The Influence of Room Air Distribution on Personalized Ventilation

from Textile Surfaces

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Personalized Ventilation

It is usual to supply an amount of air which is 1-5 times the volume of the room per hour, but a person only needs about 0.6 m^3 per hour. Theoretically it should be possible to supply a much smaller amount when the air is supplied direct to the breathing zone.

PV gives the possibility of having individual control of the thermal comfort. Also it makes it possible to have both cold air in the breathing zone and warm surroundings.

A PV system can create cold, warm or clean surroundings locally in large places.

By supplying the air direct to the breathing zone it is ensured that the air has not been contaminated by other persons. This minimizes e.g. cross infection and passive smoking.

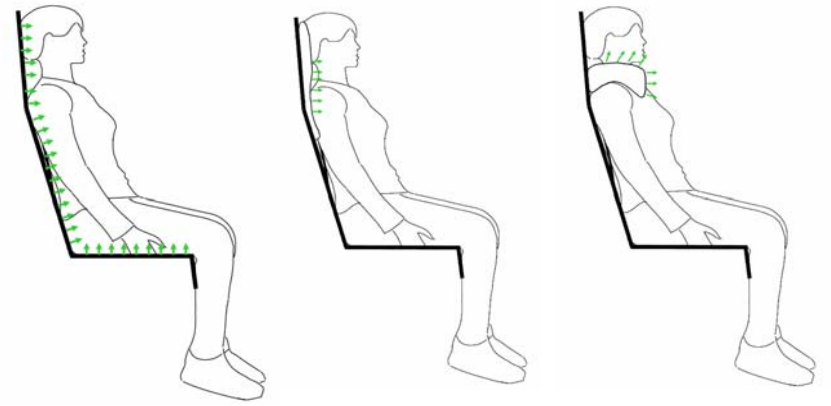
Airborne Diseases

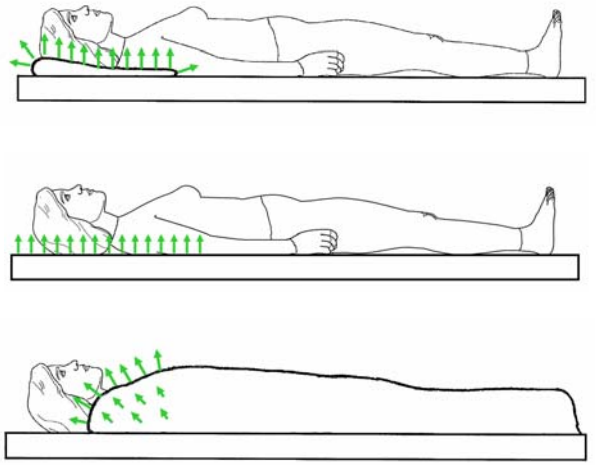
Low Velocity PV System

The personalized ventilation system (LVPV)) utilizes the situations where the head or the body is in natural contact with surfaces as:

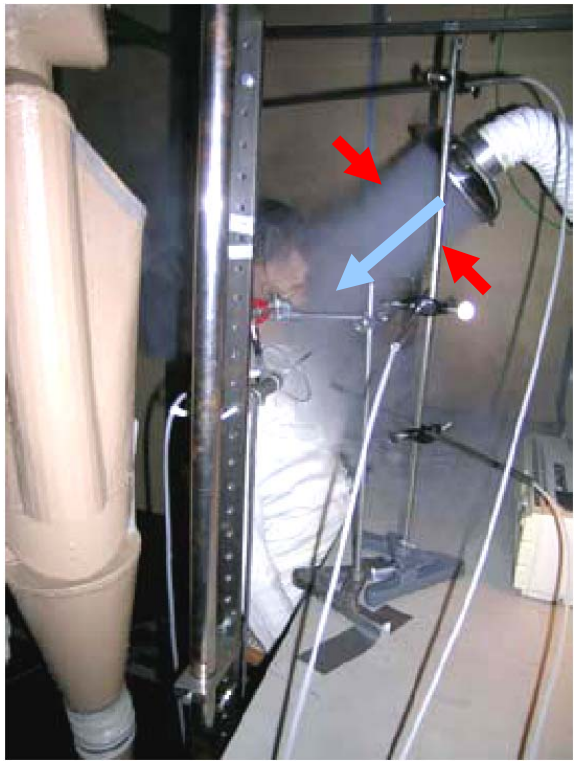
chairs, beds, pillows, clothing, headrests, blankets, mattresses, walls, etc.

The surfaces are also designed to be supply openings of fresh air, for example by the use of fabric as a diffuser.

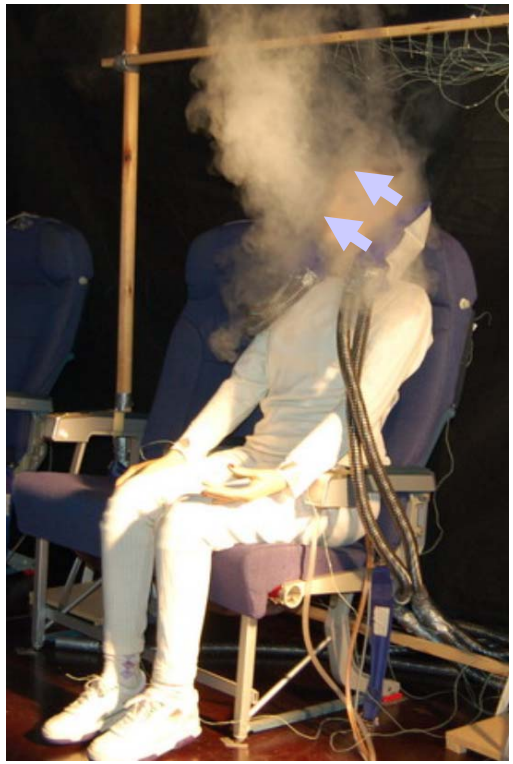




Does the General Air Distribution Influence the PV System?



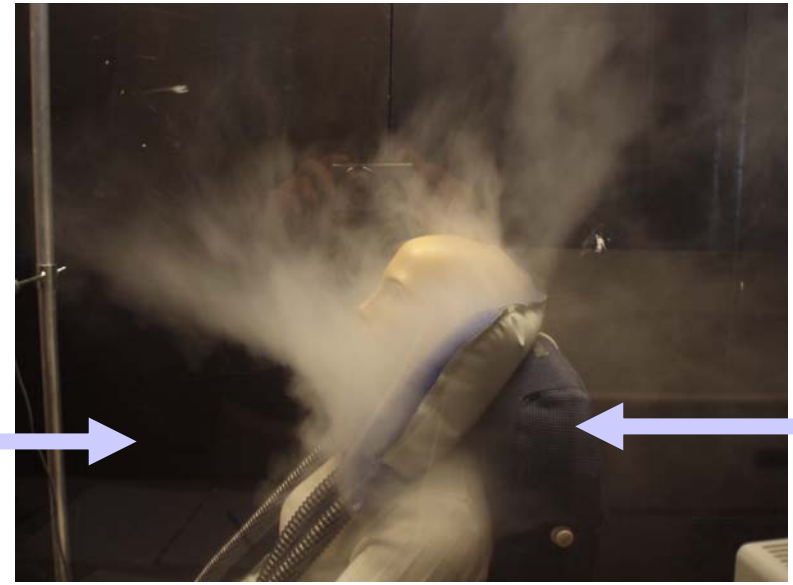
High momentum flow with entrainment



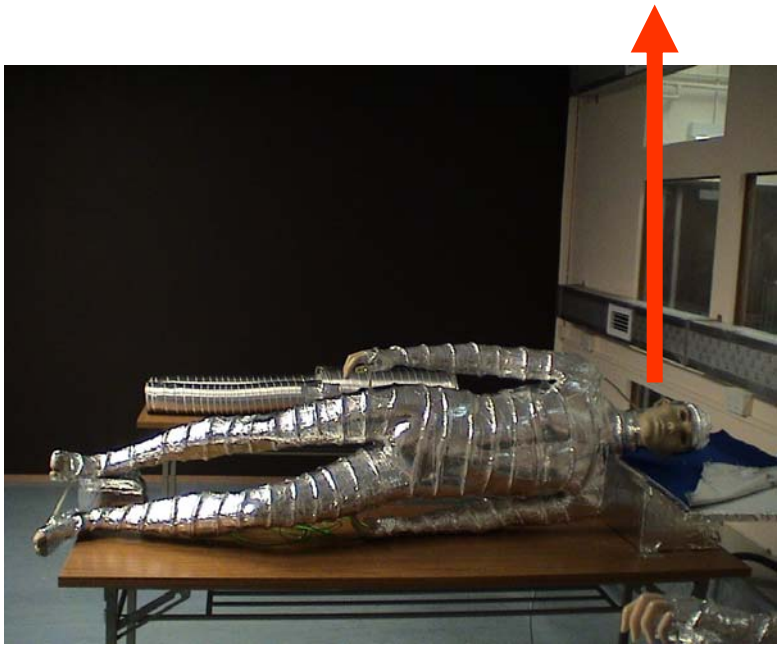
Low velocity supply to the boundary layer

