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ELECTRIC POTENTIAL DIFFERENCES AGAINST THE SURROUNDINGS AND DISCOMFORTS IN INDOOR ENVIRONMENTS*

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Abstract—In order to examine whether the factors causing work-related discomfort in indoor environments included electrostatic phenomena, the entire staff, or a randomized part of the staff, of four offices (108 persons in all) were examined. Subjects were interviewed, the indoor climate investigated and the voltage between each subject and an earthed reference point measured. The offices were clean and well-ventilated, and the potential differences were moderate (mean 0.42 kV in rooms with close-fitted carpets and 0.04 kV in rooms with other flooring materials; range of peak voltages −3.78 to +1.76 kV).

The prevalence of symptoms of irritation of the eyes, face or upper respiratory tract did not differ between office employees for whom the mean voltage relative to earth was above 0.5 kV and those for whom it was below 0.5 kV, indicating that electrostatic phenomena of this magnitude are unimportant in this regard. Further investigations of the effect of higher voltages are desirable.

INTRODUCTION

THEORETICALLY, the electrostatic charge of persons working on insulating floors might attract airborne dust in a way similar to that in which dust is attracted to electrostatic dust filters. The capacitance of the human body is considerable (MARBLE *et al.*, 1977), and it has been demonstrated that the electrostatic charge of aerosols affects the pulmonary deposition on inhalation (FERIN *et al.*, 1983; JOHN and VINCENT, 1985). This investigation was performed to find out whether electrostatic charge could induce or exaggerate local irritation in the face and upper respiratory tract.

MATERIALS AND METHODS

In four large and modern offices in which employees had reported problems of 'sick building syndrome', including irritation of skin, eyes and respiratory tract, either the whole staff or a randomized part of it was interviewed. If the randomized person was not at work when the study was performed, a substitute was interviewed, and in all 76 women and 32 men were examined. At the same time the voltage between each person interviewed and an earthed reference point were recorded.

The interviews were standardized and included questions about symptoms of irritation of skin, eyes and respiratory tract. Any time relations between office work and occurrence of symptoms were noted. The symptoms reported were regarded as work-related if they commenced during the working day and disappeared within 1–2

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days of stopping work. Immediately after the interviews, the workers examined reported their subjective assessment of various factors, including work satisfaction and five different environmental factors (temperature, air humidity, lighting, dustiness and draughtiness) on visual analogue rating scales (MAXWELL, 1978). At the same time, the air humidity and temperature were measured with an Assman psychrometer.

Measurements of the voltage between the people examined and an earthed reference point were performed during 5 min of ordinary office work and during two types of standardized activity (rubbing of the seat against the chair and a short walk in the work room). The measurements were made with a rebuilt field-strength meter (Eltex 0 475 C) coupled to an electrode attached to the wrist of the person examined. The other electrode was connected to the earthed reference point. The response was recorded continuously on a chart recorder and on an electronic data logger.

Statistical analysis was by two-sided Student's t-test and χ^2 test, Fisher's exact test of 4-field tables (one-sided P-value), and correlation.

RESULTS

In all, 36 subjects (six men and 30 women) complained of work-related irritation of the eyes, skin or respiratory tract. Four men and nine women felt irritation at two or all three of these. During ordinary office work the maximum positive voltage between the subjects and the earthed reference point was 1.76 kV and the maximum negative voltage was −3.78 kV. As is shown in Table1, the mean voltage at ordinary work was slightly but significantly higher than during a short walk in the work room, while it did not differ significantly from the mean voltage induced by rubbing the seat against the chair.

TABLE 1. PAIRED DIFFERENCES BETWEEN MEAN VOLTAGES AT WORK AND, RESPECTIVELY, DURING A SHORT WALK IN THE WORK ROOM AND WHEN RUBBING THE SEAT AGAINST THE CHAIR

	Paired difference (kV) (M ± SD)	No. of paired observations	95% confidence interval
Difference between voltage at work and:			
during a short walk	0.41 ± 0.58	108	0.30 to 0.52
when rubbing the seat	0.08 ± 0.61	108	−0.04 to 0.20

The relative humidity varied between 15 and 35%. Within this range of humidity, there was a significant negative correlation ($r = -0.46$) between the absolute value of the mean voltage at work (deviation from zero, irrespective of sign) and the relative air humidity. Lowering humidity tended to increase the potential difference between the subject and earth. The correlation between mean voltage and temperature was not significant ($r = 0.10$).

