Air Distribution and Personal Environmental Control in Aircraft Cabins

Peter V. Nielsen
Aalborg University

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.

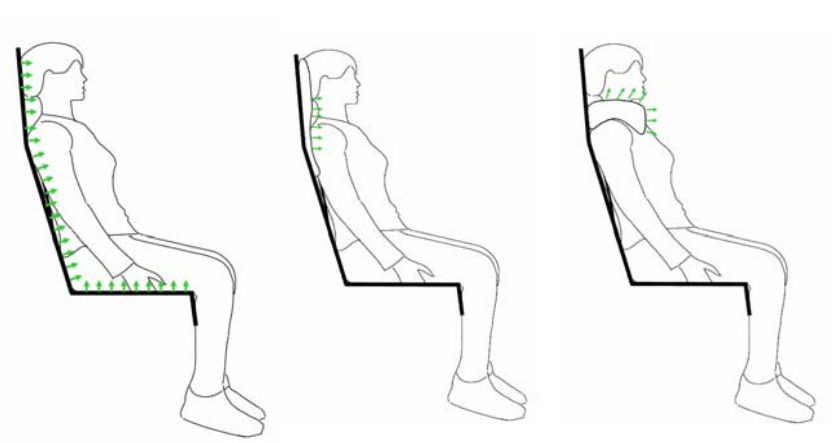
By supplying the air direct to the breathing zone it is ensured that the air has not been contaminated by other persons. This minimizes e.g. cross infection and passive smoking.

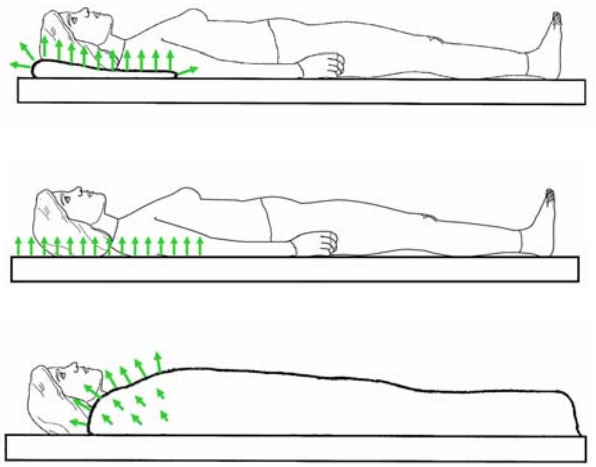
Low Velocity PV System

The personalized ventilation system (PV) 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.

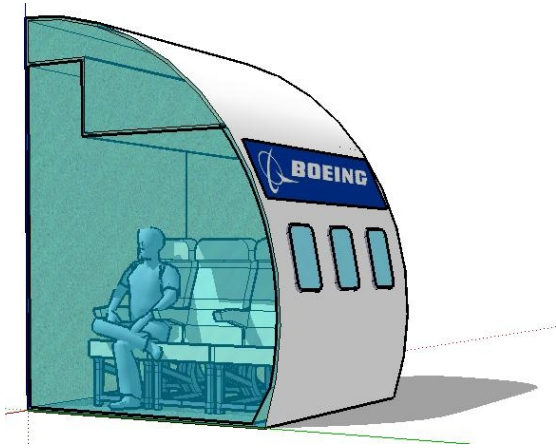
The surfaces are also designed to be supply openings of fresh air, for example by the use of fabric as a diffuser.





Overview of the Talk

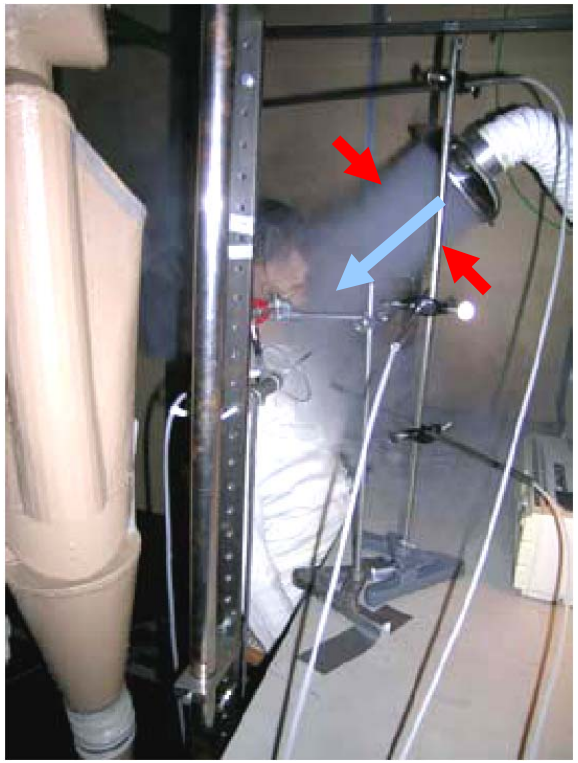
-Experiments in wind tunnel



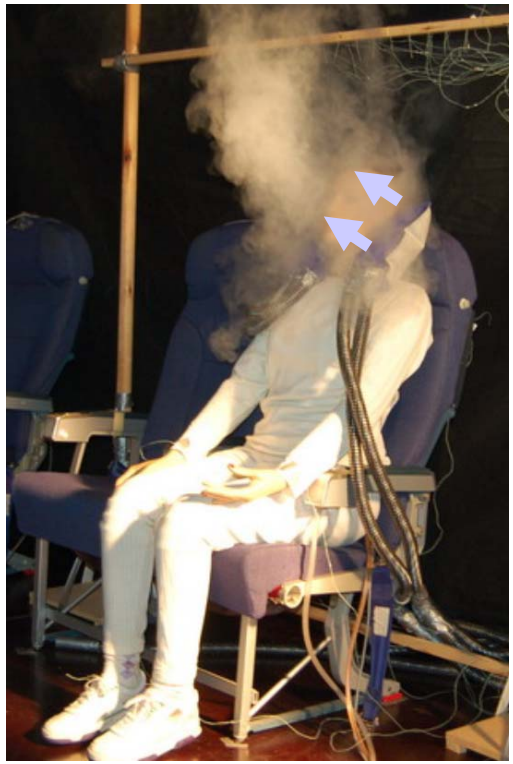
-Experiments in an aircraft cabin

- Various subjects

Does the General Air Distribution Influence the PV System?