The Influence of Room Air Distribution

Aircraft seat and headrest
Draught, and its influence
on the effectiveness

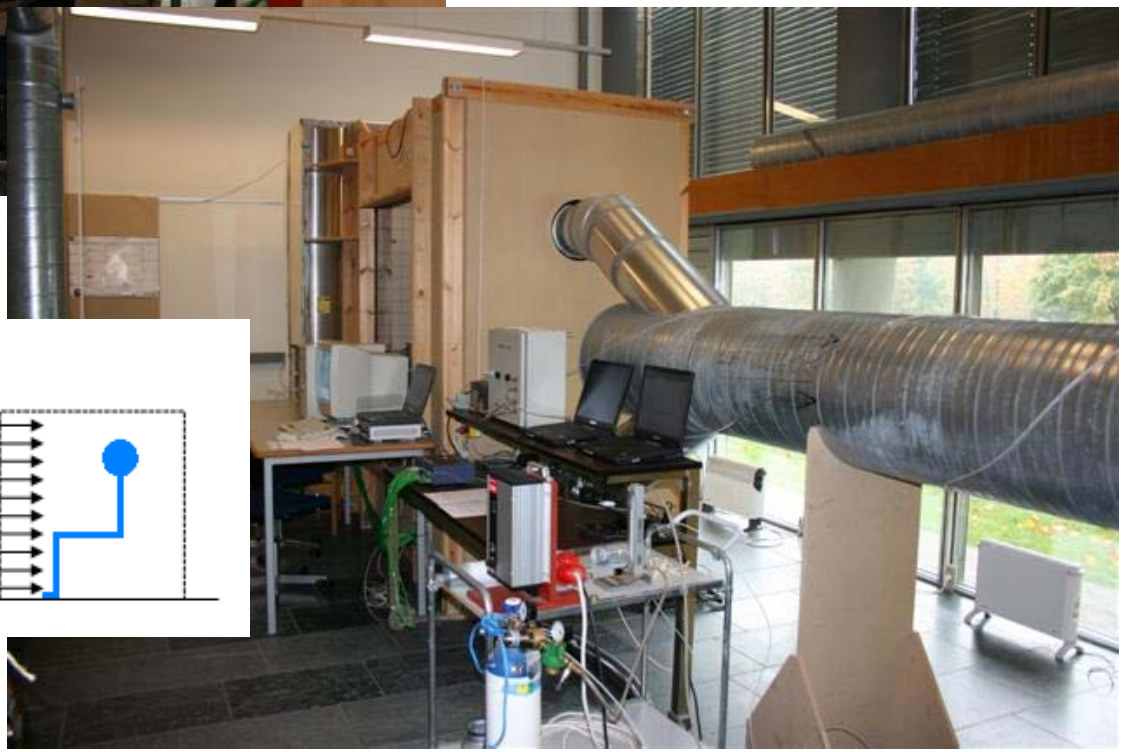


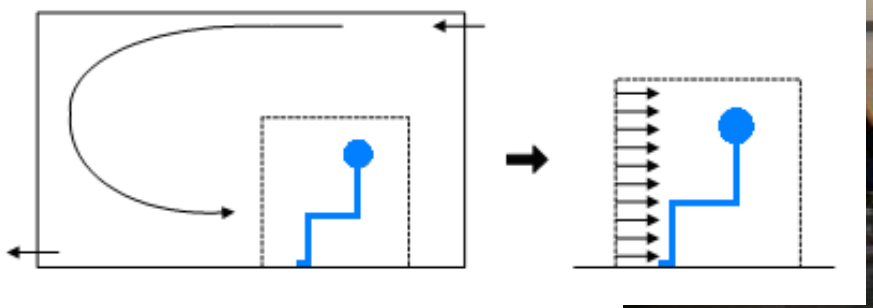
Chair with diffuse surface



Hospital ward
Protecting people
from a source patient

Wind Tunnel





Peter V. Nielsen, Aalborg University

Effectiveness

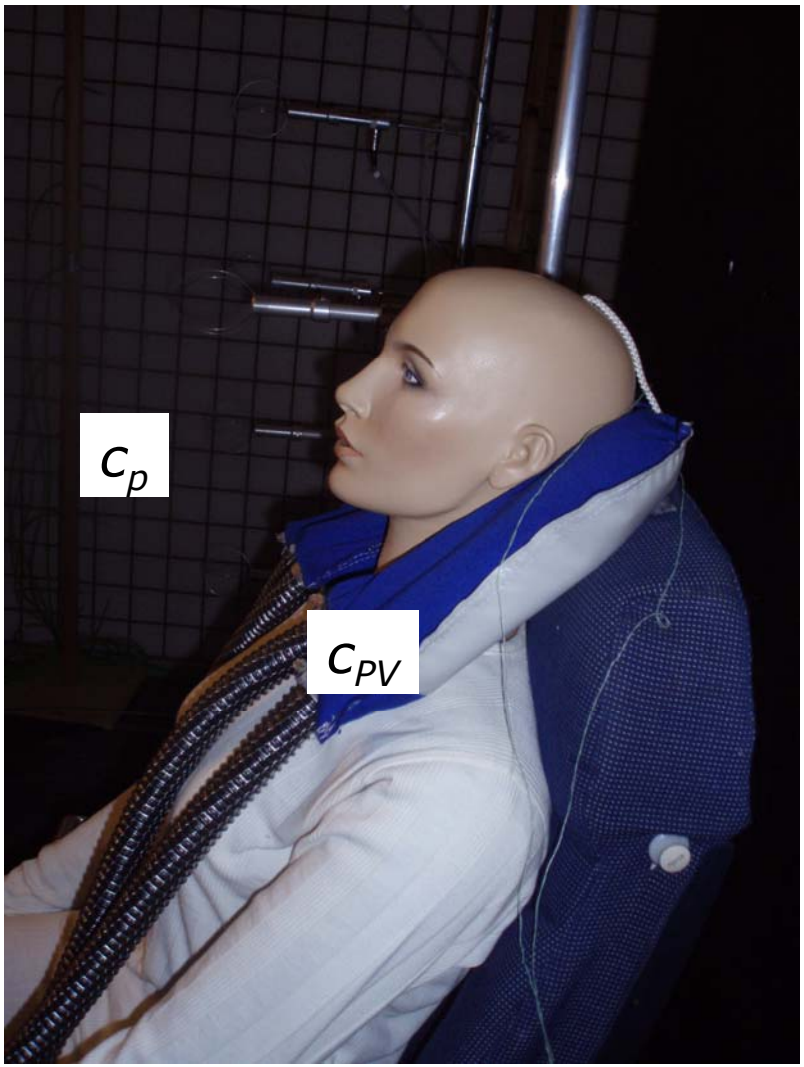
The effectiveness of personalized ventilation

If the concentration in the inhalation is c_{PV}

$\varepsilon_{PV} = 1.0$

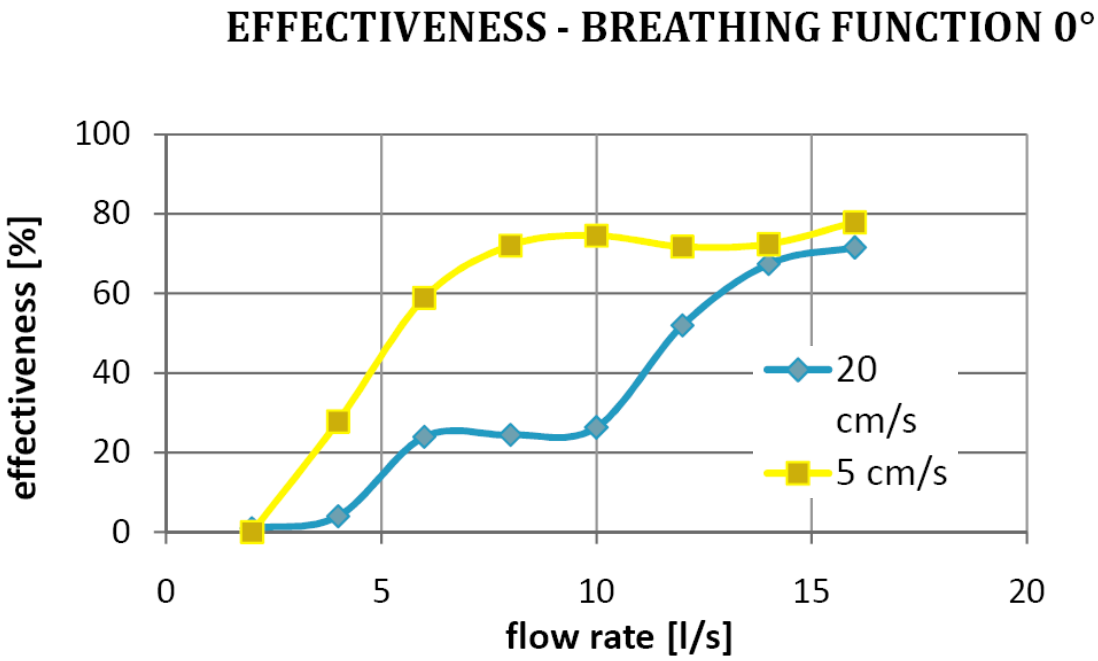
If the concentration in the inhalation is c_p

