Cohort Based Training CBT4–

Internal Heat Gains: what do they mean for air distibution and how they should be taken into account?

PROJECT 101119726 — HumanIC — HORIZON-MSCA-2022-DN-01

Risto Kosonen

30.6.2026

Learning outcomes

- Basic understanding of air distribution
- Basic understanding of ventilation effectiveness
- Basic understanding of Interaction of convective flows and jets

HumanIC project has received funding from the European Union's Horizon Europe research and innovation program under the Marie Sklodowska-Curie (HORIZON-MSCA-2022-DN-01, project no 101119726

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Flow elements and air distribution methods

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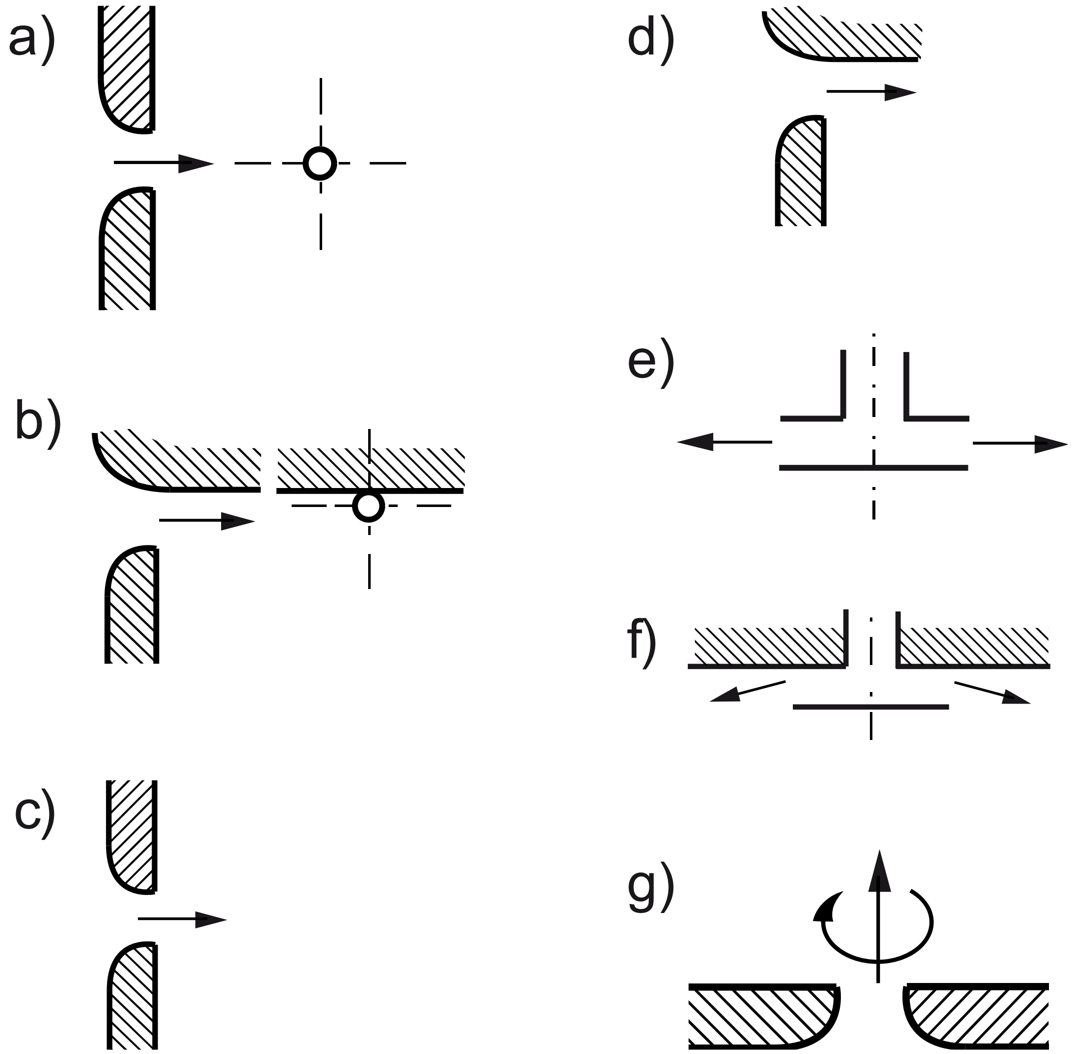
Basic types of jets for room air distribution



a) three-dimensional free jet,
b) three-dimensional wall jet,
c) two-dimensional free jet,
d) two-dimensional wall jet,
e) radial free jet,
f) radial wall jet,
g) free jet with swirl

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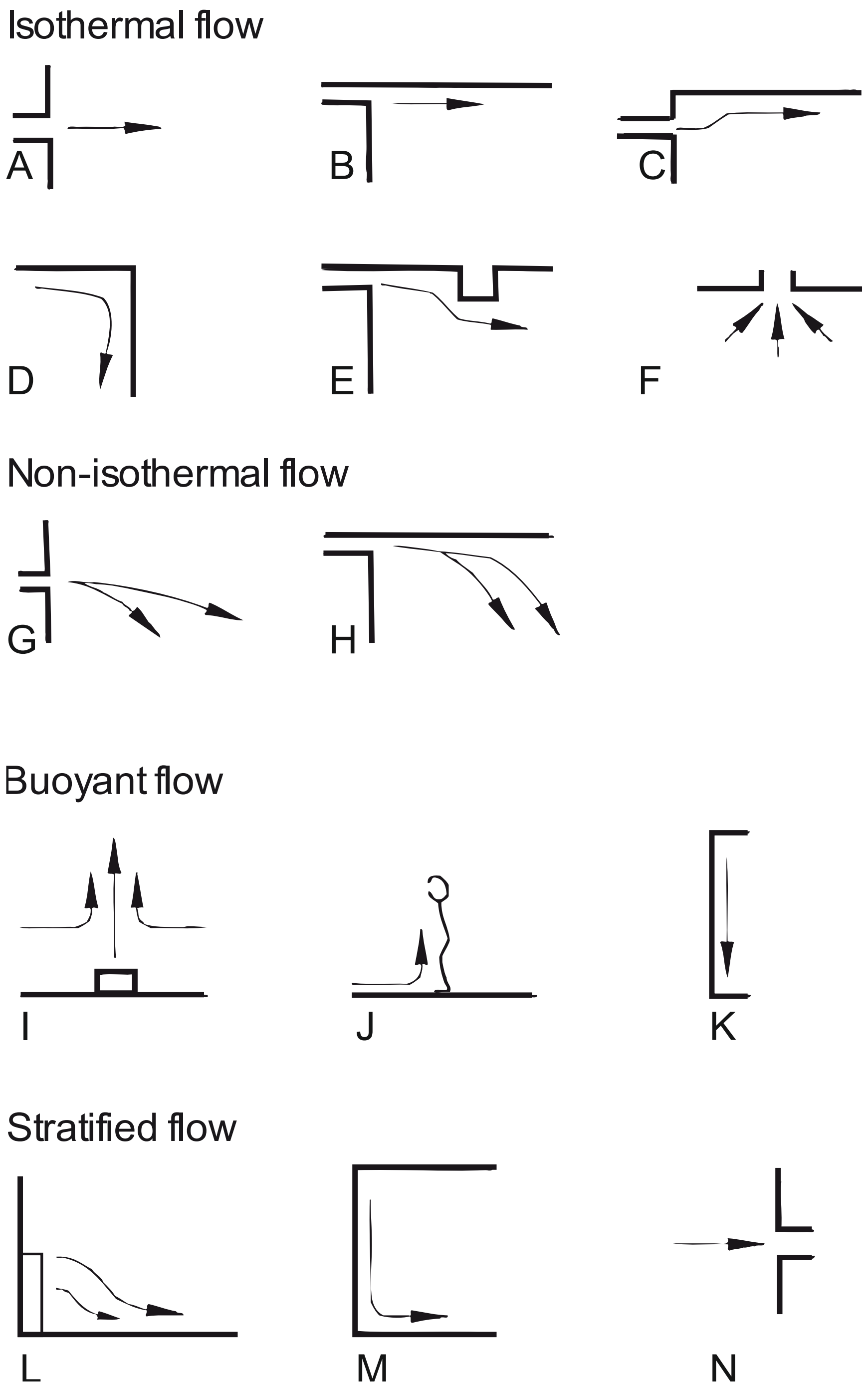

Flow elements in room air movement

- A to C show three kinds of supply jets
- D and E show disturbance of the jets
- F is exhaust opening
- G and H are non-isothermal flow elements
- I shows a thermal plume above a heat source
- J shows natural convection around a human body
- K shows cold downdraught at a wall
- L is stratified flow from a low-impulse opening
- M is cold downdraught
- N, is exhaust flow with vertical temperature gradient

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Common Technologies for Room Spaces

Air- water systems:

Chilled Beam (convective)
Radiant Cooling (panels and TABS)
Ventilation & fan-coils

All- air systems:

Mixing Ventilation and Displacement
Ventilation (large spaces)