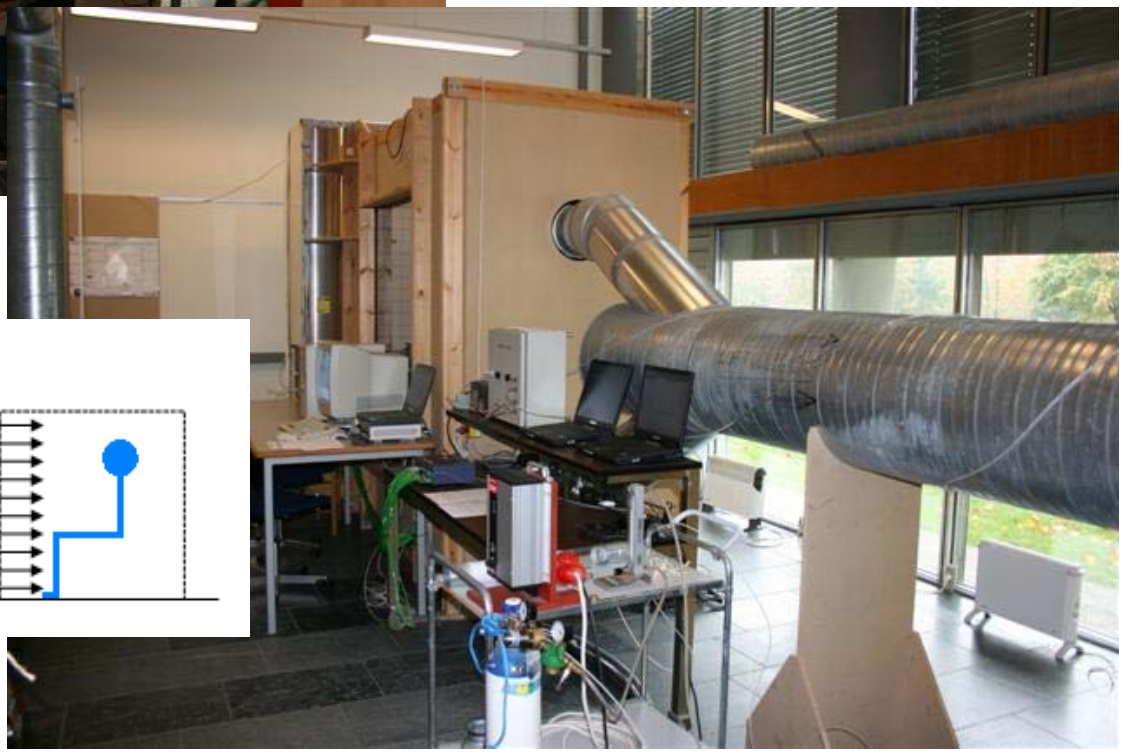


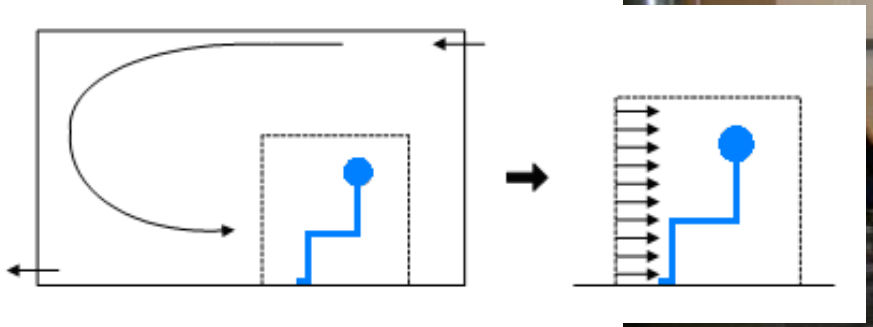
High momentum flow with entrainment



Low velocity supply to the boundary layer

Wind Tunnel





Peter V. Nielsen, Aalborg University

Effectiveness

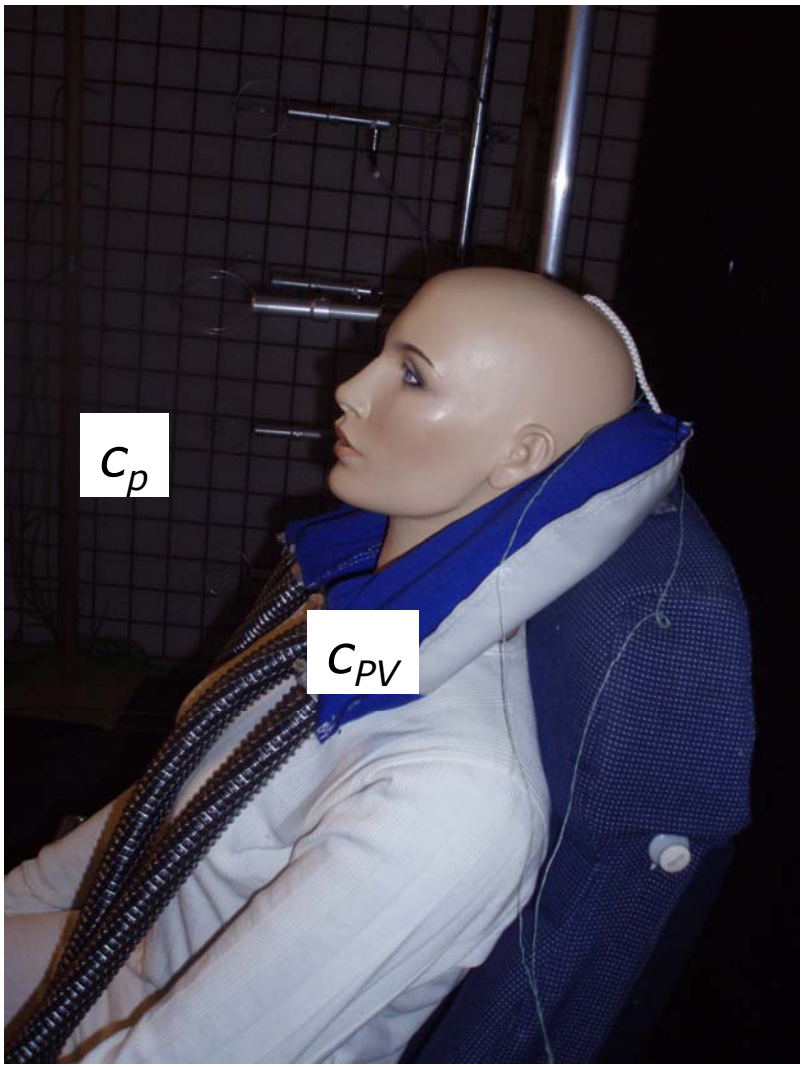
The effectiveness of personalized ventilation

If the concentration in the inhalation is c_{PV}

$\varepsilon_{PV} = 1.0$

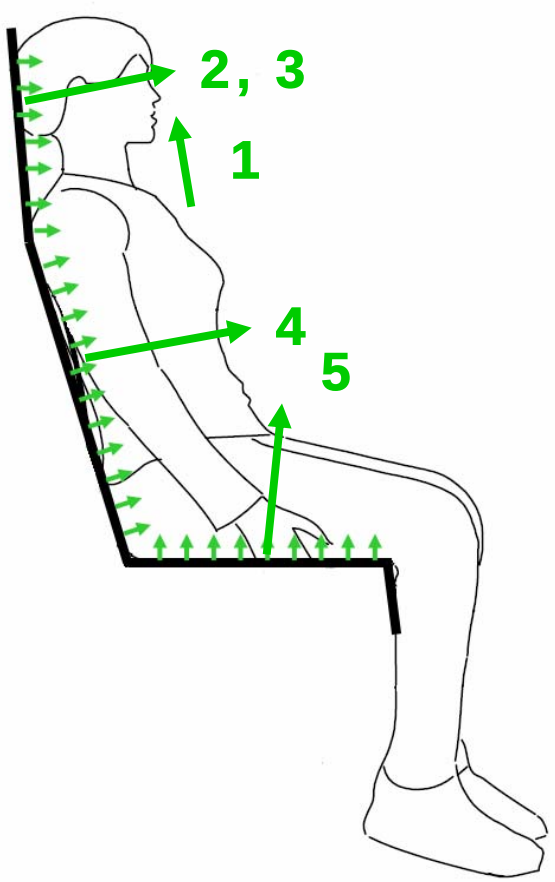
If the concentration in the inhalation is c_p

