

Irritating and Annoying Effects of Passive Smoking

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The acute irritating and annoying effects have been investigated in field and laboratory studies in relation to the concentration of some smoke components in the air. At the workplace 30 to 70% of the indoor CO, NO and particle concentrations are due to tobacco smoke; 25–40% of the employees are disturbed and annoyed by smoke, one quarter suffers from eye irritations at work. Subjective eye, nose and throat irritations and eye blink rate increase with increasing smoke concentration as well as with increasing exposure duration. Irritations are mainly due to the particulate phase of environmental tobacco smoke, whereas the gas phase is to a large extent responsible for annoyance. It is concluded that an average healthy person can be exposed to an acceptable cigarette smoke level which produces a carbon monoxide concentration of 1.5 to 2.0 ppm. Above these limits, counter-measures to protect passive smokers are necessary. The required fresh air supply values are presented.

(Key Words: Passive smoking, irritations, eye blink rate, annoyance, threshold limit values)

INTRODUCTION

Several studies were carried out to investigate the air pollution due to tobacco smoke and its acute effects, in order to draw some conclusions from a possible dose-response relationship on the environmental tobacco smoke concentration tolerable for men. Such a limit of tolerance could give some indications for measures to protect non-smokers, like for instance the dimension of fresh air supply to a room.

METHODS

A field study in 44 workrooms and two series of laboratory experiments in a climatic chamber, in which cigarettes were smoked by a smoking machine, were carried out. *The degree of air pollution due to tobacco smoke* was evaluated by measuring the concentrations of carbon monoxide (CO), nitrogen oxide (NO), formaldehyde, acrolein, particles (PM) and nicotine in the air according to the methods described elsewhere (1, 2, 6). The part of the pollutants due to tobacco smoke was obtained by subtracting the background levels before smoking from the concentrations during smoking. These difference values are hereafter call-

ed ΔCO , ΔNO a. s. o.

The degree of acute irritating and annoying effects of exposed persons was simultaneously determined by means of questionnaires and measurements of eye blink rate, considered as an objective measure for eye irritations (for more details see (1) and (6)).

FIELD STUDY: RESULTS AND DISCUSSION

Table 1 summarizes some results of the chemical measurements.

The comparison of these Δ -values with the measured absolute indoor concentrations reveals that 30–70% of the measured indoor concentrations of CO, NO and particles are due to tobacco smoke.

The correlation between the gas phase components ΔCO and ΔNO is relatively high (Pearson correlation coefficient $r = 0.73$). However, the correlations with ΔPM are low. Therefore carbon monoxide can be considered as a useful indicator for nitrogen oxide, but neither for the particulate matter nor for nicotine.

In Figure 1 some results of the interview are represented, separated into groups of smokers and non-smokers.

From Figure 1 it can be deduced that:

1. Approximately one third of the employees qualifies the air with regard to smoke at work as bad.
2. Forty percent are disturbed by smoke.
3. One quarter of the persons reports eye irritations at work.
4. Non-smokers react significantly more to environmental tobacco smoke than smokers.

Employees suffering from hayfever reported significantly more eye irritations at work than those without hayfever. Furthermore, 72% of the interviewed non-smokers and 67% of the smokers are in favour of a separation into smoker and non-smoker workrooms; 49% even support a partial or total prohibition of smoking at work.

LABORATORY STUDIES: RESULTS AND DISCUSSION

A first series of experiments was carried out to analyze the acute effects of environmental tobacco smoke in relation to the smoke concentration and the duration of exposure. The analysis of the questionnaire showed that the irritating effects are most pronounced on the eyes, followed by the nose and finally by the throat. Figures 2 and 3 illustrate the results obtained for subjective eye irritations and eye blink rate of subjects being exposed to different smoke concentrations which were kept constant for one hour.

Two facts are obvious:

1. Mean eye irritation increases with increasing smoke concentration, determined by ΔCO levels.
2. Mean eye irritation increases with the duration of exposure in spite of constant smoke concentration.

The same, but less pronounced result, has been observed for nose and throat irritations. Annoyance—which has also been determined by means of a questionnaire—shows a different development than irritations: it increases rapidly as soon as smoke production begins and, after 10 to 15 min, it remains approximately constant during the rest of the exposure. Thus the duration of exposure has nearly no influence on the degree of annoyance.

The mean incidences of people with strong or very strong subjective eye irritations after an exposure to an environmental tobacco smoke of 40 and 60 min respectively are reported in Fig. 4.

