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PROTECTION OF NON-SMOKING PERSONS AGAINST CIGARETTE SMOKE BY AIRFLOW

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ABSTRACT

The protection of non-smoking persons against cigarette smoke is a very popular subject. In Germany the ‚pro' and ‚contra' of non-smoking regulations especially in public accessible areas like restaurants, train stations or in governmental buildings is discussed in a more and more controversial way. Especially the discussion about passive smoking and negative health effects through passive smoking lead to the demand of an effective protection of nonsmokers. But often even in ventilated rooms an effective protection of nonsmokers can not be reached, because the concept of the ventilation system and the airflow is not designed for this purpose.

The aim of the study is to show that with a normal ventilation system an effective protection of nonsmokers can be reached if some rules are observed. In the first part of this study different airflows are compared with regard to their ability to prevent a smoke transportation from smoking areas to non-smoking areas. The efficiency of the protection-effect of different airflow patterns (mixing flow, displacement flow) are discussed. In addition to the general description of the different airflow patterns the transportation of cigarette smoke as a contaminant is discussed in detail for mixing- and displacement flow.

The second part of the study offers additional possibilities in combination to the airflow to prevent a smoke transportation into non-smoking areas.

KEYWORDS

Airflow, Cigarette Smoke, Smoke Protection, Displacement Flow, Mixing Flow, Contaminant Distribution, Smoking Areas, Non-smoking Areas, Ventilation Effectiveness

INTRODUCTION

The protection of non-smoking persons against cigarette smoke is a very popular subject. In Germany the ‚pro' and ‚contra' of nonsmoking regulations especially in public accessible areas like restaurants, train stations or in governmental buildings is discussed in a more and more controversial way (Stiftung Warentest (1996). Especially the discussion about passive smoking and negative health effects through passive smoking lead to the demand of an effective protection of nonsmokers. But often even in ventilated rooms an effective protection of nonsmokers can not be reached, because the concept of the ventilation system and the airflow is not designed for this purpose.

The methods and airflow patterns described in the following chapters are not "new technology" or new scientific results but an attempt to use common and approved methods for new tasks and to provide more comfort for people in ventilated rooms. In the following sections the contaminant distributio describes especially the distribution of tobacco smoke. Also the term "smoke protection" is to b understood in the sense of "protection against smoke annoyance" and not in the sense of "preventio of negative health effects". Whether or not the smoke protection described in the following text ca protect persons against the negative health effects of passive smoking is not subject of this article.

CRITERIA FOR SMOKE PROTECTION

To describe the effectiveness of a room air flow against the distribution of tobacco smoke tw common values are often used to describe airflow and contaminant distribution in rooms.

1. Ventilation effectiveness $$\varepsilon_{v,p} = \frac{c_o - c_i}{c_p - c_i} \quad (1$$

2. Contamination Degree $$\mu = \frac{1}{\varepsilon_{v,p}} \quad (2$$

Both values give the concentration of a contaminant (for example tobacco smoke) in a room point related to the exhaust concentration c_O (with c_i as the supply concentration) and describes th improvement of the air quality in a point of a room. The contamination degree μ is more useful describe the air quality because low values of μ mean low concentrations and good air quality.

AIRFLOW AND SMOKE PROTECTION - EVALUATION OF DIFFERENT AIRFLOWS I REGARD TO THE PROTECTIVE EFFECT AGAINST SMOKE

Normally two airflow patterns are used in ventilated spaces: The mixing flow and the displaceme flow (see figure 1). The notion displacement flow (source flow) is used here to define the airflow fro the "real" displacement flow in the meaning of a plug flow (figure 1 right).

The mechanics of the displacement flow (figure 1 center) are often described in literature (for exam in Fitzner (1991), Krühne (1995)) and is assumed to be as known for the following chapters. The movement of the displacement flow supports the protective effect against the contaminant distributi because the room is divided in two zones and air from the lower air zone moves upwards along t person and leads to an additional improvement of the air quality. Due to the fact that tobacco smoke emitted from or near a person a large amount of smoke is transported upwards into the upper air lay For the persons in the room an improvement of air quality can be reached (figure 2).

