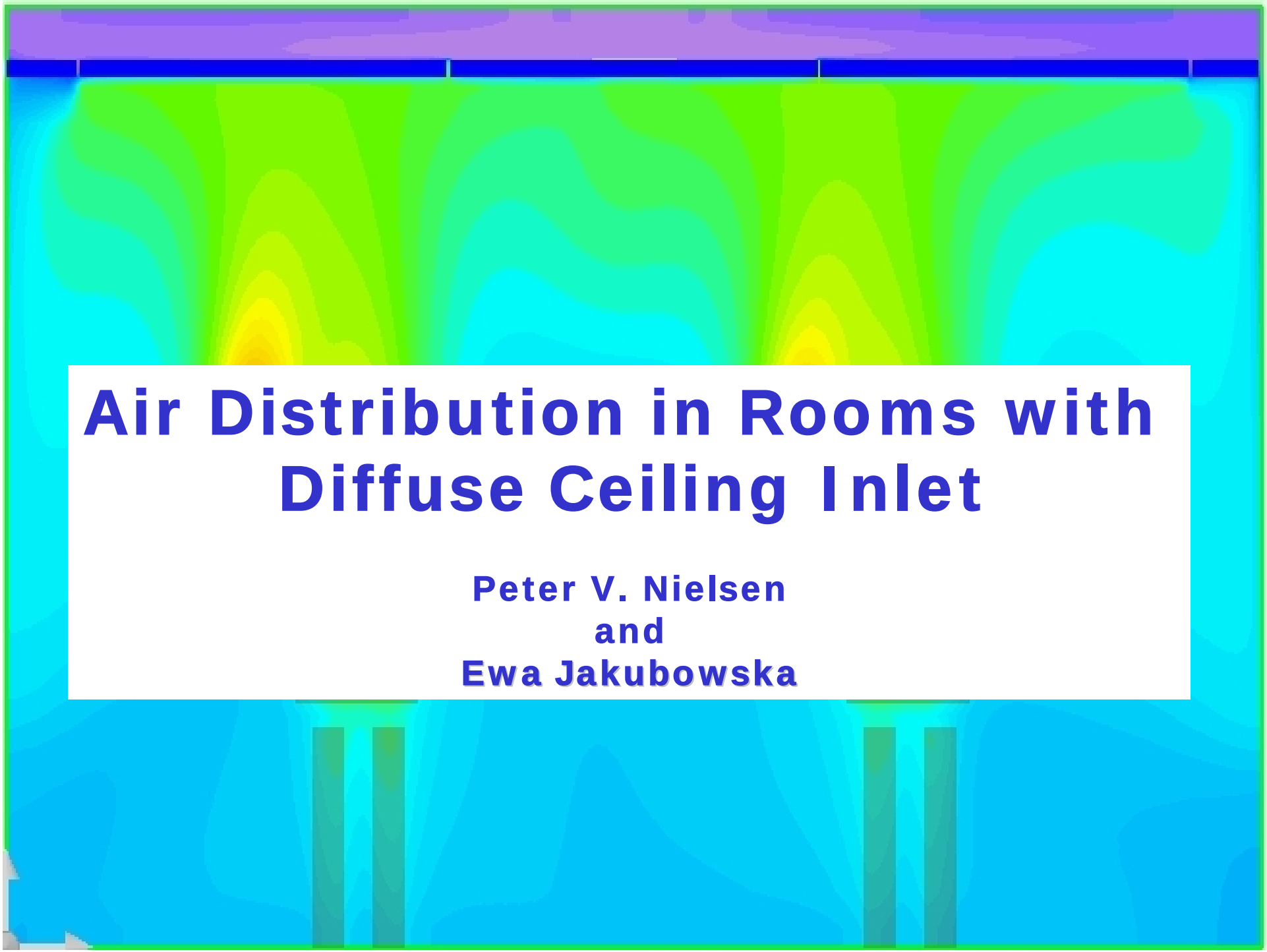
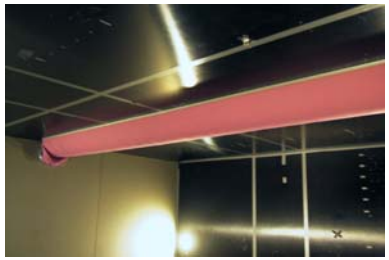