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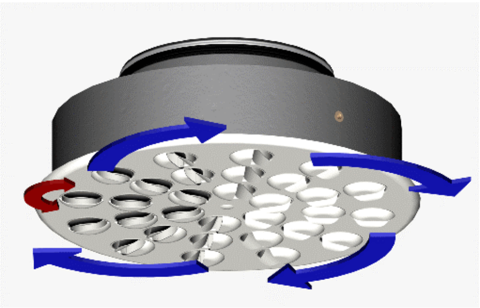
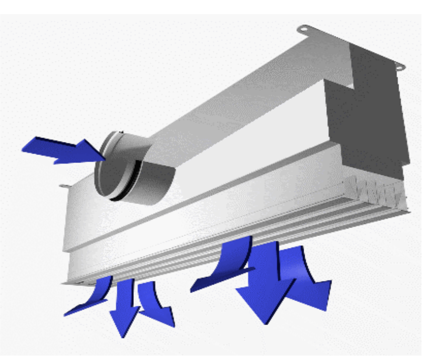
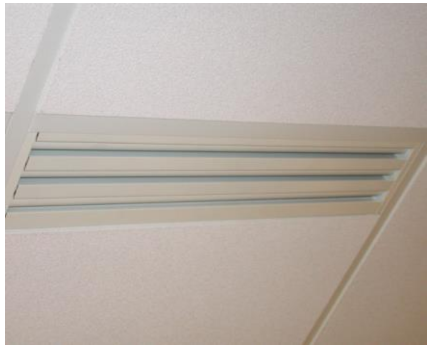
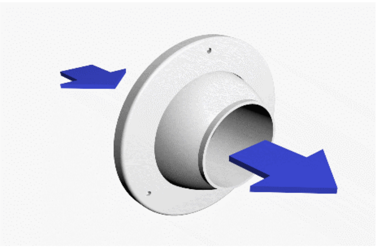
Some typical diffusers with high momentum flux




- Radial flow: multi-nozzle diffuser

- Linear flow




- Nozzle

Courtesy of Halton

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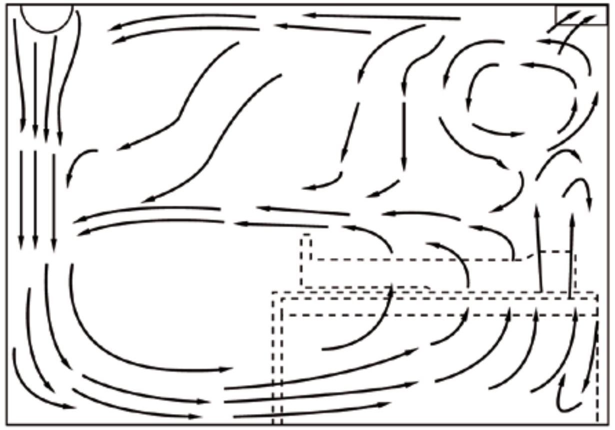
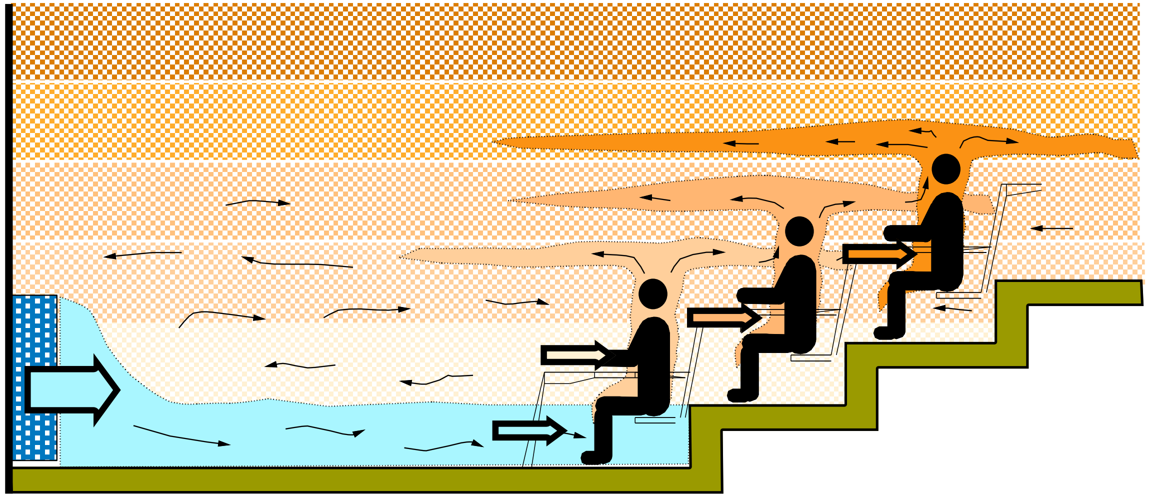
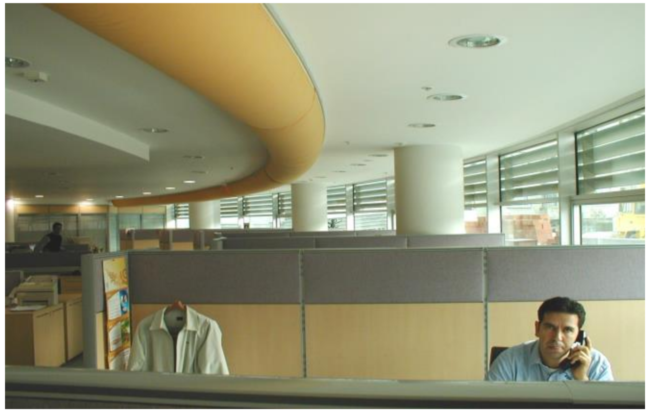
Air distribution methods with low momentum flux







A low impulse textile duct terminal in exposed installation

Displacement ventilation in auditorium

HumanIC

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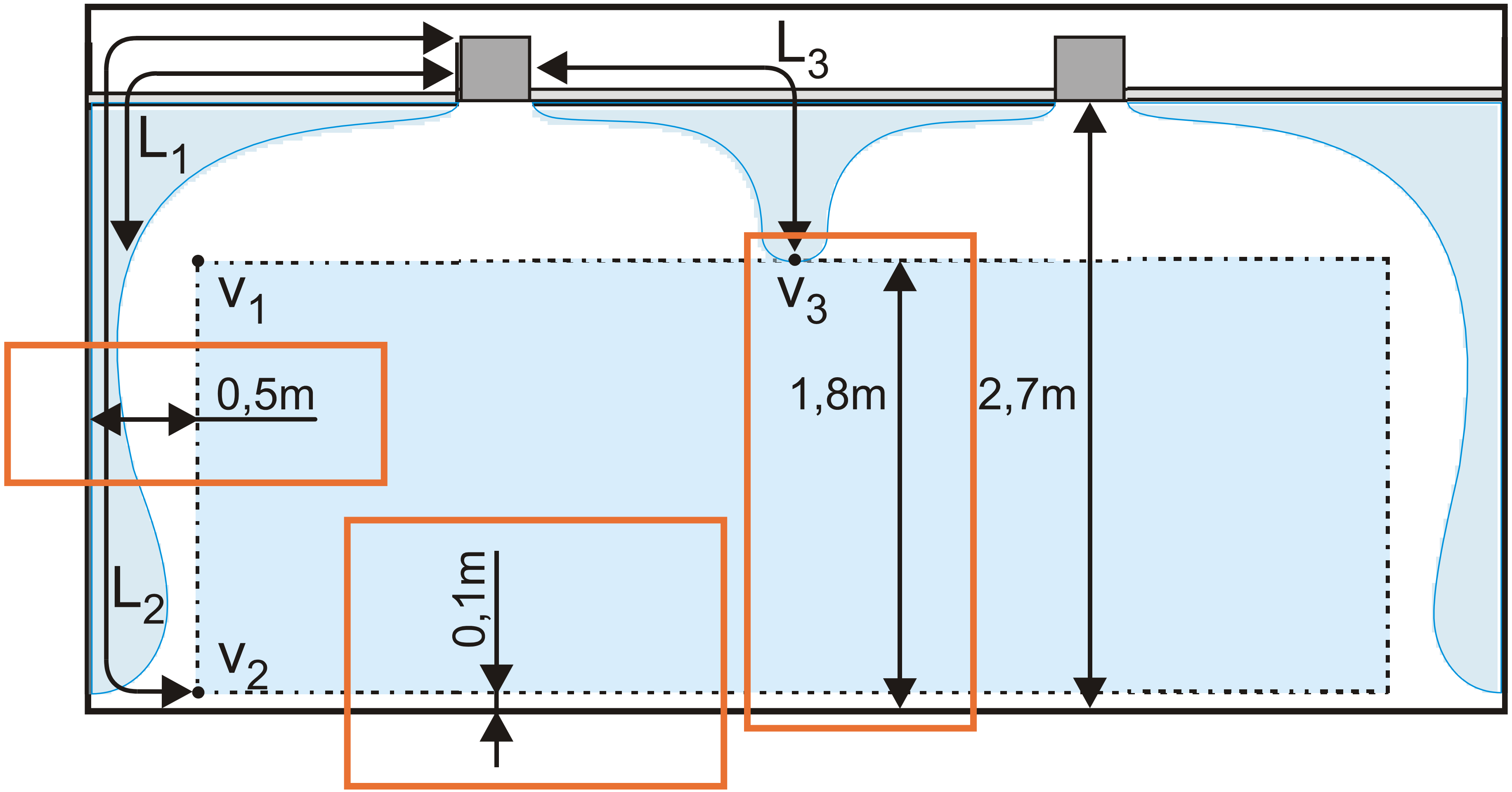
Air Velocities in the Boundaries of the Occupied Zone should be Analyzed