$\varepsilon_{PV} = 0.0$

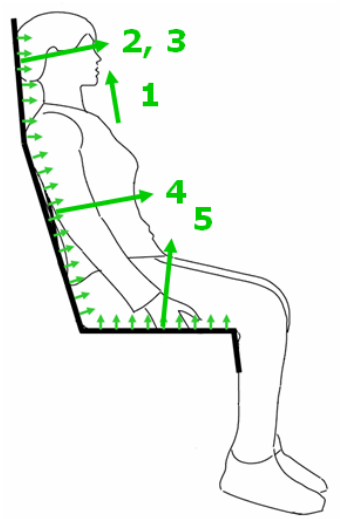


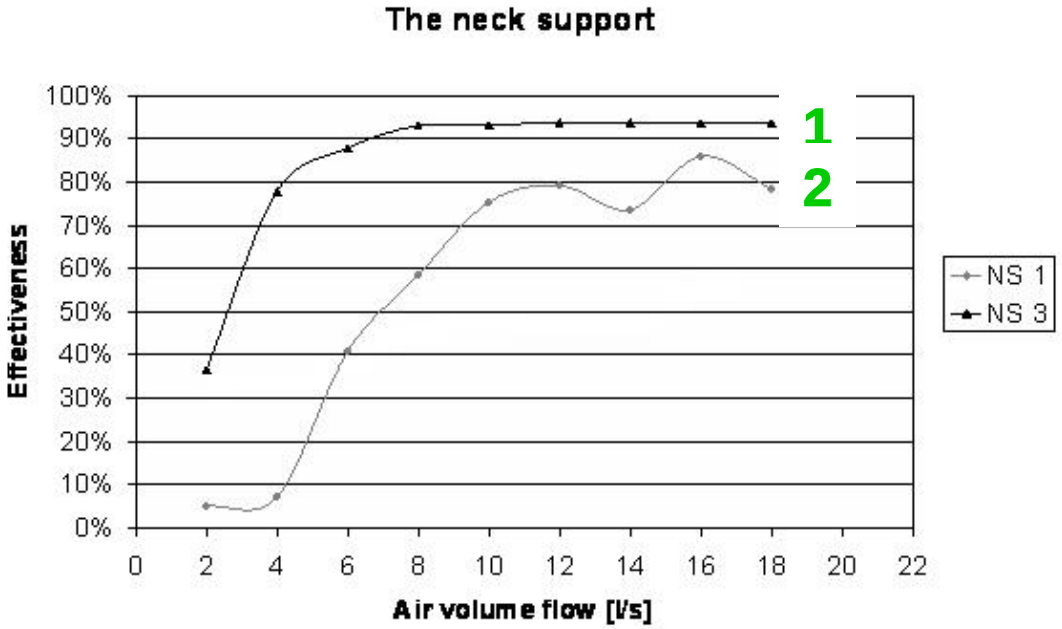
Air Supplied Direct to the Boundary Layer

Five different paths into the boundary layer.

