IETI Transactions on Ergonomics and Safety
http://ieti.net/TES/

2018, Volume 2, Issue 2, 22-29, DOI: 10.6722/TES.201812_2(2).0004

ASBESTOS-RELATED OCCUPATIONAL RISKS

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Abstract Despite the common knowledge of its harmful effects, asbestos is still used worldwide. It is estimated that about 125 million workers around the globe are exposed to asbestos in the workplace, while at least 90,000 people die annually from asbestos-related diseases. Asbestos dust is generated during mining, during separation of fibres from the serpentine part, and during processing in various industry branches. Employees involved in these production processes are especially at risk. Chronic exposure to asbestos can increase the risk of asbestosis, lung cancer, and mesothelioma. Asbestos exposure is usually reduced through replacement of asbestos with materials with similar properties and through the use of personal protective equipment. Disease prevention requires the implementation of strict asbestos removal procedures, ban on further use, and registering of persons exposed to asbestos, including their follow-up or preventive medical check-ups.

Keywords: Asbestos; occupational risks.

1. INTRODUCTION

Asbestos is a natural silicate mineral of fibrous and crystalline structure. It is naturally occurring in two forms: serpentine and amphibole. Serpentine asbestos includes the mineral chrysotile, which has the widest commercial application. Amphibole asbestos includes the minerals actinolite, tremolite, anthophyllite, crocidolite, and amosite.

Asbestos is widely used owing to its unique physicochemical properties. Due to their convenient properties, asbestos and materials containing asbestos are still widespread in the occupational and natural environment, even though they have been banned in the European legislation. Asbestos is most commonly used in the manufacture of insulating materials, asbestos paper and filters, brakes and clutches, and protective firefighting clothes against radiation and heat, as well as a construction material, for shipbuilding, for steam boiler insulation, and for a variety of household applications.

Despite the existing legislation, which limits and prohibits the use of asbestos-containing products, its use and the related exposure to asbestos in both the occupational and the natural environment are still prominent. In most products, asbestos is not pure but is bound to form other composite materials. Over time the materials wear out, which disintegrates the composite material matrix and leads to asbestos fibre emissions.

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Potential health risk to workers exposed to asbestos depends on the concentration of asbestos fibres, the duration of exposure, the frequency of exposure, and the size, shape, and chemical composition of the fibres.

Risk prevention and reduction measures are established according to a risk assessment for asbestos exposure. Risk assessment is mandatory before any work with potential risk of asbestos exposure can begin.

2. USE OF ASBESTOS

It is estimated that there are currently over 3,000 different products containing asbestos on the market. Despite the knowledge of its harmful effects, it is still widely used throughout the world. The largest consumption of asbestos and asbestos-containing products was registered in China (ca. 30%), India (15%), Russia (13%), Kazakhstan (5%), and Brazil (5%) [1].

Even though there are laws and measures in place that prohibit the use of asbestos, it is still a health and environmental hazard in Serbia, because it is widespread, especially in construction materials, in water distribution pipes, and brake systems in cars and vessels. In addition to a ban on use in construction, asbestos-containing products are no longer manufactured in Serbia.

Serbia was home to two asbestos mines – Stragari and Korlaće. Asbestos extracted from these mines was used in Serbian companies “Jugoazbest”, in asbestos-based construction products, and “Fiaz”, Kruševac, for brake disc manufacture.

According to the data from 2011, an estimated 30% to 70% of the water supply network was made of asbestos. The report on the environmental impact of the activities of the Electric Power Industry of Serbia from 2006 showed that the insulation material in thermal power stations “Nikola Tesla” A and B contained around three tonnes of asbestos, while the construction material in thermal power station Kostolac contained around five tonnes [2].

In the occupational environment, asbestos fibres can be found during mining, manufacture of asbestos-based products, or after the destruction of asbestos-containing materials (insulation material, asbestos paper, brakes and clutches, asbestos powder, flour, talc-mortar, and others).

3. ASBESTOS EXPOSURE

Exposure to asbestos is not hazardous until its fibres are dispersed from the composite materials of which they are a part. Over time the materials wear out, which causes disintegration of the composite material matrix and leads to the dispersal of asbestos fibres [2].