Critical locations to check air velocities to prevent draught

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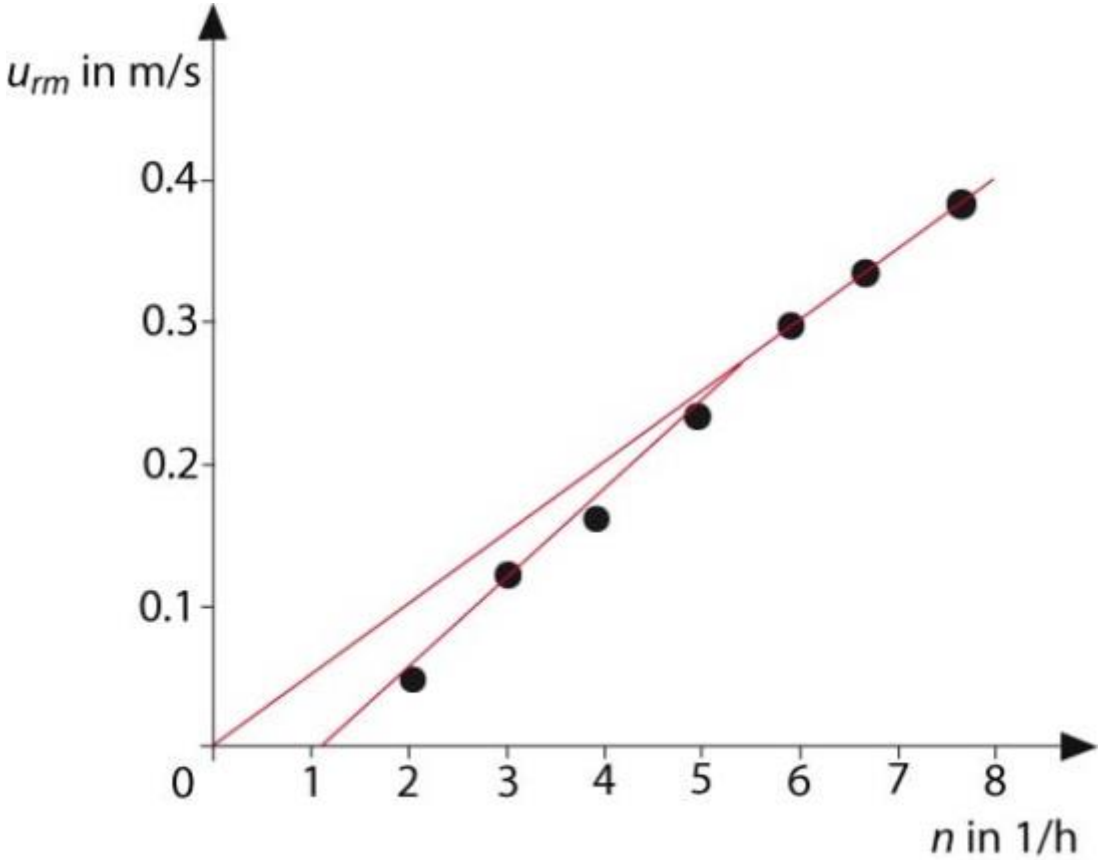
Maximum velocity, u_{rm}, measured in the occupied zone of a room versus air change rate in the case of isothermal mixing air distribution



Higher airflow rate means higher air velocities in somewhere in the occupied zone.

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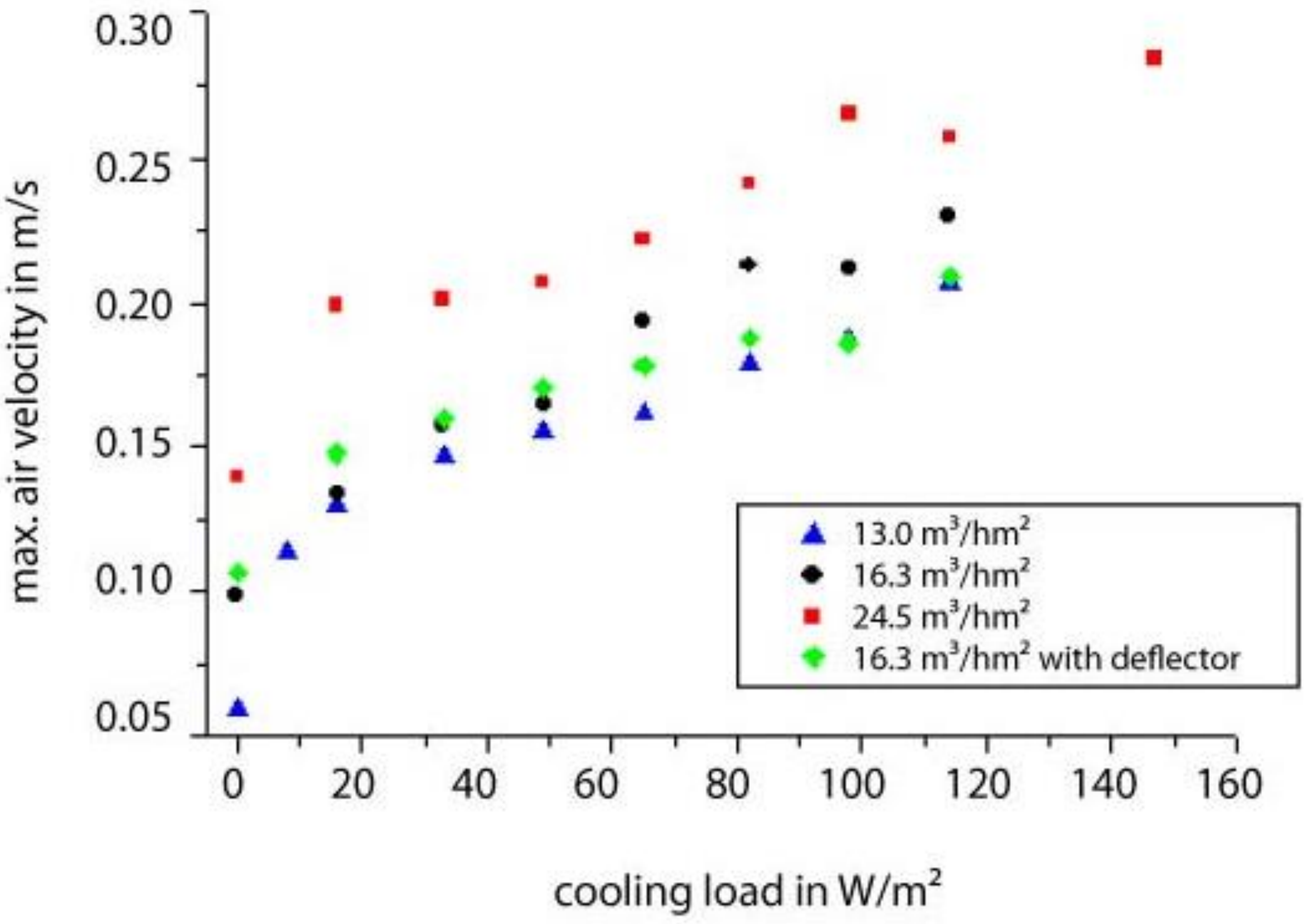
The maximum air velocity as a function of the floor area based cooling load.



The gradient of the maximum velocity is enhanced by decreasing supply air flow rates

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Buoyancy or momentum driving forces