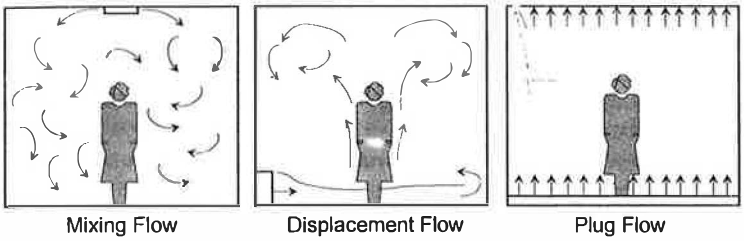

Figure 1: Different airflow patterns

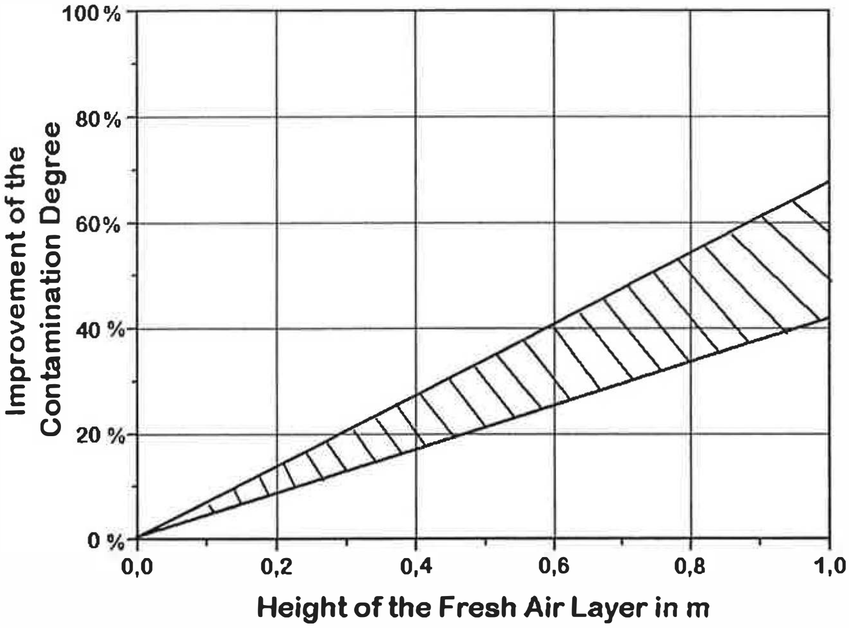

Figure 2: Improvement of the contamination degree at a person in a height of 1,1 m related to the contamination degree in the environment at the same height (Krühne and Fitzner 1994)

Together with additional steps described later a contaminant stratification like described by Brohus and Nielsen (1994) or the effects of breathing and movement (Bjørn et. al. (1997)) can be prevented. Perquisite for an improvement of the air quality is that the fresh air layer in the lower room part is higher than 0,6 m - like shown in figure 2 - then an improvement of the air quality up to 40% can be reached.

Due to the reduced horizontal contaminant distribution with displacement flow the contamination degree decreases strongly with the distance to the contaminant source (figure 3). Related to the mixing flow, were the horizontal air exchange is significantly higher than in a displacement flow, the displacement flow is much more effective to protect people against high smoke concentrations. Figure 3 shows the contamination degree with an increasing distance from the contaminant source for mixing- and displacement flow. It can be seen, that the contamination degree is significantly higher for a distance of one meter than with displacement flow because the contaminant is distributed into the room around the source and is not transported into the upper room air layer.

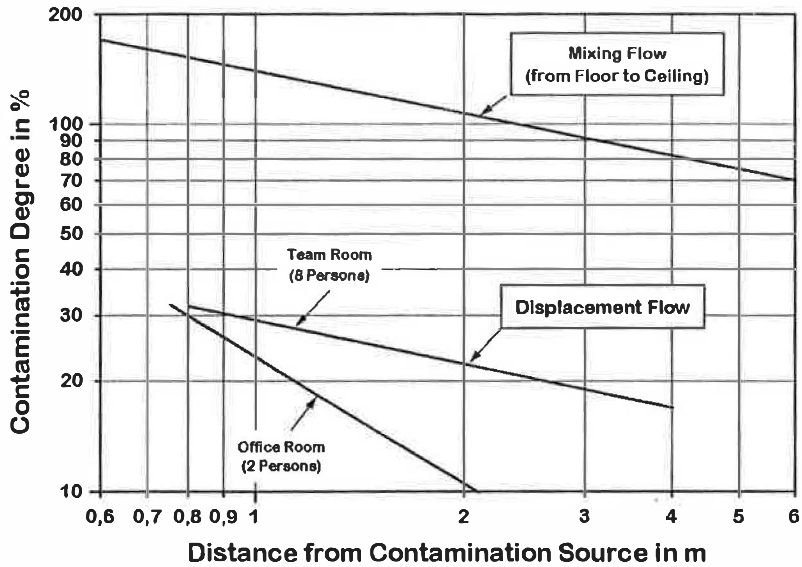

Figure 3: Decrease of contamination for mixing- and displacement flow (Fitzner (1981 and 1996))

ADDITIONAL STEPS FOR SMOKE PROTECTION AND EXAMPLES

From the airflow mechanics described above it can be seen that the displacement flow is to be preferred against the mixing flow if a smoke protection in rooms should be reached. But the smoke protection without additional supporting steps is not really sufficient. The best combination of airflow and additional steps varies with the requirements of the use of the room (e.g. restaurant, public waiting rooms, trains) and the general room conditions (geometry, floor levels, entrance situation). In general the following additional steps are possible:

With the separation of smoking and non-smoking areas (figure 4) in combination with the displacement flow a separation can be reached with relatively small distances between both areas. The protective effect is supported by the arrangement of the air inlets opposite each other in both areas.