Air Distribution in Rooms with Diffuse Ceiling Inlet

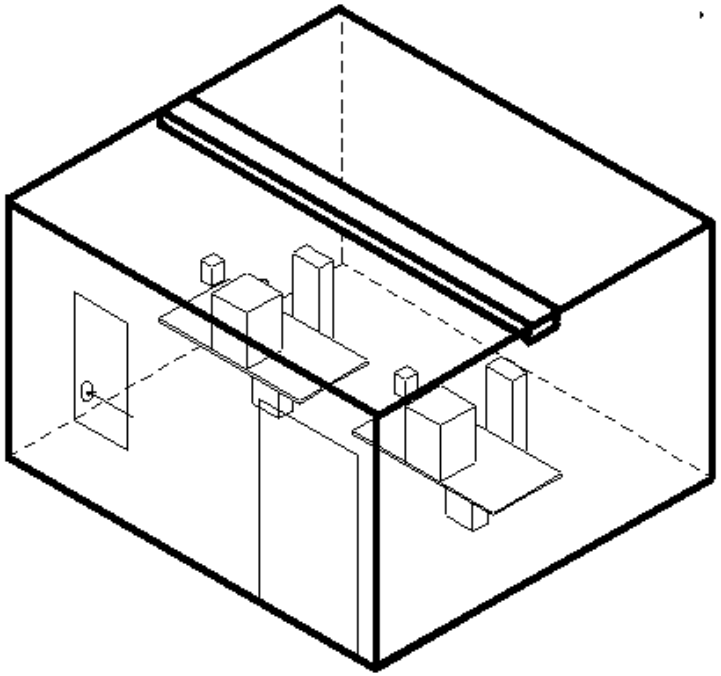
Peter V. Nielsen
and
Ewa Jakubowska

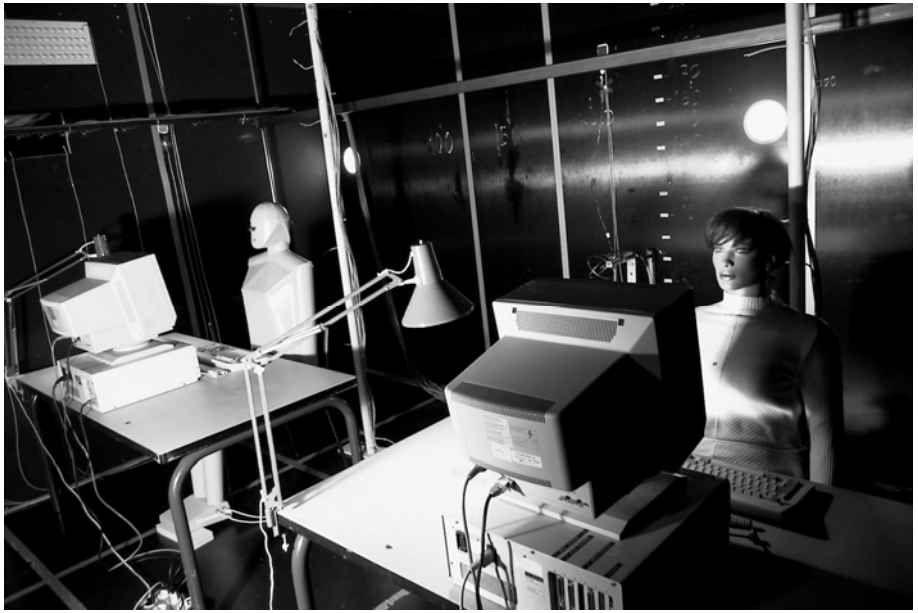
Six Different Air Distribution Systems

-Tested in the same geometry and with the same load



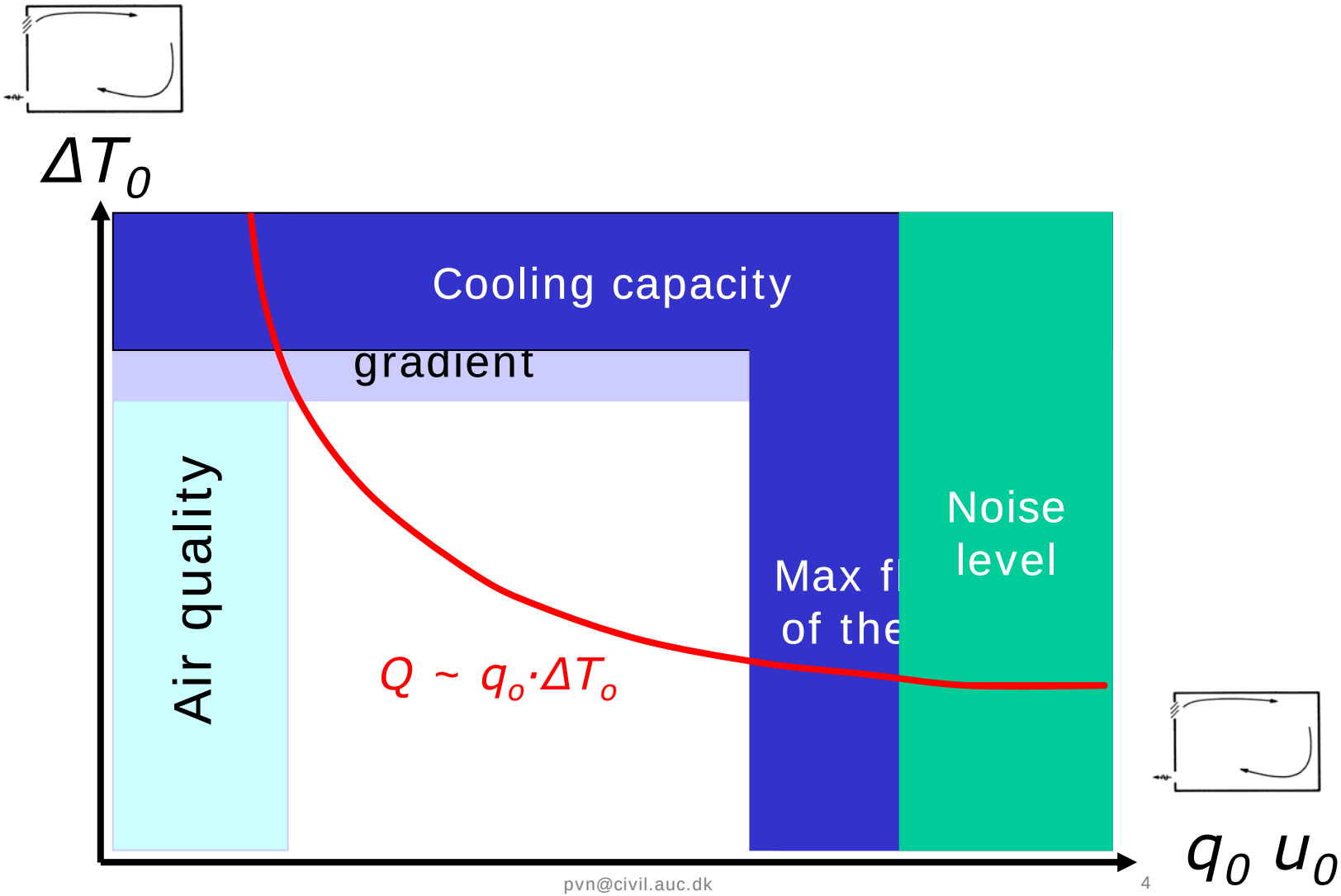
The Test Room with Two Persons





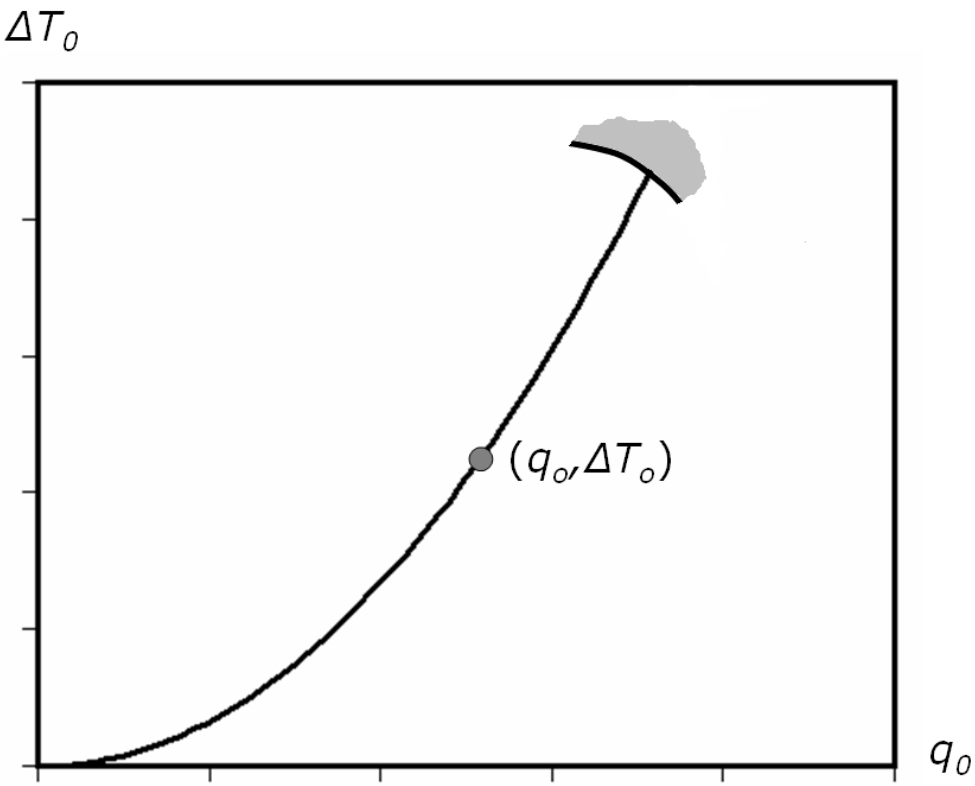
The test room is the IEA Annex 20 room with length, width and height equal to 4.2 m, 3.6 m and 2.5 m.
The heat load consists of two PCs, two desk lamps and two manikins producing a total heat load of 480 W.

The q_o-ΔT_o Design Chart



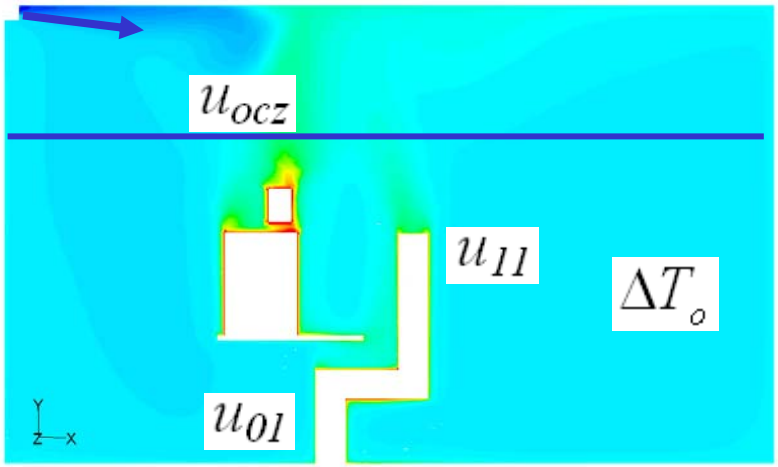
The q_o-ΔT_o Design Chart

Dimensional analysis shows that $u/u_o = f(Ar)$ for fully developed turbulence. For $Ar = const_1$, $u_o = 0.15\ const_2$



