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PROBLEMS OF MEASURING INTERMITTENT EXPOSURE TO ASBESTOS DUST

K. RÖDELSPERGER[1], H.-J. WOITOWITZ[1] and K. SPURNY[2]
Institute of Occupational and Social Medicine, University of Giessen, Giessen[1] and Institute of Aerobiology, Grafschaft/Sauerland[2], F. R. Germany

ABSTRACT

During roof covering with asbestos cement sheets 18 dust measurements on 11 open-air construction sites were undertaken, each with up to eight sampling instruments and a TM-digital tyndallometer. The total and the fine dust mass concentrations were determined, so were the asbestos content of the fine dust, the fibre concentrations and the time course of the fine dust concentration.

By static long duration measurements in open-air cutting places, where corrugated sheets of asbestos cement were cut with a grinding machine, the concentration values of 0.5 to 1.5 free chrysotile fibres/ml (length ≥ 5 μm) were recorded. A threefold amount of free fibres (length < 5 μm) and a great part of fibres aggregated to cement particles were also found. The mean fibre length was 5 ± 3.5 μm with a mean diameter of 0.40 ± 0.26 μm. Considering an asbestos content of about 10%, in open-air cutting places mass concentration of the fine dust of asbestos cement of 0.1 to 0.78 mg/m^3 was determined with a median of 0.37 mg/m^3. In contrast personal samplings made on cutting roofers had considerably higher values of fine dust concentrations of 0.5 to 5.8 mg/m^3 with a median of 1.39 mg/m^3. The tyndallometric measurements showed clearly that dust can be registered only during cutting times. During the cutting of asbestos cement sheets with a grinding machine peak concentrations of fine dust exceeding 77 mg/m^3 (mean 28.4 mg/m^3) may occur. During the process of cutting, which amounts to 6% of the working time, a high mass concentration of the fine dust of asbestos cement is to be expected, in the range of a 16-fold long-term mean value. Regarding the open question of a specific biological effect of an intermittent exposure to asbestos fine dust, these results are necessary for the epidemiological evaluation of the health risk of roofers working with asbestos cement products.

The fibrogenic and oncogenic risk for employees, who are temporarily – even for a few minutes – exposed to peak concentrations of asbestos fine dust, can not, at present, be sufficiently evaluated[8,11]. For the evaluation of exposure at a workplace a limiting value is used in the Federal Republic of Germany – e.g. for chrysotile fine dust – of 0.1 mg/m^3 or 2 F/ml, which is a one-year mean for an exposure of 8 hours daily. Therefore it was not found necessary to perform routine measurements of peak concentrations.

Many workplaces show characteristic peak concentrations. This applies for instance to the friction lining industry, brake service[7,12], asbestos insulation[4,5,9] and especially to open-air cutting places of asbestos cement products on construction sites. Peak values can occur during minutes or seconds while installing large-size corrugated sheets during the short-time cutting process with the grinding machine.

From the medical point of view the peak concentrations in workplaces have been considered as hazardous to health as a constant influence of asbestos fine dust. The main argument points to a relatively long duration of the biological processes. Fibre incorporation through macrophages in the lung takes about 3 hours while cytotoxicity lasts for 24 hours[6]. On the other hand according to Enterline's epidemiological studies the relative risk of lung cancer is twice greater for repair workers with a short-time exposure to asbestos dust than for employees working in factories with a constant exposure to asbestos dust[4,5].

In inhalation experiments with animals Davis found that the increase in the deposition of asbestos fine dust in the lung was relatively insignificant in the case of peak concentrations as compared to constant exposure[3]. However, in inhalation experiments on rats with quartz dust DQ 12, Vielhaber and co-workers noticed that intermittent dusting – even with quarter doses – was followed by a maximal macrophage concentration and a strongly decreased oxygen consumption of these cells, as compared to constant dusting[13]. Considering the indicated possibility of exhausted macrophage reproduction and increased cytotoxicity, analogue experiments with peak concentrations of asbestos fine dust should be made.

Therefore it seems necessary to analyse, from the point of view of occupational medicine, the intensity and time course of asbestos fine dust concentration in open-air cutting places of asbestos cement products on building sites. As far as we know special methods have not yet been published.

MATERIALS AND METHODS

On 11 open-air building sites asbestos cement dust measurements of 1 to 8 hour duration (median = 4.7 hours) were performed during 18 days. The investigations referred to roof coverings with corrugated sheets of asbestos cement mostly of the size 1.50 × 0.90 m or 2.50 × 0.90 m. From these sheets edges placed one above the other had to be cut off with a grinding machine. Altogether eight static and personal dust samplers were employed for measuring the fibre concentration as well as the total and the fine dust mass concentration (Table 1).