The protective effect of displacement flow and separation can be increased if separation walls are used additionally. The separation walls must not necessarily be in the height from floor to ceiling but must provide a flow protection in the lower room level (closed to the floor) up to approx. 1,5 m (figure 5).

In rooms with areas in different floor levels the arrangement of the smoke and non-smoking areas should be as shown in figure 6 if an effective smoke protection should be reached. With the incorrect arrangement of the zones (figure 6 left) the contaminant flow is directed from the smoking to the non-smoking section and no effect can be reached. With the opposite arrangement (figure 6 right) a good smoke protection can be reached with mixing or displacement flow.

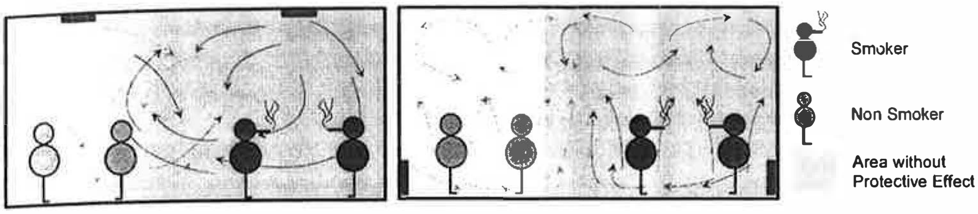

Figure 4: Local separation with mixing- and displacement flow

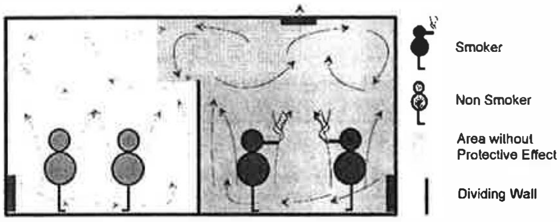

Figure 5: Influence of dividing walls

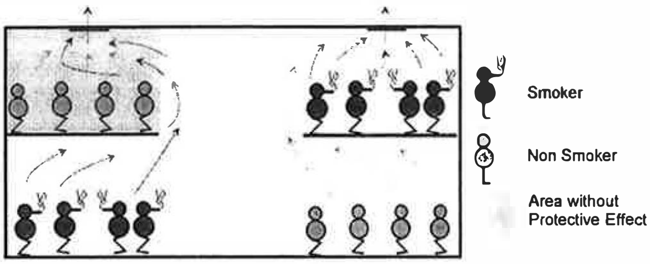

Figure 6: Location of smoking areas with separation in different levels

The use of separation walls is particularly useful if in addition to the normal air flow an overlaid cross flow takes place (figure 7). Uncontrolled overlaid cross flows are induced normally in rooms with openable windows or with doors to ambient conditions. Controlled cross flows induced by pressure differences through the ventilation system can be used to control the contaminant distribution in rooms.

The air distribution system must be designed according to the desired effect. If an air distribution in the lower part of the room is planed, the pressure difference between upper and lower room part must lead to an airflow upwards.

An additional example for overlaid cross flow is the flow in trains. Due to the pressure distribution outside of the train a directed airflow takes places against the train direction like shown in figure 8.

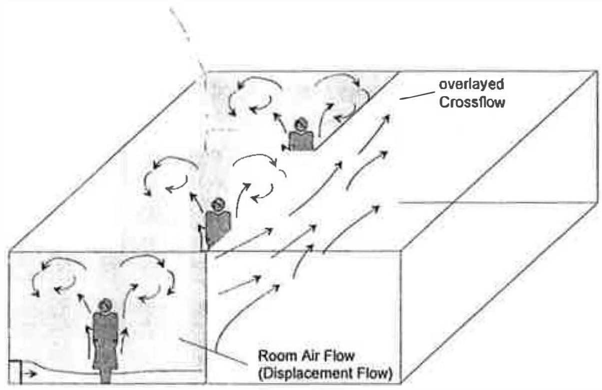

Figure 7: Room air flow and overlaid cross flow

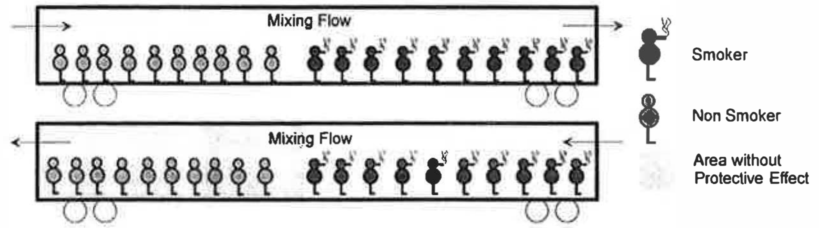

Figure 8: Airflow in trains with smoking areas

RESUME

A complete protection against tobacco smoke can be reached only in a non-smoking environment. But simple and known methods together with common airflow can provide a reasonable smoke protection for non-smoking people without expensive technology.

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