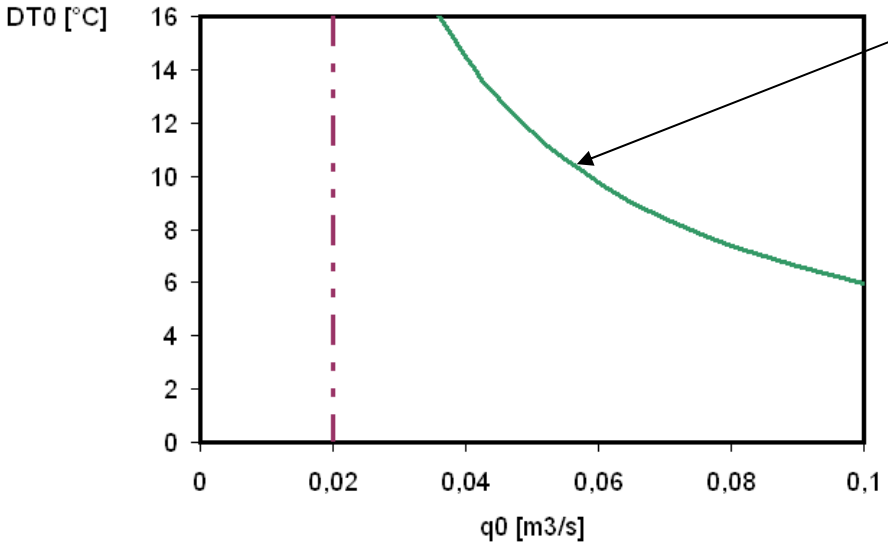
$Ar \sim \Delta T_o/u_o^2$

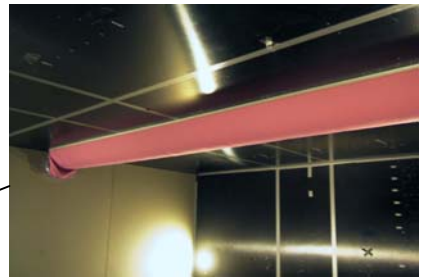
Design of an Air Distribution System



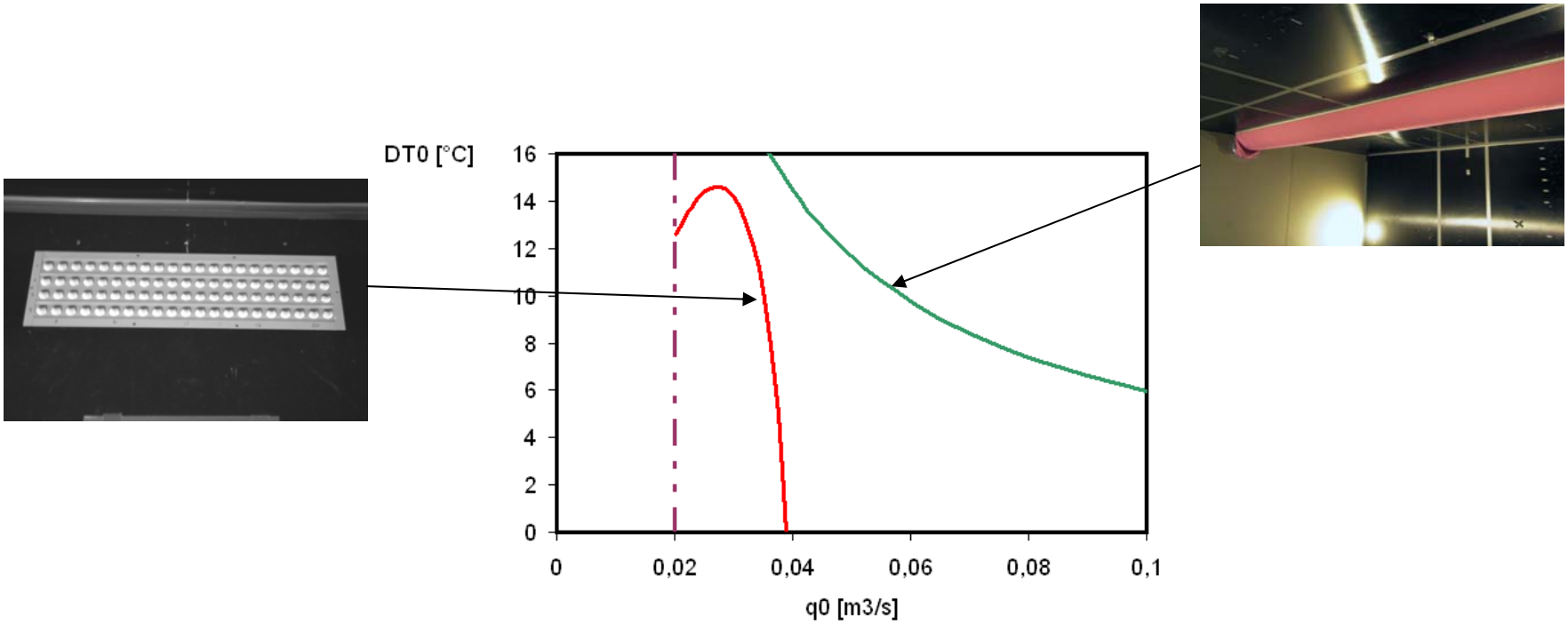
- Design according to maximum velocity entering the occupied zone
- Design according to maximum velocity at ankle height
- Design according to maximum velocity at the neck
- Restricted vertical temperature gradient

