

NOTES

Occupational Exposure to Asbestos During Renovation of Oil-Shale Fuelled Power Plants in Estonia

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Many thousands of tonnes of asbestos were used in buildings in the past, especially for thermal insulation of pipes and boilers in power plants. Occupational exposure to asbestos dust now mainly occurs during demolition, renovation and routine maintenance activities. The objective of this study was to evaluate occupational exposure to airborne asbestos during renovation of solid oil-shale fuelled power plants carried out in 2001–2003. Air monitoring inside and outside of the renovation area was performed. The concentration of airborne fibres in the working environment increased during renovation but the valid limit value (0.1 fibres/cm^3) was not exceeded.

asbestos occupational exposure power plant renovation

1. BACKGROUND

Asbestos and asbestos-containing materials have been used in quite large quantities especially during the second part of the 20th century in Estonia. Total raw asbestos (chrysotile) was imported from the former Soviet Union as there are no asbestos deposits in Estonia. The use of asbestos and asbestos-containing products peaked in the 1960–80s and diminished at the beginning of the 1990s. The production of asbestos-cement sheets and the intensive building of industrial and housed constructions during this period attest to that fact. In 1995 the production of asbestos-containing materials stopped in Estonia.

Numerous asbestos and asbestos-containing products were used for thermal insulation during the building of power plants in the north-east region of Estonia. The Baltic and the Estonian power plants (plants 1 and 2, respectively), which were built in the 1960–1970s, are among the

largest power plants in the world using solid oil-shale fuel and their workers are simultaneously exposed to asbestos, oil-shale dust, oil-shale fly ash and oil-shale soot. Estonian oil shale has a low heat value and high ash content of about 45%.

There is ample medical evidence of the health hazards caused by asbestos, proving that it is indisputably a major health risk. Exposure to asbestos is known to cause lung cancer, cancer of the pleura and the peritoneum (mesothelioma), asbestosis and pleural diseases. In addition, some studies have indicated a link between exposure to asbestos and certain other cancers (of the larynx, gastrointestinal tract and kidneys). A typical feature of all asbestos-induced diseases is a long delay, of often decades, between initial exposure and the onset of the disease. In many developed countries, in the most affected age groups, mesothelioma may account for 1% of all deaths and 5–7% of all lung cancers can be attributed to occupational exposure to asbestos. Besides low-level exposure

may lead to asbestos-related diseases, although high exposure for long periods is linked more clearly to these illnesses [1, 2, 3, 4].

The first step to chart hazards in the working environment in Estonia (with the labour force of 0.65 million) was taken by the National Board of Health Protection at the beginning of 1996. Identification of occupational hazards and risk was carried out. The results of the analysis showed that 16% of Estonian industrial workers were exposed to different hazards and among those 4 300 workers were exposed to oil-shale dust [5]. The number of Estonia's workers exposed to carcinogens in 1997—according to the CAREX (CARcinogen EXposure) database—was about 180 000 (28% of employed persons). The most common exposures were solar radiation, environmental tobacco smoke, wood dust, crystalline silica and diesel exhaust. Exposure to asbestos in this international information system was slightly less prevalent: 0.3–1.1% of the exposed [6].

Several series of experimental investigations were carried out in order to determine the carcinogenicity of Estonian oil-shale soot as well as soot from oil-shale fuel oil. All the investigated samples of soot showed a relatively low (14–1 200 ppm) benzo(a)pyrene content. The benzene extract of shale fuel oil exerted a considerably weaker carcinogenic action than the extract of soot of solid shale [7]. It has been experimentally shown that oil-shale fly ash does not induce lung tumours but increases substantially the frequency of lung tumours induced by benzo(a)pyrene [8].

Some morphological investigations were carried out to clarify the pathogenicity of industrial dust produced in the mining and processing of Estonian oil shale. Histological examination of the lungs of workers in the oil-shale industry taken at necropsies showed that the inhalation of oil-shale dust over a long period (more than 20 years) may cause occupational pneumoconiotic changes in the lungs of oil-shale miners. The pneumoconiotic process develops slowly and is characterized by changes typical of the interstitial form of pneumoconiotic fibrosis in the lungs. The results of experimental studies also indicated a mild fibrogenic action of Estonian oil-shale dust [9].

Hygienic evaluation of contact with asbestos-containing dust at thermoelectric power plants in Russia showed that insulating workers were exposed to asbestos in concentrations sufficient to cause asbestos-related diseases including malignancies. The study showed that workers who did not directly work with asbestos were also exposed to asbestos-containing dust. So all personnel of heating power stations could be considered at risk of asbestos-related diseases [10]. Mean concentration of total dust measured in normal working conditions in the Baltic power plant was $5.30 \pm 3.13 \text{ mg/m}^3$, whereas in the main service levels of the power plant it was $7.80 \pm 4.64 \text{ mg/m}^3$. Exposure levels during different maintenance and repair activities varied [11]. Evaluation of occupational exposure to the principal contaminants, including respirable dust (coal dust) and asbestos, during routine activities in coal-fuelled power plants revealed that 4 out of 203 respirable coal dust samples were greater than the limit of detection ($0.13\text{--}0.37 \text{ mg/m}^3$), and 12 out of 61 area asbestos samples had concentrations greater than the limit of detection, $0.003 \text{ fibres/cm}^3$ [12].