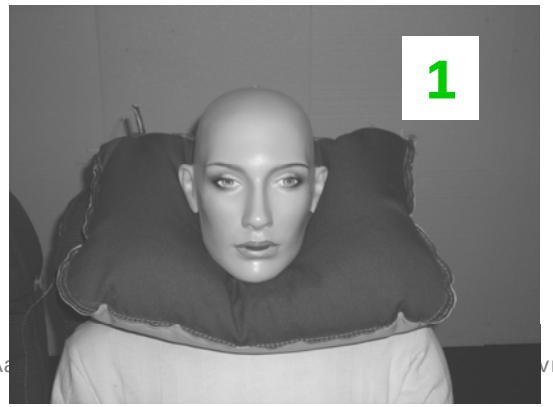


Neck Support Pillows



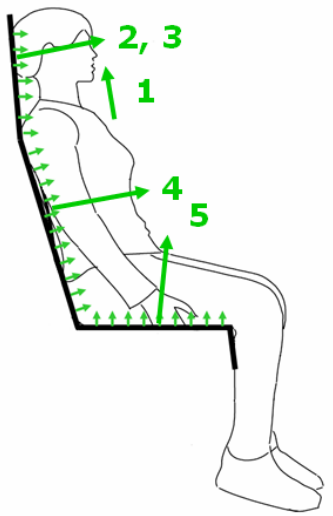


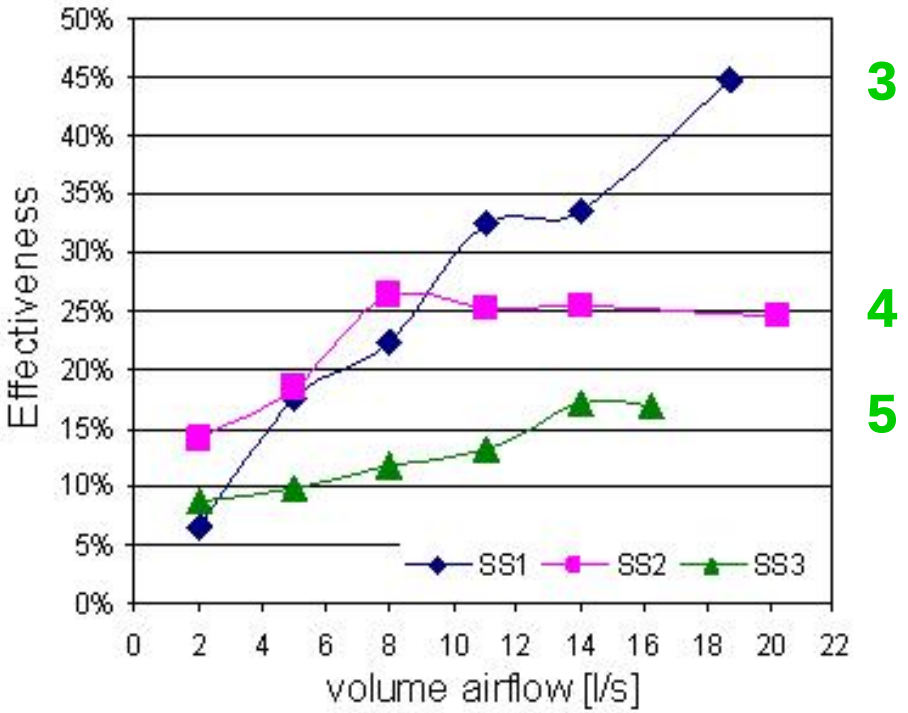
NS 3



NS 1

Seat as Diffuser

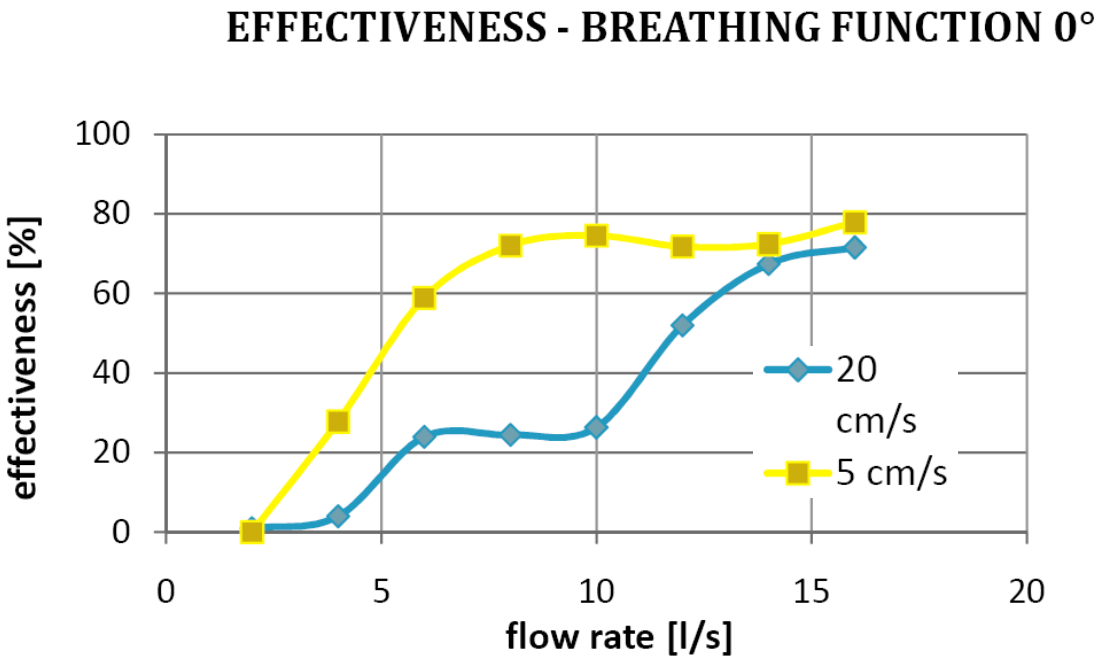




Supply areas are white

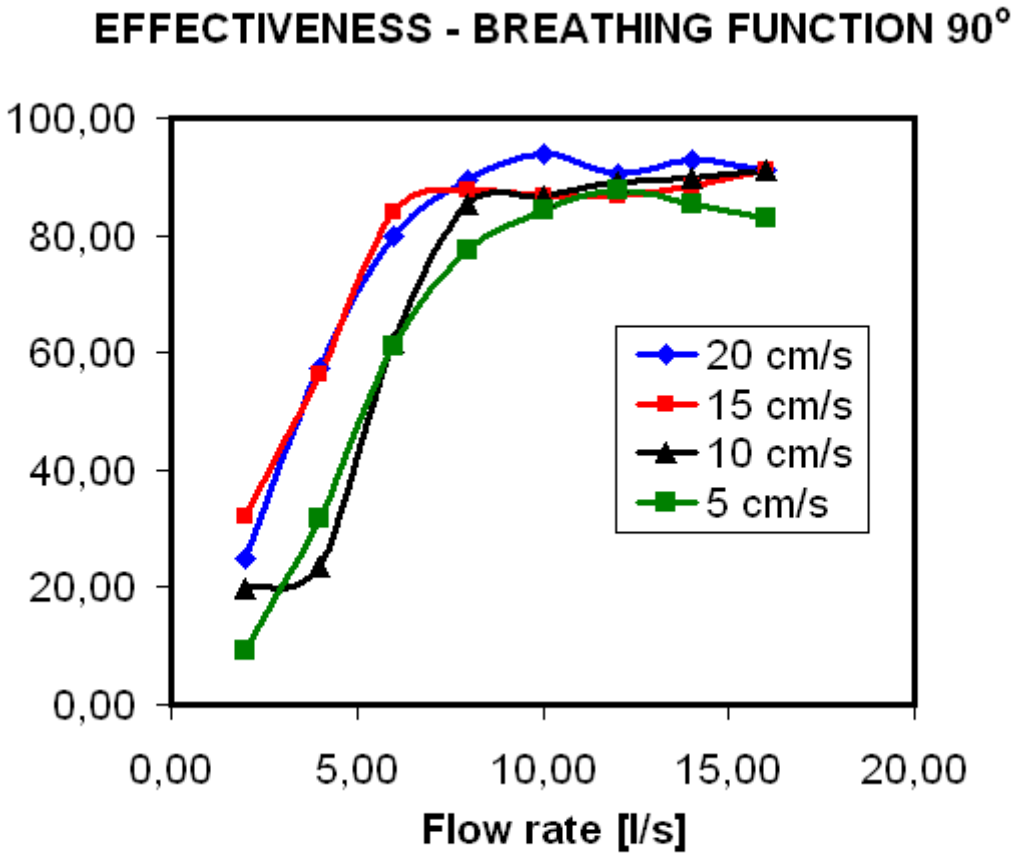
Frontal Draught

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



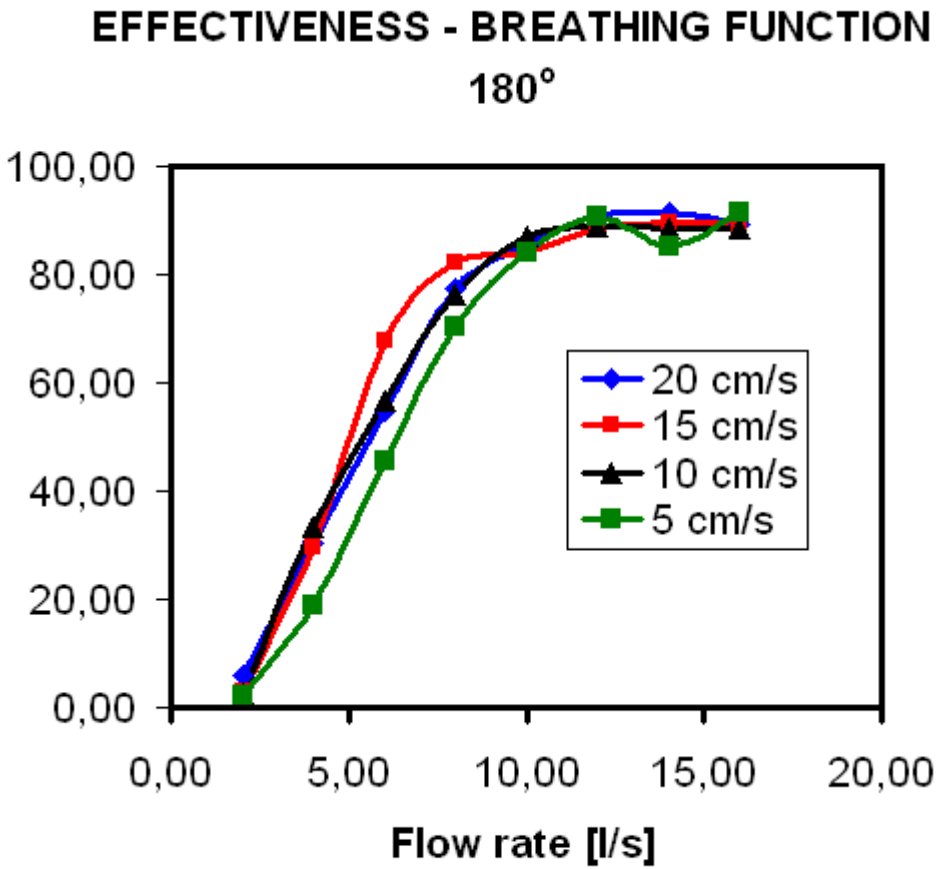
Draught from the Right-Hand Side

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



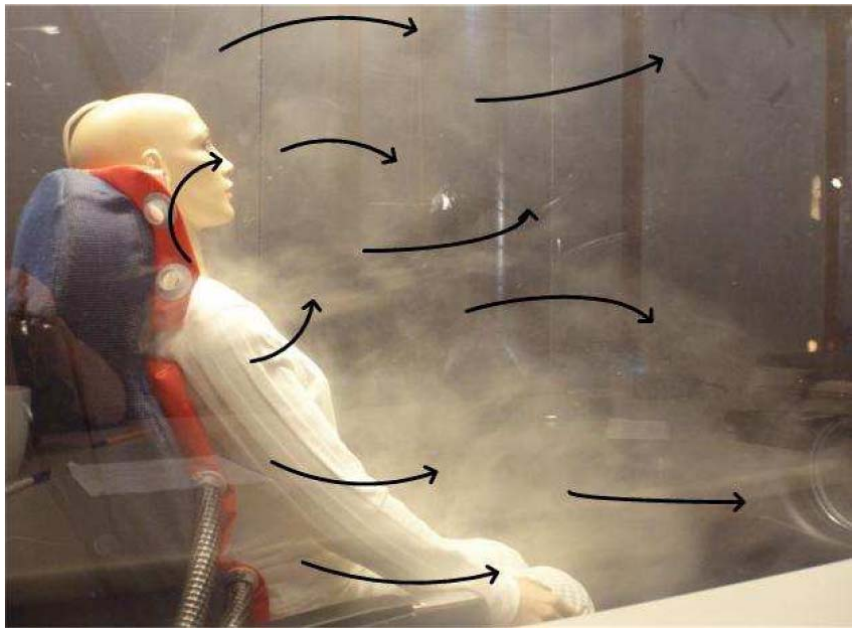
Draught from Behind

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

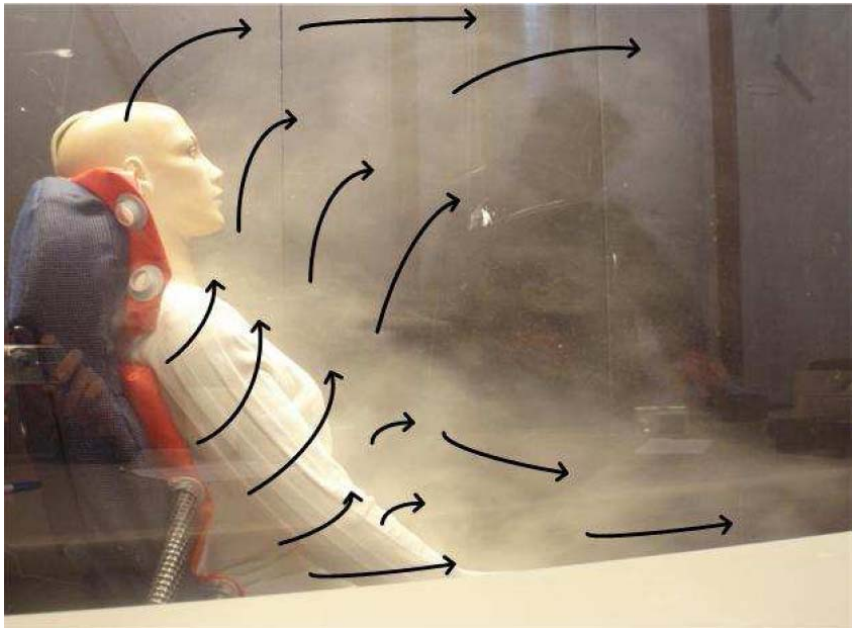