The time course of fine dust concentration was measured with a TM-digital tyndallometer. Following comparative measurements with a VC 25-sampler of asbestos cement dust in a wind tunnel and also taking into account the characteristics of the instruments[1,2] it was possible to estimate the fine dust mass concentration provided that the dust composition remained constant. The wind speed was simultaneously and consecutively recorded and every single cutting process was electronically marked through the running time of the grinding machine. In addition it was possible to operate the VC 25-sampler in such a way that sampling was limited to the grinding periods.

RESULTS

Fibre analysis

Scanning electron microscopy of the filter deposits obtained by static samplers in open-air cutting places showed concentrations of 0.5 – 1.5 free fibres/ml with a length of over 5 μm. The number of free fibres below 5 μm in length was three times as large. In addition, 0.1 to 2.5 times more fibres were aggregated to cement particles and therefore were not evaluated.

The fibre length and diameter distributions were identical on the different building sites. From the mean geometrical diameter 0.4 ± 0.26 μm an aerodynamic average diameter of 1.1 ± 0.7 μm could be calculated. The mean fibre length was 5 ± 3.5 μm. More than 95% of all fibres were chrysotile as the element analysis shows.

Determination of the mass concentration

The results of static sampling in open-air cutting places with instruments placed in the wind direction show that the median fine dust mass concentration was 0.37 mg/m^3 (range 0.1 – 0.78).

The total dust amount determined in random samples was always about three to four times higher than the fine dust portion. The median concentrations

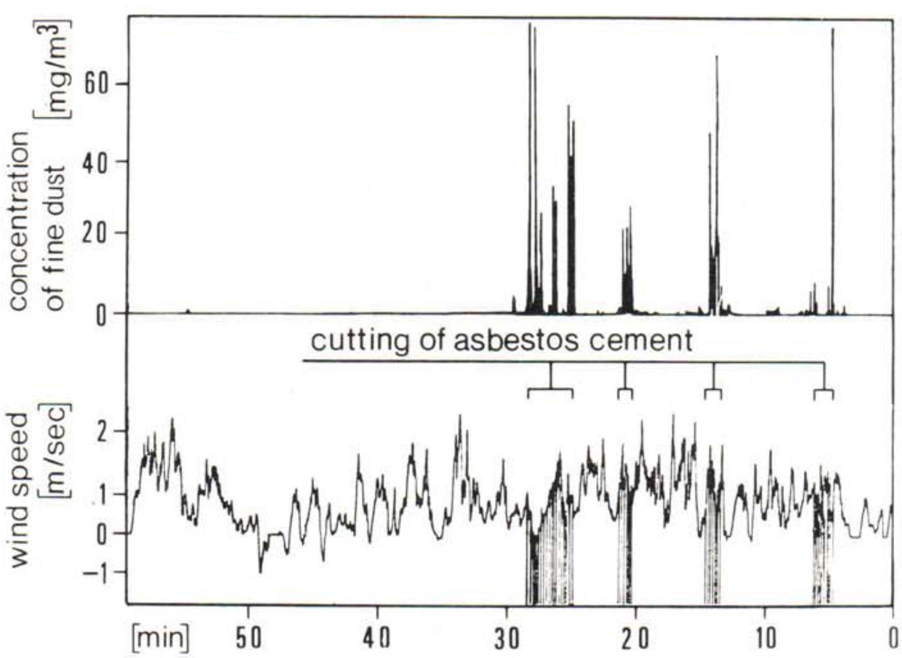


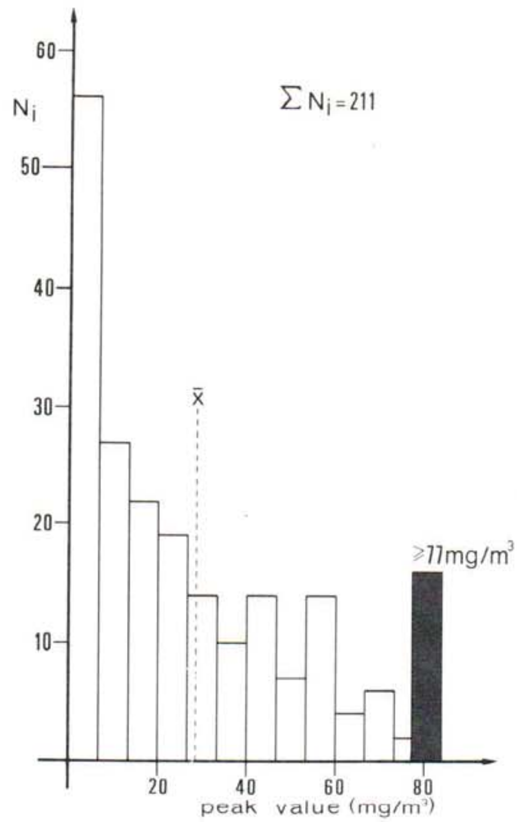
FIG. 1 – Time course of fine dust mass concentration on an open-air cutting place, where asbestos cement sheets are cut for a roof. The time constant of the TM-digital is 0.6 sec.