$\varepsilon_{PV} = 0.0$



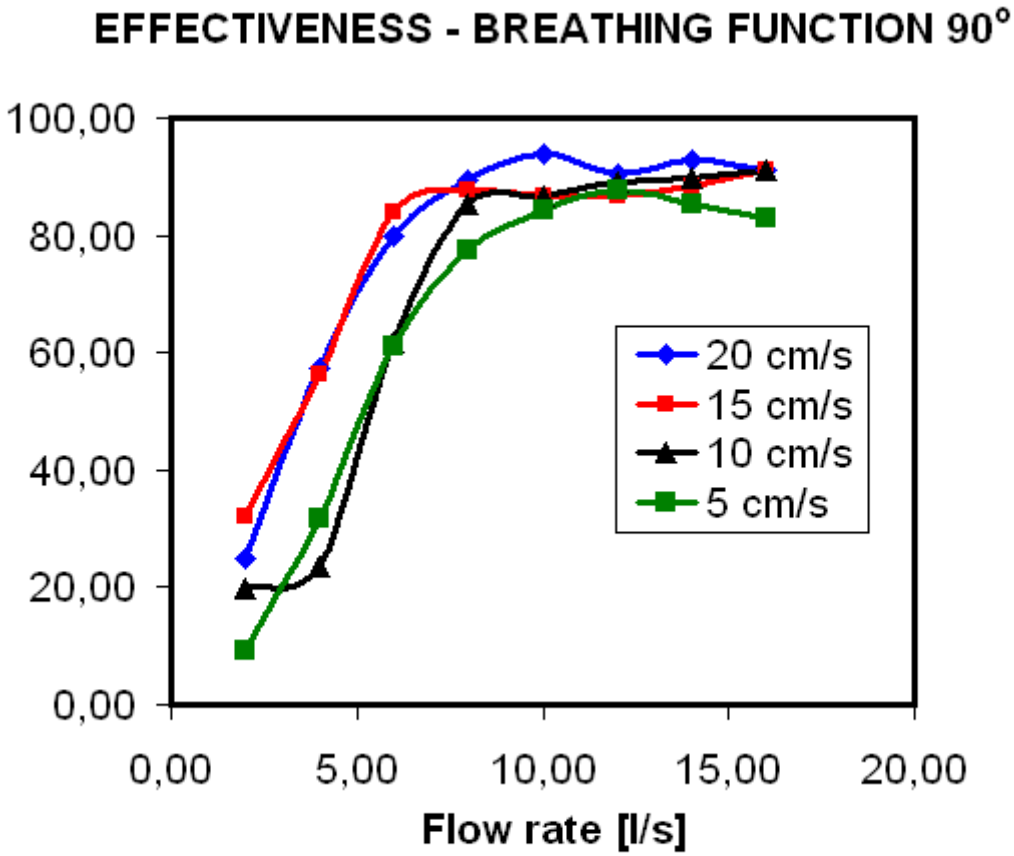
Frontal Draught

q_{PV} = 10 l/s
u = 10 cm/s



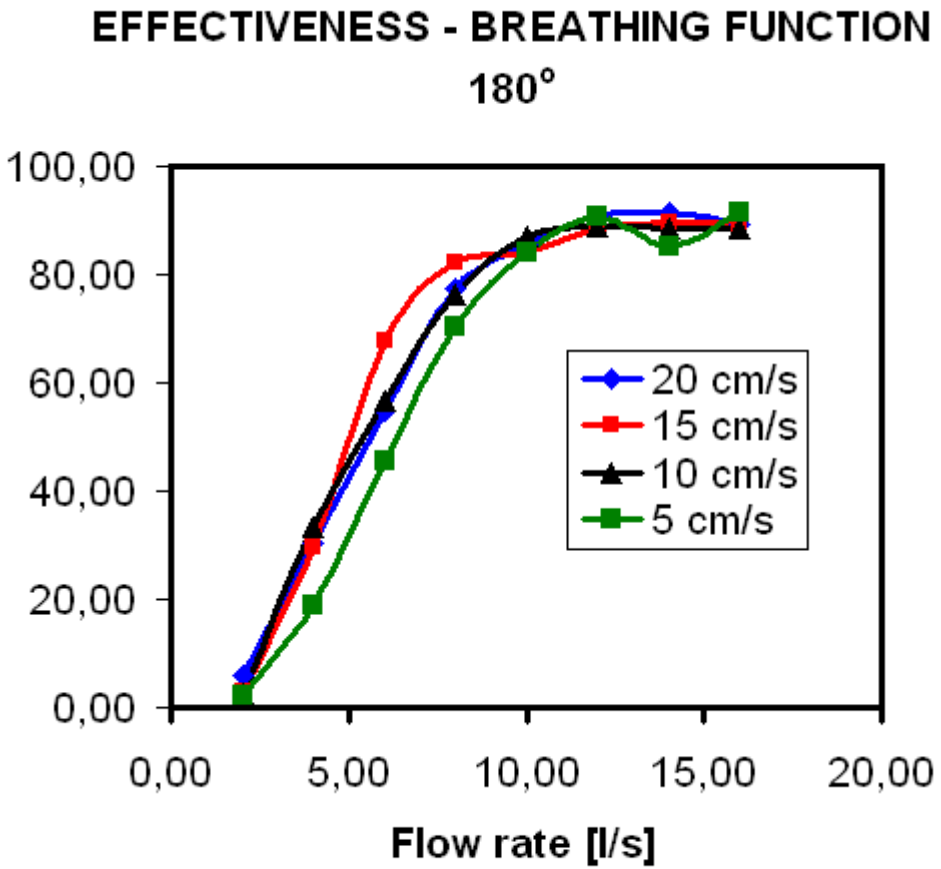
Draught from the Right-Hand Side

q_{PV} = 10 l/s
u = 10 cm/s



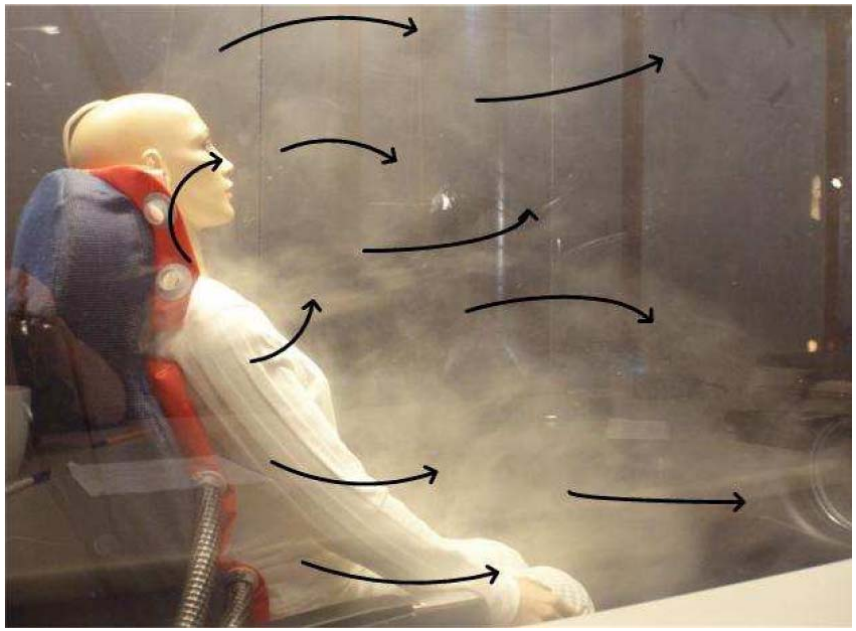
Draught from Behind

q_{PV} = 10 l/s
u = 10 cm/s

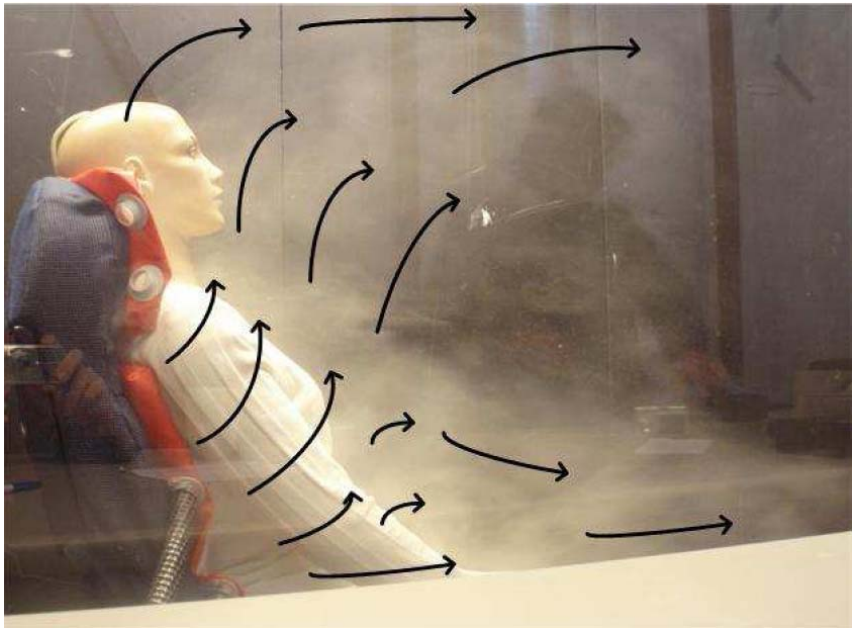


Chair with Diffuse Surface

Results with flow from behind, q_{PV} = 8 l/s



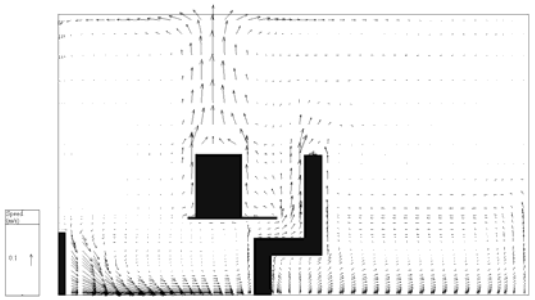
u = 0.05 m/s



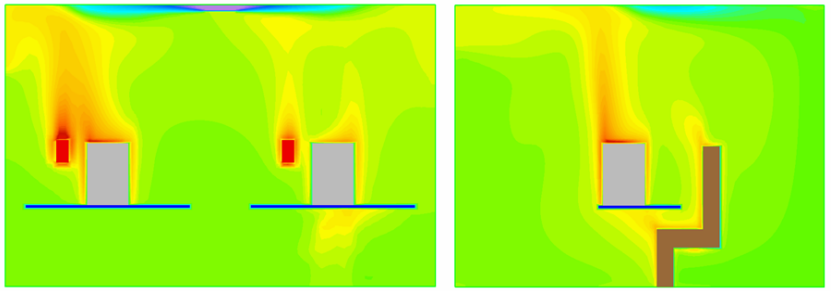
u = 0.20 m/s

A General Experience

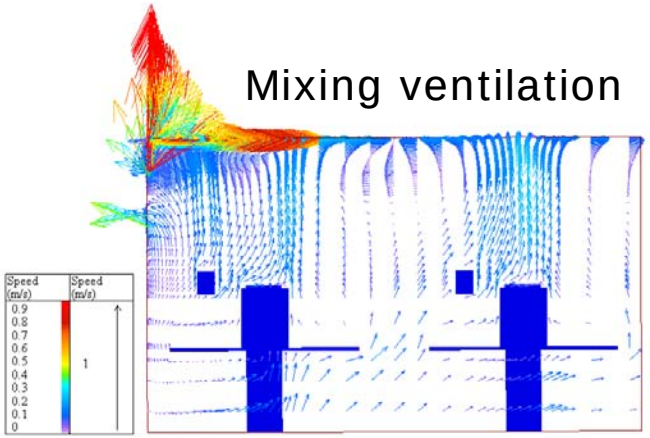
The PV air flow follows the person's thermal boundary layer, and this boundary layer and plume are very stable in most air distribution systems



Displacement vent.

