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ESTIMATION OF EXPOSURE TO ASBESTOS-CEMENT DUST ON BUILDING SITES

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INTRODUCTION

Besides workers in the asbestos industry and the asbestos-cement industry a large number of *users* of asbestos cement and other asbestos-containing products may be exposed to asbestos-cement fine dust. For example, in the Federal Republic of Germany about 100,000 to 120,000 tons of asbestos are processed into about 1.2 million tons of asbestos-cement products, which are handled by workers on building sites. About 50,000 roofers employed by about 6000 roofing companies handle asbestos-cement sheets, which amount to 80% of asbestos-cement production. While dust control is well established in the asbestos industry, exposure of users has not been investigated carefully up to now.

It is the aim of this epidemiological study on asbestos-related fibrogenic risk to estimate the exposure to asbestos fine dust for this relatively large group of persons. A longitudinal study would be necessary to assess the tumour risk due to this exposure.

MATERIALS AND METHODS

Dust measurements, which have already been published in part (Rödelsperger et al., 1979, 1980), were made on about 40 building sites during roofing and siding work and during installation of ventilation shafts and fire insulation. Altogether, four static and four personal dust samplers and a Tyndallometer were used. Mass concentrations of total dust and fine dust were determined. For static sampling, the asbestos content in the fine dust was measured by infrared spectrography.

Fibre counting and fibre analysis were done by phase-contrast and by scanning electron microscopy.

In addition to the dust measurements, occupational histories of workers were taken, together with an extended medical examination. Up to now 61 roofers, out of a projected cohort of 400 workers handling asbestos-cement products for eight years or more, have been examined. For the occupational histories, standardized questionnaires on chronic bronchitis (for details, see Smidt, 1978) and a standardized inquiry form concerning the handling of asbestos-cement products, other asbestos-containing materials and man-made mineral fibres were used.

RESULTS AND DISCUSSION

Dust measurements

Most of the dust measurements were made during roofing operations with corrugated asbestos-cement sheets. Tyndallometer measurements showed high concentrations of fine dust only during the use of the grinding machine. This machine is commonly used to cut sheet corners which overlap on the roof: this is usually done on a stack of sheets in the open air at a fixed location (type 1) or directly on the roof (type 2).

Figure 1 shows that the probability density function of the ratio of cutting time to sampling time is log-normal. Cutting time is about 3-13% of the total working time, with a mean value of 5.7%. This value can be compared with the mean value for the cutting time per eight-hour shift, which was estimated to be 16% from histories of the roofers.

The probability density function of fine dust mass concentration measured by static and by personal sampling on type 1 building sites also shows a log-normal behaviour (Fig. 2). Measured values ranged from 0.1 to 1.35 mg/m^3 for static and from 0.13 to 7.6 mg/m^3 for personal sampling; median values were 0.34 mg/m^3 for static and 1.0 mg/m^3 for personal sampling. The mean values and confidence intervals, estimated from the measured values for a log-normal probability density function (Coenen & Riediger, 1978), are listed in Table 1. The chrysotile content of the fine dust as determined by infrared spectroscopy amounted to about 10%.

In Table 1, type 2 and type 1 building sites are compared. On type 1 building sites, only one out of three workers is exposed to high dust concentrations at open-air cutting locations, and those working on the roof are exposed to only a minor degree. In contrast, on type 2 building sites, two or more workers use the grinding machine on the roof. Roofers who are not cutting are exposed, as *bystanders*, to a similar degree. Although cutting time is approximately the same on the two types of building sites, the time course of dust generation is completely different.

FIG. 1. CUMULATIVE DISTRIBUTION FUNCTION OF THE RATIO OF CUTTING TIME:SAMPLING TIME

Measured on building sites during cutting of corrugated asbestos-cement sheets (n = 17), compared with the ratio of mean daily cutting time: 8 hours (n = 93) estimated from questionnaires

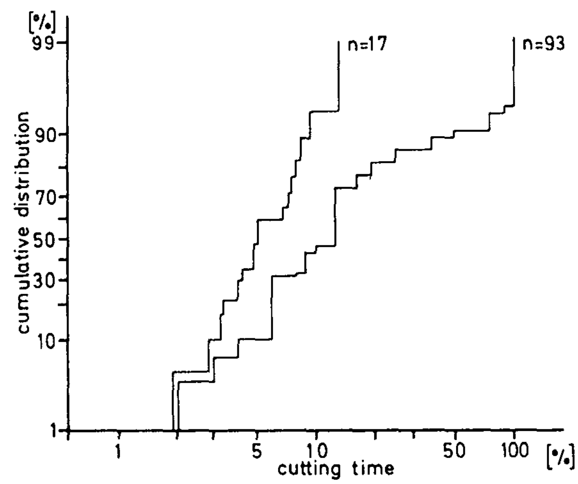


FIG. 2. CUMULATIVE DISTRIBUTION FUNCTION OF FINE DUST MASS CONCENTRATION AT OPEN-AIR CUTTING LOCATIONS ON BUILDING SITES DURING ROOFING WITH CORRUGATED ASBESTOS-CEMENT SHEETS