Figure 4 clearly discloses that there is a marked increase of the incidence of strong eye irritations between the smoke levels corresponding to 1.3 and 2.5 ppm ΔCO . Based on these results, *a possible limit to protect healthy people in their everyday environment against impairment of well-being by environmental tobacco smoke should lie in this range, i.e. between 1.5 and 2.0 ppm ΔCO* . Indeed a marked increase from about 3 to over 10% of subjects with strong eye irritations appears therein. The upper concentration limit of 2.0 ppm ΔCO is for instance already reached when 2 cigarettes are smoked per hour in a room of 80 m³ with a single airchange. Hence *counter-measures to protect passive smokers are desirable when the ΔCO level reaches 1.5 ppm and are necessary when it hits 2.0 ppm*. The lower limit should be applied to workplaces where passive smokers can hardly escape the exposure, and the upper limit to restaurants and other places, where people usually go voluntarily and for a shorter lapse of time.

Calculations show that a fresh air supply of 33 m³ per hour and per smoked cigarette is necessary to keep the ΔCO concentration below the proposed upper limit of 2.0 ppm; for the lower limit, 50 m³ per hour and per smoked cigarette are required. Depending on the number of persons present in a room, *a fresh air supply of 25 to 45 m³ per hour and per person is necessary in order not to exceed the upper limit*. In other words: the ventilation has to be 2 to 4 times higher than in a room where nobody smokes (in which only 12 to 15 m³ per hour and person are required). For that reason the increased ventilation as a measure to protect passive smokers is not recommendable from the energetical point of view. Therefore, whenever possible, organisational measures, such as a separation into smoker and nonsmoker rooms or a prohibition of smoking, rather than an increased fresh air supply, should be taken into consideration.

A second series of laboratory experiments (3, 4, 5) was carried out to determine which components of tobacco smoke are mainly responsi-

ble for irritations and annoyance. By comparing the degree of irritations and annoyance of acrolein, of formaldehyde alone and of the gas phase alone to the one of the whole sidestream smoke, it was found that

—acrolein as well as formaldehyde are only to a minor extent responsible for the irritations due to the sidestream smoke of cigarettes

—the gas phase is to a large extent responsible for the annoyance due to the sidestream smoke of cigarettes

—The particulate phase is to a very large extent responsible for the irritating effects of the sidestream smoke, since eye blink rate (see Fig. 5) as well as subjective eye irritations are much lower with the gas phase alone than with the total sidestream smoke.

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Table 1 Air pollution due to tobacco smoke in 44 workrooms

Δ -value = "Indoor concentration during work" minus "indoor concentration before work"

Component	number of samples	mean value	standard deviation	maximum
Δ CO (ppm)	353	1.1	1.3	6.5
Δ NO (ppb)	348	32	60	280
Δ PM ($\mu\text{g}/\text{m}^3$)	429	133	130	962
Δ nicotine ($\mu\text{g}/\text{m}^3$)	140	0.9	1.9	13.8

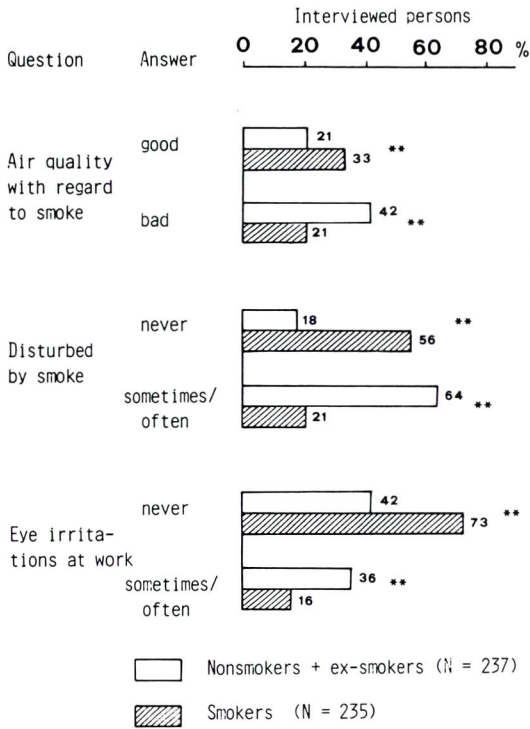


Fig. 1 Evaluation of air quality and effects due to environmental tobacco smoke at the present workplace. Results of 472 employees in 44 workrooms.

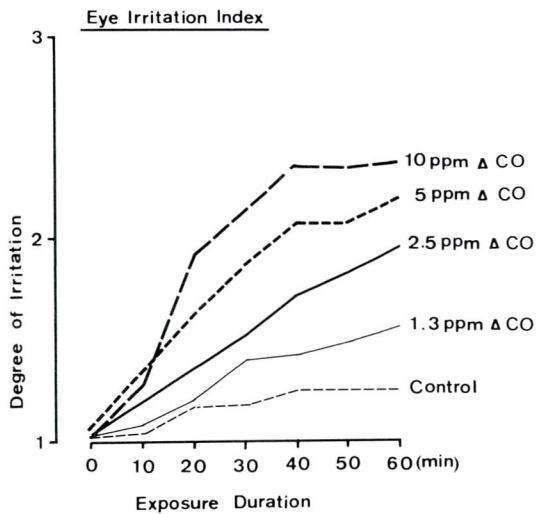


Fig. 2 Mean subjective eye irritations due to environmental tobacco smoke, related to smoke concentration and duration of exposure. Δ CO = CO level during smoke production minus background level before smoke production. 32 to 43 subjects. 0 min: measurement before smoke production. Period 0 to 5 min: Increasing smoke concentration. Period 6 to 60 min: constant smoke concentration.