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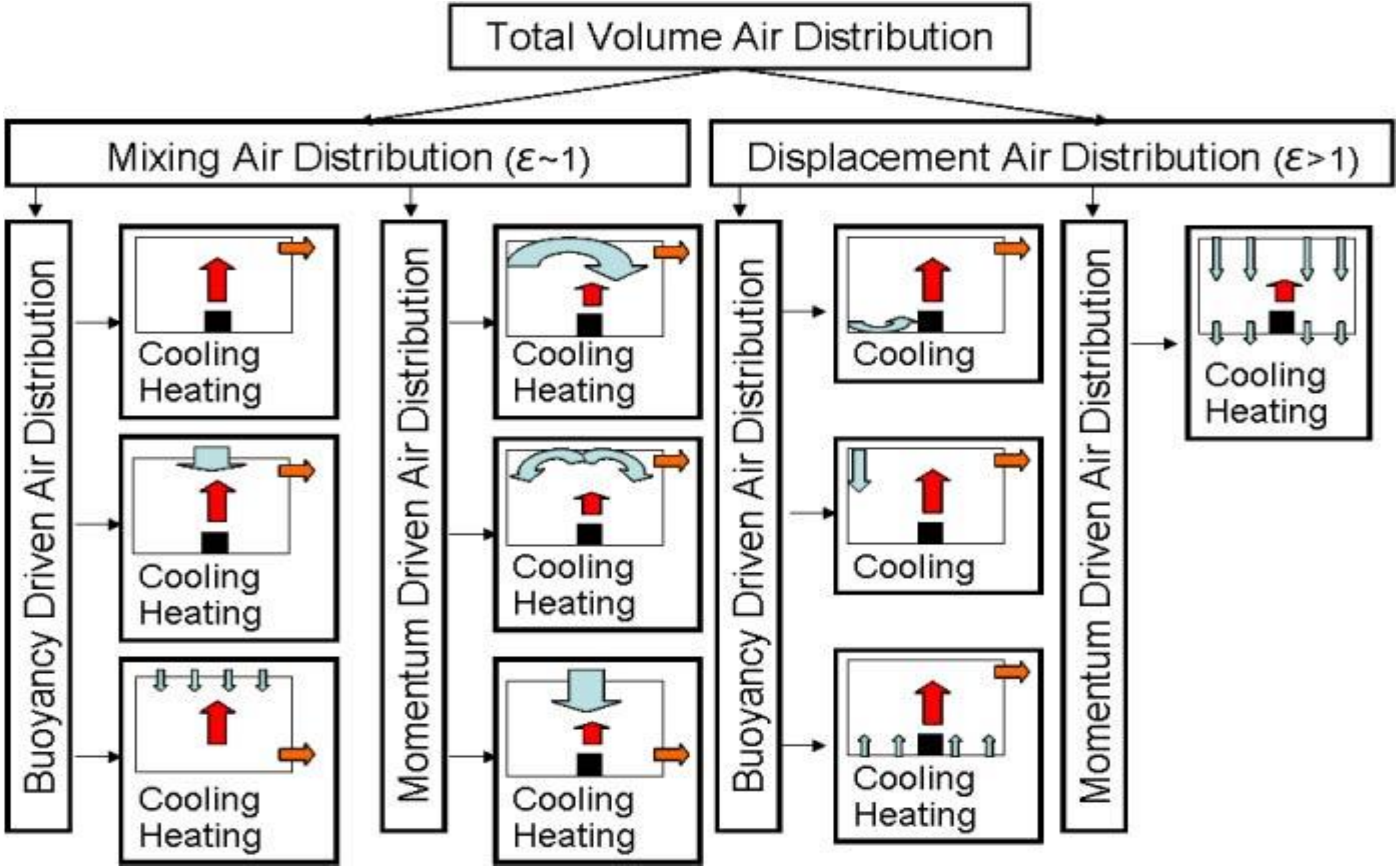
Air distribution modes: buoyancy or momentum driving forces.



Mixing Ventilation, Muller et al., REHVA Design Guide 19

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Archimedes number is the driver of air distribution

$$\mathrm{Ar} = \frac{\beta g h_o (T_e - T_o)}{u_o^2}$$

$$\mathrm{Ar}_{\mathrm{ratio}} = \frac{T_e - T_o}{q_o^2}$$

Where T_o and T_e are supply air temperature and return air temperature, the supply velocity at the diffuser, u_o. the height of the supply opening, h_o

q_o is the flow rate equal to the product of the supply velocity and supply area $u_o{\cdot}a_o$.

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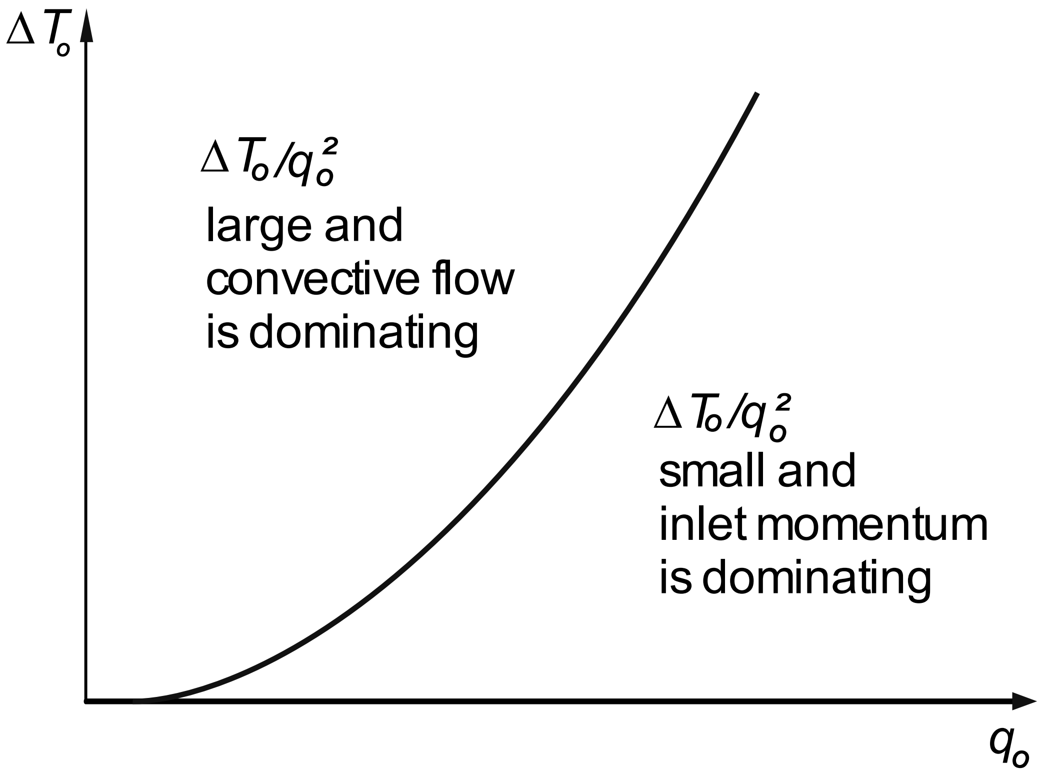
Principle determination of airflow in a room based on the critical Archimedes ratio



For the conditions in the left side of the curve the air distribution is dominated by convective flow while inlet momentum flow is dominating for the conditions at the right side of the curve.

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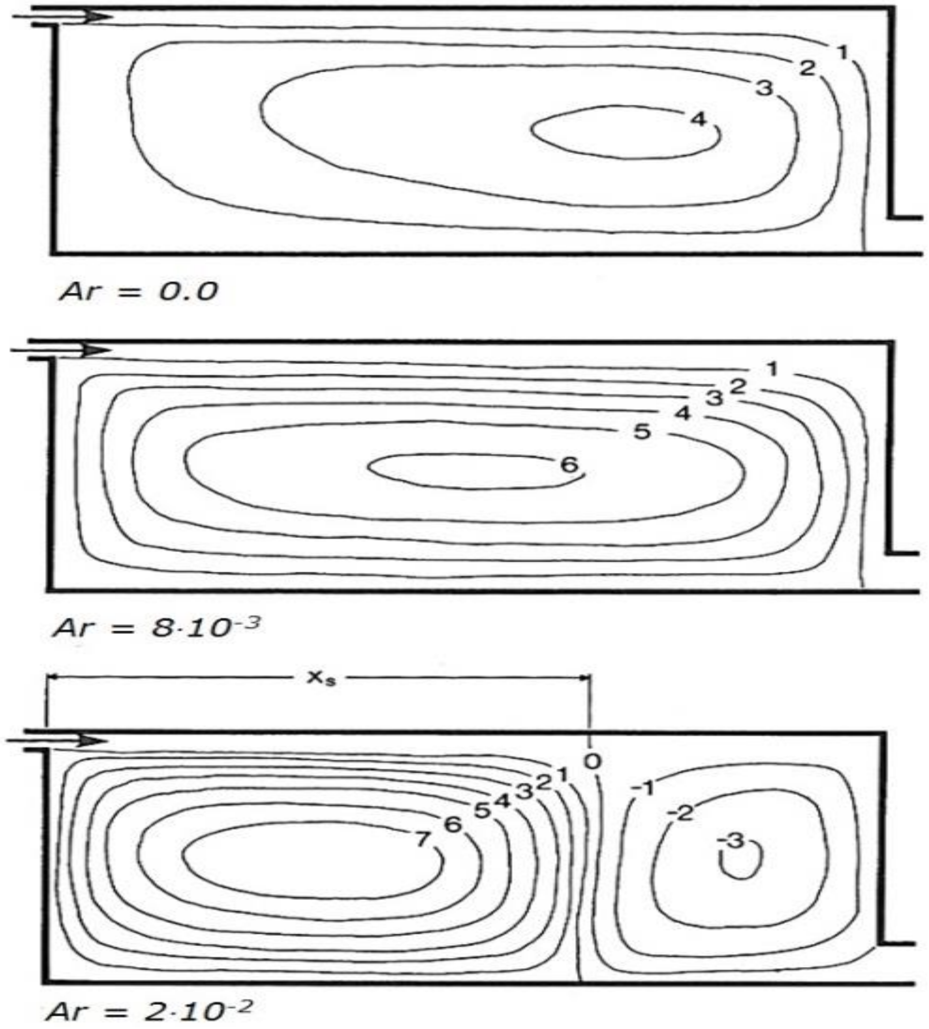
Streamline distribution in a room at different Archimedes numbers.



Increasing load results in an increasing air velocity and reduction of the penetration depth of the supply jet.