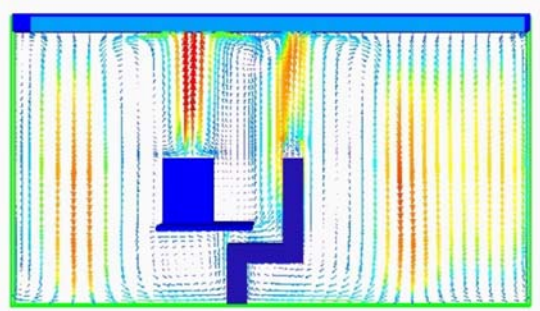


Ceiling-mounted diffuser



Mixing ventilation

Vertical downward vent



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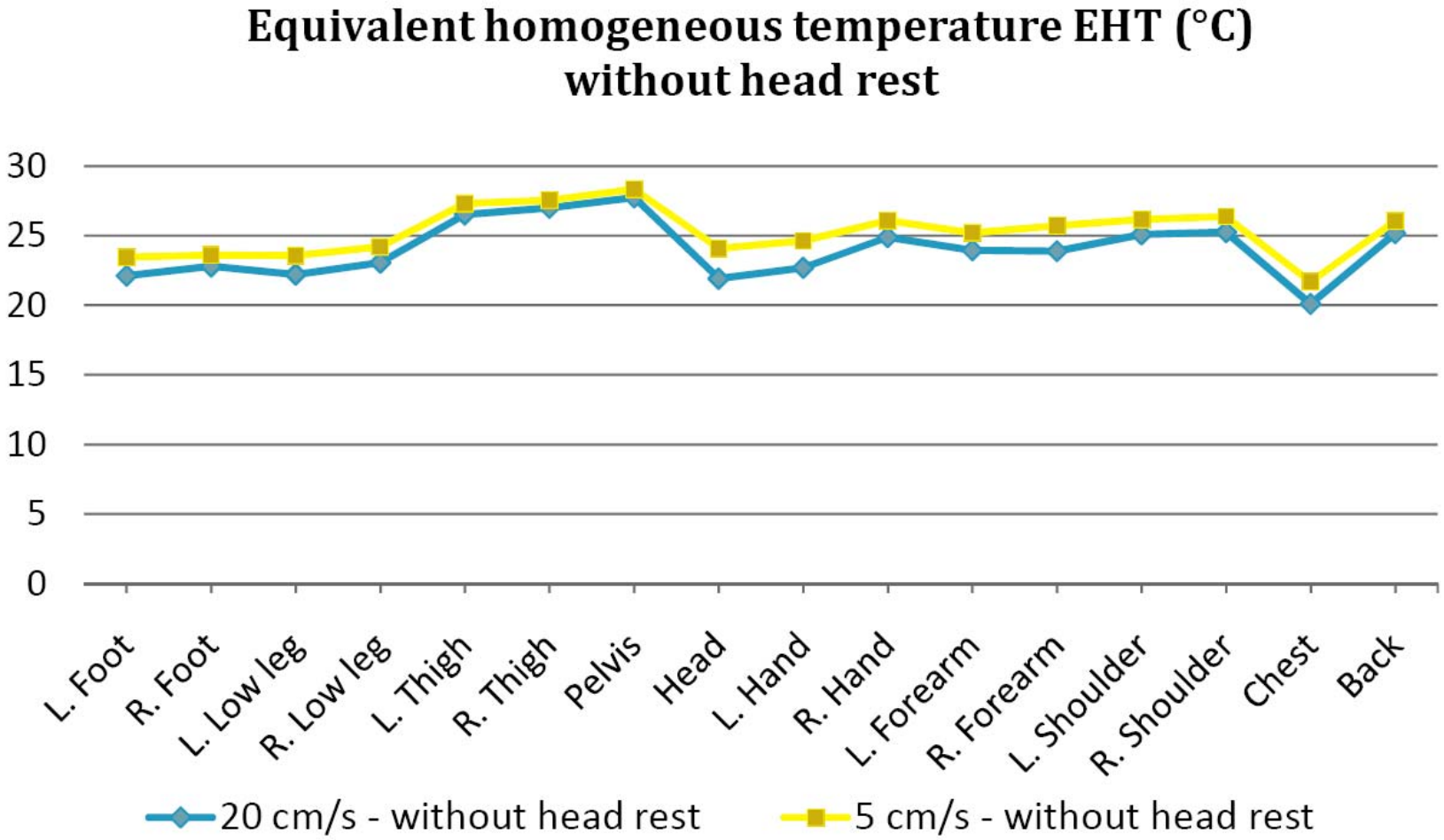
Equivalent Homogeneous Temperature

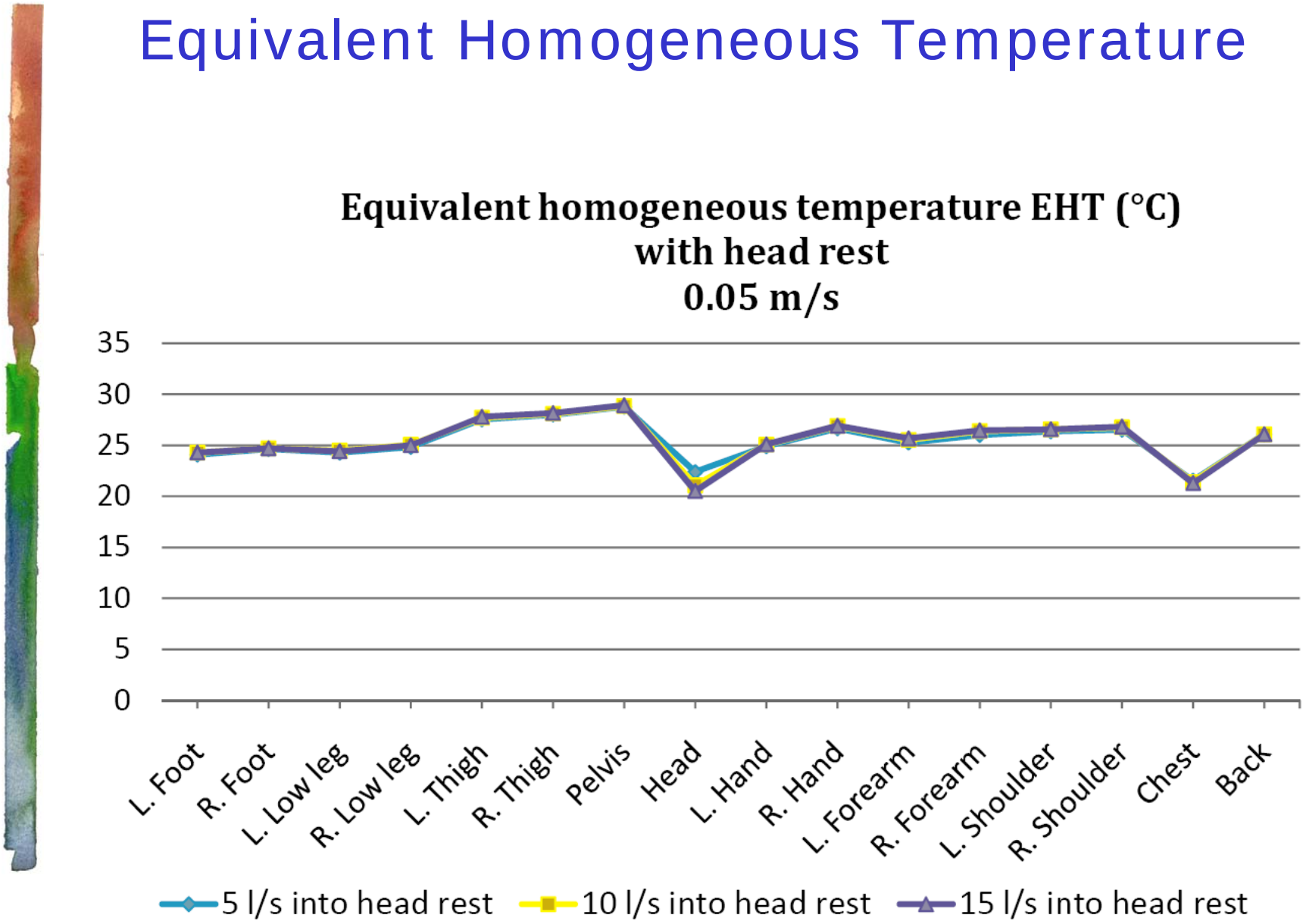
The equivalent homogeneous temperature *EHT* is the temperature of a homogeneous environment in which the same amount of heat is lost as in the actual environment.

Homogeneous conditions are achieved when the air temperature is equal to the mean radiant temperature, when air temperature gradients and radiant temperature asymmetry in all directions are negligible and when the air velocity is lower than 0.05 m/s.

