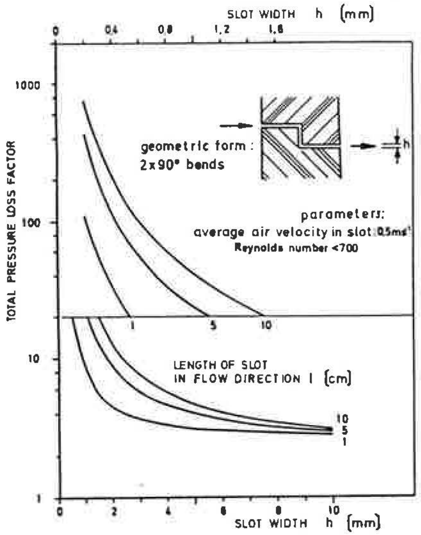

Figure 3:

Total pressure loss factor vs. slot width with different values of the length of slot in flow direction

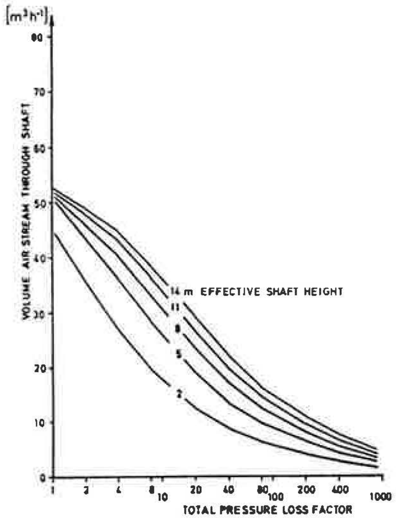

Figure 4:

Volume air stream through shaft vs. total pressure loss factor with different values of effective shaft height, examples calculated on the basis of the indicated model.

parameters:

shaft cross section	10/10 cm
temperature diff.	20 K
wind velocity	3 ms^{-1}
terrain class	III
wind pressure factor	-0.5
average roughness of shaft intern.surface	0.003 m

AIR OUTLETS FOR DISPLACEMENT FLOW AND THEIR INFLUENCE ON FLOW PATTERN WITH VARIOUS KINDS OF HEAT SOURCES

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Abstract

Displacement flow is enabled by air outlets which inject the air with a very low and unidirectional velocity. The flow pattern in the room is mainly influenced by the kind and distribution of heat sources in the room. In recent years displacement flow has become and more popular, as a type of flow in air conditioned spaces. Three main tasks, namely

- to save energy,
- to improve comfort, and
- ventilation efficiency

were the main reasons to think about the advantages of this flow.

Equally distributed outlet and heat sources

The main difference between displacement and dilution or mixing flow is that the distribution of heat sources and the location of air outlets have an important influence on the flow, because buoyancy has an important local impact.

Two general types of displacement flow can be differentiated:

1. Flow from the ceiling to the floor,
2. Flow from the floor or the lower parts of the side walls to the ceiling.

The original understanding of displacement flow is a piston flow. This type is stable in a limited region of Ar-Numbers (see Annex).

In case of equal distribution of heat sources and air outlets this limitation was found by (1)

with $Ar < 40$ for downward and
$Ar < 400$ for upward flow.

Downward flow

Downward flow of this type is found in clean rooms with so called unidirectional flow. The total ceiling is covered by fabric which produces unidirectional flow. Downward flow with local outlets is given in the case of operation room air outlets.

Fig. 1 shows the geometry of a typical room and the dimensions of the outlet consisting of fabric. It is the aim of this outlet to get a very low contamination index near the patient.

Fig. 2 shows the contamination index vs. Ar-Number for 2 different outlet dimensions (2).

Upward flow

Displacement flow from the floor even in the stable region is only like a piston flow, if heat sources do not have a major influence. As soon as a heat source moves more air upwards, than air is introduced to the room, a new type of displacement flow appears which is called source flow (Quell-Lüftung).

Near the floor a layer of air is established. The thickness of this layer roughly depends on the air volume which enters the room and the amount of air which is transported upwards as function of the height and load of the source.

The air outlet is installed near the floor. The exit velocity is about 0,2 m/s.

Fig. 3 shows a photograph with a person as heat source.

A person moves about 150 m^3/h of air upwards (3). 70 m^3/h of air are injected in the shown case.

In a typical office, the geometry is more complicated. Besides the persons there are further heat sources, as the walls of the room, tables and machines.

Tables and walls produce another flow pattern. If the surface temperature is slighly higher than the air temperature, only a small heat flux to the air takes place. The air moves slightly upwards and then spreads across the room, thus forming a second horizontal layer (Fig. 4).

At least a complicated air flow pattern will be found in the room depending on the number and kind of heat sources and the amount of air which is brought into the room. A typical temperature distribution as measured in an office is shown in Fig. 5.

Ventilation efficiency

The ventilation efficiency can be expressed by the contamination index which depends on the place and kind of the source. In the case shown in Fig. 3, the tracer gas was injected at the place of one person. At the place of the second person in the office 2 m apart the gas concentration was measured. We found a concentration of 10 % related to the exhaust air concentration.

