VOC exposure in Belgian dwellings – evaluation with a temperature and humidity based emission model

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SUMMARY
In this research a VOC model for medium density fibreboard (MDF) incorporating the influence of temperature and humidity is derived from literature to replace the traditional method of using a constant emission model. Using this new VOC model in a CONTAM model, two ventilation systems for dwellings according to the Belgian standard and two demand controlled systems were simulated. Other factors included occupancy and type of heating system (with or without floor heating). The results show that using a constant emission model is not an adequate method to evaluate occupant VOC exposure. The constant flow ventilation system will always perform better than the demand controlled variant, this difference in performance is small compared to large differences seen in the absence or presence of floor heating.

KEYWORDS
DCV ; emission models ; VOC ; temperature ; humidity

1 INTRODUCTION
In the performance assessment of demand controlled systems, often, only the CO^2 level and humidity are evaluated as they are indicators of comfort. However, it is well known that building materials, furniture and many other products emit VOCs depending on temperature, humidity and age. These emissions can result in long exposure to concentrations exceeding health guidelines.

In simulations, VOCs are typically taken into account by assuming constant emissions based on the emission rate after 3, 7 or 28 days in a small-chamber emission test. The objective of this research was to find and use a floor-emission model dependent on temperature and humidity. With this model, occupant exposure levels for two standard ventilation systems according to the Belgian ventilation standard and two demand controlled systems were compared. Demand controlled systems, which do not supply nominal airflow continuously, carry the risk of accumulating VOCs during periods of lowered ventilation rates. Different types of families are simulated to check if the occupancy profile has a significant impact. Scenarios with and without floor heating are also simulated. This investigation is part of the IEA EBD Annex 68.

2 METHODS
Recent research led to models for a temperature dependent diffusivity, D_m (Deng at al., 2009) and a humidity and temperature dependent starting concentration C_o (Liang et al., 2016). These correlations were introduced in the simplified emission equation from Xiong et al. (Xiong et al., 2013) resulting in simple temperature and humidity dependent emission model. The modelled contaminant is formaldehyde from 12 mm MDF, assumed to be used as flooring material. This model was implemented in simulation software, CONTAM. The CONTAM model is an adaptation off the model that has been used in previous research concerning the Belgian NBN D50-1 standard (Laverge and Janssens, 2013).

3 RESULTS & DISCUSSION

The results obtained by simulations show that the influence of temperature and humidity is significant and causes seasonal differences in VOC exposure. Using a constant emission model in the performance assessment will overestimate the exposures during the summer months and underestimate them during the winter months. Additionally, peak values for the more humid spaces of the house are severely underestimated in both value and occurrence.

Results also indicate that the use of floor heating drastically increases VOC exposure of the occupants. For both scenarios with and without floor heating, peak exposure will occur in rooms with extraction. The strong temperature dependence implies the potential importance of modelling emission decay as a function of previously emitted VOCs rather than a function of time. Comparison of the standard ventilation systems and the demand controlled systems revealed that the latter systems always performed worse. In both systems, some level of VOC accumulation occurs when the heating is on. However, lower flow rates in the demand controlled system will result in notably higher VOC levels. Relative to the difference in systems with or without floor heating, the influence of the choice of ventilation system is small (Figure1).

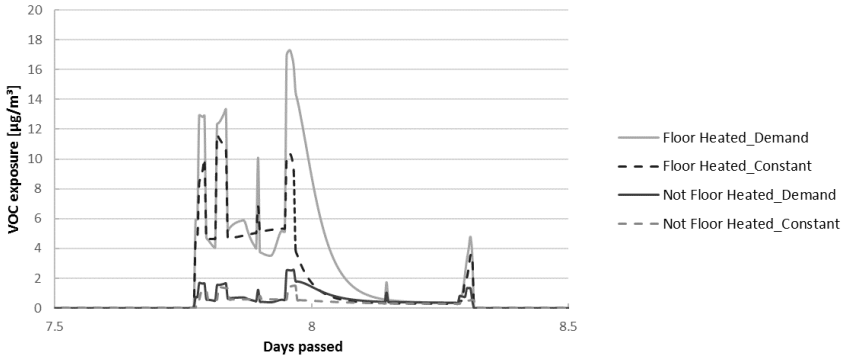

Figure 1. Detailed comparison of 4 cases.

5 CONCLUSIONS

This easy-to-use model combines the theoretical background of VOC modelling from a chamber emission test with the practical use in simulation software like CONTAM. Currently, the application of this model is limited to MDF as the needed characteristic values are only known for this material. Overall, these results highlight the importance of choosing low polluting floor materials in conjunction with demand controlled systems and humid spaces, especially with floor heating.

6 REFERENCES

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