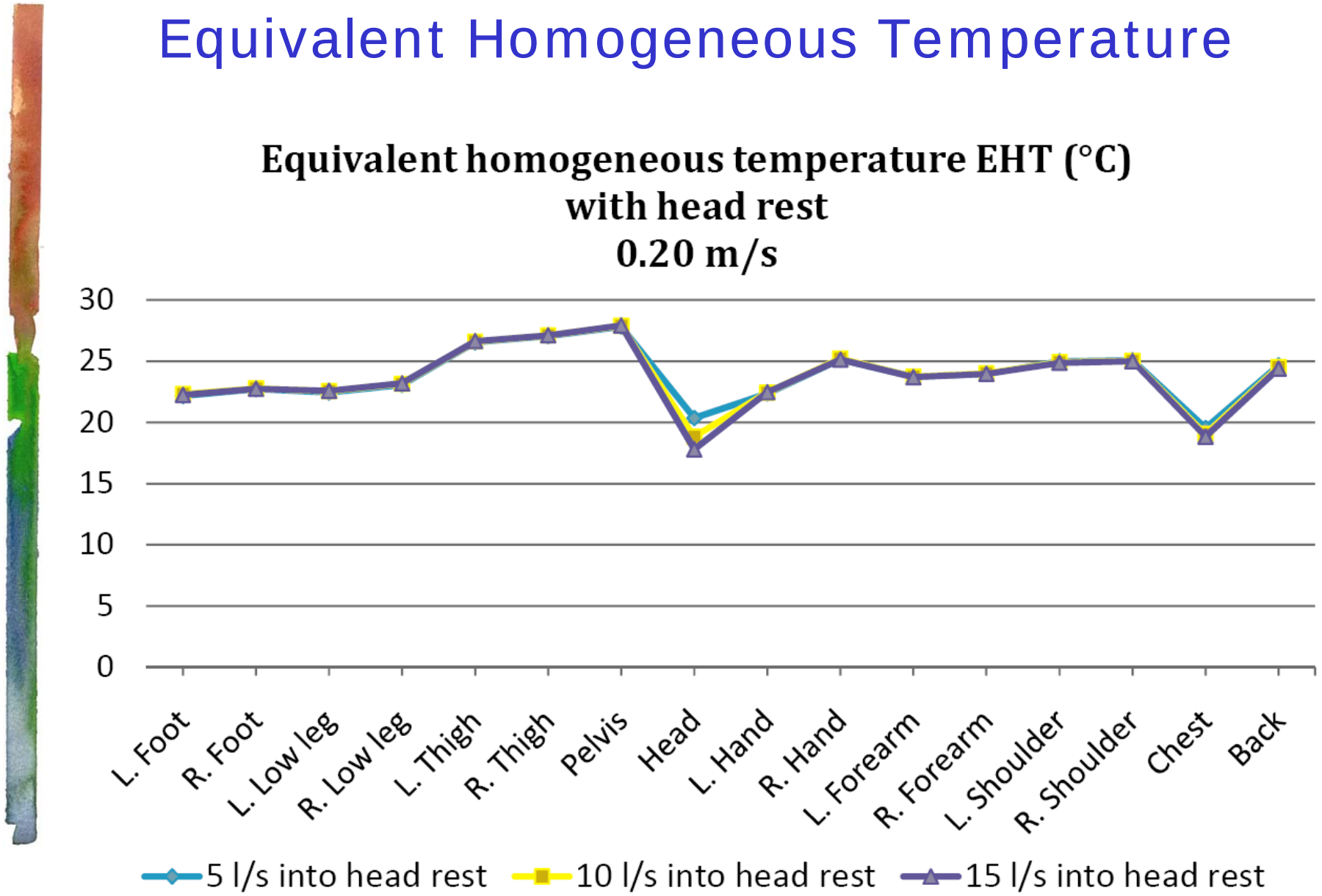
Equivalent Homogeneous Temperature



Equivalent Homogeneous Temperature



Equivalent Homogeneous Temperature

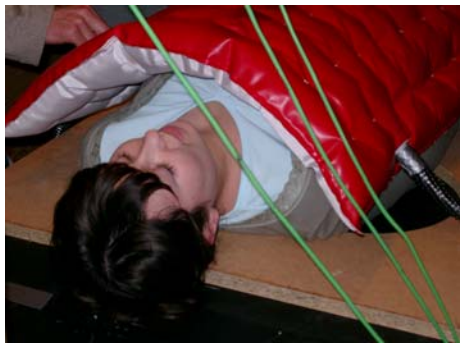


Thermal Comfort

9 persons have tested the different aerodynamics systems for draught, noise, air quality and temperature.

The tests were only exploratory, because the systems were not optimized for the above-mentioned variables (no damping of noise, no temperature or moisture control and no stuffing in pillows and blankets).






Minimizing of Cross Infection in a Hospital

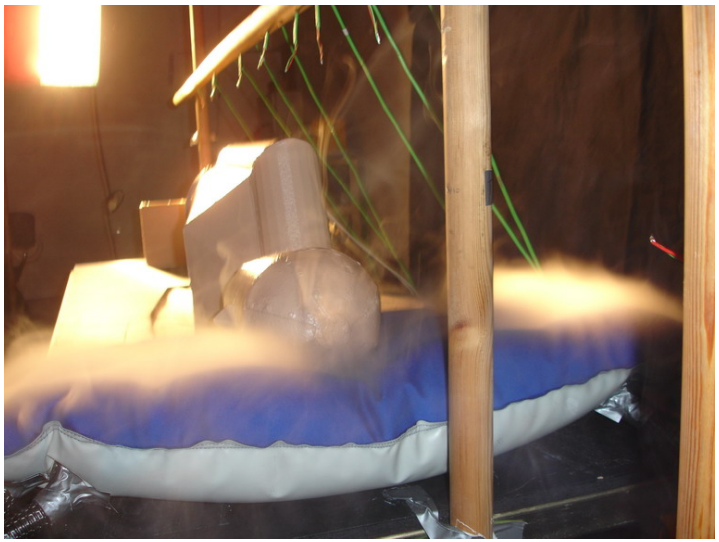
Personalized ventilation can protect people from airborne epidemics
The combination of a PV system and a general ventilation system can also be used for source reduction

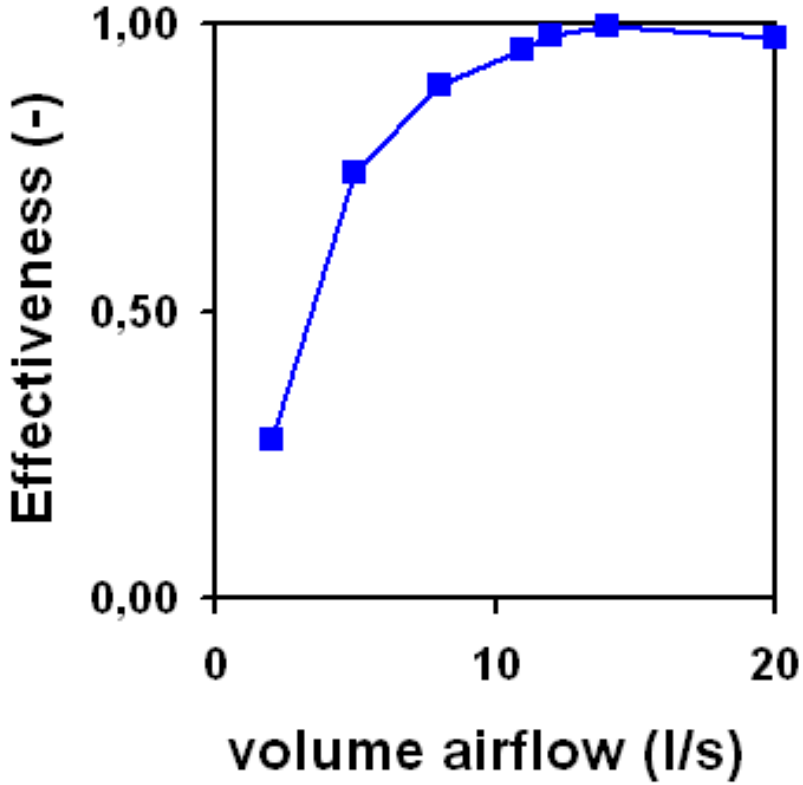
PV combined with:

Displacement ventilation

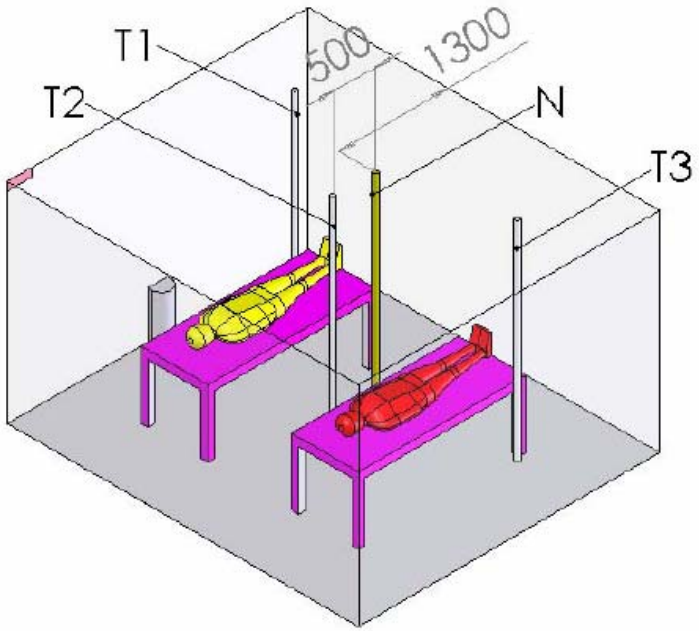
Vertical ventilation

The PV Diffuser for a Patient in a Bed



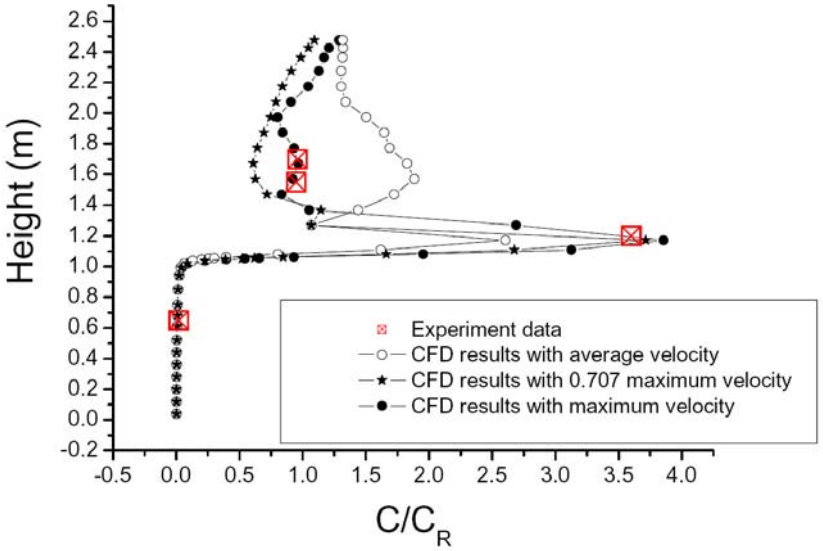


Test Room for Study of Cross Infection



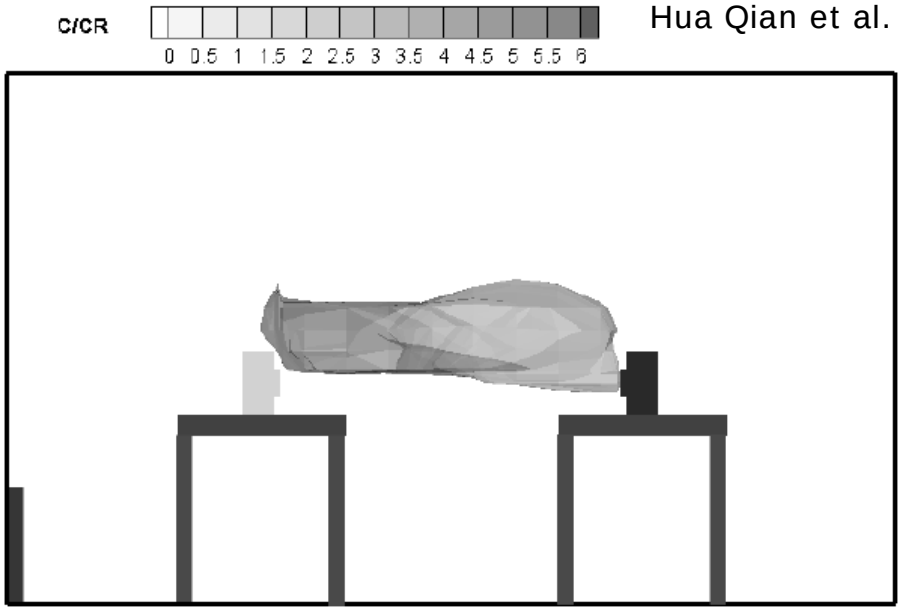
Hua Qian et al.