Design Chart

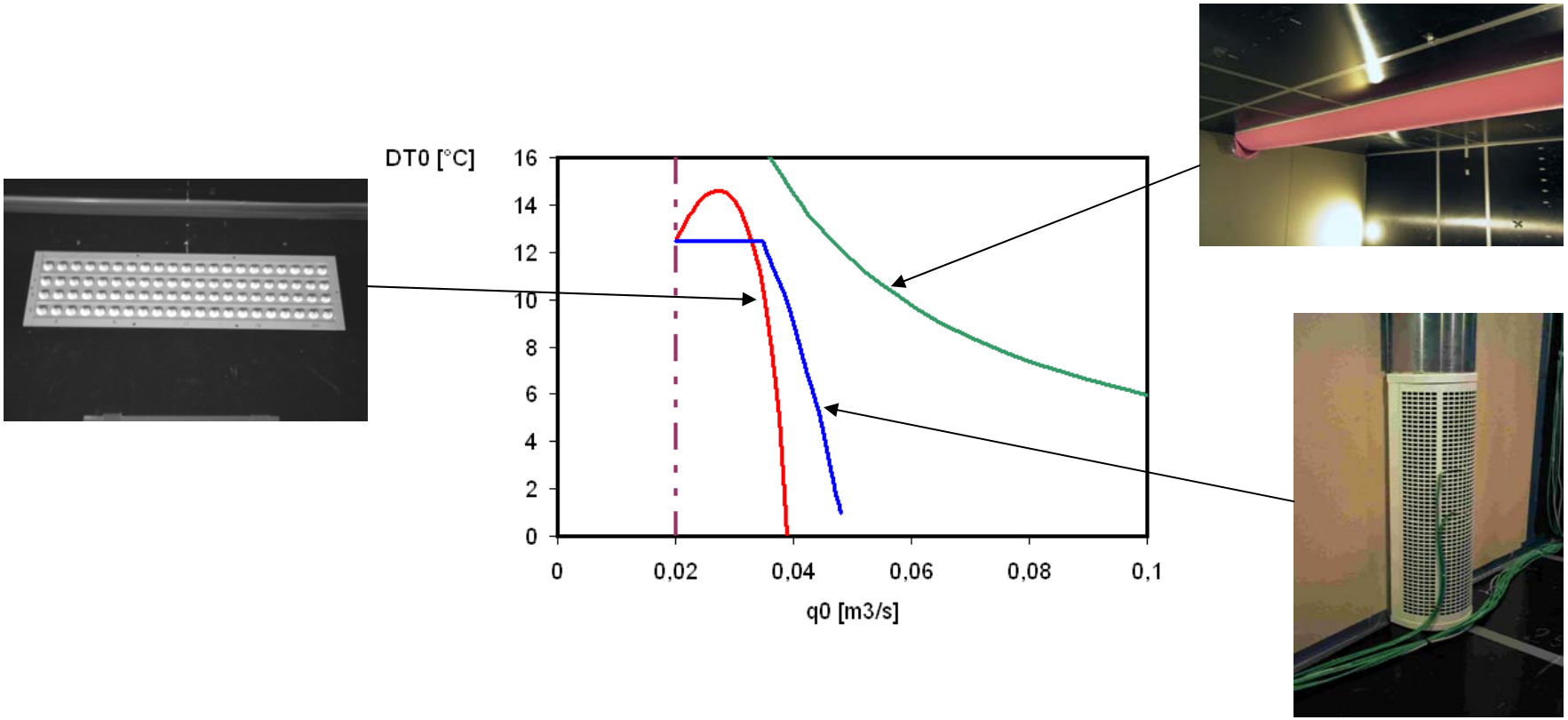




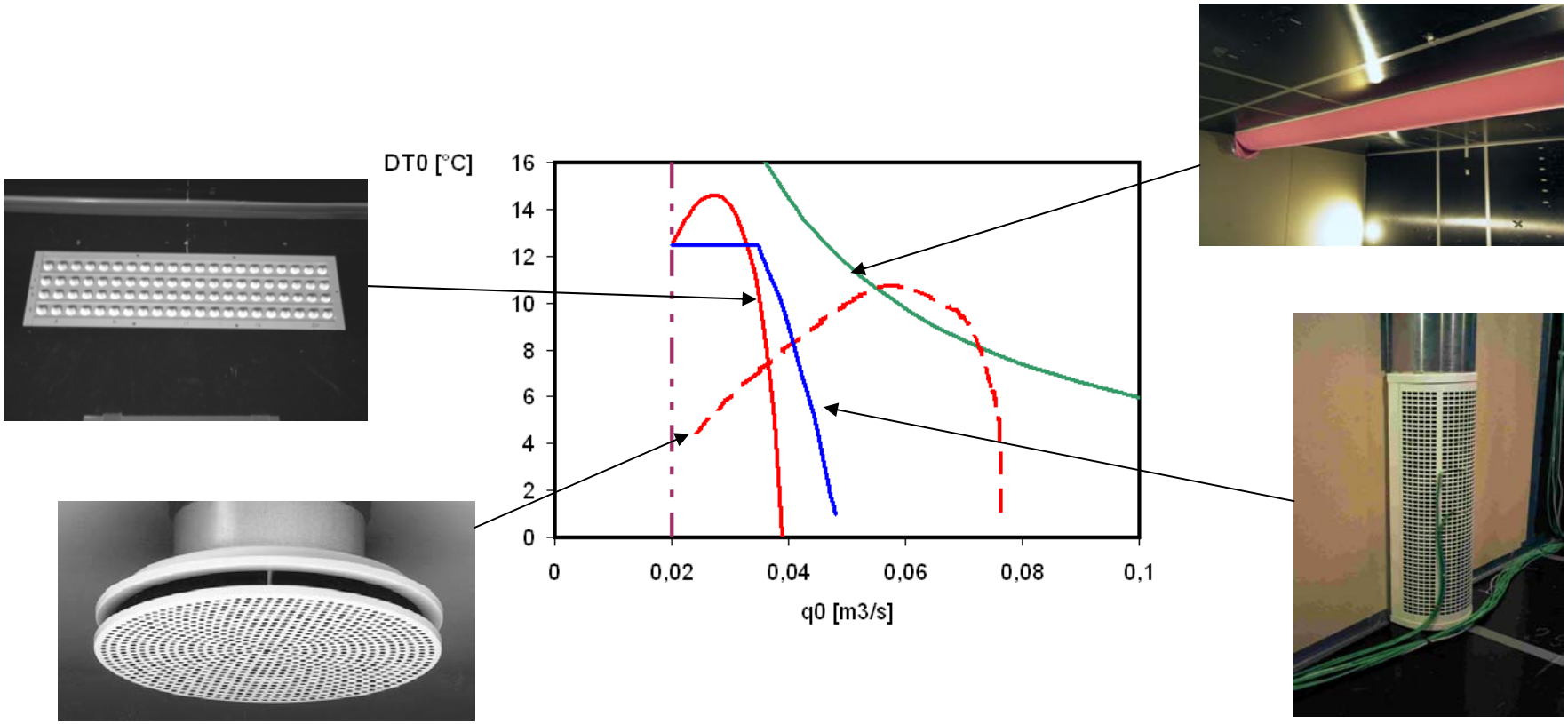
Design Chart



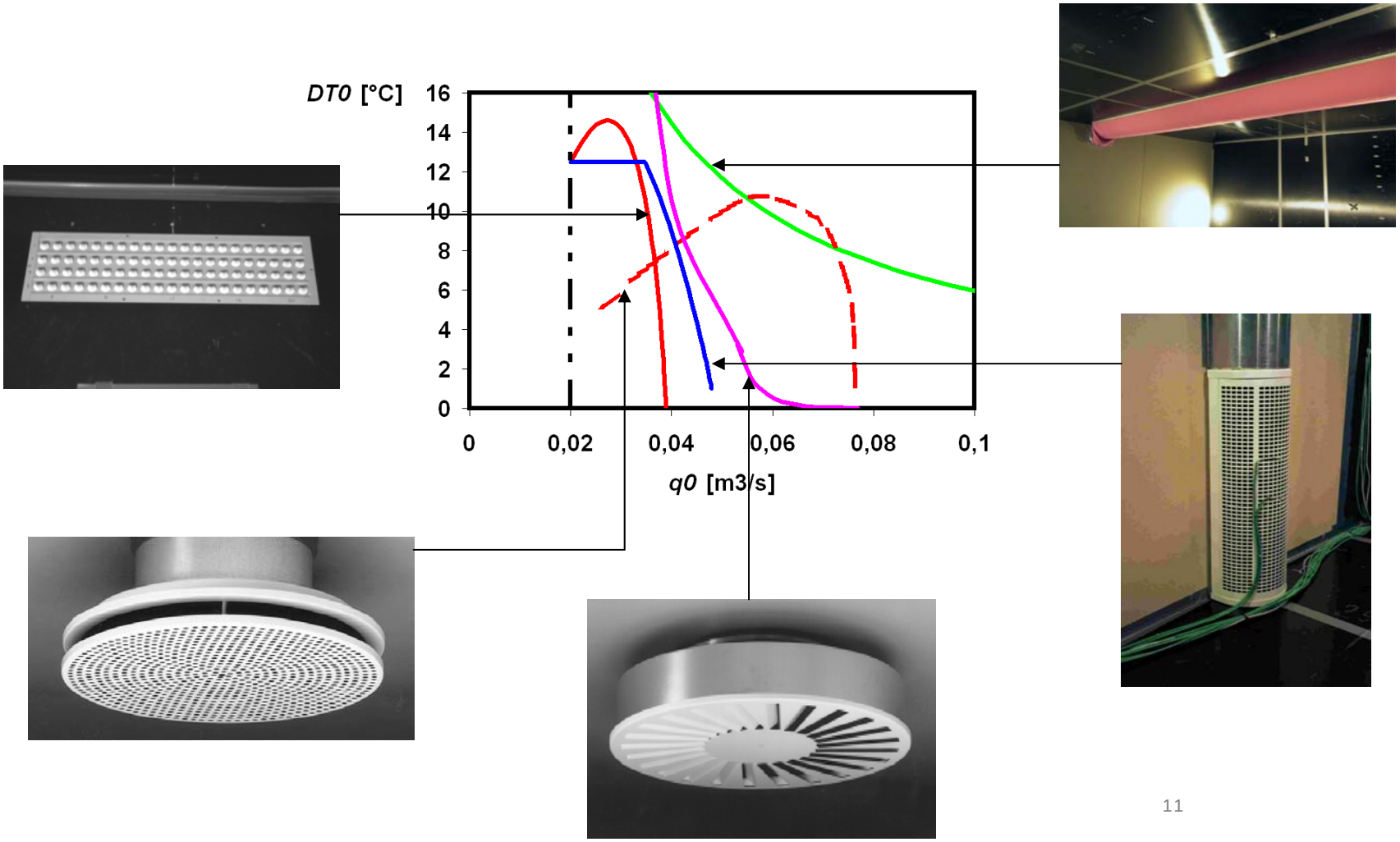
Design Chart



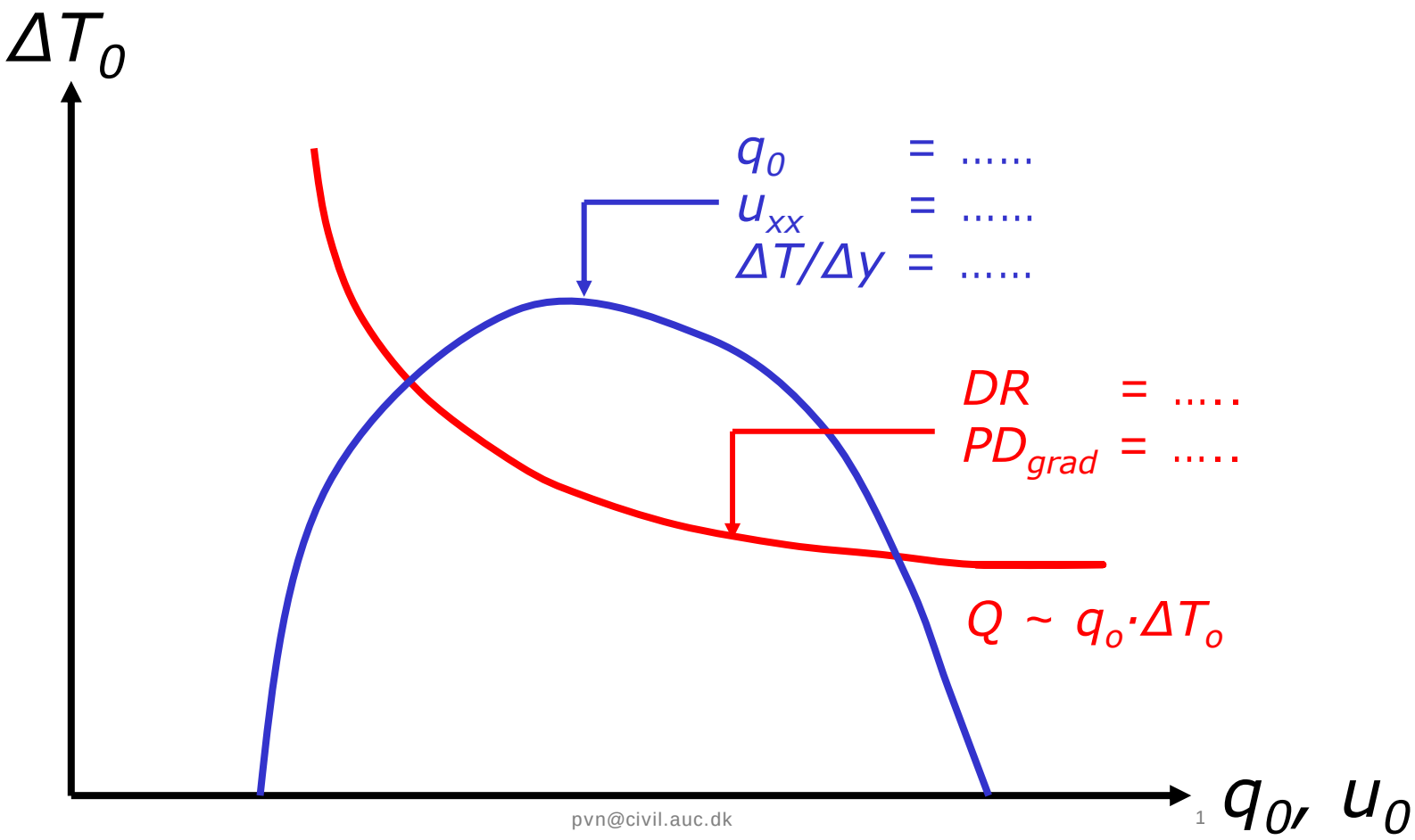
Design Chart



Design Chart

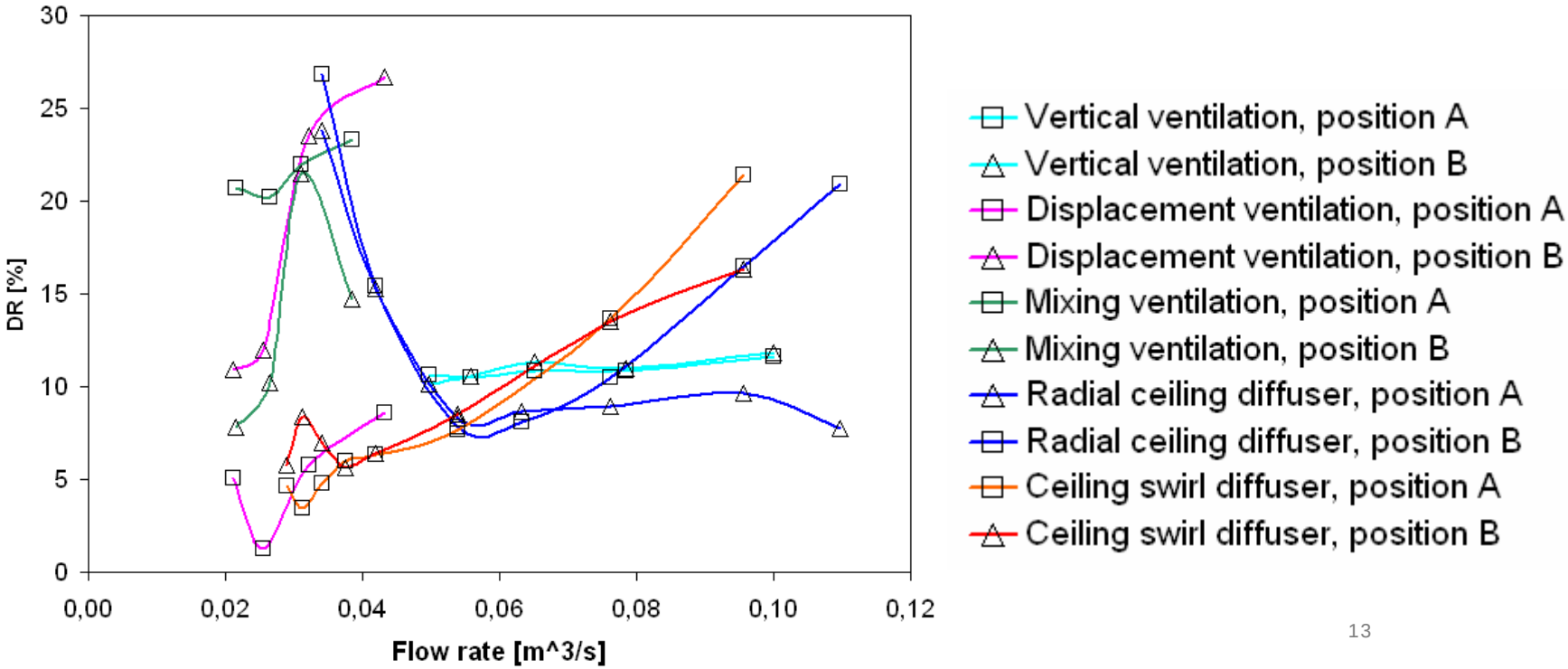


Optimal Working Conditions inside the Design Chart



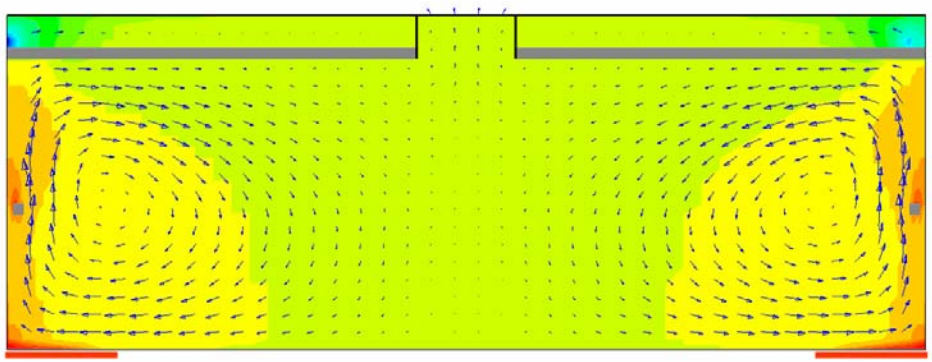