Chair with Diffuse Surface

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



u = 0.05 m/s



u = 0.20 m/s

Transmission of the Severe Acute Respiratory Syndrome on Aircraft

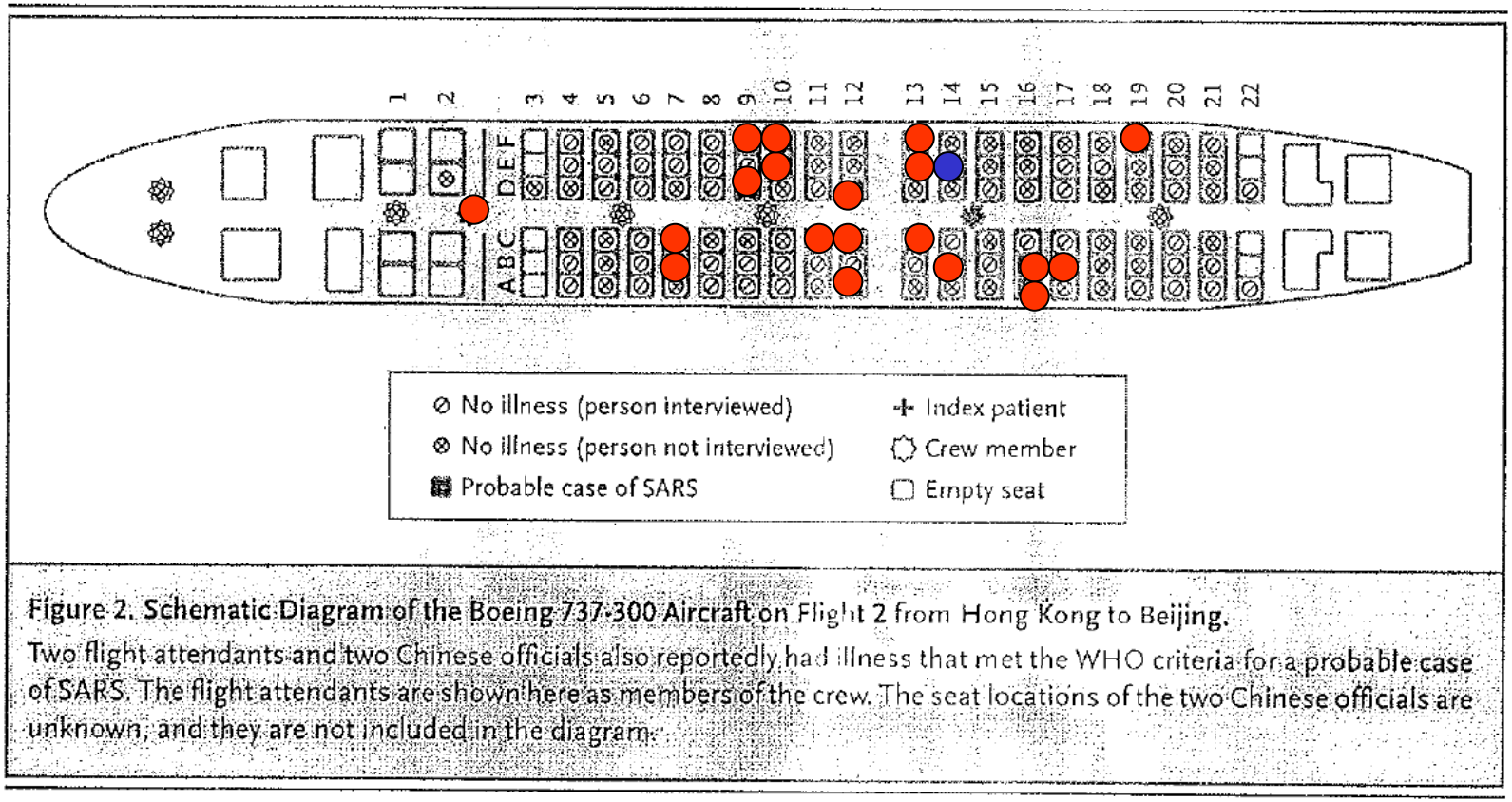


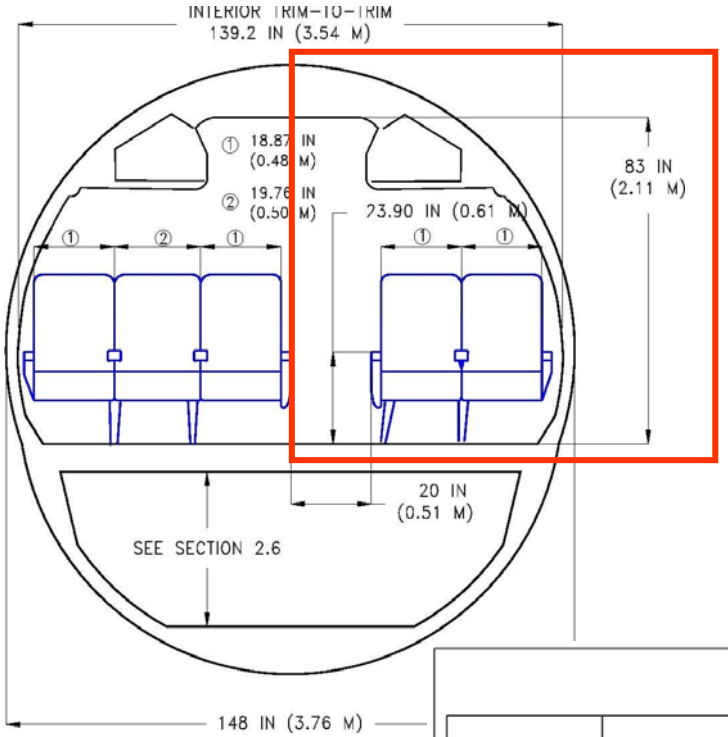
Figure 2. Schematic Diagram of the Boeing 737-300 Aircraft on Flight 2 from Hong Kong to Beijing.
Two flight attendants and two Chinese officials also reportedly had illness that met the WHO criteria for a probable case of SARS. The flight attendants are shown here as members of the crew. The seat locations of the two Chinese officials are unknown, and they are not included in the diagram.