We have limited information about the health status of workers exposed to asbestos and asbestos-containing dust in Estonia. For example, the cancer of the pleura, lungs and larynx among active male workers of Electricité de France—Gas de France were studied in association with asbestos exposure using a case–control design within the cohort of the company's workers. The cohort included about 1 400 000 person-years, corresponding to a mean of 117 000 persons per year. During the observation period (1978–1989), 12 cases of pleural cancer, 310 cases of lung cancer and 116 cases of larynx cancer were registered in the cancer register of the company's social security department. This study showed that occupational exposure to asbestos could increase the risk of pleural and lung cancer in a sector in which exposure levels were not considered to be high compared with other industrial settings [13].

To protect workers from risks related to occupational exposure to asbestos, the first regulation which restricted the use of asbestos

was enforced in Estonia in 1993. In 2000 the use of asbestos and asbestos-containing products was prohibited in Estonia by the Decree of the Minister of Social Affairs "Restrictions of the handling of hazardous chemicals to population and the environment". Asbestos-containing elements of industrial equipment can be used until the end of their assumed working life; after that they should be replaced with asbestos-free materials [14]. The ban on asbestos prevents risk of new exposure, but it does not exclude damage from past exposure. Health effects from asbestos exposure may continue even after exposure has ceased. Therefore, occupational exposure to asbestos now mainly occurs during demolition, renovation and routine maintenance activities. Some activities, if not adequately controlled, can also contaminate the surrounding area.

In 2001 the renovation of Estonia's biggest solid oil-shale fuelled electric power plants started. The aim of this renovation was to make the production of electricity more economic and environment friendly. To perform this renovation a new technology was used and some processes were made more automatic. One energy block from each plant was renovated. Two new boilers and turbines were built. The renovation works were carried out in the middle of plant 1 and on one side of plant 2. The renovation area was isolated but not completely because this was impossible in large power plants. During the renovation asbestos-containing materials were no longer used. About 1 000 persons participated in the renovation activities, mainly specialists from Finland, but Polish and Estonian companies took part in them, too. Thus, the aim of this study was to evaluate occupational exposure to airborne asbestos in power plants during renovation.

2. MATERIAL AND METHODS

Occupational exposure to airborne asbestos and the distribution of fibres in the plants (from the ground floor up to 36 m in plant 1, and from the ground floor up to 40 m in plant 2) during normal working activities were examined. A total of 138 samples was collected to measure airborne fibre concentrations at different service

levels. From each service level an average of 12 area samples was taken. At the same time safety requirements for working in the power plant had to be followed. During the renovation air was monitored inside and outside the renovation area of the turbine hall and the boiler-house in the main service levels (from the ground floor up to 10 m). A total of 304 samples with a sampling time from 2 to 4 hrs was taken, 156 from plant 1 and 148 from plant 2. Fibres that had a maximum length of over 5 μm , diameter of under 3 μm and the length-to-diameter ratio of over 3:1 were counted at magnification of 500. A G22 Walton-Beckett gradicule (Carl Zeiss, the UK) with a diameter of 100 μm in the object plane was used for counting fibres. Membrane filters (mixed ester of cellulose) of 0.8- μm porosity, mounted in an open-face filter holder and battery-operated pumps were used for air sampling. The sample flow rate (2 L/min) was established at the beginning and checked at the end of each sample period. Airborne fibre concentrations were reported with the arithmetic mean and its standard deviation. The sampling and analysis were carried out according to Asbestos International Association (AIA) standard guidelines for airborne asbestos fibres [15].

3. RESULTS

The concentration of airborne fibres reduced vertically in the both power plants. The highest airborne fibre concentrations were found in the main service level, i.e., 8 and 10 m from the ground floor, respectively, 0.034 ± 0.011 (Figure 1) and 0.023 ± 0.007 fibres/cm³ (Figure 2).

The mean concentrations of airborne fibres in the working environment of the boiler-house and the turbine hall in plant 1 during normal working activities was 0.024 ± 0.009 ($N = 84$), during the renovation period 0.038 ± 0.016 ($N = 76$) fibres/cm³; whereas the respective average concentrations in plant 2 were 0.017 ± 0.005 ($N = 61$) fibres/cm³, and 0.024 ± 0.014 ($N = 87$) fibres/cm³ (Table 1).