Asbestos dust is generated during mining, during separation of fibres from the serpentine part, and during processing in various industry branches, which puts employees involved in these production processes at risk. Workplace atmospheres can contain particles with a length of 1-5 microns as well as longer particles, from 10 to 30 microns long.

WHO studies have shown that asbestos dust is more likely to cause cancer than the asbestos ingested orally.

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There is no limit value for asbestos exposure that is considered to be completely safe. Thus, any exposure is treated as hazardous and the more a person is exposed, the higher the risk of disease becomes [2].

According to the Rules on Preventive Measures for Safe and Healthy Work during Asbestos Exposure, the limit value of exposure is 0.1 asbestos fibres per 1 cm3 of air during an eight-hour workday.

Potential human risk factors include the following: asbestos fibre concentration; duration of exposure; the frequency of exposure – how often a person was exposed over a given period; and size, shape, and chemical composition of asbestos fibres.

During asbestos exposure, when long and thin fibres are inhaled, they reach the lower parts of the respiratory system and the alveolar space. There they are retained in the lungs for prolonged periods and are more toxic than shorter and thicker fibres. For instance, fibres of amphibole asbestos, such as tremolite, actinolite, and crocidolite are retained longer in the lower respiratory tract than the fibres of chrysolite, which are similar in size. Thicker fibres reach the upper respiratory tract, but not the lungs, which are the location of their induced toxicity. Short and thin fibres also play a role in the pathogenesis of asbestos-related diseases [2].

4. HEALTH EFFECTS OF ASBESTOS

According to the classification of toxic substances, asbestos belongs in a special group of toxic substances (dusts).

Dusts are usually defined as aerosols, solid toxic particulates, and their mixtures in workplace atmospheres. Dusts are divided into organic and inorganic. Inorganic dusts are of metallic and mineral origin, whereas organic dusts can be artificial (plastic and synthetic materials) or of plant or animal origin.

Dusts can also be classified according to the intensity of pulmonary tissue reaction, manifested as pulmonary fibrosis, into fibrogenic dusts, which cause an intensive pulmonary tissue reaction and destroy the alveoli and alveolar blood vessels, and non-fibrogenic dusts, which cause a minimal lung tissue reaction.

Asbestos is not harmful because of its chemical composition but because of its needle-like structure, which easily puncture the pulmonary membranes and lead to chronic inflammation, the body's reaction to the presence of a foreign body.

Asbestos fibres float in the air and if they are inhaled into the lungs, they can easily bypass natural filtration, deeply penetrate the pulmonary tissue, and cause serious health effects. Research has shown that the inhalation of longer, more stable fibres, such as tremolite or other amphibole fibres, contributes to certain diseases [2].

Chronic asbestos exposure can increase the risk of lung cancer, mesothelioma, as well as pleural disorders. Diseases due to asbestos exposure take longer to develop.

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Asbestos exposure is more likely to result in a disease if the asbestos concentration is higher, if the exposure lasts longer, and/or if the exposure is more frequent.

The operating mechanism of asbestos fibres is still unknown, but they are believed to irritate tissues in which they are nested over time and to cause changes that ultimately lead to a disease.

Pleural changes, such as thickening, calcification, and plural effusion, are early markers of asbestos exposure. Diseases due to asbestos exposure have been diagnosed in workers handling asbestos and in the general population living in the vicinity of asbestos mines or processing plants.

As a mineral with diverse biological effects, asbestos can cause pulmonary fibrosis, better known as asbestosis, lung cancer, pleural thickening and calcification, and asbestos warts on the skin.

The WHO lists the following diseases as being directly associated with asbestos inhalation: asbestosis, mesothelioma, and lung cancer following asbestosis (malignant lung disease).

Of all the aforementioned diseases, only asbestosis is non-malignant, whereas mesothelioma and lung cancer are malignant lung diseases. Most cases of lung cancer or asbestosis in workers occurred only 15 or more years after the initial exposure. The occurrence of malignant lung diseases, such as lung cancer or pleural cancer, depends on the duration and intensity of asbestos exposure, as shown in Table 1.