Local Discomfort

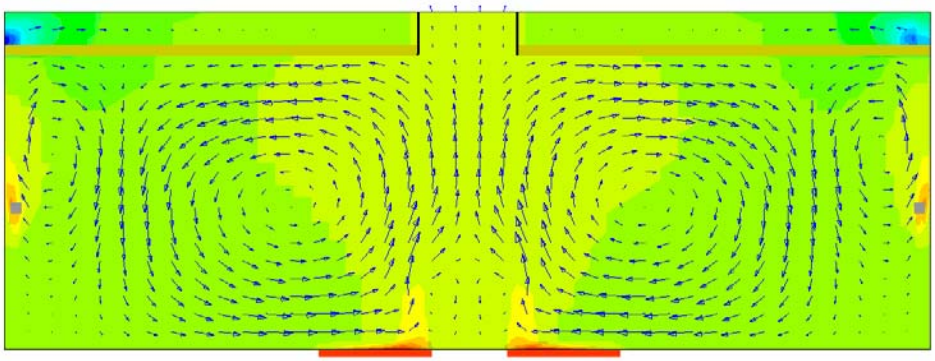
Draft rating, *DR,* versus air flow rate q_o for the five systems and for two locations. Location A is close to the end wall, and location B is close to the diffuser.



Livestock Buildings in DK

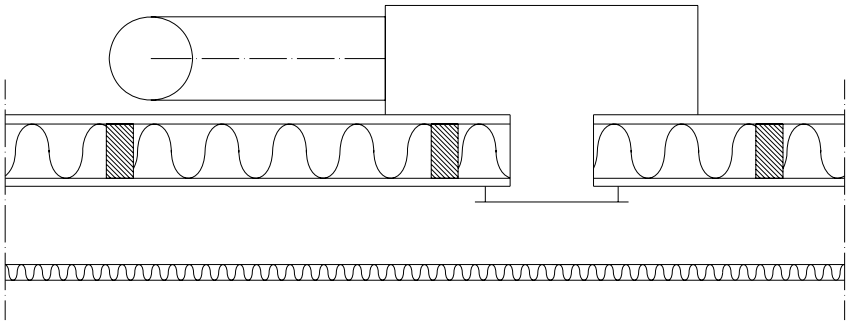
90 % of the market today in ventilation of livestock buildings in DK is by Diffuse Ceiling Inlet

