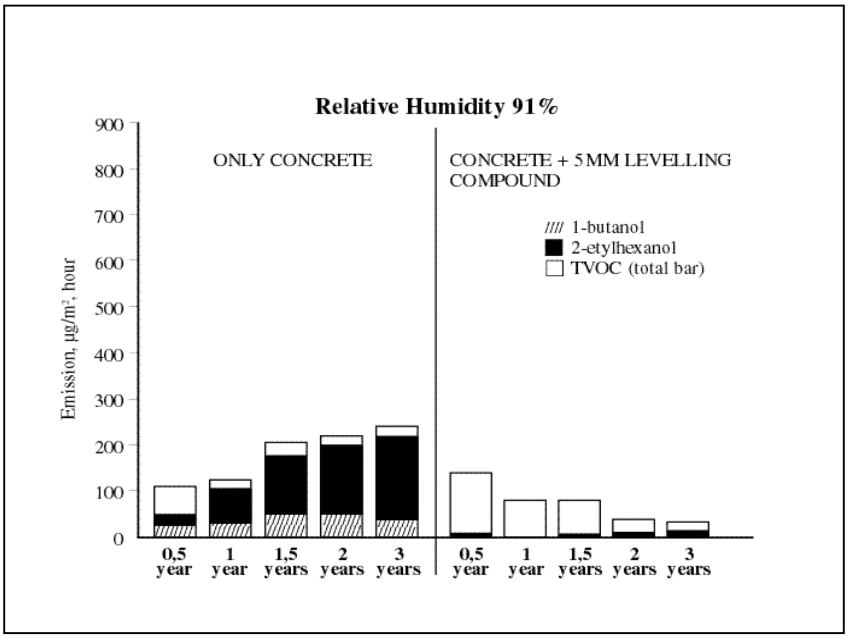


**Figure 4** Development of emissions over time from PVC flooring adhered to concrete with or without levelling compound. Moisture in substrate 91% RH.

Figures 4 and 5 show the great significance of the moisture level for the development of emissions over time. For a relative humidity of 91%, as in Figure 4, the concrete sample has a steady increase of emissions over time, while with the levelling compound, there are hardly any emissions of alcohols detected.

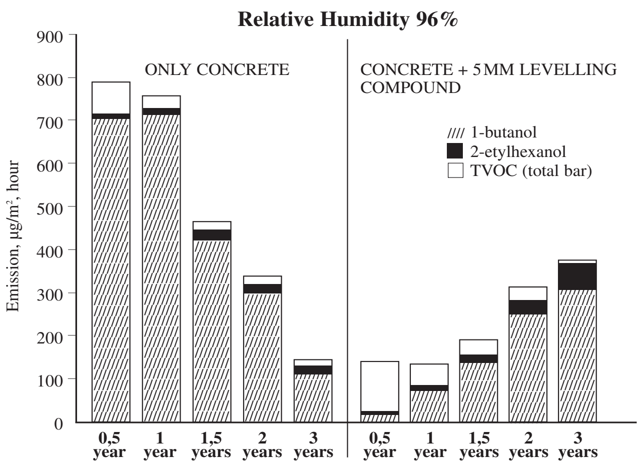


**Figure 5** Development of emissions over time from PVC flooring adhered to concrete with or without levelling compound. Moisture in substrate 96% RH.

Looking at Figure 5, with an RH of 96%, the picture is different. The concrete sample has very high emissions already at the first measurement, with some decline at later ages. But the important information from this figure is that the sample with the levelling compound shows relatively low emissions in the beginning, but they increase considerably with time.

The lack of barrier effect at high humidity is certainly caused by the fact that there is a critical humidity when water forms continuous water channels in the substrate materials. Then the alkali ions can be transported through the levelling compound and attack the adhesive.

Similarly, it was found that a too thin layer of the levelling compound (<5 mm) could be too little to act as a barrier to alkali attack in the long run. Going back to Figure 3, it was found that the majority of the results on the high-end side of the scale were associated with either long time exposure at high humidity or levelling layers less than 5 mm.

## CONCLUSIONS

Low alkali levelling compounds, based on calcium aluminate cement, can act as a barrier to alkali attack on adhesives and floorings from an aggressive substrate, such as concrete. A necessary condition, however, is that the levelling layer is thick enough (minimum 5 mm) and that the moisture in the substrate does not exceed 90% RH, in order to have some safety margin. This can be achieved either by sufficient external drying of the concrete or by use of a so-called self-drying concrete with a low water–cement ratio. The combination of a low alkali levelling layer and a self-drying concrete makes it possible to reduce drying times in the building process to a minimum.

## ACKNOWLEDGEMENT

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