Annex

Ar	Ar-Number
x	typical distance, in this case distance between ceiling and table
Δt	temperature difference between exhaust and entering air
g	gravitation constant
v	exit velocity

References

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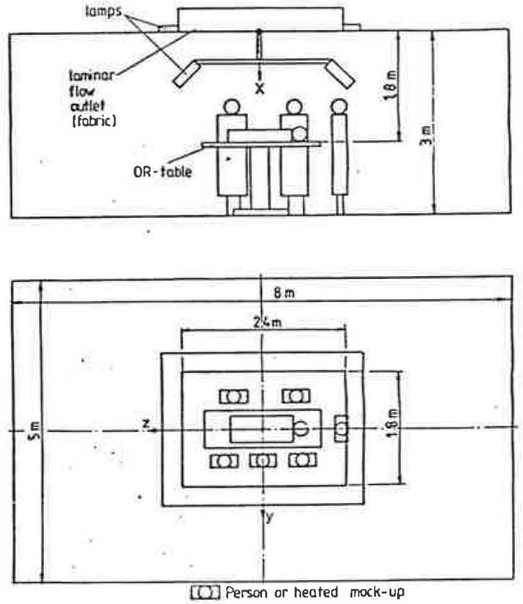

Fig. 1 Dimensions of an operation room with a laminar flow outlet

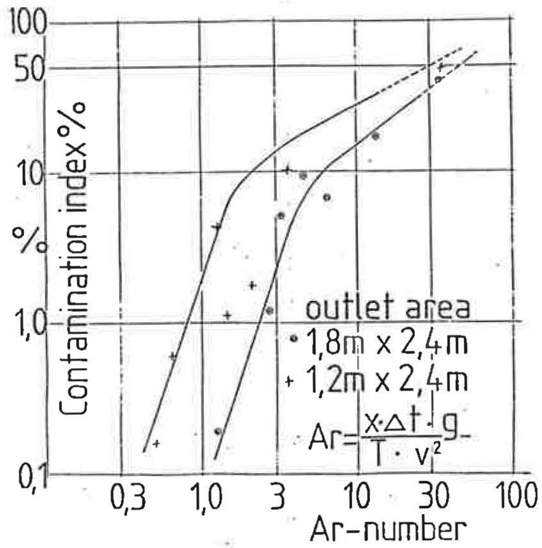

Fig. 2 Contamination index vs. Ar-number under two laminar flow outlets

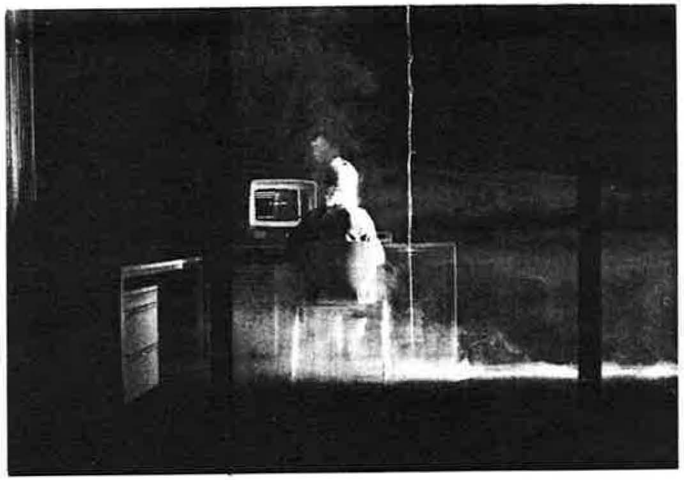

Fig. 3 Flow pattern in an office room with source-flow

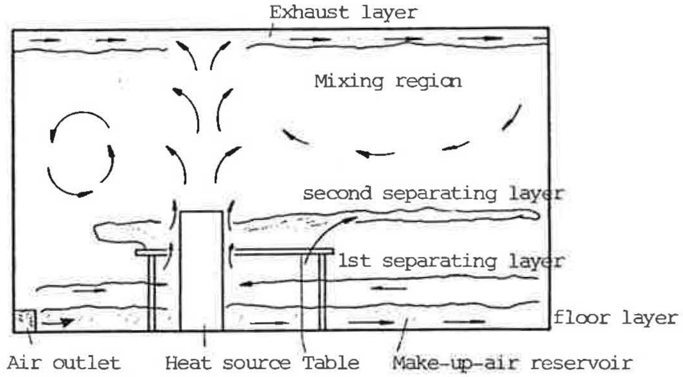

Fig. 4 Scheme of the flow pattern

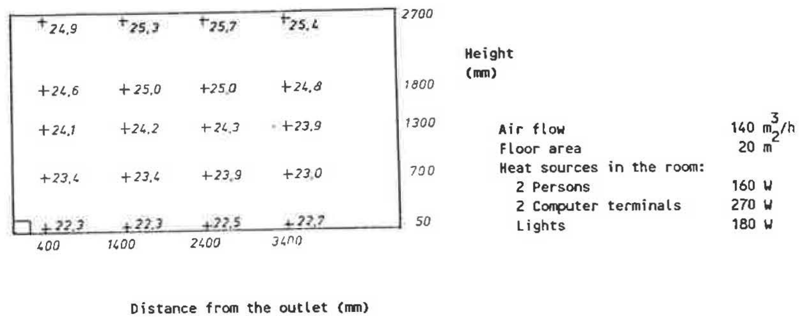

Fig. 5. Temperature distribution in °C in a vertical section