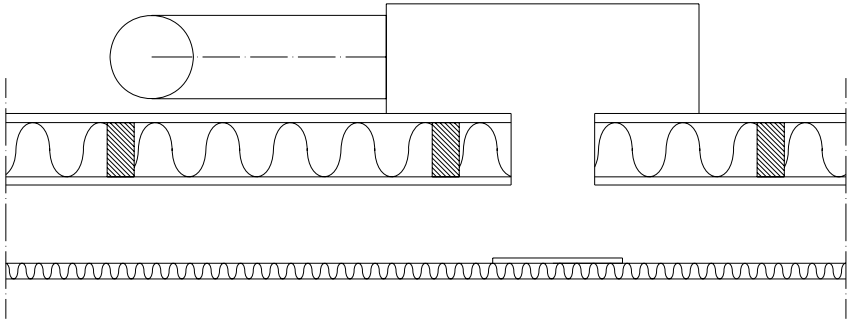


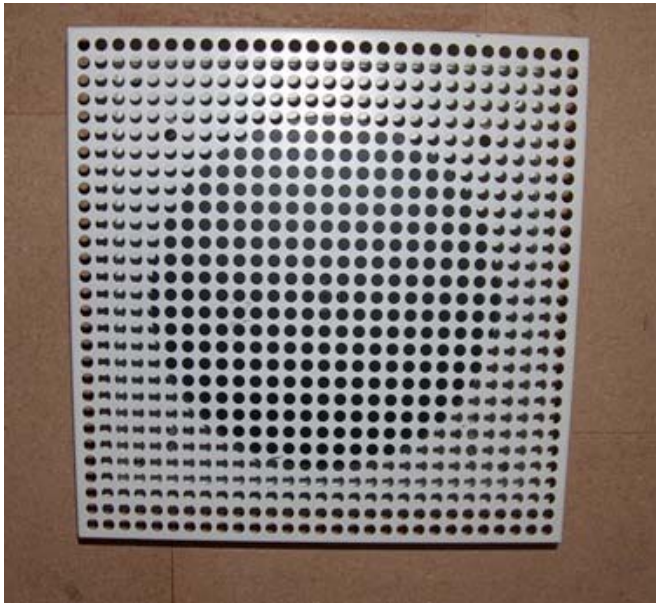


Rockfon Ceiling

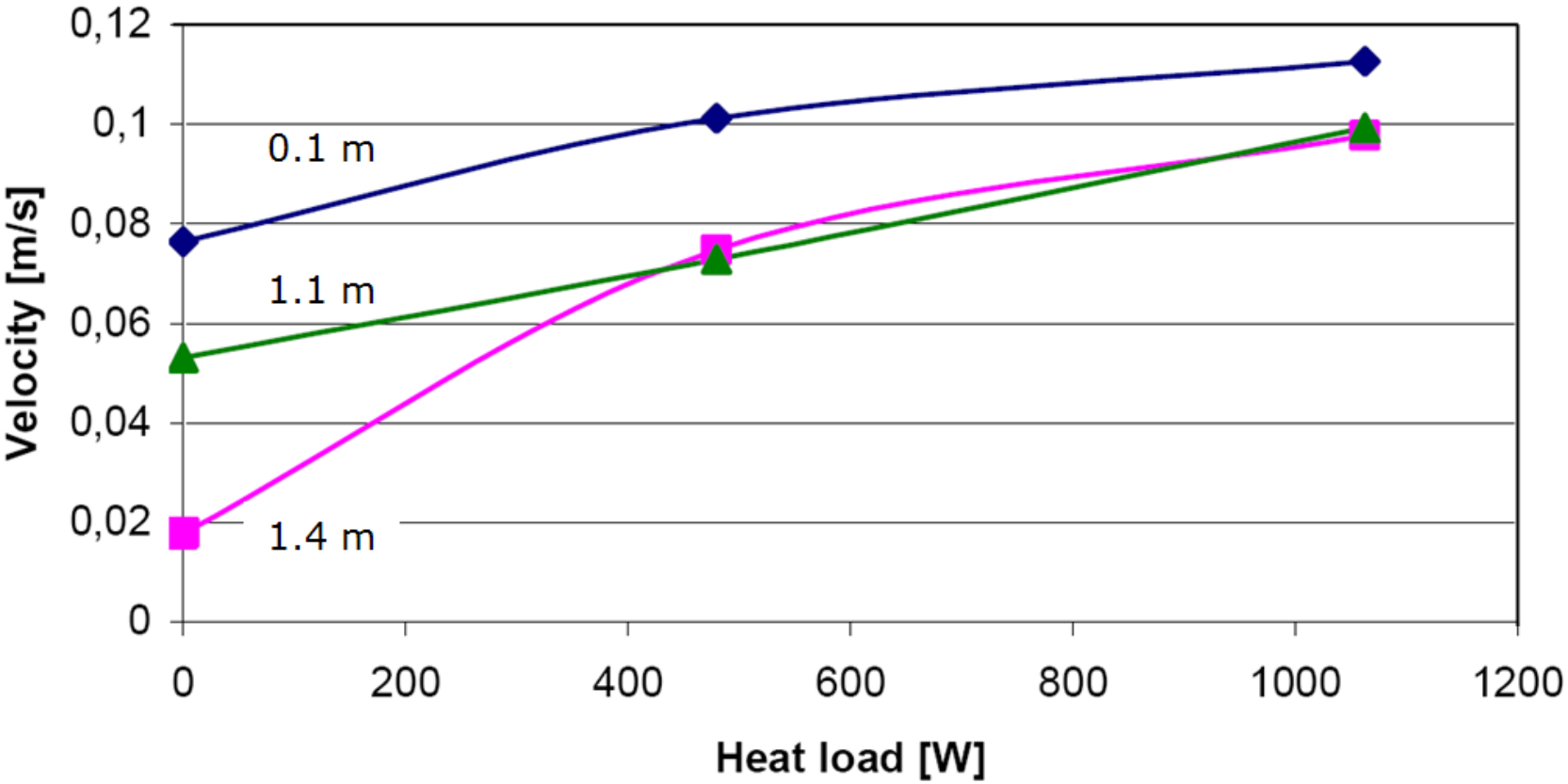
Types of Diffuser





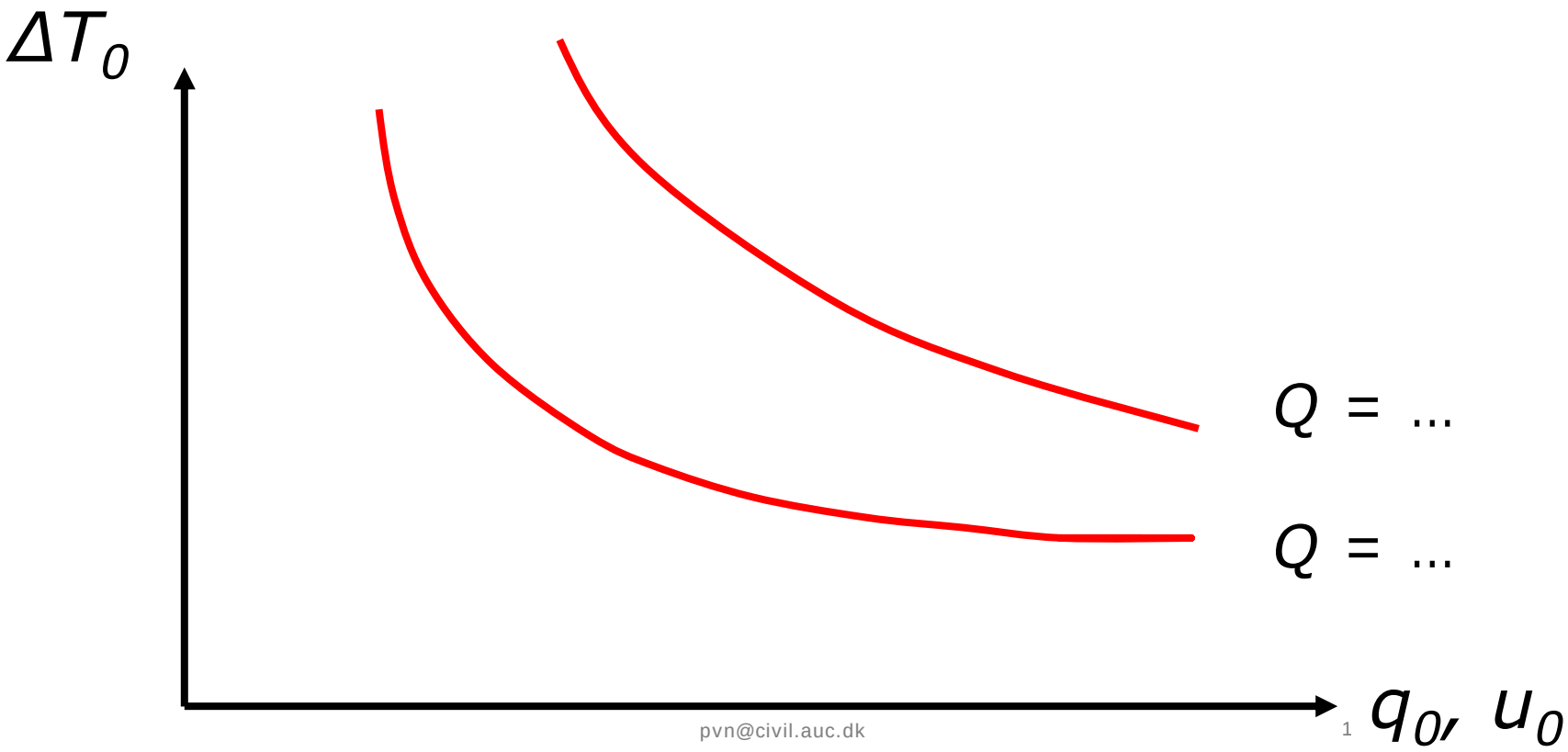


Velocity Versus Heat Load

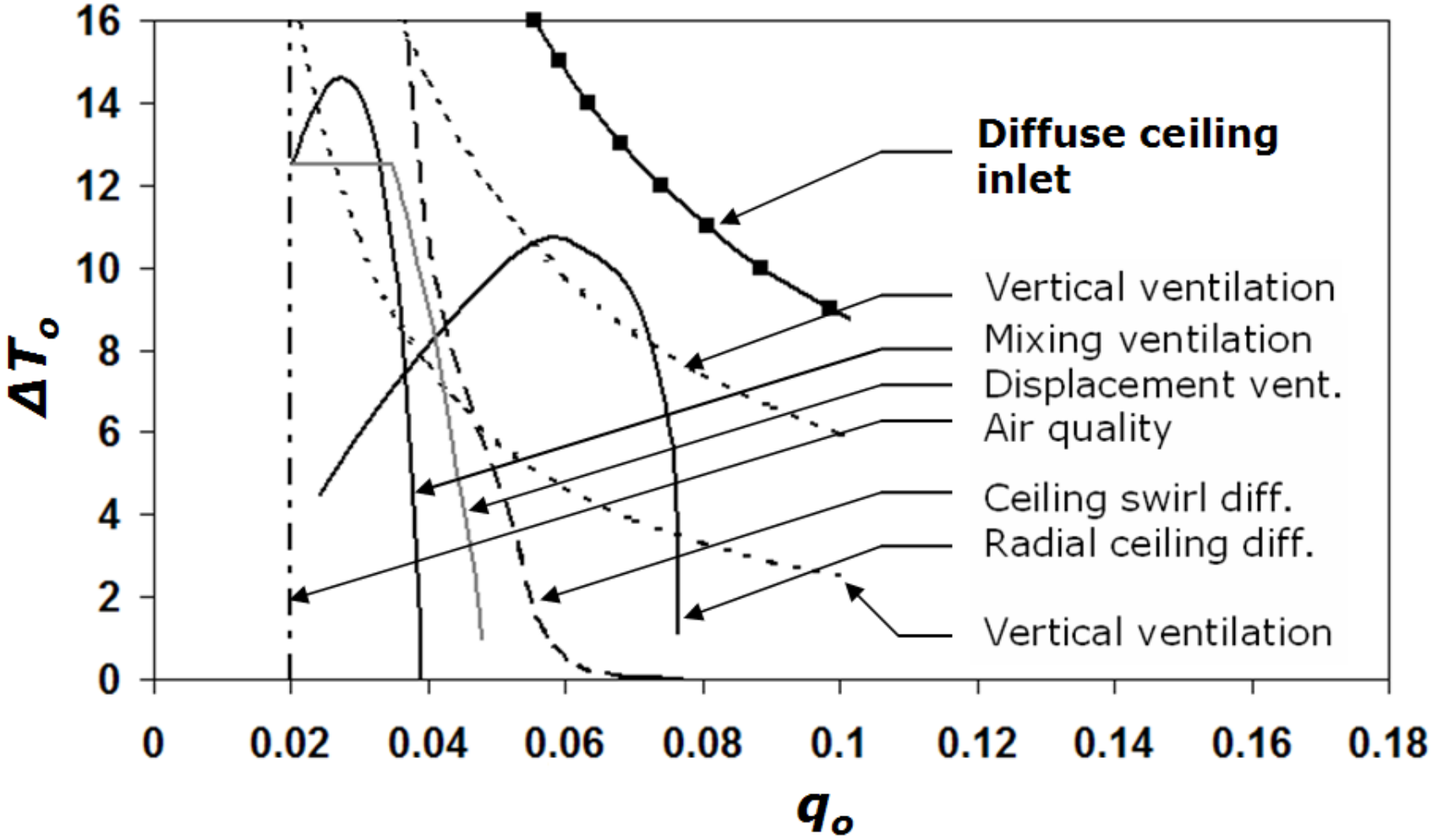


