A correlation derived from multiple CFD simulations

OBJECTIVE
A correlation for predicting gas temperatures in a room adjacent to a room involved in a pre-flashover fire is discussed in this poster. A correlation has been derived from computer simulation results and validated with data from fire experiments.

BACKGROUND
Advanced computer modelling software, that can predict smoke spread and compartment temperatures, has been developed during the last decades. With zone models and computational fluid dynamics (CFD), it is possible to e.g. calculate smoke layer heights, species and temperatures in a multi-room geometry. The programs are generally good tools for fire engineering purposes, but they do not remove the need for simpler engineering correlations. Simple correlations can be used for hand-calculations to get a first estimate of e.g. smoke layer geometries, in performance based design of a building and help the fire engineer to determine if it is necessary to perform a detailed CFD calculation. Simple correlations can also be a useful tool to use in sensitivity analysis or in fire risk analysis.

The method presented in this poster has been performed in three steps. In the first step numerous CFD simulations with the computer software FDS 5.6 have been conducted. Input files to FDS, with randomly sized two-room configurations, were created with a Matlab script. Approximately 140 FDS files for simulations with different geometries, openings, wall materials, fuels and heat release rates were created with a Matlab script. In the second step a statistical analysis has been conducted with the statistical software package SPSS (Statistical Package for the Social Sciences) [7]. The smoke layer temperature in the adjacent room was retrieved from the FDS simulations and was used as dependent variable in the statistical analysis. The heat release rate, area of boundary surfaces of both enclosures, ventilation factors for both openings and heat transfer coefficient were used as independent variables. A multiple linear regression analysis of the logarithmic values of the variables were conducted in SPSS.

In the third step the correlation was tested and validated against results from full-scale experiments both found in literature and conducted within the project.

SUMMARY OF RESULTS
All included variables were statistically significant and the correlation had a correlation coefficient, R2 values of approximately 0.9 with respect to the data from the simulations (figure 2). The most important variable was the heat release rate. A validity check was performed by studying data from real fire tests. Three sets of experimental data were studied and the results of the validity check can be found in figure 3. It is considered to be a good agreement between the calculated and measured temperatures since the maximum difference is less than 20%.

A reliability check was performed by looking at the grid sensitivity of six of the presented cases. The mesh size was determined by following the recommendations of [8].

REFERENCES
9. Rutherfoord, L., Experimental Results for Pre-Flashover Fire Experiments in Two Adjacent ISO Compartments, Department of Civil Engineering, University of Cambridge, Christchurch, New Zealand.
11. Johansson, N. and van Hees, P., “Smoke Layer Temperature in an Adjacent Room –” and is financed by The Swedish Fire Research Board (Brandforsk) and BBFS (The Swedish NPPs Fire Safety Group). The purpose of the project is to find underlying factors to why some fires grow large.

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Figure 2: A trend is obvious when comparing the results from the CFD calculations with temperatures calculated with the correlation.

Figure 3: In the graph the results from real fire experiments are compared to temperatures calculated with the found correlation.

Figure 4: Illustration of the grid sensitivity. The quota is smoke layer temperature in the coarse grid divided by the smoke layer temperature in the fine grid.

Figure 1: A fire occurs in a room and smoke spreads to a adjacent compartment. There is an opening between the fire room and the adjacent room and between the adjacent room and the outside.