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CFD boundary conditions for contaminant dispersion, heat transfer and airflow simulations around human occupants in indoor environments

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Abstract

Indoor computational fluid dynamics (CFD) simulations can predict contaminant dispersion around human occupants and provide valuable information in resolving indoor air quality or homeland security problems. The accuracy of CFD simulations strongly depends on the appropriate setting of boundary conditions and numerical simulation parameters. The present study explores influence of the following three key boundary condition settings on the simulation accuracy: (1) contaminant source area size, (2) convective/radiative heat fluxes, and (3) shape/size of human simulators. For each of the boundary conditions, numerical simulations were validated with experimental data obtained in two different environmental chambers. In CFD simulations, a small release area of a contaminant point source causes locally high concentration gradients that require a very fine local grid system. This fine grid system can slow down the simulations substantially. The convergence speed of calculation is greatly increased by the source area enlargement. This method will not influence the simulation accuracy of passive point source within well-predicted airflow field. However, for active point source located within complicated airflow filed, such an enlargement should be carried out cautiously because simulation inaccuracy might be introduced. For setting thermal boundary conditions, convection to radiation heat flux ratio is critical for accurate CFD computations of temperature profiles around human simulators. The recommended convection to radiation (C:R) ratio is 30:70 for human simulators. Finally, simplified human simulators can provide accurate temperature profiles within the whole domain of interest. However, velocity and contaminant concentration simulations require further work in establishing the influence of simplifications on the simulation accuracy in the vicinity of the human simulator.

Keywords: CFD; Boundary conditions; High-concentration gradients; Human simulators; Point source areas; Indoor environment

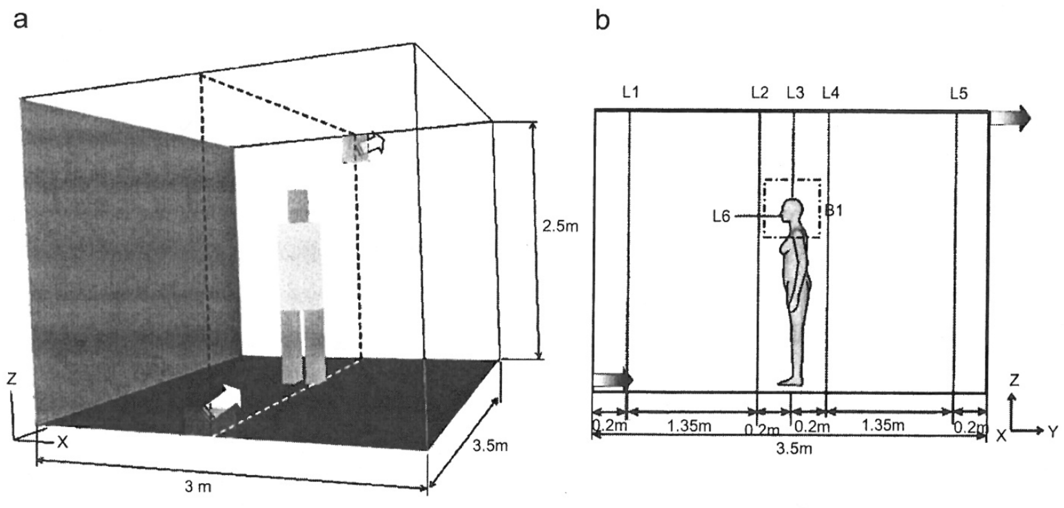

Fig. 5. The second chamber experiments (a) experimental domain size, and (b) measuring vertical pole positions (L1–L5).