—— static sampling; ---- personal sampling

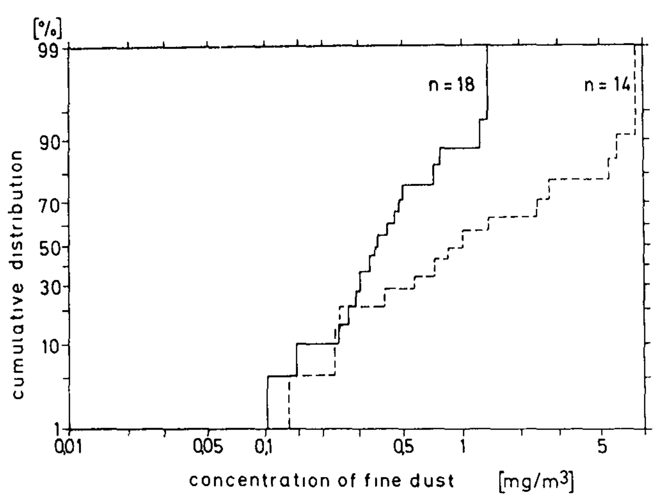


Table 1. Estimated mean values and confidence intervals of the mass concentration of fine dust measured by static and personal sampling on building sites during the cutting of asbestos-cement sheeting

Roofing with corrugated asbestos-cement sheets	Sampling	No.	Estimated mean value (mg/m³)	Confidence interval (mg/m³)
Cutting in stacks (type 1)	Static	19	0.51	0.37 - 0.79
	Personal	14	2.2	1.3 - 8.9
Cutting on roofs (type 2)	Static	3	0.5	0.2 - 35
	Personal	8	1.82	0.85 - 9.81

When the different frequency and type of exposure for cutters and bystanders are taken into account, mean exposure to chrysotile fine dust is about the same for both types of building sites: about 0.11 mg/ m^3, or about half of the mean value of exposure to asbestos fine dust of cutting workers on type 1 building sites.

During cutting with the grinding machine, the mass concentration of fine dust estimated with the Tyndallometer showed peak values ranging above 80 mg/m^3. This means that *peak concentrations* of fine chrysotile dust may be more than 8 mg/m^3. Correspondingly, light microscopy measurements show fibre concentrations of more than 100 fibres/ml of length > 5 µm when the sample is taken within the dust cloud caused by the grinding machine. Close to the head of the employee, fibre concentrations of 0.6-41 fibres/ml of length > 5 µm were observed during the cutting process; the mean value of nine such measurements was 20 fibres/ml. Since high fibre concentrations occur only during cutting, which, on average, amounts to 6% of the working time, the daily mean value calculated from fibre concentration during cutting processes reaches only 1.2 fibres/ml. The mean daily fibre concentration to which workers roofing with corrugated sheets are exposed is estimated to be half this value for both types of building sites (0.6 fibres/ml).

Analysis of fibre length and diameter distributions in the scanning electron microscope shows wide variations between samples. The ratio of fibres with a length > 5 µm to the total number of free fibres ranges between 4 and 60%, with a median value of 25%. Mean values of fibre length ranged from 1-5 µm and fibre diameter from 0.1-0.4 µm.

Histories

Up to now, occupational histories of 61 roofers employed by 33 roofing companies have been evaluated. Since some of the workers were engaged in more than one position, 93 were analysed in all. The frequency of roofing with sheets of corrugated asbestos-cement sidings and of roofing with asbestos-cement shingles, where the grinding machine is not used, are presented in Table 2.

Table 2. Occupational histories of 61 roofers: frequency of handling asbestos-cement products

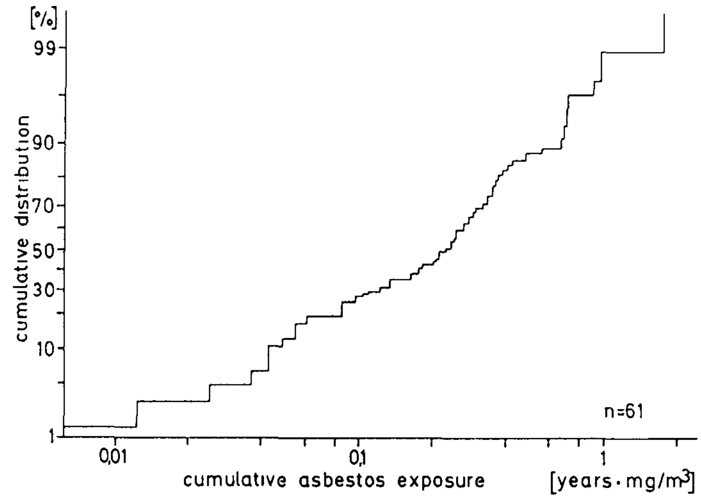
Product	Handling frequency (days/year)	
	Median	Mean ± SD
Corrugated sheets	34	39.2 ± 31.2
Shingles	30	39.4 ± 39.8
Front plates	25	30.3 ± 29.2