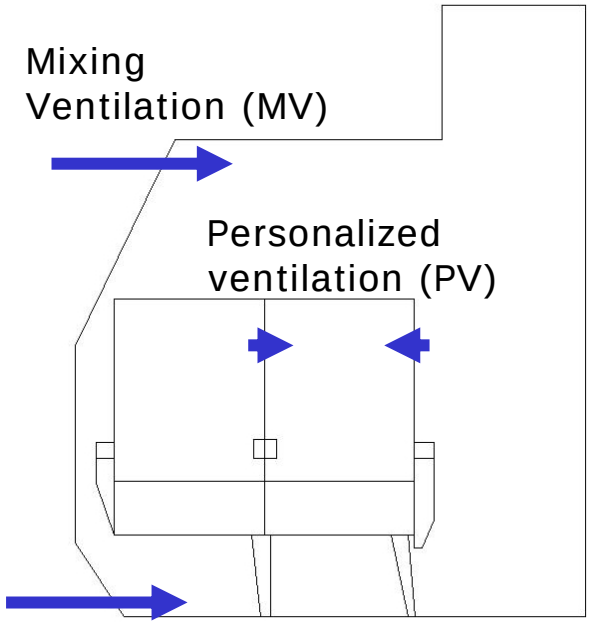
AN OUTBREAK OF INFLUENZA ABOARD A COMMERCIAL AIRLINER

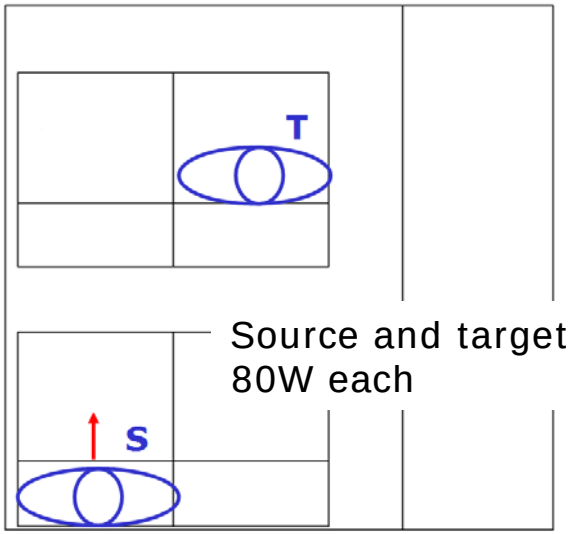
Moser, M. R., T. R. Bender (Alaska Investigations Division, Center for Disease Control, Anchorage, AK 99501), H. S. Margolis, G. R. Noble, A. P. Kendal and D. G. Ritter. An outbreak of influenza aboard a commercial airliner. *Am J Epidemiol* 110:1–6, 1979.

A jet airliner with 54 persons aboard was delayed on the ground for three hours because of engine failure during a takeoff attempt. Most passengers stayed on the airplane during the delay. Within 72 hours, 72 per cent of the passengers became ill with symptoms of cough, fever, fatigue, headache, sore throat and myalgia. One passenger, the apparent index case, was ill on the airplane, and the clinical attack rate among the others varied with the amount of time spent aboard. Virus antigenically similar to A/Texas/1/77 (H3N2) was isolated from 8 of 31 passengers cultured, and 20 of 22 ill persons tested had serologic evidence of infection with this virus. The airplane ventilation system was inoperative during the delay and this may account for the high attack rate.