In rooms equipped with close-fitted carpets, the mean voltage between the subject and earth was −0.42 ± 0.44 kV (M ± SD), compared with 0.04 ± 0.11 kV in rooms with other flooring materials. The difference between close-fitted carpets and other flooring materials in inducing high voltages was highly significant ($P < 0.001$).

No significant increase of symptoms of irritation of the eyes, face or upper

respiratory tract was observed in persons for whom the absolute value of the mean voltage was 0.5 kV and higher, compared with persons with lower mean voltages at ordinary office work (Table 2). Neither the work-related symptoms in the eyes, face and upper respiratory tract, nor the assessment of work satisfaction, nor subjective evaluation of air humidity and dustiness in the room, was associated with significant differences in mean voltage between subject and earth.

TABLE 2. RELATION BETWEEN MEAN VOLTAGES (ABSOLUTE DEVIATION FROM ZERO) OF INDIVIDUALS AT WORK AND IRRITATION OF THE FACE, EYES AND RESPIRATORY TRACT

Symptoms of irritation	Voltage	
	<0.5 kV	≥0.5 kV
No	57	15
Yes	29	7

Fisher's $P=0.66$, $\chi^2=0.0285$.

DISCUSSION

Effects on health associated with office or home environments are diffuse and non-specific. However, irritation of mucous membranes in the eyes and upper respiratory tract is common (TURIEL *et al.*, 1983; FINNEGAN *et al.*, 1984; HEDGE 1984; VALBJØRN and KOUSGÅRD, 1984; ROBERTSON *et al.*, 1985; BURGE *et al.*, 1987; VALBJØRN and SKOV, 1987), and indoor environments could be as potent as industrial ones in inducing it (NORBÄCK *et al.*, 1987). People working or living in new rather than in old buildings often complain. Modern ventilation systems with air conditioning seem to be associated with a higher prevalence of complaints than are more traditional ventilation systems with active exhaust and passive supply of air (ROBERTSON *et al.*, 1985): chemical, physical, microbiological and psycho-social factors have been suggested as possible causative agents, and the aetiology is probably multifactorial.

It seems reasonable to assume that the movements of airborne particles are influenced by the electric field around electrostatically charged individuals (ANCKER *et al.*, 1984). Particles moving towards them ought to land preferentially on protruding parts of the body (where the electric potential gradient is greater), and these include areas such as the nose and around the eyes, so that theoretically a large field strength could increase the irritative effects of airborne dust there.

In the Danish Town Hall Study static electrical charge was found to correlate with irritation of the mucous membrane (VALBJØRN and SKOV, 1987), and it has been suggested that electrostatic phenomena due to the use of video terminals (LINDÉN and ROLFSEN, 1981; OLSEN, 1981) and of electrically insulating flooring materials (IBSEN *et al.*, 1981; NORBÄCK and TORGEN, 1987) could cause discomfort. An increased prevalence of 'dry throat' in teachers working in schools fitted with insulating carpets has been observed (NORBÄCK and TORGEN, 1987), and the results reported here demonstrate that close-fitted carpets increase the potential difference between subjects and the surroundings. On the other hand, no convincing correlations between the subjective perception of 'dry air' and low relative humidity in ordinary indoor environments have been demonstrated (GÖTHE *et al.*, 1987).

The prevalence of symptoms of irritation did not differ between office employees with mean voltages relative to earth of less than 0.5 kV as compared with those with greater mean voltages, indicating that potential differences of this magnitude do not cause significant subjective effects. The voltages recorded were however moderate, and the working environments studied clean and well-ventilated. In two of the offices investigated, the mean potential difference between man and earth was always less than 0.5 kV, while somewhat higher mean voltages were noted in the other two offices. Voltages considerably higher than those observed here could occur in indoor environments (OLSEN, 1981; BROWN and PAILTHORPE, 1986), and in conjunction with airborne dust they might promote irritation. Thus, further investigations of higher voltages in conjunction with dust-producing activities are desirable.

A 'spin-off' observation was that the mean potential differences between man and earth at office work could be reproduced in simple and rapid tests, such as rubbing the seat against the chair. This could facilitate further studies of electrostatic phenomena in indoor environments.

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