Displacement Ventilation, Stratification of Exhalation



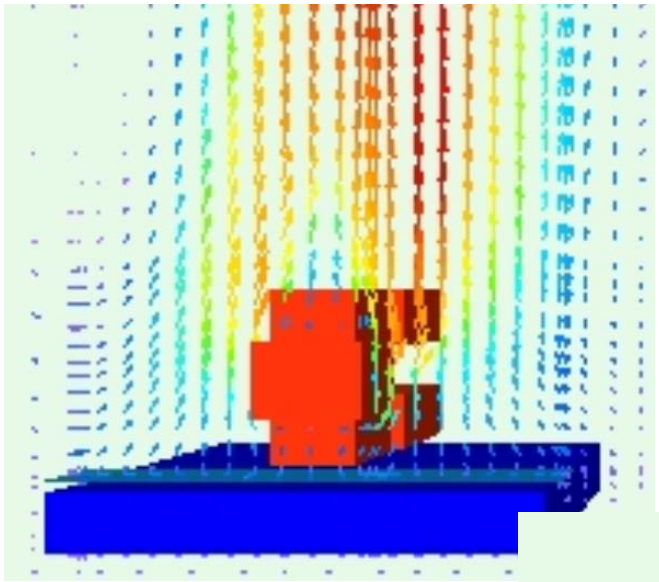
Vertical concentration gradient, measurements and predictions

CFD predictions



Hua Qian et al.

Source Patient and a LVPV Pillow

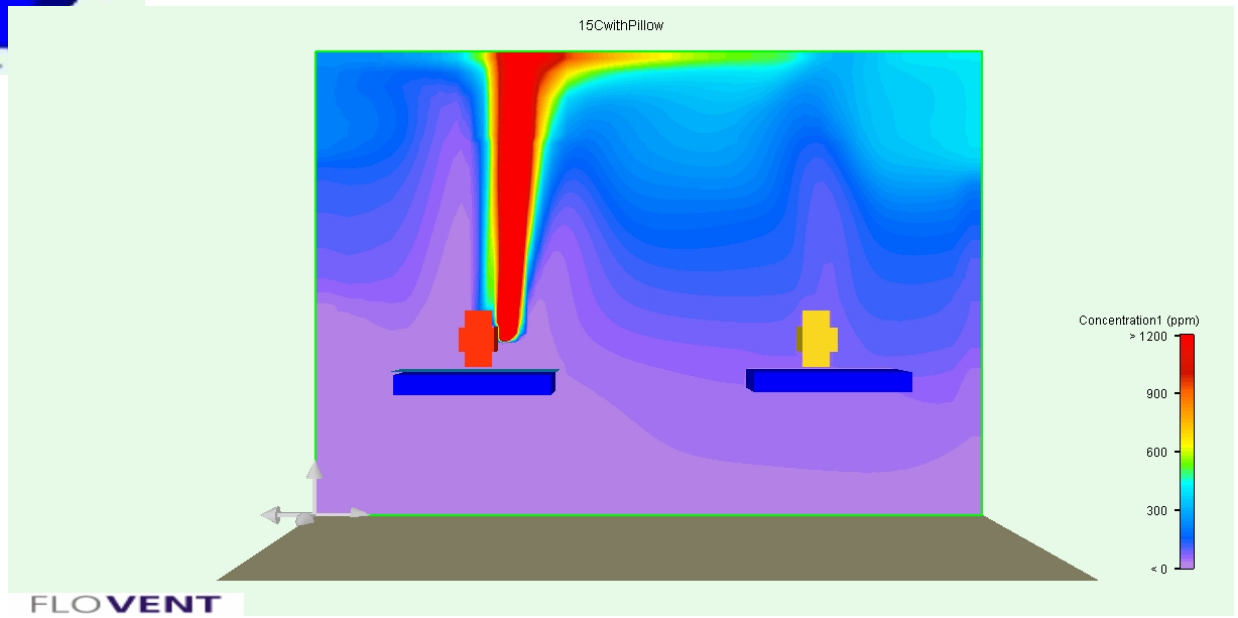


Velocity distribution

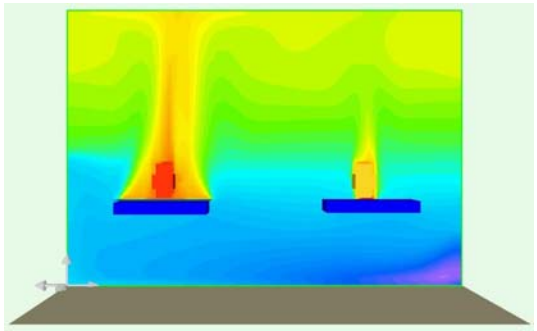
T_o = 15 °C
T_{PV} = 22 °C

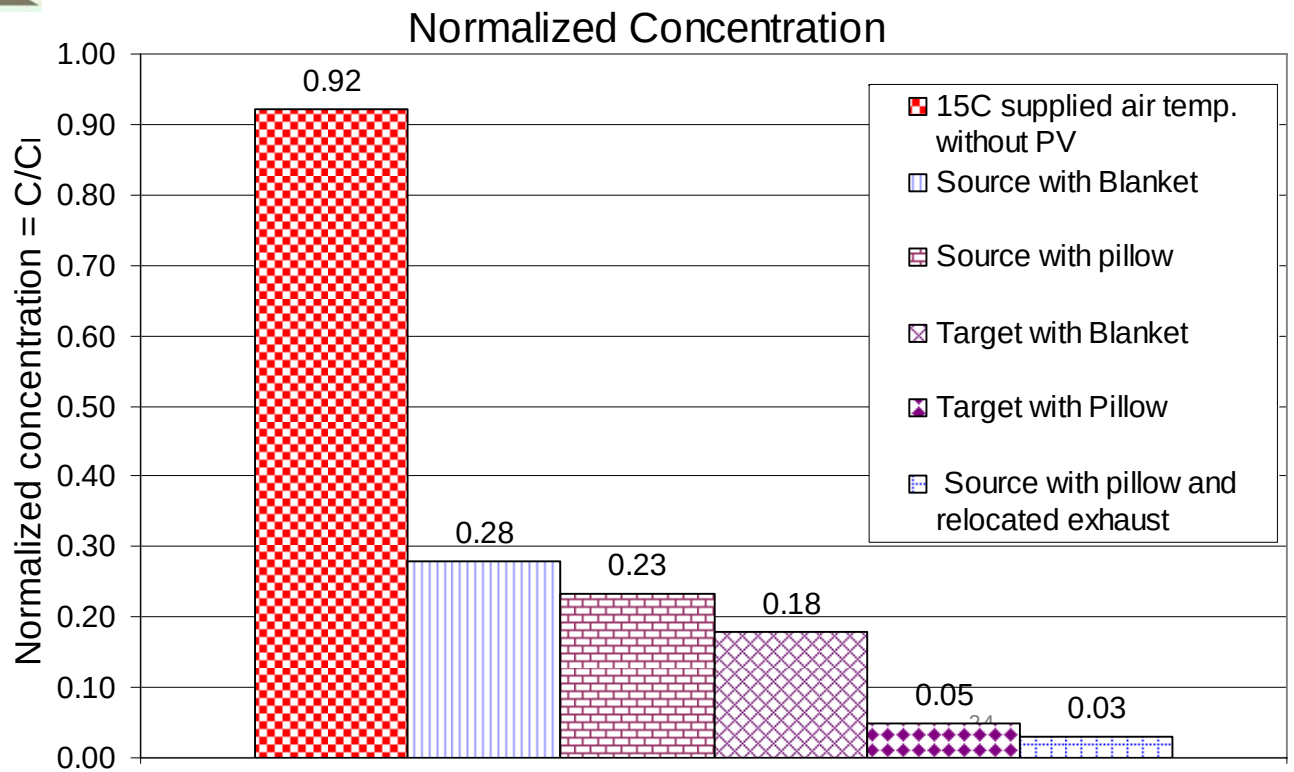
q_o = 0.05 m³/s
q_{PV} = 0.02 m³/s

Concentration distribution



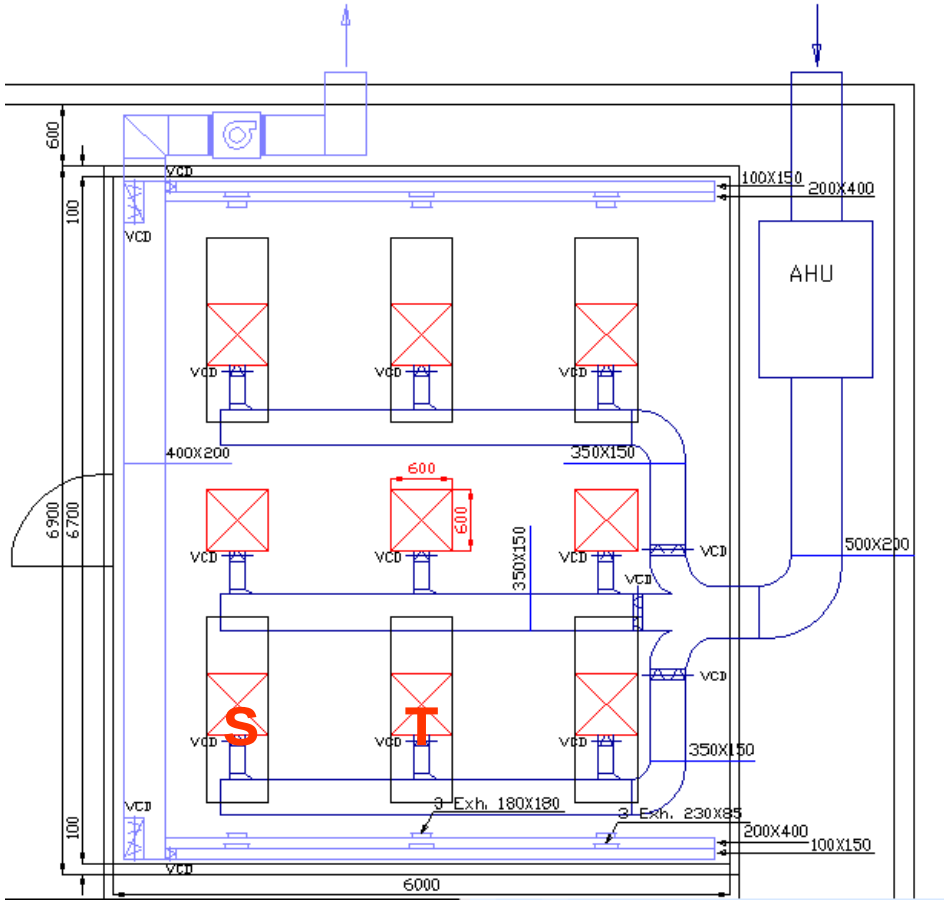
Normalized Concentration in the Inhalation of the Target Manikin