In general, the airborne fibre concentrations in the turbine halls were lower than in the boiler-houses. The concentration of airborne fibres

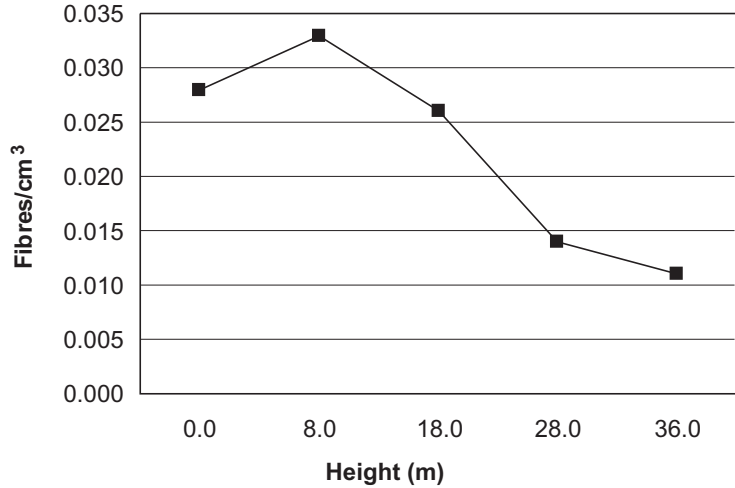


Figure 1. Airborne fibre concentrations (fibre/cm³) in plant 1.

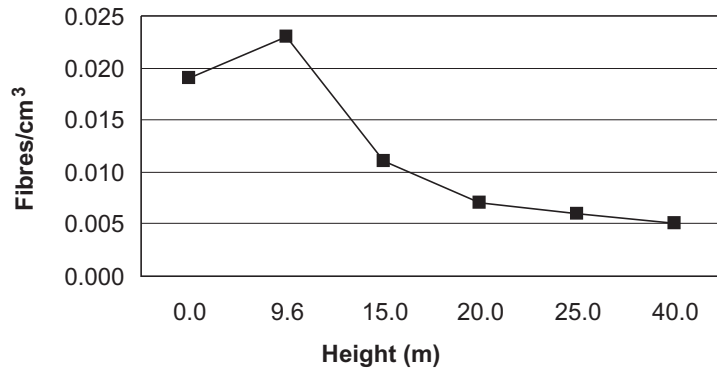


Figure 2. Airborne fibre concentrations (fibre/cm³) in plant 2.

TABLE 1. Airborne Fibre Concentrations (fibre/cm³) Before and During Renovation of Power Plants

Sampling Site	No. of Samples	<i>M</i> ± <i>SD</i>	Range
Before renovation			
Plant 1			
Boiler-house	58	0.034 ± 0.011	0.010–0.049
Turbine hall	26	0.014 ± 0.004	0.007–0.024
Plant 2			
Boiler-house	38	0.023 ± 0.007	0.006–0.038
Turbine hall	23	0.011 ± 0.003	0.005–0.018
During renovation			
Plant 1			
Boiler-house	30	0.043 ± 0.022	0.010–0.079
Turbine hall	46	0.032 ± 0.014	0.010–0.072
Plant 2			
Boiler-house	35	0.028 ± 0.020	0.006–0.072
Turbine hall	52	0.019 ± 0.013	0.005–0.053

in the working environment increased during renovation but the limit value was not exceeded. Therefore, airborne fibre concentrations in the older power plant (Plant 1) were higher in the normal working conditions and increased slightly during the renovation period.

4. DISCUSSION

Asbestos and asbestos-containing materials were used for thermal insulation of boilers, turbines, water and steam pipes in power plants in the past. Many are still there. Therefore the presence of asbestos in the buildings poses a danger that asbestos materials may become damaged over time and release fibres into the air.

According to the occupational health and safety requirements for asbestos works [16] employers are obliged to check regularly the state of the working environment and carry out measurement of asbestos fibres in workplace air. During renovation activities these requirements are fulfilled by employers. The current limit value for asbestos in workplace air in Estonia is 0.1 fibres/cm³. This control limit value corresponds to Directive 2003/18/EC [17].

The use of area samples alone in determining individual exposure must be viewed with caution because area samples are not recommended for measuring personal occupational exposure to asbestos dust. However, area sampling can be useful if the dust is uniformly distributed over large areas [15]. On the basis of previous studies our power plants can be classified to this group of buildings [11].

A study of personal and area airborne asbestos concentrations during asbestos abatement suggest that area and personal samples were not significantly different and exhibited a good correlation using regression analysis. Area sample fibre concentrations were shown in this study to have a larger variability than personal measurements [18].

Considering that asbestos-containing thermal insulation materials were often used in power plants and many of them are still there, the concentration of airborne asbestos fibres in the

working environment should be determined regularly.

Airborne fibre concentrations in the two power plants under study were relatively low, but any level of asbestos exposure carries a health risk as there is no safe level of exposure to asbestos fibres. So all workers of the power plants have been exposed to asbestos in the course of their occupation and could be assigned to the group at risk from asbestos-related diseases. According to Directive 2003/18/EC [17] workers' exposure to dust arising from asbestos or asbestos-containing materials at work must be reduced to a minimum and, in any case, below the limit value.

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