Design Chart

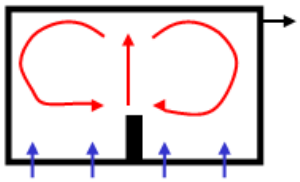
Systems where a certain heat load Q generates draught independent of ΔT_o and q_o



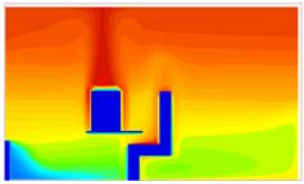
q_o - ΔT_o Design Chart



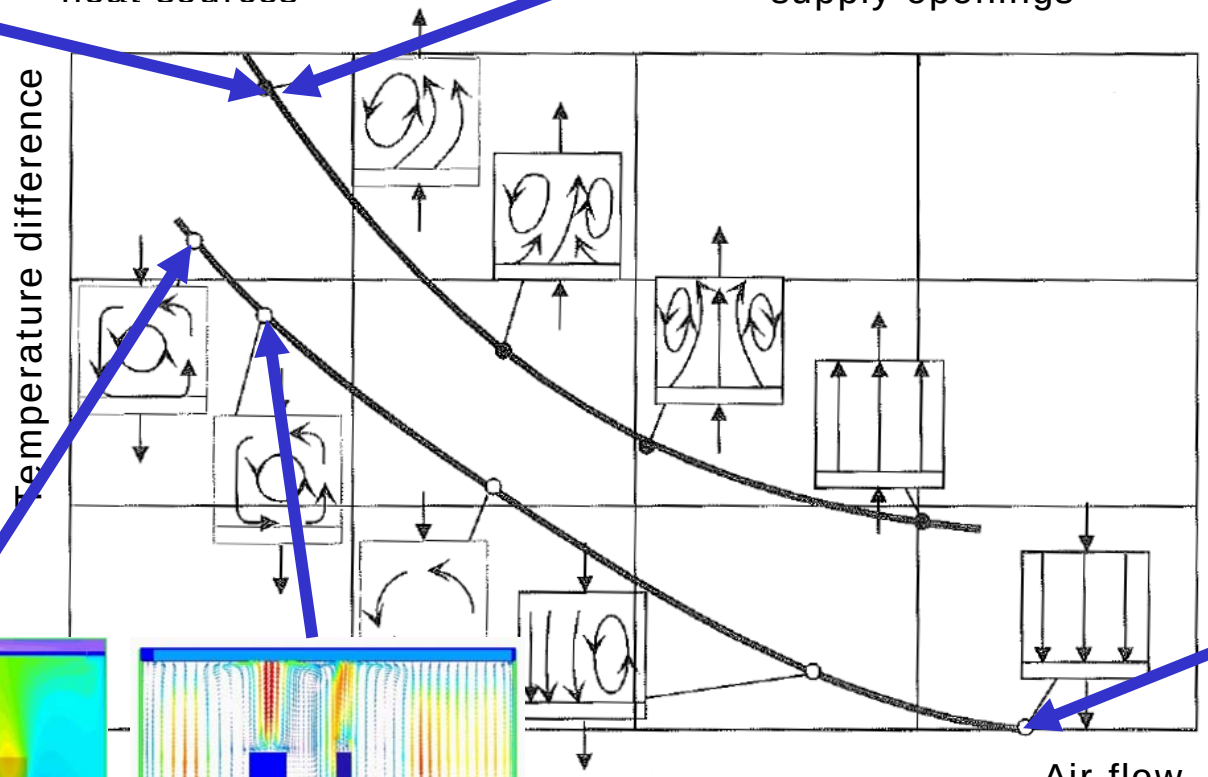
The Fluid Mechanics of the Air Distribution