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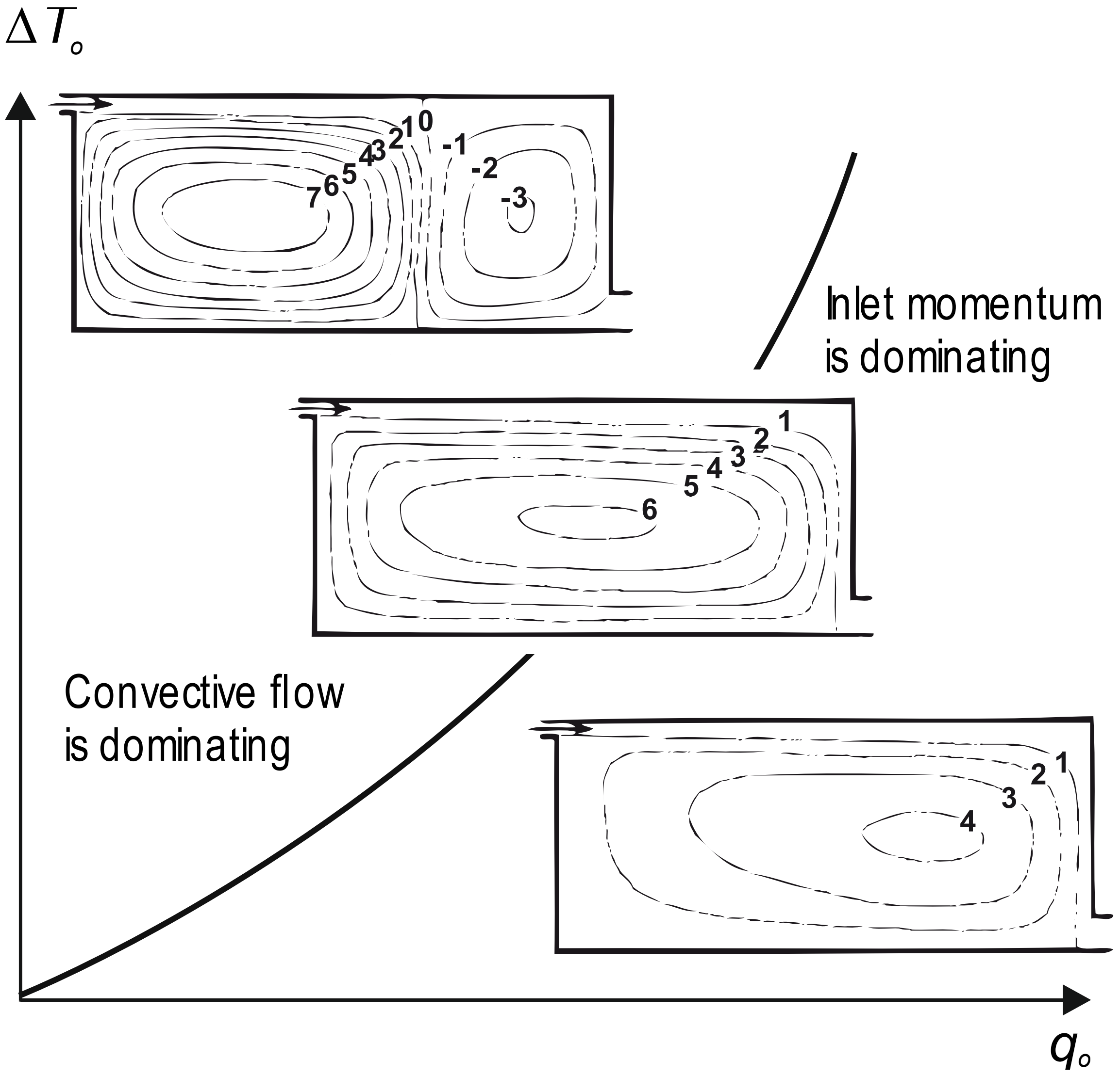
Three situations arranged according to the size of the critical Archimedes number



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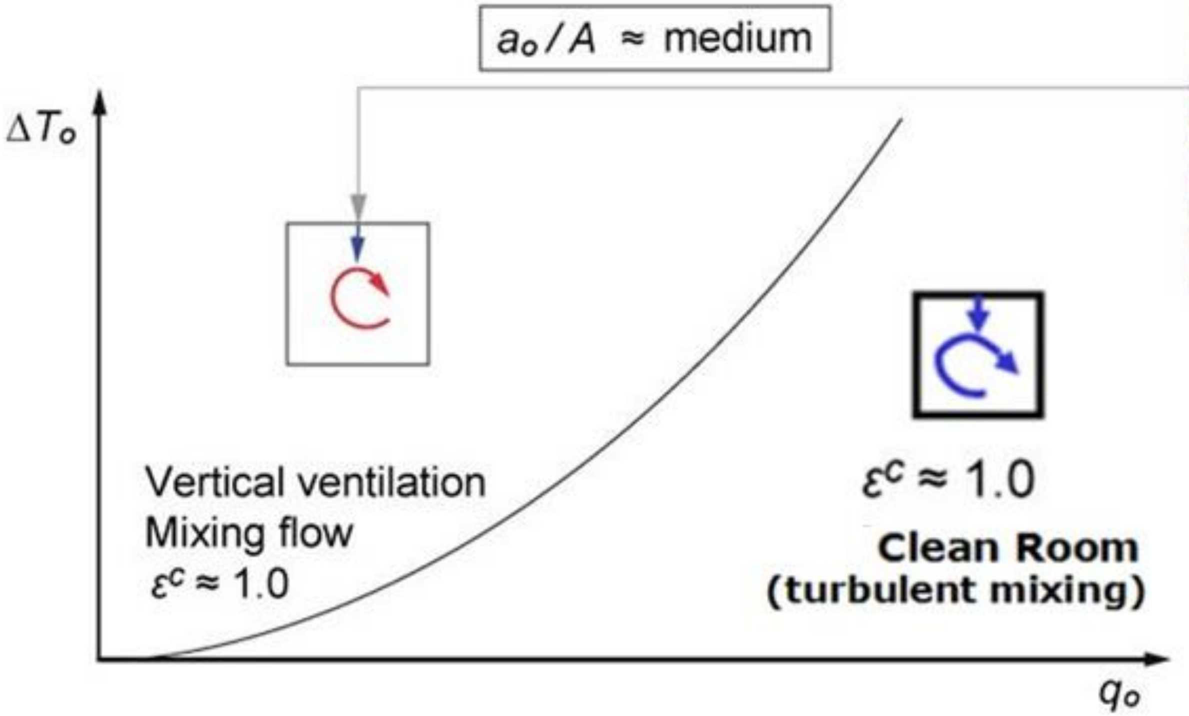
Low and high momentum mixing ventilation



Mixing ventilation could be based on convection flows or high momentum flux jets

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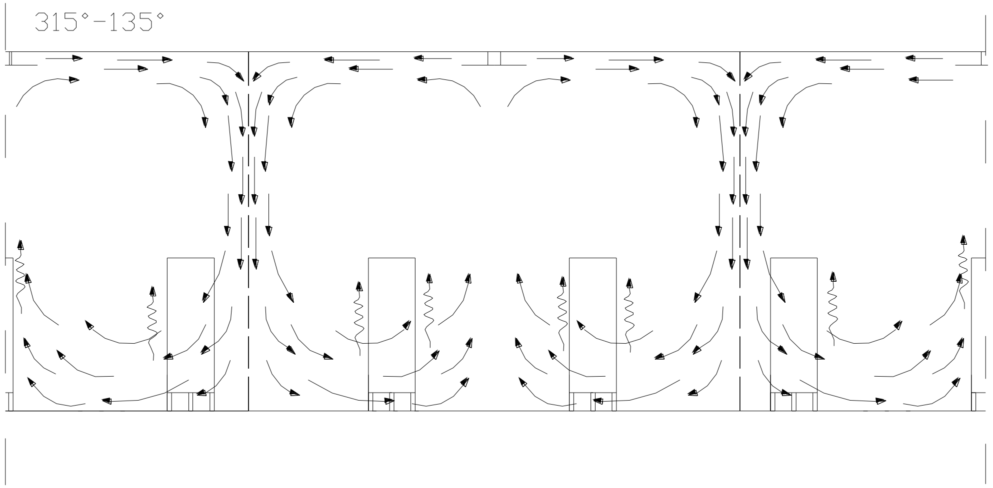
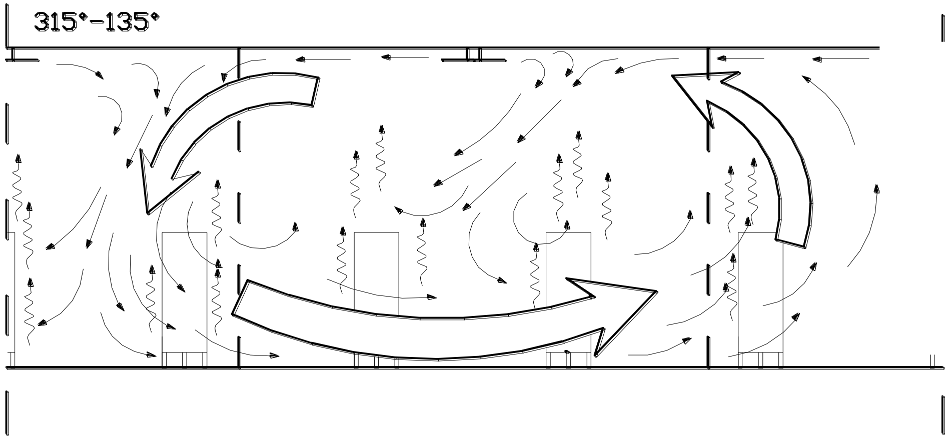
With the high heat gain, the flow structure changed





Cubic shaped air flow pattern are established at supply air flow rate of 16.3 $m^3/h,m^2$ and thermal heat load of 16 W/m^2 (top);

The cubic shaped flow pattern is removed by a room filling air vortex, if the heat load exceeds approximately 50 W/m^2 (bottom).

