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FIBERS RESPIRABLE IN THE AIR

Abstract. The paper presents the characteristics of respirable fibers. Respirable fibers are defined as fibers less than 3 μm in diameter, more than 5 μm in length, and a length to thickness ratio of the fiber greater than 3:1. Such dimensions of the fibers allow them to hang in the air and have the ability to travel long distances. Examples of respirable fibers are residues of asbestos products or artificial mineral fibers. The respirable size of the fibers is considered to be a physical carcinogen. The cause of diseases is long-term effects on the respiratory system. Asbestos is assigned a first hazard category. Its permissible concentration limit in the preparation is 0.1% by mass. Exceeding this value requires including this dangerous substance in the classification of any mixture. The need for research on the concentration of respirable asbestos fibers in the atmospheric air is emphasized.

Key words: fibers respirable, environmental pollution, asbestos, impact on human health.

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ВОЛОКНА, ЯКІ ВДИХАЮТЬСЯ НА ПОВІТРІ

У статті представлені характеристики вдихуваних волокон. Респіративні волокна визначаються як волокна діаметром менше 3 мкм, довжиною більше 5 мкм і відношенням довжини до товщини волокна більше 3:1. Такі розміри волокон дозволяють їм висіти в повітрі і мати здатність подорожувати на великі відстані. Прикладами вдихуваних волокон є залишки азбестових виробів або штучних мінеральних волокон. Розмір волокон, який можна вдихнути, вважається фізичним канцерогеном. Причиною захворювань є тривалий вплив на органи дихання. Азбесту присвоєно першу категорію небезпеки. Його допустима концентрація в препараті становить 0,1% мас. Перевищення цього значення вимагає включення цієї небезпечної речовини до класифікації будь-якої суміші. Наголошується на необхідності дослідження концентрації вдихуваних азбестових волокон в атмосферному повітрі.

Ключові слова: волокна, які вдихаються, забруднення навколишнього середовища, азбест, вплив на здоров'я людини.

Introduction

Respirable fibers are the result of weathering the residues of asbestos products or artificial mineral fibers. Artificial mineral fibers are introduced on an increasing scale as substitutes for asbestos. The products are offered in loose form, as well as in the form of mats, plates, tapes, cords, cardboard and paper. These products are characterized by good insulation properties (thermal, electrical and acoustic) and chemical resistance [1].

Products containing artificial mineral fibers are used in industrial and housing construction and in plants using them to produce their own products – ceramics plants, aviation plants, power plants, shipyards, automotive industry, household appliances plants. Refractory ceramic fibers are a group of synthetic mineral fibers (amorphous or crystalline) with flame retardant properties (i.e. high temperature stability).

The pathogenic effect of respirable fibers occurs as a result of their inhalation from the air. This means that only the release of respirable fibers into the atmosphere and their inhalation poses a health hazard. The occurrence and type of pathology depends on several elements: the type and dimensions of fibers, their concentration, the duration of the organism's exposure to them, and the effectiveness of biological cleansing mechanisms and the possible presence of other toxic factors [2; 3]. Respirable fibers can also be present in water, drinks and food, from where they enter the human body. However, there is no evidence that asbestos enters the body through the alimentary tract is harmful to health. The harmfulness of respirable fibers does not result directly from their chemical composition, but from the mechanical influence of the thinnest naturally occurring fibers in the human lungs. The physical and aerodynamic characteristics of the fibers are responsible for the varying degree of penetration and the amount of fibers entering the respiratory system. It was also noted that simultaneous exposure to asbestos dust and tobacco smoke causes synergism in the carcinogenic effects of these agents.

The main reasons for the release of respirable fibers from asbestos products are corrosion of asbestos-containing products and damage to asbestos-containing products [4]. Asbestos-containing products corrode after reaching their technological age. Spontaneous dusting of fibers in the case of the most commonly used asbestos

boards (containing 9–12% of asbestos) occurs most often after 30 years of use. Fiber emission can be increased or occur earlier in broken or cracked slabs as well as due to biological corrosion due to the presence of mosses and algae. Breaking, crushing, cutting, grinding asbestos-containing products is caused by improper use and improper disassembly. It can also occur due to the influence of the weather. Renovation, modernization and technical wear and tear, which progresses over time, make asbestos products a hazardous waste. Asbestos-containing waste is generated mainly when replacing panels on roofs and facades, when removing asbestos-cement fittings from ventilation and smoke ducts in all kinds of buildings, as well as during renovation or modernization of heat exchangers.

Physical properties of fibers as a carcinogenic factor

Respirable fibers, including asbestos fibers, have a pathogenic effect on the human body as a result of inhaling them from the air. On the other hand, the negative health effects resulting from the supply of asbestos dust to the body through the alimentary tract, e.g. with water supplied through pipes made of asbestos-containing materials, are negligible.