Experiment in an Aircraft Cabin



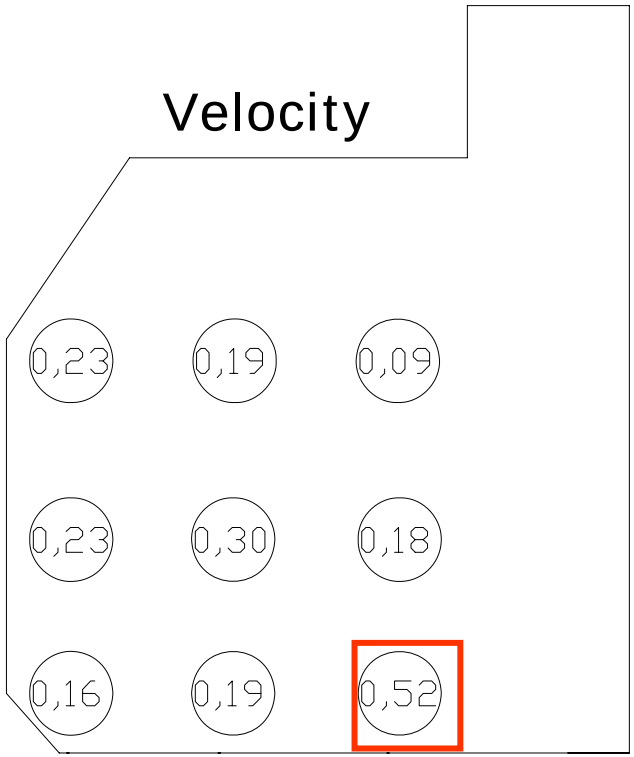


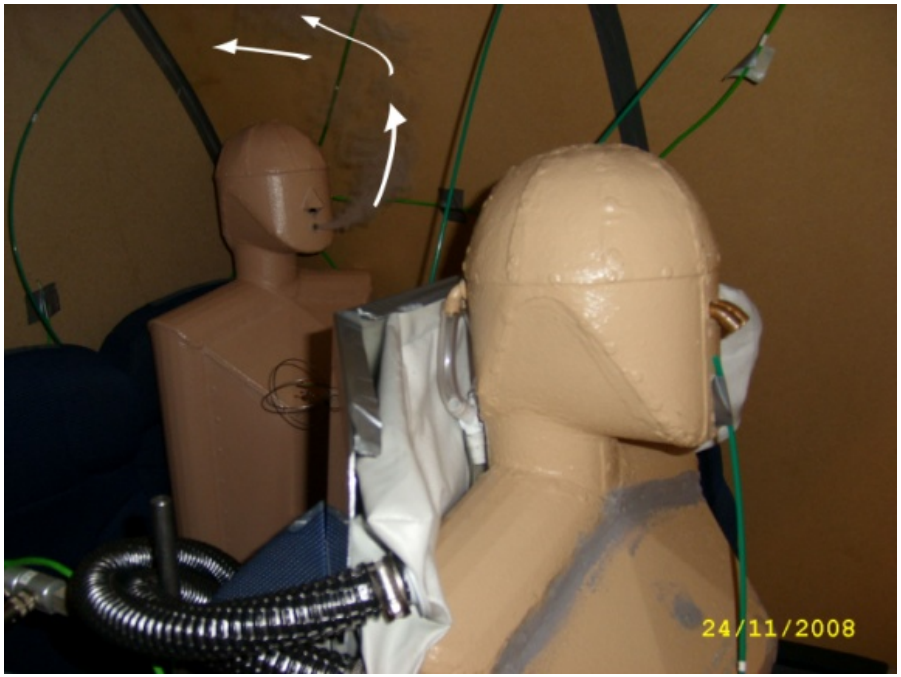


Source and target manikin
80W each

The Cabin

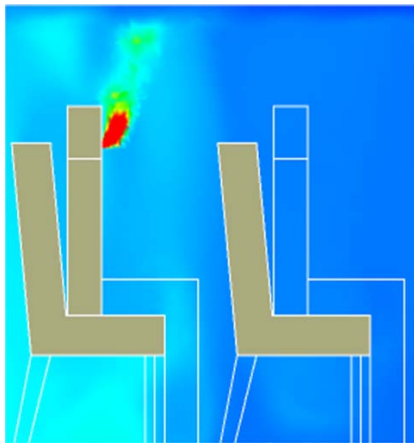
Mixing Ventilation, 40 l/s





ΔT_y ~ 1 K

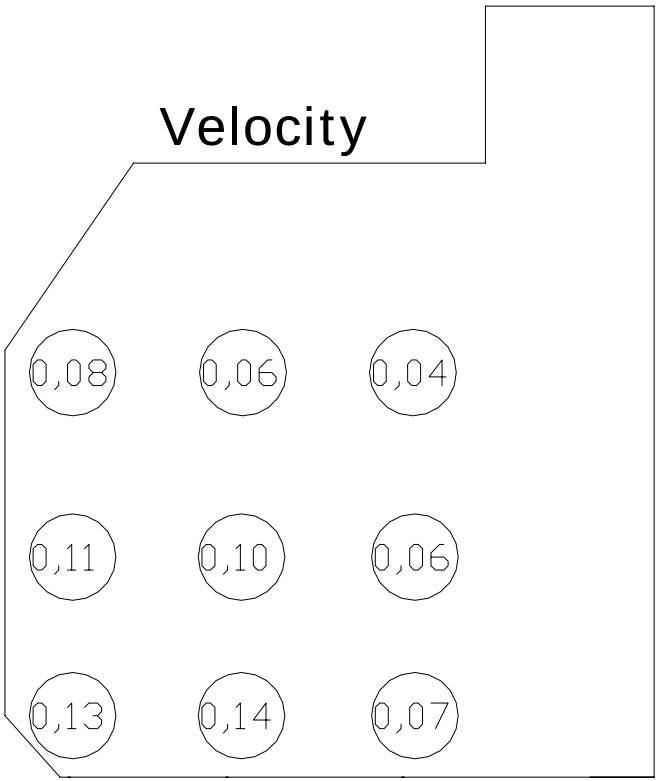
c_{exp}/c_R = 0.97

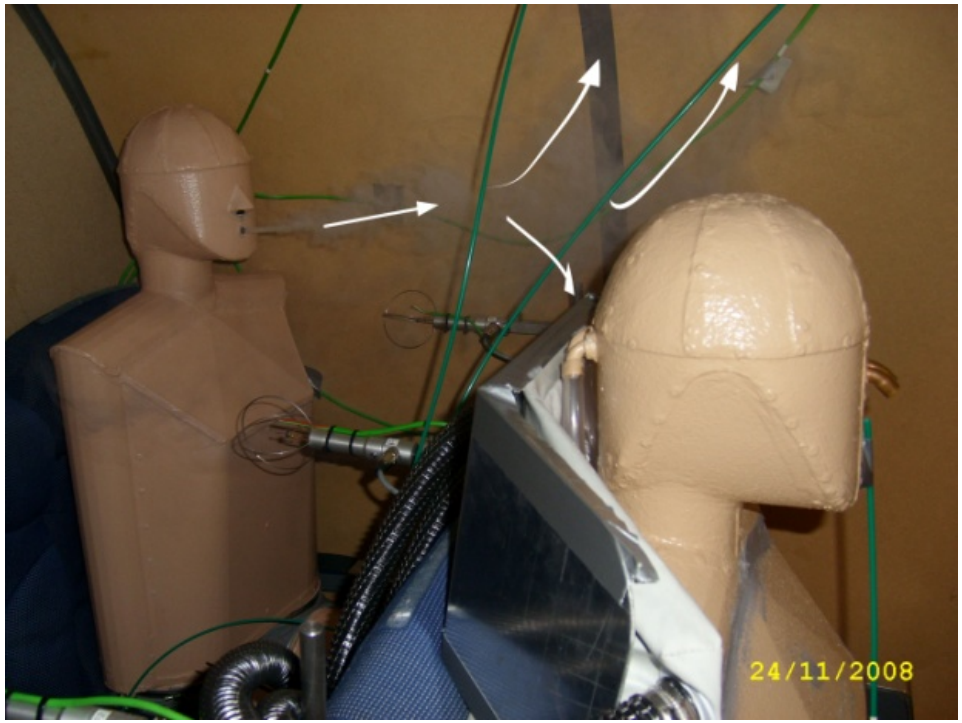


c_{exp}: exposure concentration
c_R: return concentration

Peter V. Nielsen, Aalborg University pvn@civil.auc.dk

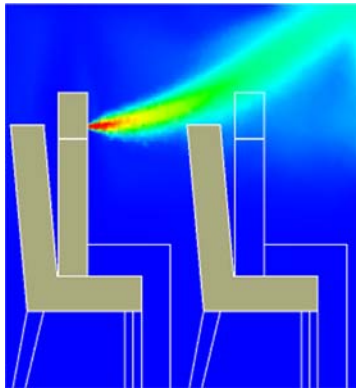
Displacement Ventilation, 40 l/s





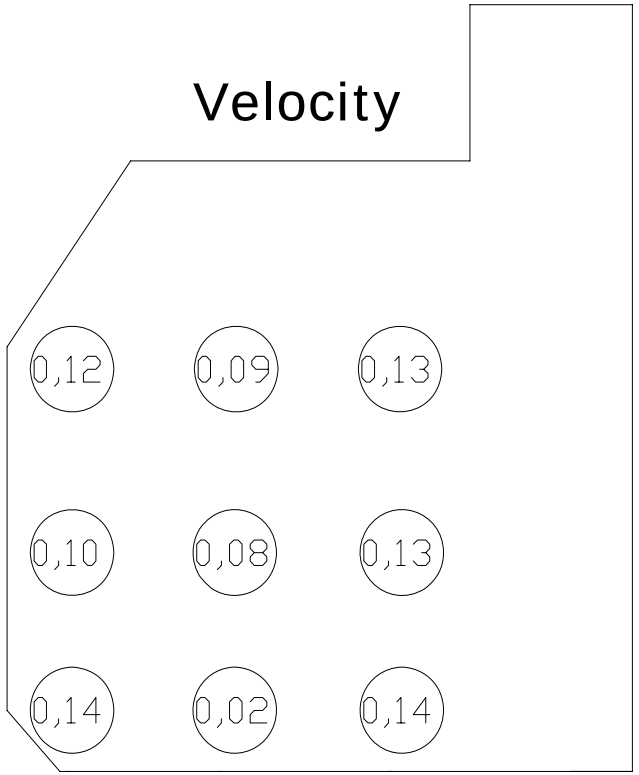
ΔT_y ~ 3 K

c_{exp}/c_R = 0.25



Peter V. Nielsen, Aalborg University pvn@civil.auc.dk

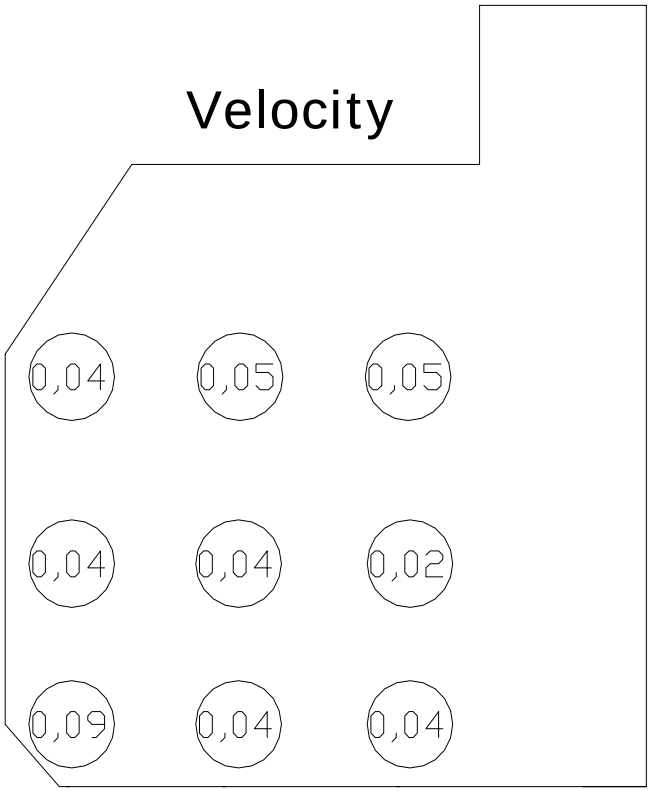
Mixing Ventilation, 10 l/s and Personalized Ventilation, 10 l/s

