Overpressure in airtight houses in case of a fire

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INTRODUCTION

Earlier performed studies towards fires in airtight dwellings call attention for the safety of residents and fire services in case of a fire. With experiments and simulations pressure peaks in an early stage of the fire were experienced, which makes it harder for residents to escape from the building [1,2]. The executed experiments and simulations focused on the building envelope and neglected balanced mechanical ventilation systems. The goal of the research was to gain insight in the influence of the balanced mechanical ventilation system on the overpressure in case of fire in airtight dwellings.

METHOD

In multiple dwellings Nieman Raadgevende Ingenieurs performed airtightness measurements with and without mechanical vents included. With the acquired data the equivalent surface area of the mechanical vents can be calculated. The surface area is required to perform simulations in a multi-zone model, CFAST. However, CFAST assumes turbulent air flows through openings with a default flow exponent of 0.5, while according to the measurements laminar flows with higher flow exponents occur. This limitation will result in an underestimation of the air flows which leads to an overestimation of the pressure differences.

A correction model has been developed to change the surface area of the openings for different pressure intervals, in order to simulate the airflow through openings more accurately. After running the correction model two times the airflow simulated in CFAST corresponds with the measurement results.

RESULTS

The simulations that consider ventilation openings show little differences with the simulations that neglected ventilation openings (Figure 1). Due to the ventilation openings the pressure peak is reduced, but in an early stage of the fire development the pressure increase is similar.

In order to assess the results, a threshold of 30 Pascal was established, which is seen as the maximum pressure difference whereby residents can open the front door by pulling. For all three fire growth rates consideration of the mechanical ventilation openings cannot prevent exceedance of the threshold within roughly two minutes (Figure 1). For single-family dwellings with people who can leave without assistance the required total evacuation time is 3 minutes [3].

The model contained multiple compartments and since some connections between compartments were relatively small it was expected that there would be pressure differences between compartments. Compartment 2 and 3 were connected by a 2 cm high slit under a closed door and compartment 2 had an 'open' connection with compartment 1 and 4. When a fire was started in compartment 3 the pressure increase in this compartment was larger than in the other compartments. However, this difference in pressure increase does not prevent exceedance of the threshold for save evacuation in compartment 1, where the front door is located.

CONCLUSION

Despite the fire growth rate and location of the fire, the pressure increase in airtight dwellings is too high in the first three minutes to assure safe evacuation of building occupants. The mechanical ventilation system has only an influence on the pressure peak, which can be reduced with a few hundreds of Pascal, depending on the fire scenario. The extension of available evacuation time is only a few seconds.

Modern airtight buildings maintain a potential danger for building occupants due to high pressures which make it more difficult to escape. Smoke gas explosion and backdraft are still potential risks for fire services. ■

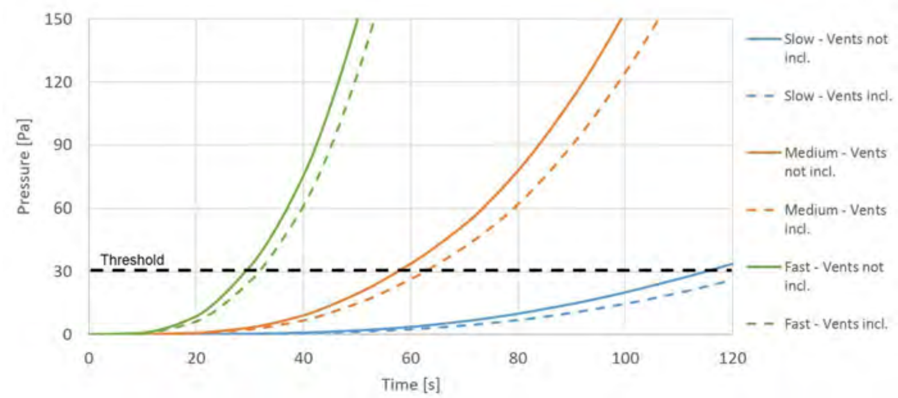

Figure 1. Pressure increase after ignition for different fire growth rates, mechanical vents included and excluded

[1] van den Brink, V. (2015). Fire safety and suppression in modern residential buildings. TU Eindhoven – master thesis
[2] Fourneau et al. (2012). Comparison of fire hazards in passive and conventional houses. Chemical engineering transactions 26: 375-380
[3] Hagen, R., & Witloks, L. (2014). The basis for fire safety. Arnhem: Instituut Fysieke Veiligheid.