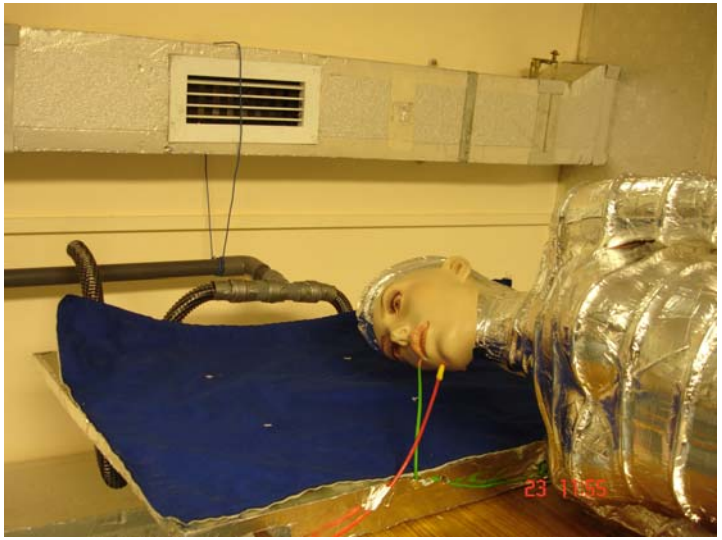




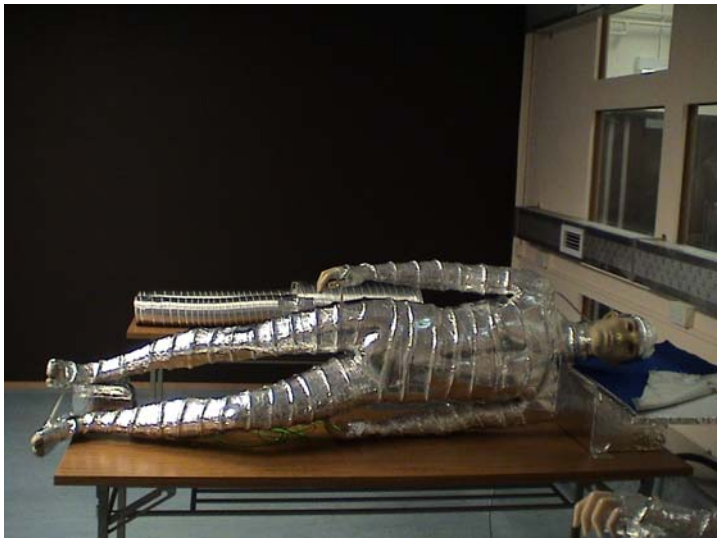
PV System Combined with Vertical Ventilation

SARS room, Hong Kong University



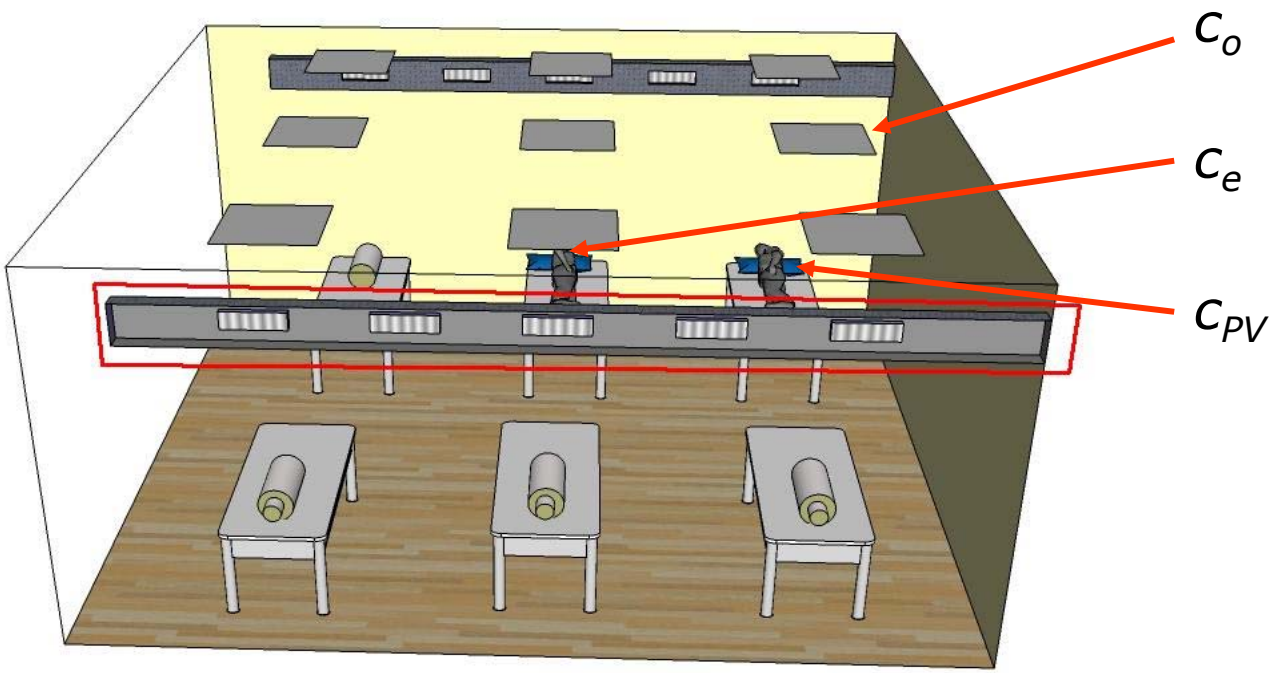


S-patient



T-patient

PV System Combined with Vertical Ventilation, one Pillow



Personal exposure index

$$\varepsilon_{\exp,PV} = \frac{C_{e(NOPV)} - C_0}{C_{e(PV)} - C_{PV}}$$

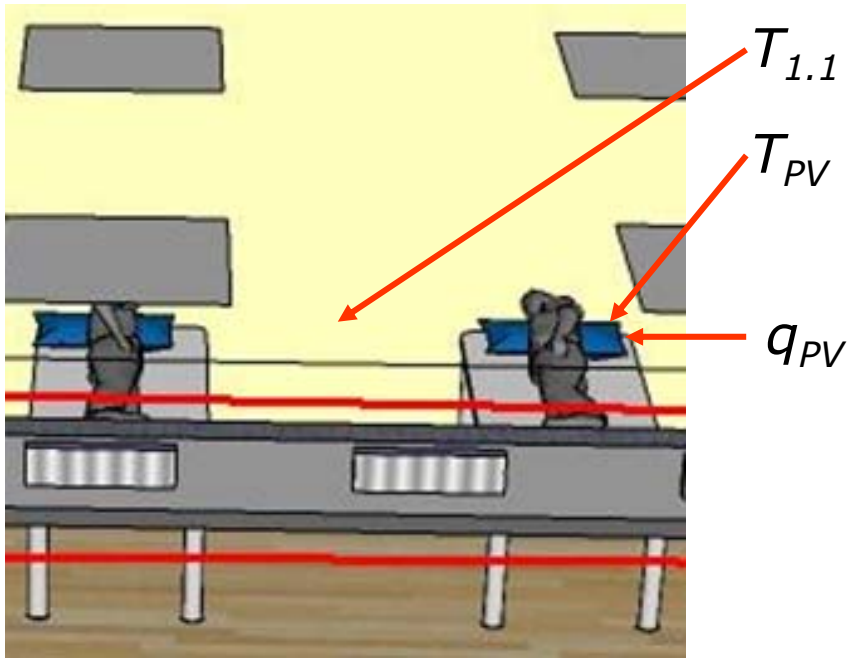
PV System Combined with Vertical Ventilation

$\varepsilon_{exp,PV}$ and ε_{PV} are functions of q_{PV}, $T_{1.1}$,T_{PV}, q_o and T_o.

It was not possible to seperate the variables in the experiments.

We used similarity Principle to describe $\varepsilon_{exp,PV}$ and ε_{PV} as *f(Ar)* where