TABLE 1

Static and personal dust samplers for measuring the fibre concentration as well as the total and the fine dust mass concentration used in open air cutting places of asbestos cement sheets on building sites. Input velocity 0.1 – 2.3 m/sec.

Type of sampler			Producer	Pore-size (μm)	Filter material	Determination of asbestos content
Static	Fibre concentration	Nucleopore-sampler	Self-produced after Spurny	0.4	Polycarbonate	Scanning electron microscopy Electron microprobe
	Fine dust	VC 25-sampler	Sartorius, Göttingen	8.0	Cellulose nitrate	Infrared spectrography
		TM-digital	Leitz, Wetzlar			
	Total dust	GC 25-sampler	Sartorius, Göttingen	Fibre filter	Polystyrene	
		Nucleopore-sampler	Sartorius, Göttingen	0.4	Polycarbonate	
Personal	Fibre concentration	Fibre-sampler	Casella, London	0.8	Cellulose acetate	Phase contrast microscope
		SSG	Self-produced after Riediger[10]	0.4	Polycarbonate, Cellulose acetate	Scanning electron microscopy Electron microprobe
	Fine dust	Fine dust-sampler	Casella, London	8.0	Cellulose acetate	Infrared spectrography
	Total dust	SSG	Self-produced after Riediger[10]	0.4	Polycarbonate, Cellulose acetate	

FIG. 2 – Frequency of the peak heights by tyndallometrically estimated asbestos cement fine dust mass concentrations during the cutting times of a 5-hour roofing procedure on an open-air cutting place (see also Figure 1). Dark column: surpassing full scale reading.



of fine dust measured by personal sampling (n = 11) were 1.39 mg/m³ (range 0.5 – 5.8) which was 1.2 – 12.7 times higher than the values obtained by static sampling. The median of the ratio between the static and personal measurements of asbestos cement dust was about 1 : 3.6. The chrysotile content was about 10% when measured with infrared spectrography.

Time course of the fine dust mass concentration

An example of the time course of tyndallometrically determined fine dust mass concentration is shown in Figure 1. The examined cutting processes in open-air cutting places of roofers last about 3 to 13% of the working time (median = 6%). Peak fine dust mass concentrations of different intensity can only be observed during cutting times. Figure 2 shows the distribution of the peak concentrations estimated with the help of a tyndallometer during the working process shown partially in Figure 1. The mean peak height is 28.4 mg/m³ (median = 20 mg/m³). Eight per cent of the fine dust mass concentration exceeds the full scale reading of 77 mg/m³.

DISCUSSION

The time course of the mass concentration of asbestos fine dust can be recorded by instruments similar to the TM-digital tyndallometer. For that purpose the exact dust situation of the workplace has to be known. One of the most important variables for the sampling result in open-air cutting places are the wind conditions. Due to this variable and to the fact that during the cutting processes it is necessary to move from place to place, the dust arriving at static samplers is expected to be very different. The results of personal dust samplers are 1.2 to 12.7 times higher than those of the normally used static samplers. The median of the ratio between the static and personal measurements is 1 : 3.6. Therefore from the view of occupational medicine it is necessary to introduce personal dust samplers to evaluate the health risk of roofers in open-air cutting places of asbestos cement plates on building sites. Regarding the limiting value of chrysotile fine dust of 0.1 mg/m^3, the results obtained with a static sampler might suggest that normally even 50% of this value is not reached. On the other hand the results obtained by personal sampling show an excess of the limiting value in most cases. The measurements of peak concentrations indicate that dust only occurs during cutting times. But in the course of long-time sampling dust concentrations are averaged over the whole measuring period. According to these results, the occuring dust amounts could also be related to the mere cutting time. In this case the daily mean value of dust concentration must be multiplied by the ratio of the sampling time to the cutting time to get the peak concentrations.

As this proportion equals 16 : 1 in its median, a mass concentration of asbestos fine dust which is 16 times higher than the daily mean value, is to be expected during the cutting time.

Regarding the open question of a specific biological effect of an intermittent exposure to asbestos fine dust these results are necessary for epidemiological evaluation of the health risk of roofers working in open-air cutting places with asbestos cement products and correspondingly exposed employees.

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