Although dust measurements are not yet complete, we can state already that generation of fine dust with the grinding machine is most intense during roofing with corrugated asbestos-cement sheets. Such operations were carried out on up to 125 days per year; more than half of the roofers handled such sheets on more than 34 days a year. All roofers also work with other asbestos-containing products, such as shingles and siding.

Dust exposure is expressed as the cumulative dose, which is calculated from the product of dust concentration and duration of exposure. This procedure has also been used by other authors (Bader et al., 1961; Dreesen et al., 1938; Morse, 1967; Newhouse, 1969; Woitowitz et al., 1970). From the years of duration of employment and the number of days per year when roofing with corrugated sheets is performed, the cumulative exposure of individual workers can be calculated. Assuming an average concentration of fine chrysotile dust of 0.11 mg/m^3, we obtain the cumulative dose values presented in Figure 3. The probability density function is nearly log-normal. The median of the cumulative fine asbestos dust exposure amounts to 0.21 years·mg/m^3, and the mean is 0.29 ± 0.29 years·mg/m^3. This mean value corresponds to an exposure of three years, with an average asbestos fine dust mass concentration equal to the Federal Republic of Germany's limit value of 0.1 mg/m^3. Since the mean duration of exposure by use of corrugated sheets amounted to 16 years for the roofers, the mean exposure per year can be estimated roughly to be 20% of the limit value.

FIG. 3. CUMULATIVE DISTRIBUTION FUNCTION OF CUMULATIVE CHRYSOTILE EXPOSURE, CALCULATED FOR THE USE OF CORRUGATED ASBESTOS CEMENT SHEETS

A mean daily chrysotile fine dust concentration of 0.11 mg/m^3 is assumed during roofing with corrugated asbestos-cement sheets. The mean duration of exposure amounted to 16 years.



Dust exposure can also be calculated from the daily mean value of *fibre concentration*, which has been estimated to be 0.6 fibres/ml of length > 5 µm. Unlike the chrysotile fine dust mass concentration, the fibre concentration ranges below the limit value of 2 fibres/ml of length > 5 µm; therefore, the mean value for the cumulative fibre exposure, which is calculated to be 1.6 ± 1.6 years·fibres/ml, corresponds to an exposure of only 0.8 years to the limit value of 2 fibres/ml of length > 5 µm. Although this cumulative exposure level is low compared with past exposure in the asbestos industry, an epidemiological follow-up study of this large population of roofers working with asbestos-cement products would seem to be necessary.

SUMMARY

In the Federal Republic of Germany, about 1.2 million tons of asbestos are handled on building sites, for example, by roofers, carpenters and ventilation fitters. The objective of this study was to determine both the exposure to dust during the handling of asbestos-cement products on building sites and the possible resulting fibrogenic health hazard. In order to assess the tumour risk, this cross-sectional study should be enlarged to a longitudinal study.

Dust measurements were made on about 40 building sites with four static and four personal dust samplers and a Tyndallometer. Evaluation was performed by infrared spectrography and light and scanning electron microscopy. Peak concentrations of more than 100 fibres/ml of length > 5 μm or about 80 mg/m^3 fine dust were observed in the vicinity of the grinding machine. The asbestos content of the fine dust was about 10%. Scanning electron microscopy showed a wide variation of fibre lengths and diameters; a large proportion of fibres with diameters below 0.2 μm was found. Long-term, mean values and confidence intervals of the concentration of fine dust were calculated from the measurements. For example, the mean fine dust mass concentrations for roofers cutting corners of asbestos-cement sheets with the grinding machine amounted to 2.2 mg/m^3 when the cutting was done in the open air at a fixed location. When cutting was performed on the roof, the mean fine dust mass concentration amounted to 1.8 mg/m^3.

From the standardized histories of the first 61 roofers, the frequency of handling asbestos products and of using the grinding machine was estimated for present as well as for prior working places. From the results of dust measurements and histories, cumulative doses of 0.3 years·mg/m^3 asbestos fine dust and 1.6 years·fibres/ml were calculated.

RESUME

En République fédérale d'Allemagne, quelque 1,2 million de tonnes d'amiante sont manipulées sur les chantiers de construction, par les couvreurs, les charpentiers et les installateurs d'appareils de ventilation par exemple. Cette étude avait pour but de déterminer à la fois

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