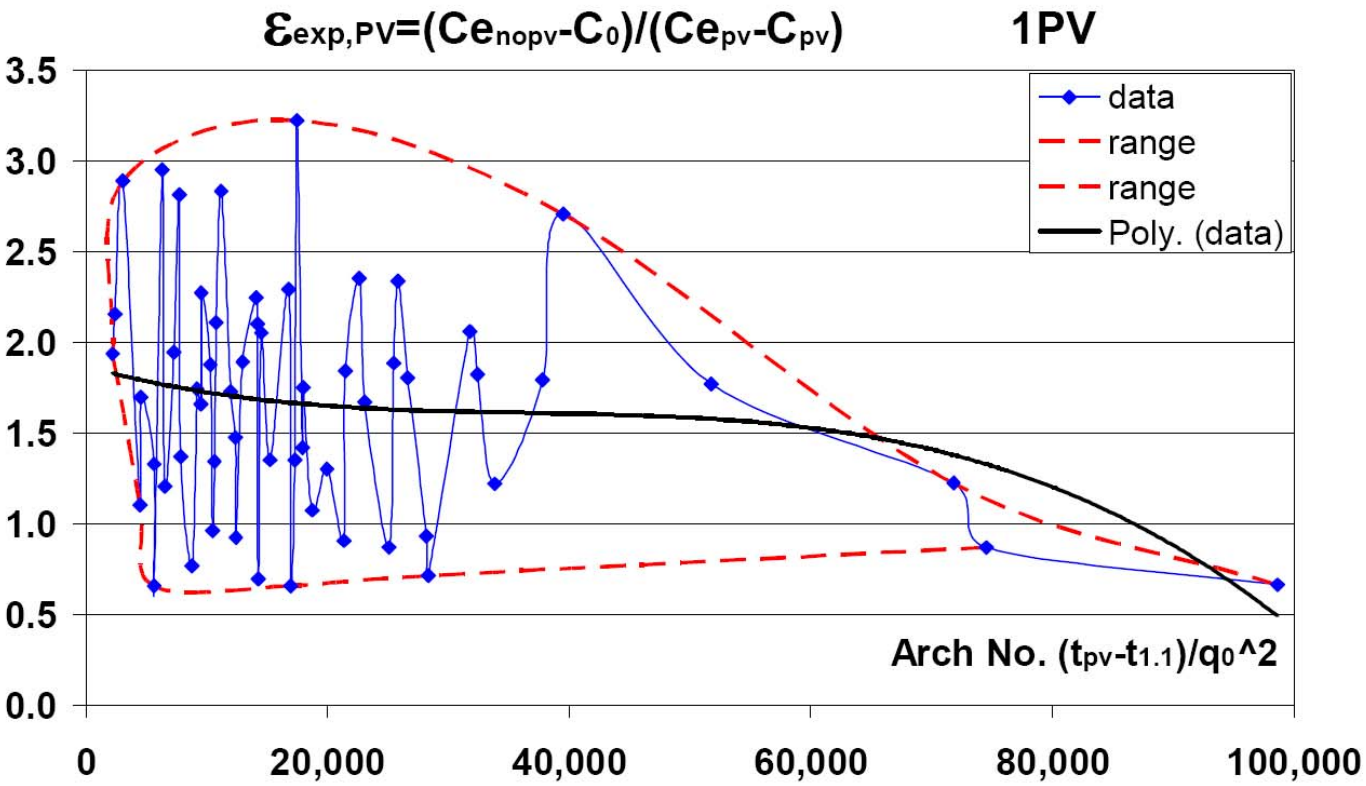
$$Ar = (T_{PV} - T_{1.1})/q_{PV}^2$$



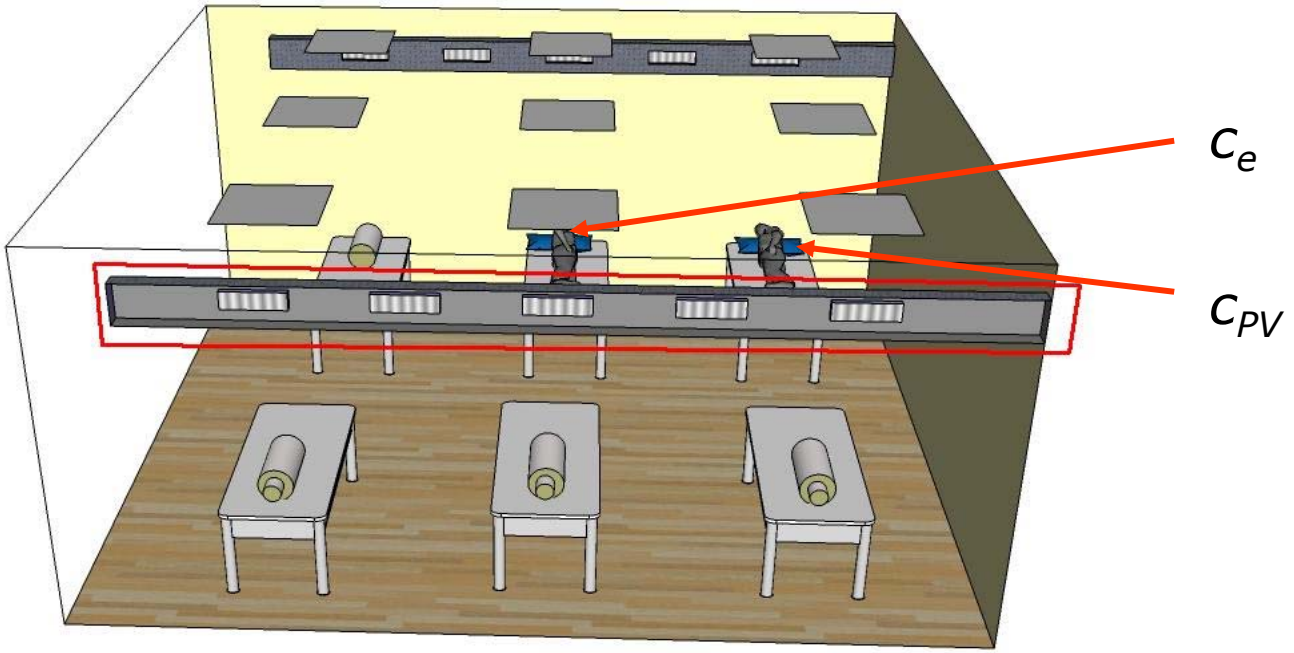
One Pillow at the Source Manikin

Personal exposure index for
T-patient with focus on
S-patient's PV.
No PV at **T**-patient

$$\varepsilon_{\exp,PV} = \frac{C_{e(NOPV)} - C_0}{C_{e(PV)} - C_{PV}}$$



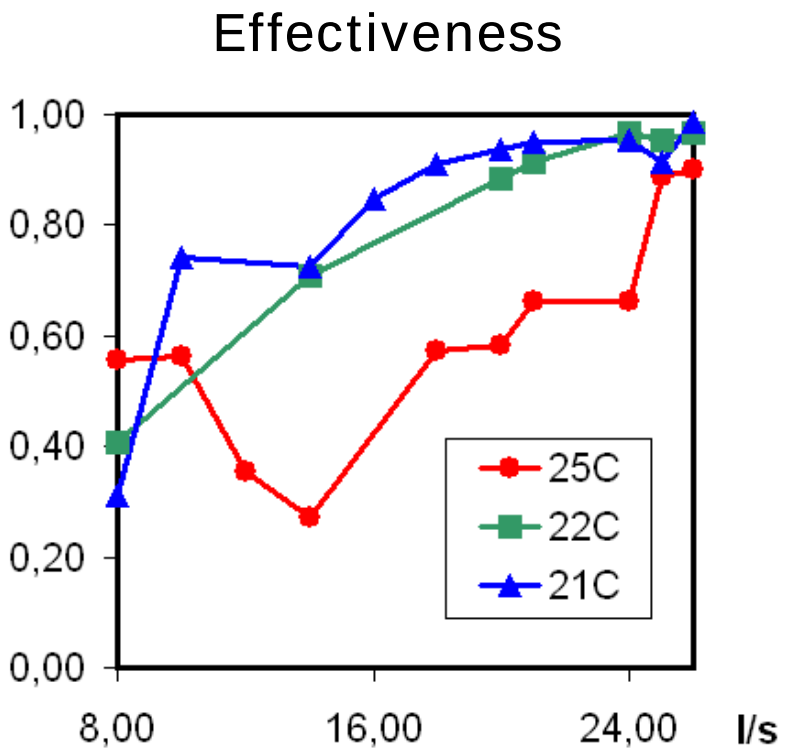
PV System Combined with Vertical Ventilation. two Pillows



Effectiveness

$$\varepsilon_{PV} = \frac{C_{e(NOPV)} - C_{e(PV)}}{C_{e(NOPV)} - C_{PV}}$$

PV System Combined with Vertical Ventilation, two Pillows

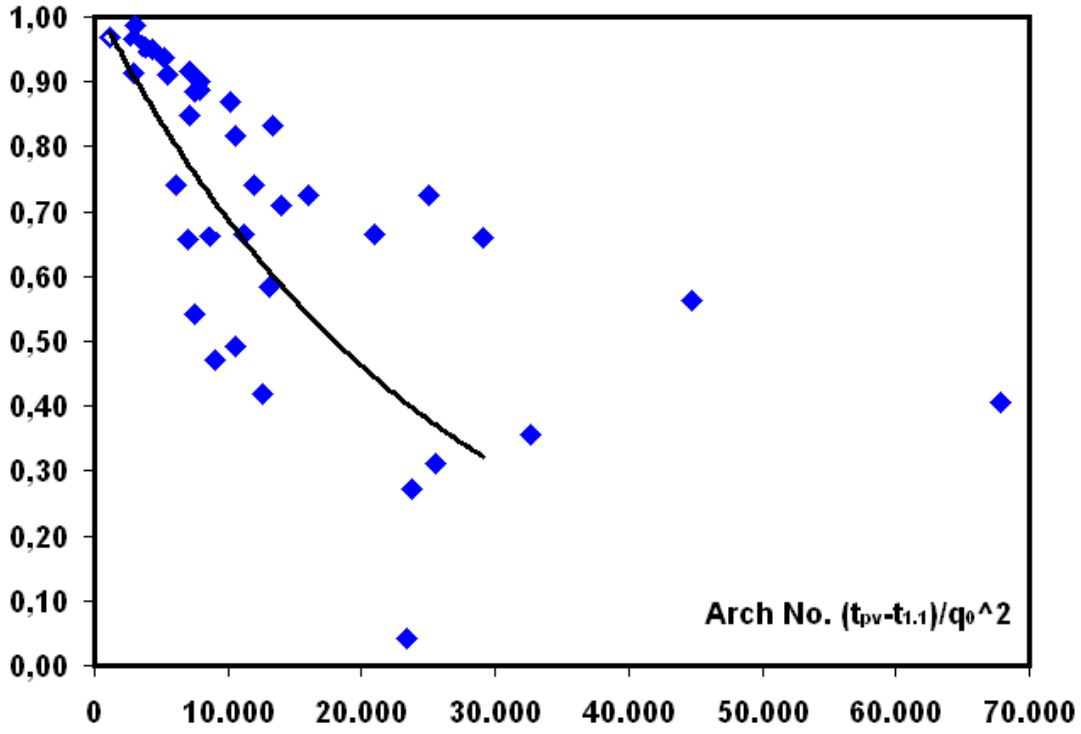


- Effectiveness (of the protection of **T**-patient)

$$\varepsilon_{PV} = \frac{C_{e(NOPV)} - C_{e(PV)}}{C_{e(NOPV)} - C_{PV}}$$

PV System Combined with Vertical Ventilation, two Pillows

$$\varepsilon_{PV} = (Ce_{nopv} - Ce_{pv})/(Ce_{nopv} - C_{pv})$$



Literature

Peter V. Nielsen, Carl Erik Hyldgaard, Arsen Melikov, Heine Andersen and Mads Soennichsen, Personal Exposure Between People in a Room Ventilated by Textile Terminals – with and without Personalized Ventilation. HVAC&R Research, Vol. 13, No. 4, July 2007.

Peter V. Nielsen, Niels M. Bartholomaeussen, Ewa Jakubowska, Hao Jiang, Oli T. Jonsson, Karolina Krawiecka, Adam Mierzejewski, Sara J. Thomas, Katarzyna Trampczynska, Marcin Polak and Mads Soennichsen, Chair with Integrated Personalized Ventilation for Minimizing Cross Infection. Roomvent 2007, 10th International Conference on Air Distribution in Rooms, Helsinki 2007.

Peter V. Nielsen, Hao Jiang and Marcin Polak, Bed with Integrated Personalized Ventilation for Minimizing Cross Infection. Roomvent 2007, 10th International Conference on Air Distribution in Rooms, Helsinki 2007.

Thank you!