The key parameter is the diameter of the asbestos fibers. Thinner fibers, less than 3 μm in diameter, reach the end parts of the respiratory tract much more easily and then remain there. On the other hand, coarser fibers, with a diameter exceeding 5 μm , mostly do not pass beyond the upper part of the respiratory system, from which they are easily excreted by, for example, expectoration. The shape of the fibers also significantly affects the degree of lung penetration: chrysotile fibers, usually twisted and of larger diameter, are located higher than amphibole fibers, with the shape of thin and straight needles, which reach the peripheral parts of these organs, usually additionally penetrating their structure. That is why we are talking about their greater harmfulness. The greatest danger to human health is posed by respirable fibers that can reach deep into the lungs and are imperceptible to the human eye. The definition contained in the Polish standard PN-88 Z-04202/02 [5] defines respirable fibers as fibers with a diameter below 3 μm , a length of more than 5 μm and a length-to-thickness ratio above 3:1. Such dimensions of the fibers allow them to hang in the air and have the ability to travel long distances. The resilient dimensions of the

fibers, among the other characteristics of asbestos, are considered to be a physical carcinogen.

Pathogenic effect of asbestos fibers on the human body

The name “asbestos” comes from the Greek word *asbestos* – indestructible, which describes its unique physicochemical properties. Asbestos is a trade name for six serpentine fibrous minerals (chrysotile) and amphiboles (amosite, actinolite, anthophyllite, crocidolite and tremolite). It defines a group of naturally occurring fibrous silicate minerals containing oxides of magnesium, calcium, sodium and iron [6].

During the period of the greatest industrial use of asbestos, the harmful effect of this raw material was confirmed, which in the following years led to the introduction of gradual restrictions and in many countries a ban on the use of products containing this mineral [7]. According to the assessment of the Ministry of Economy, in our country there are about 15.5 thousand tonnes of water and sewage pipes and chimneys containing an addition of asbestos minerals. The durability of asbestos-cement products is determined at 50 years, while the lifetime of other products is usually shorter. Regardless of the durability of asbestos products, their technical condition deteriorates with the passage of time. It was an important argument concerning the dissemination and enforcement of safe methods of operation, disposal, transport and disposal of waste resulting from these products.

As mentioned, asbestos is classified as a substance with proven carcinogenic activity, which poses a threat to human health. It is caused by long-term effects on the respiratory system, in accordance with the list constituting an appendix to the Regulation of the European Parliament and of the Council of 16 December 2008 on the classification, labeling and packaging of substances and mixtures [8] and according to the Regulation of the Minister of Health of 10 August 2012 on the criteria and method of classification of chemical substances and mixtures [9]. Asbestos is assigned a first hazard category. Its permissible concentration limit in the preparation is 0.1% by mass. If this value is exceeded, this hazardous substance must be included in the classification of any mixture [7]. Inhalation of air contaminated with asbestos dust may cause the following respiratory diseases:

- asbestosis (asbestosis) – a condition where the lung tissue slowly becomes fibrosis, leading to

respiratory failure. We distinguish three forms of asbestosis: light, moderate and severe, which are manifested mainly by: chronic inflammation of the upper respiratory tract, acute cough, alveolar murmur in the lower sections of the lungs, pleural friction, periodic subacute circulatory failure, cardiovascular symptoms;

- lung cancer – rapidly developing cancer as a consequence of asbestosis; occurs after 10–35 years from the onset of exposure; neoplasm development is accelerated by long-term asbestosis and nicotinism (7–12 times) [10];

- pleural changes – a disease occurring in the form of delimited plaques, lumps and exudative reactions; benign pleural changes are of little clinical significance; pleural thickening usually accompanies the processes of fibrosis in the adjacent lung tissue; diffuse fibrosis and pleural thickening are observed in cases of high exposure; the clinical course is often asymptomatic or there are mild symptoms in the form of dyspnoea, hyperventilation; the latency period (latency) is between 15 and 30 years;

- pleural or peritoneal mesotheliomas – a malignant neoplasm specific to asbestos, caused by the deposition of microscopic respirable asbestos fibers in the lungs, which over time are transferred to the pleura surrounding the lower parts of the lungs and cause nodules of neoplastic foci, resulting in the accumulation of serous fluid causing a reduction in volume working lungs; neoplasm develops after 10–40 years or more from the beginning of exposure;

- other neoplasms (e.g. larynx, stomach, intestines, pancreas, ovary) or lymphomas [11].

The type of pathology largely depends on the type of exposure. There are three types of it: professional, semi-professional and environmental. Occupational exposure takes place when work is performed during exposure to asbestos dust, e.g. in asbestos mines, various types of raw material processing plants, factories using asbestos products, 45 car workshops at brake and clutch replacement stations and in workplaces related to the removal of asbestos, and disposal of asbestos-containing materials. This type of exposure involves contact lasting several hours a day, which may result in occupational diseases (asbestosis, pleural mesothelioma and lung cancer). The para-occupational exposure concerns the inhabitants of the areas adjacent to mines and asbestos processing plants, as well as the families of employees of these enterprises. Asbestos dust is not

only transported by air movements, but is also carried on the shoes, clothes and hair of asbestos workers, resulting in elevated levels of fiber concentration in their homes. This type of exposure mainly causes pleural mesotheliomas, and at higher concentrations the risk of lung cancer increases.

Symptoms of asbestos exposure occur over a long period of time, even 40 years after the first exposure. The proven carcinogenic effect of asbestos fibers, absorbed into the body from the

air, was the reason for limiting its use in industry. In 2005, the trade and use of asbestos was banned in the European Union, and in Poland, by the order of the Minister of Health and Social Welfare of 1996, the use of asbestos products in construction was banned. Pursuant to the Act of June 19, 1997 on the prohibition of the use of asbestos-containing products [12], asbestos-containing products cannot be introduced, manufactured and used (with some exceptions).

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