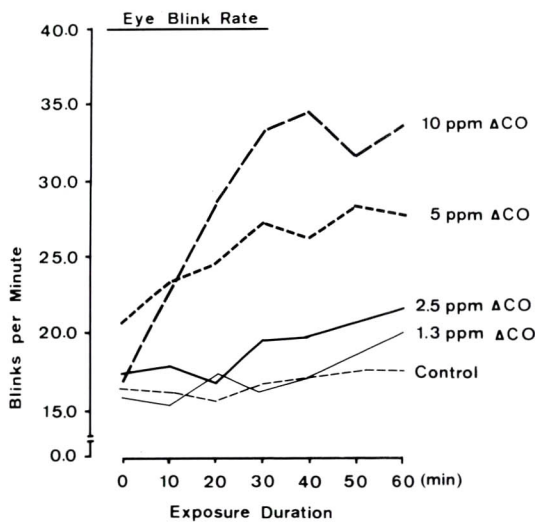


Fig. 3 Mean effects of environmental tobacco smoke on eye blink rate. Same caption as in Fig. 2.

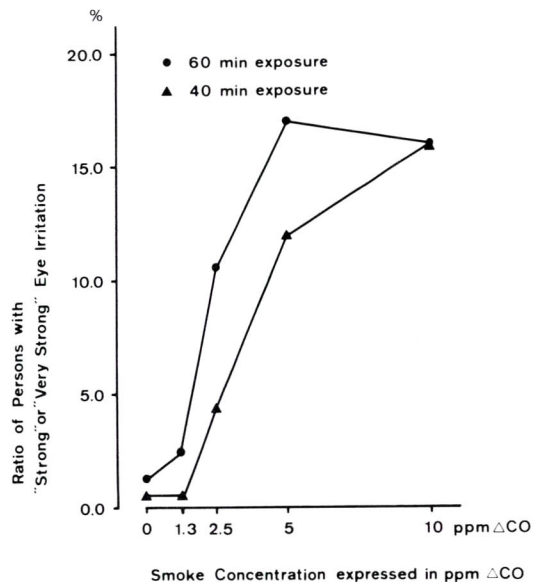


Fig. 4 Percentage of persons with strong or very strong eye irritation reacts related to the degree and duration of exposure. Same caption as in Fig. 2.

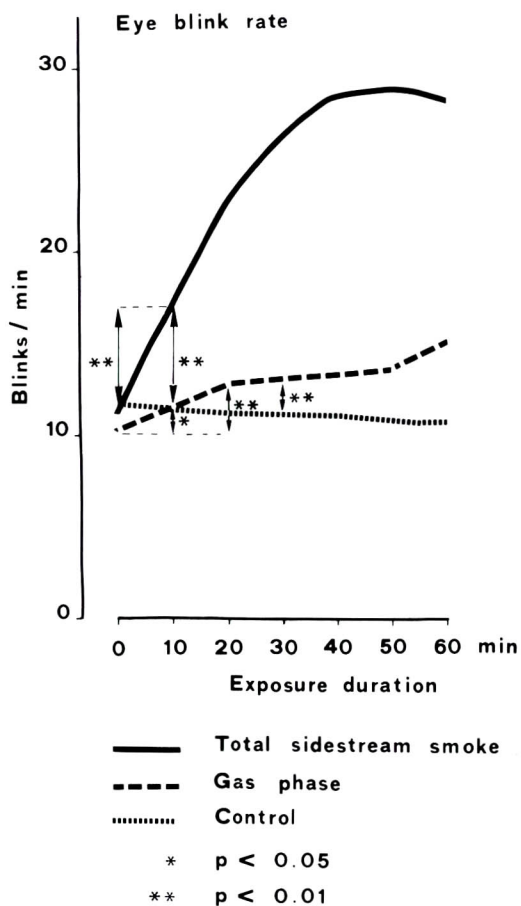


Fig. 5 *Effects of the total sidestream smoke of cigarettes and of its gas phase on eye blink rate, both exposures corresponding to a tobacco smoke induced Δ CO level of 10 ppm.*
 32 subjects. 0 min = measurement before smoke production.