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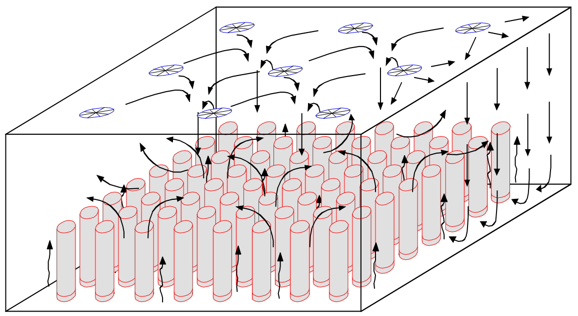
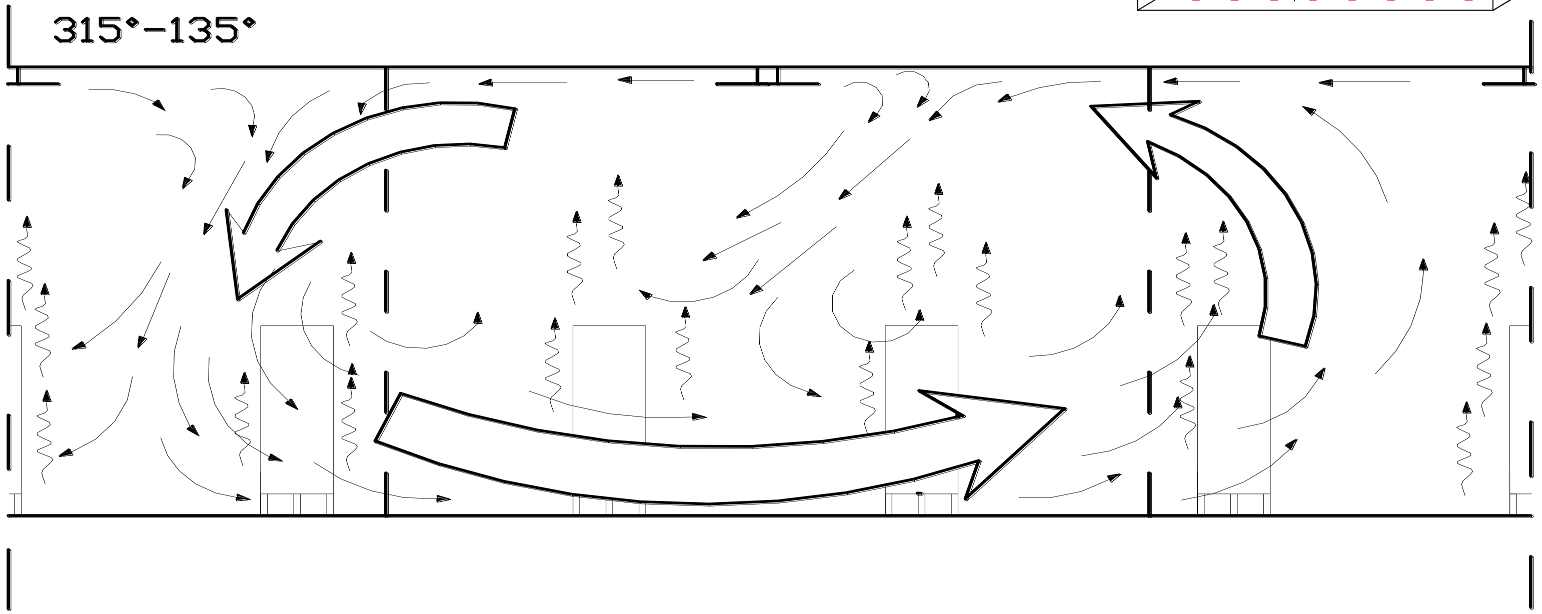
Airflow Interaction in Spaces





The cubic shaped airflow pattern is removed by a room filling air vortex, if the cooling load exceeds approximately 20-50 W/m²

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Interaction of convective flows and jets

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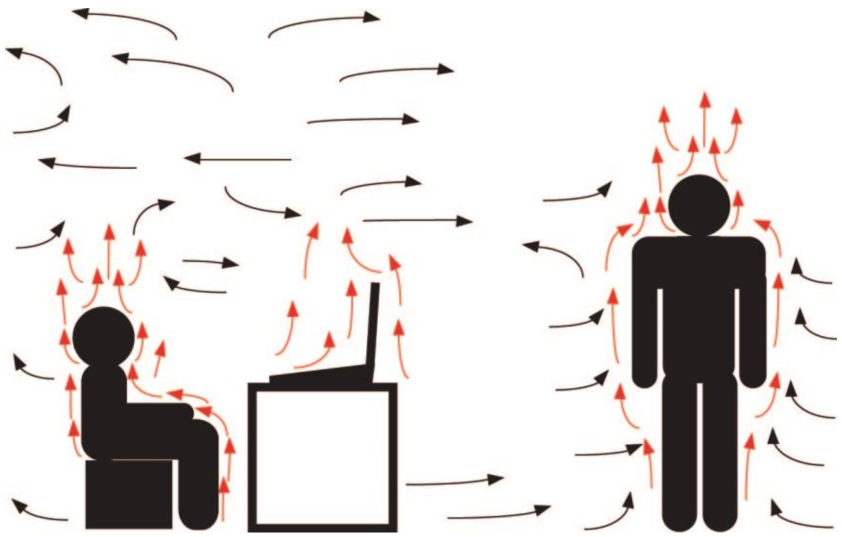
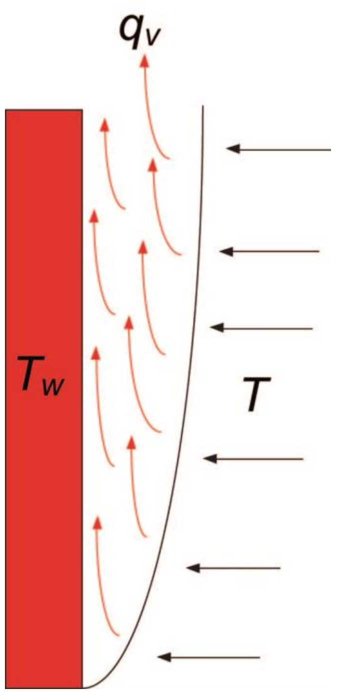
Buoyant flow elements



Thermal plumes of equipment and persons.



Thermal plume of warm/cold window

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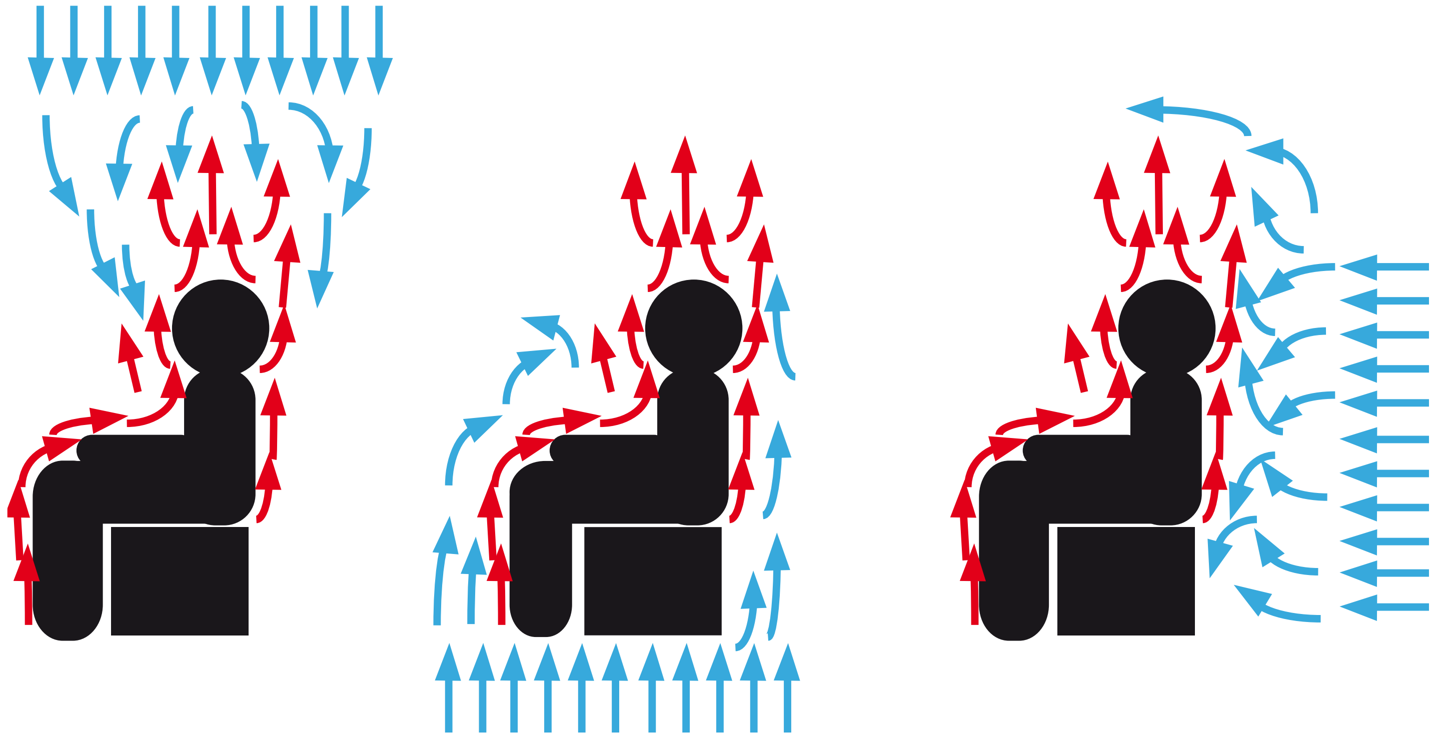
Interaction of ventilation flow with free convection flow around human body