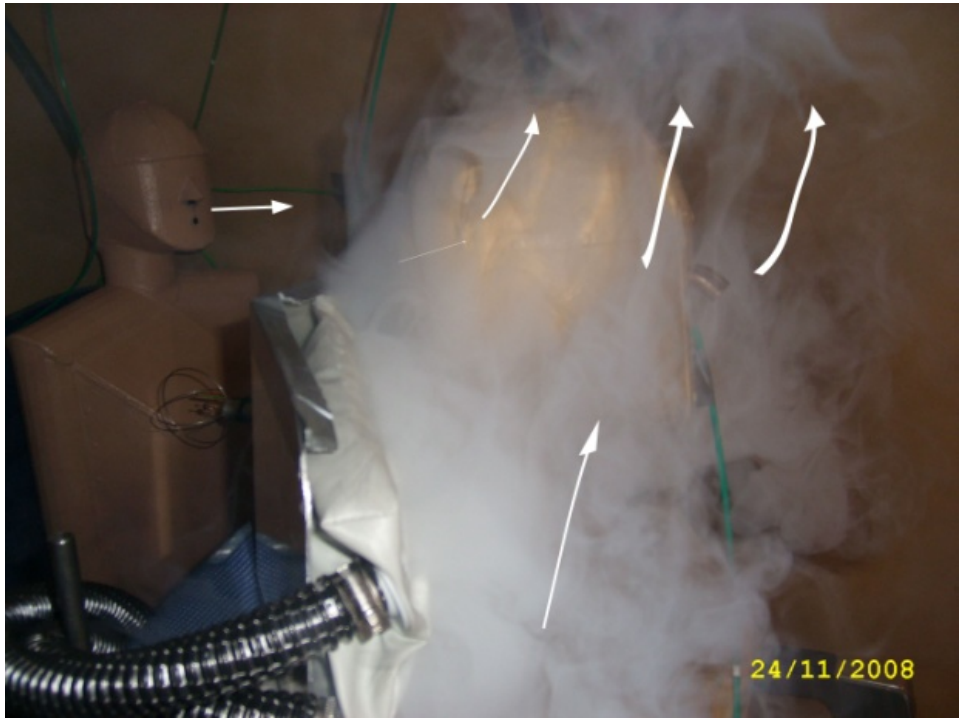


ΔT_y ~ 1 K

c_{exp}/c_R = 0.97

Displacement Ventilation, 5 l/s and Personalized Ventilation, 5 l/s

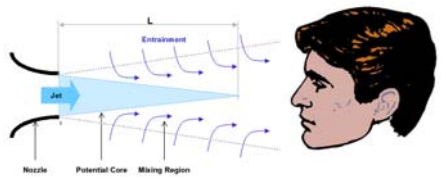


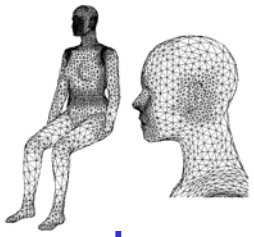


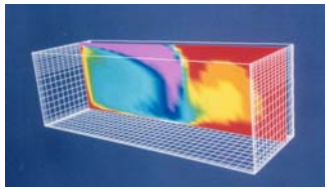
ΔT_y ~ 2.5 K

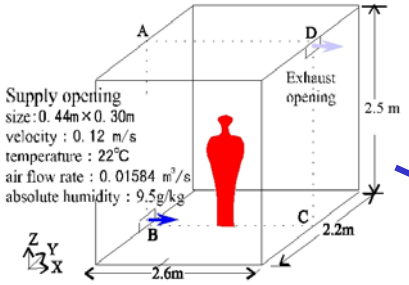
c_{exp}/c_R = 0.36

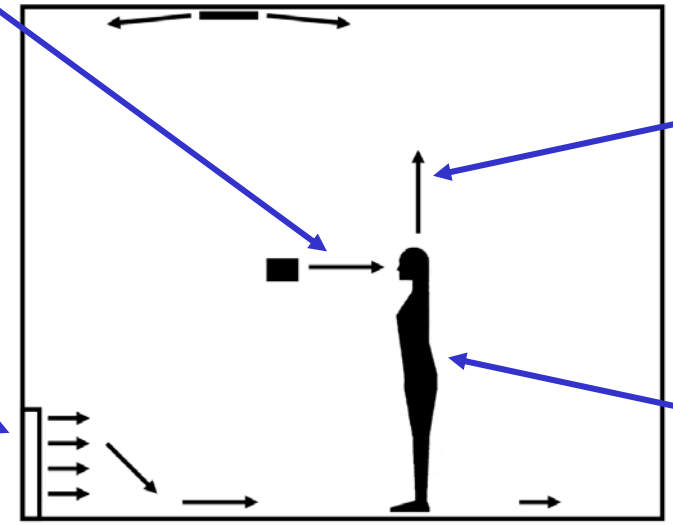
Various subjects:
www.cfd-benchmarks.com

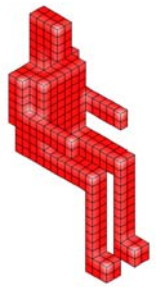






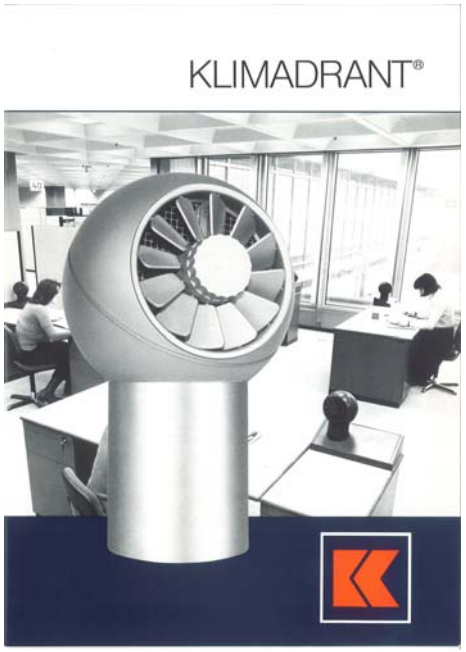






Various subjects: A Question

The perceived air quality of a device may be high, even if it generates a low personal exposure index c_R/c_{exp} **!?**



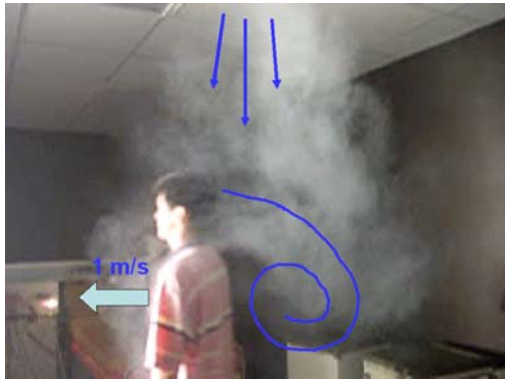
Are those systems personalized ventilation systems

c_R/c_{exp} > **?** or c_{exp}/c_R < **?**

Various subjects: Forum on Microenvironment around Persons in Ventilated Spaces

Chairs and Contributers:

H. Ezzat Khalifa, Syracuse University
Yuguo Li, The University of Hong Kong
Arsen Melikov, Technical University of Denmark
Peter V. Nielsen, Aalborg University



Thank you!