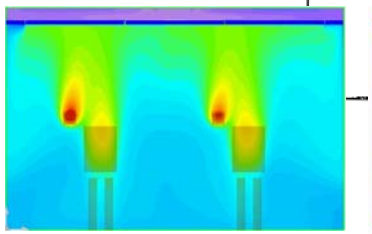


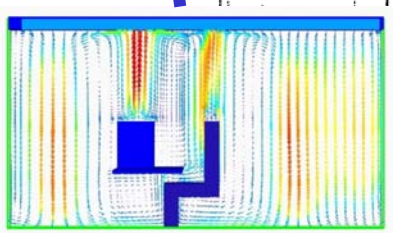
Thermal flow from heat sources

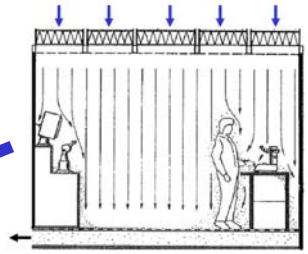


Momentum flow from supply openings



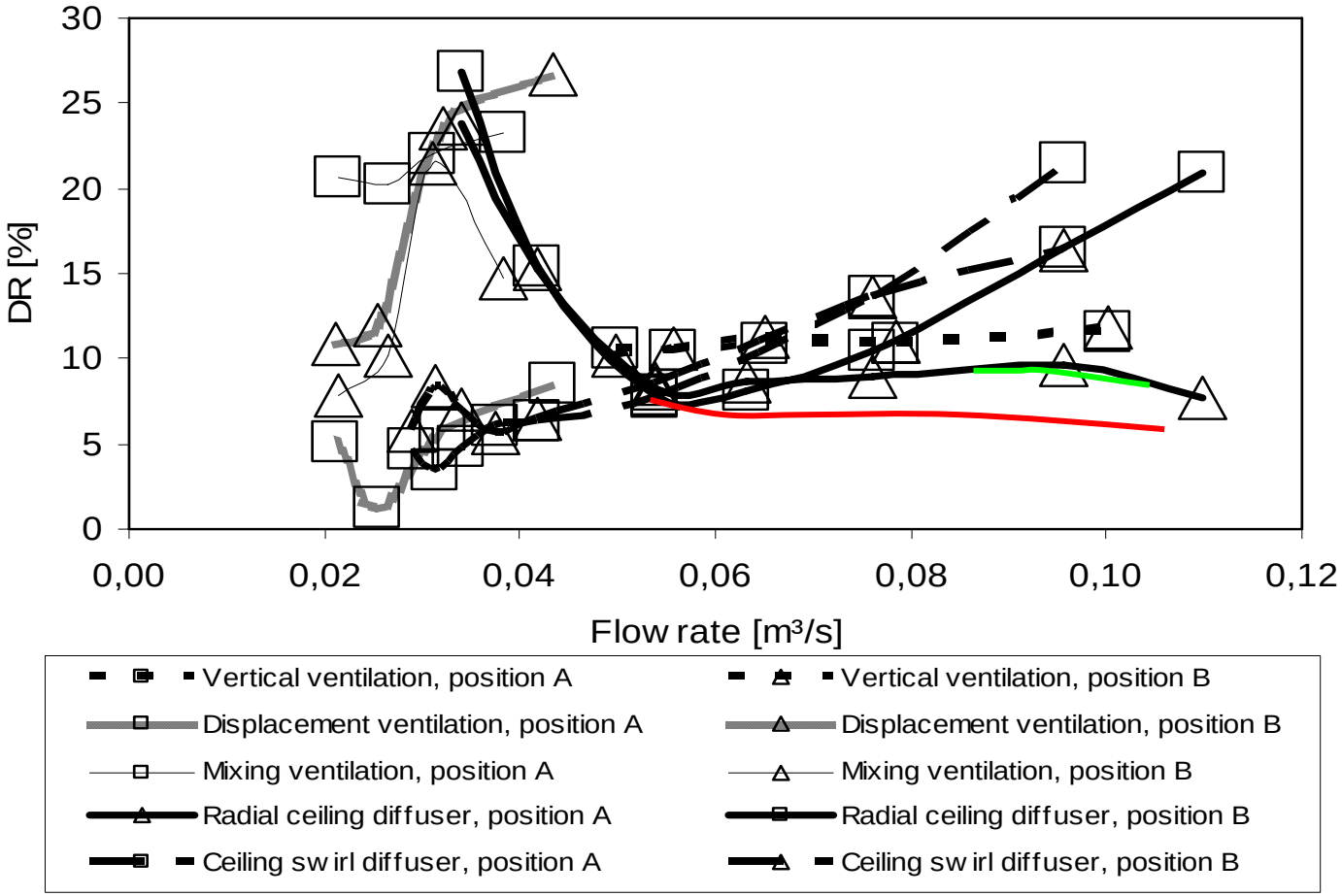




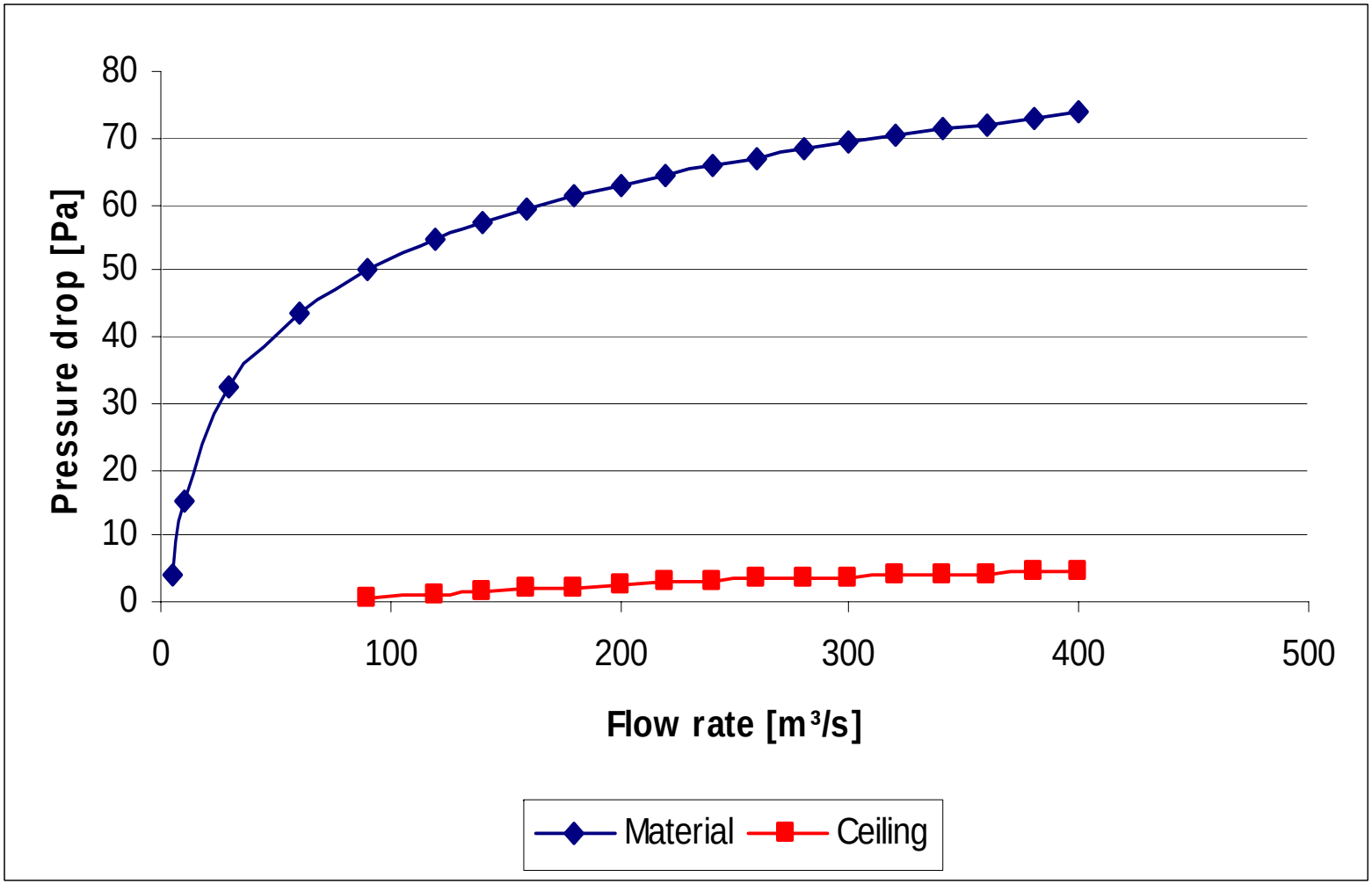


Air flow

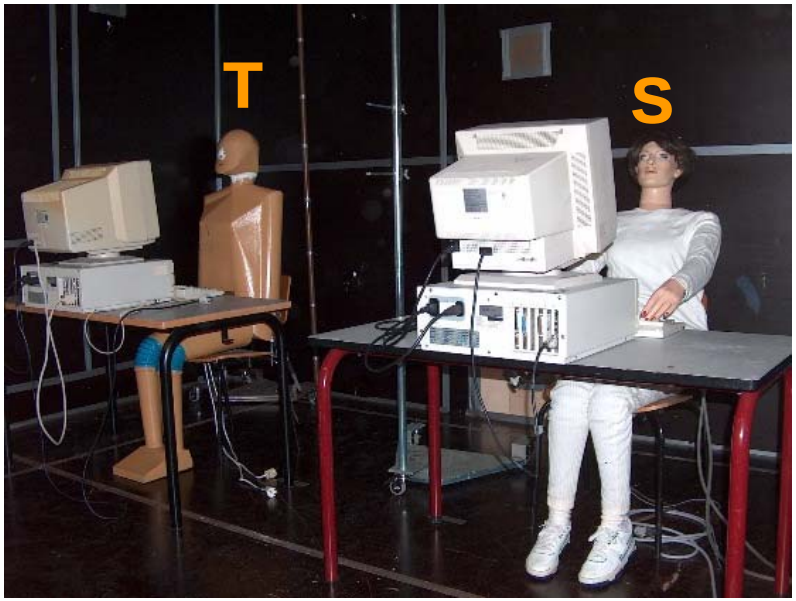
Local Discomfort



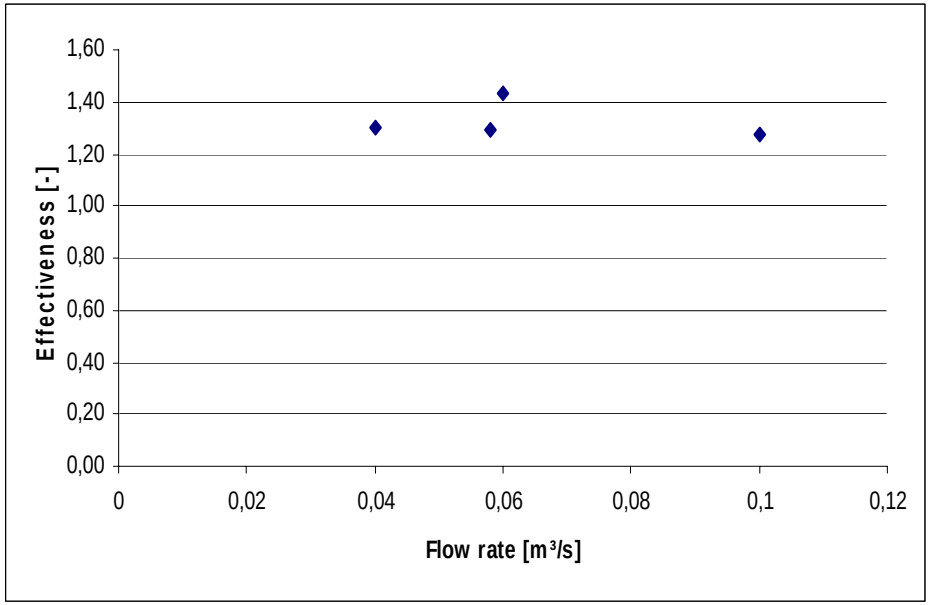
Pressure Drop across the Ceiling



Personal Exposure Index – Protection against Airborne Infection



$$\varepsilon^{c} = \frac{C_R - C_s}{C_{oz} - C_s}$$



Smoke Experiment

Smoke Experiment

Smoke Experiment

Widex / Wessberg A/S

Conclusion

- Temperature gradient << 2.5 K/m
- Velocity < 0.15 m/s
- Draught Rating – 7 %
- Handle a high thermal load
- Pleasant appearance
- Noiseless

Thank you!