Ventilation flow from bellow will assist the free convection flow and will increase the body heat loss

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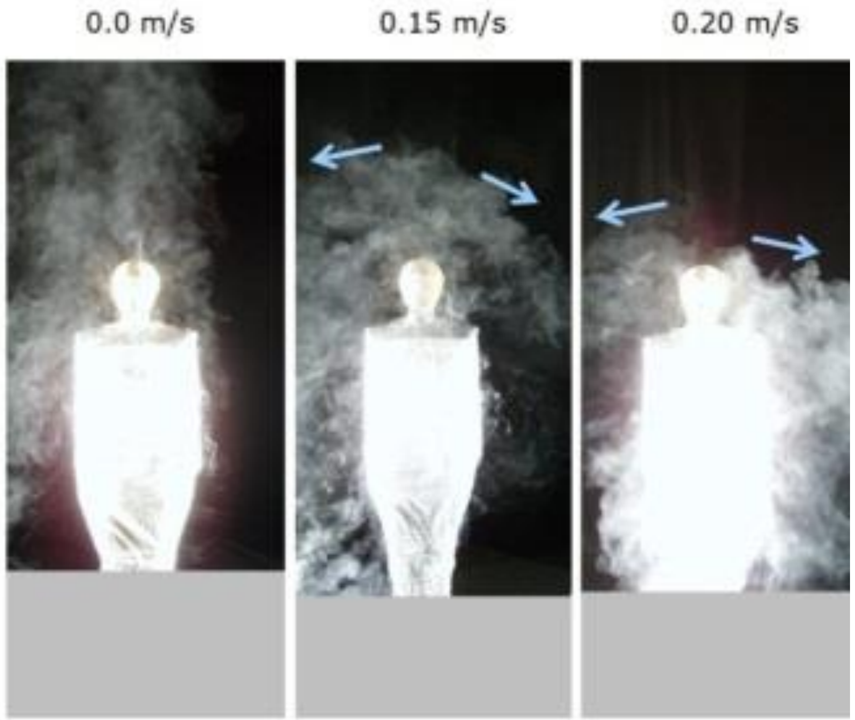
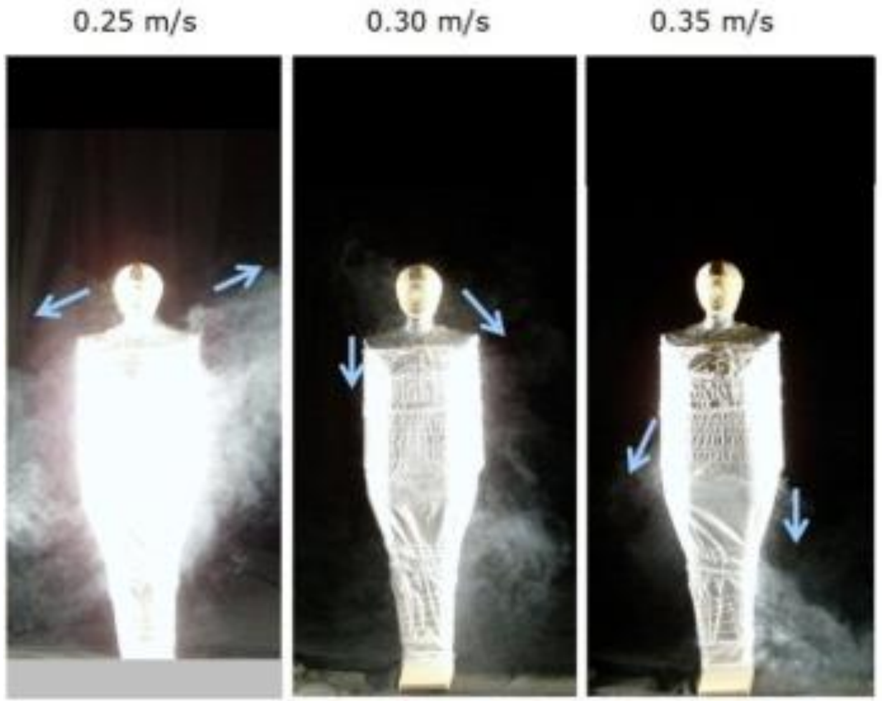
Thermal plume from standing human body and downward ventilation flow





The thermal plume above a person has an upward velocity of approx. 0.25 m/s, and this flow often prevents draught at head height

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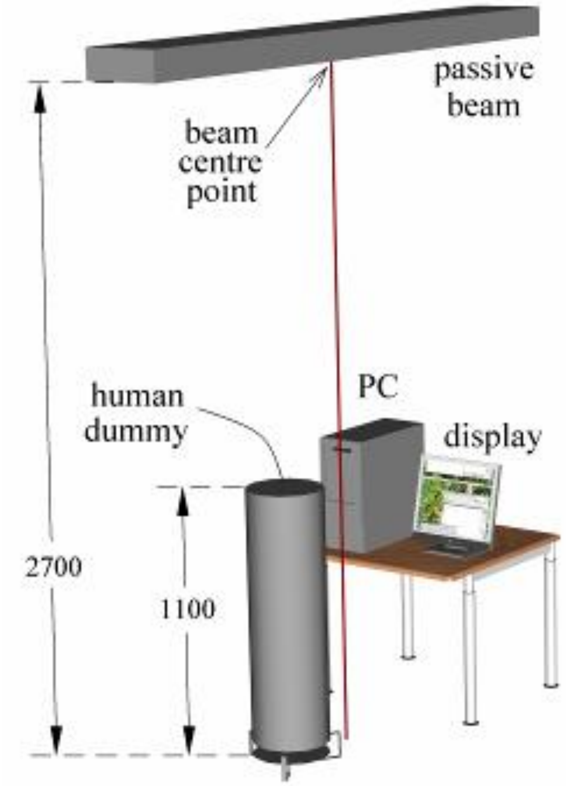
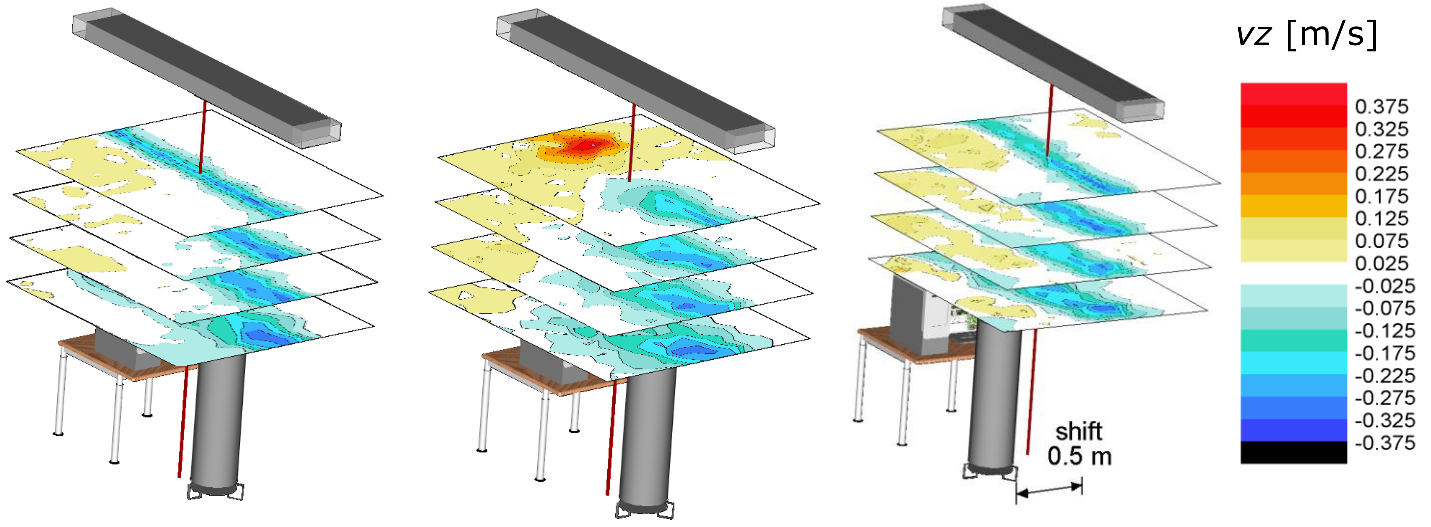
Passive beam installed over workplace





load: human + PC + display

extra load 200 W near the PC

load aside of the beam centre line

The air velocity can create draught at specific cooling capacity of the beam higher than 200 W per linear metre.

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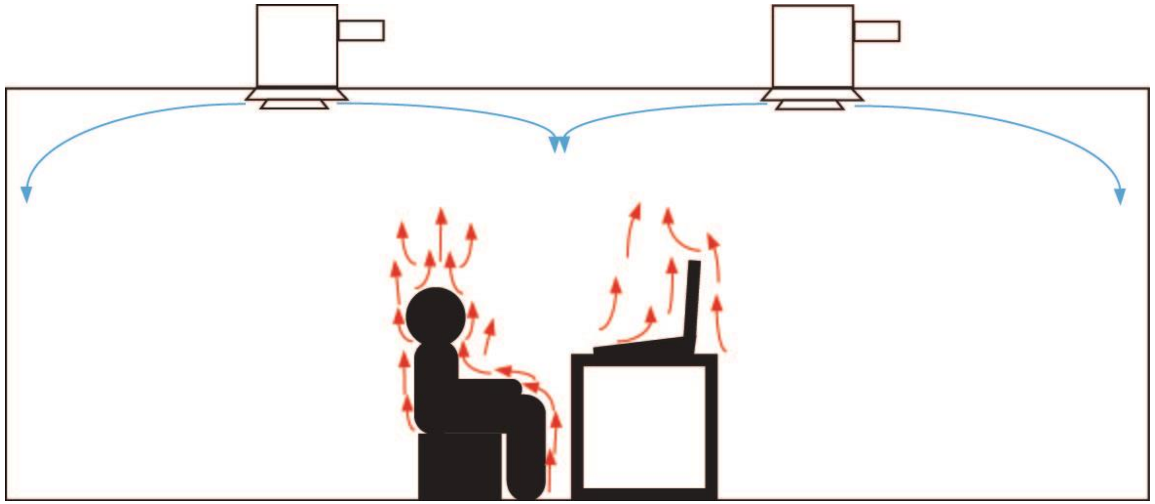
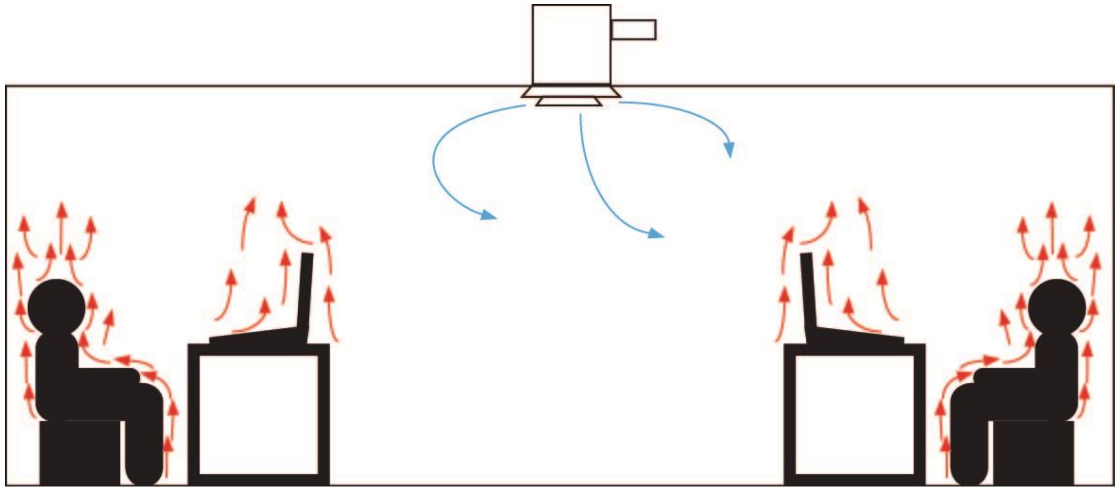
Airflow interaction affects air distribution in rooms





High heat gains turn the jet

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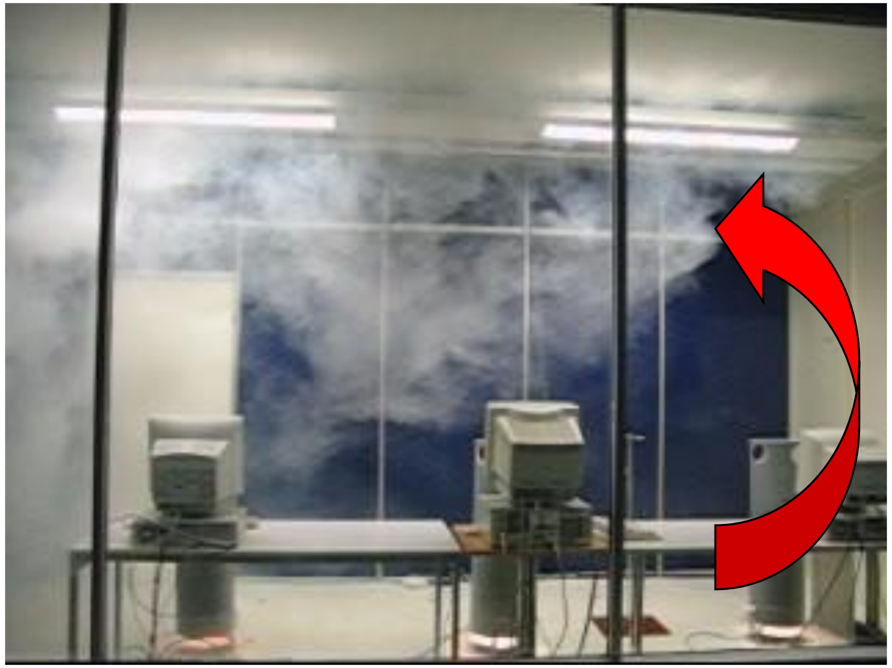
Warm window creates convection flow that has an influnce on air distribution

Swirl diffuser



Chilled beam

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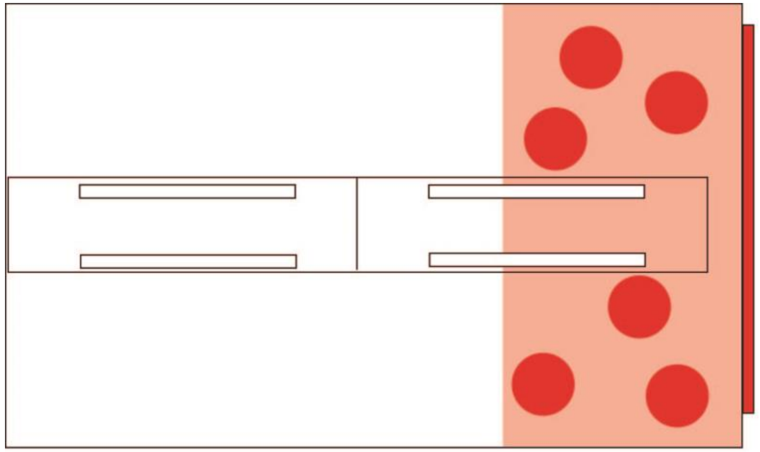
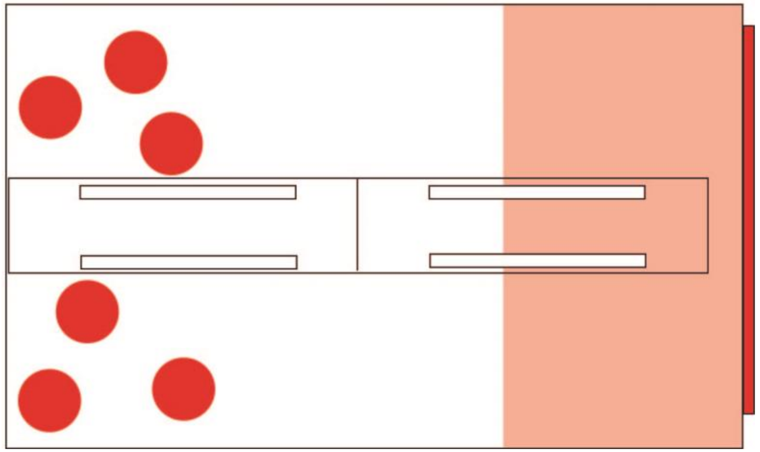
Different heat load distribution





Strong influence of the heat sources distribution on air distribution

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Short discussion

How to mitigate the effect of heat gain on air distribution ?

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THANK YOU!