The symptoms indicating some of the possible diseases due to asbestos exposure include: fatigue and dyspnoea; dry cough; asbestos warts; chronic obstructive bronchitis; and emphysema.

If any of the listed symptoms are detected, the diseases caused by asbestos can be confirmed by means of X-rays, computed tomography (CT) scans, or lung tissue biopsy.

Table 1. Diseases caused by asbestos.

FACTORS	LATENCY PERIOD	DISEASES
Fibre type	10-40 years	Acute and chronic bronchitis
Fibre size	10-40 years	Asbestosis
Fibre dose	10-40 years	Bronchial carcinoma
Industrial process	10-40 years	Gastrointestinal carcinoma
Concentration	10-40 years	Laryngeal carcinoma
Duration of exposure	10-40 years	Mesothelioma
Exposure type (work, home, environment)	10-40 years	Pericardial thickening
Smoking	10-40 years	Pleural effusion, pleural thickening
Pre-existing lung disease	10-40 years	

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Asbestosis is a lung disease characterized by scar tissue reproduction, destruction of pulmonary tissue, and reduced lung distensibility, which results in reduced inflow of oxygen [3,4].

Asbestosis is a serious, progressive, and long-lasting lung disease, which is not a cancerous, i.e. it is non-malignant. [3].

Asbestosis is a non-malignant lung disease caused by inhalation of asbestos fibres, which are then nested in small bronchi, bronchioles, and alveoli.

Inhalation of asbestos fibres can irritate pulmonary tissue, causing scar tissue and subsequently asbestosis. The scars make breathing very difficult. Asbestosis develops slowly and can vary from asymptomatic, through debilitating, to potentially fatal.

Due to slow disease progression and the late onset of symptoms, asbestosis takes about 20 years of asbestos exposure to develop. There is no 'threshold' dose or a 'safe' dose that would not lead to asbestosis.

Since the operative mechanism of asbestos fibres is still unknown, it is assumed that the body tries to dissolve the microfibers by increasing acidity. However, acidity has little effect on the fibres but instead destroys the surrounding tissue. Increase in acidity inside the body causes an inflammatory process, which in turn leads to pleural inflammation, inducing pleural thickening over time, with granulation tissue, while fibrosis develops in the lungs. The pathogenesis of asbestosis is still unknown, but there are several theories: the mechanistic theory – asbestos fibres similar to needles traumatize the pulmonary tissue and cause microhaemorrhages; theory of fibrosis induction with silicic acid – it is released slowly from asbestos and has a toxic effect on the pulmonary parenchyma; theory of immunological reaction – asbestos corpuscles in the organism are coated with proteins, thus acquiring antigenic properties. The entire process unfolds over several stages: initial damage; alveolitis; fibroblast proliferation; alveolar collapse; and collagen production and deposition into the pulmonary interstitium. The first symptoms occur after 15 to 20 years of exposure. Shortness of breath, or dyspnea, is the main symptom of asbestosis. In time, chronic pulmonary insufficiency can develop [5,6].

Figure 1. X-ray image of lungs with asbestosis [3].

Mesothelioma is a malignant disease of the pleura and/or the peritoneum. This type of malignant disease is highly specific and, according to what is known thus far, it is directly associated with

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asbestos inhalation. In nearly 50% of the cases, the mesothelioma metastasizes and spreads locally, ultimately leading to death. Pleural effusion is an early marker of mesothelioma.

The time required for the diagnosis of mesothelioma is 30 or more years after initial asbestos exposure. The precise cause of this tumour is unknown, but it is assumed that professional exposure to asbestos is a significant risk factor. Scientists list amphibole asbestos as one of the causes of mesothelioma, owing to long periods of their retention in the lungs.

Statistical data of the affected show that as many as 75% of persons with pleural mesothelioma have been exposed to asbestos to a certain extent.

Cases of mesothelioma were most often registered among miners, persons working with grinding machines, persons transporting asbestos, persons manufacturing friction materials, textile, asbestos cement pipes, and roofing materials, and persons involved in shipbuilding. Common high-risk jobs also include construction workers, plumbers, welders, and electricians.

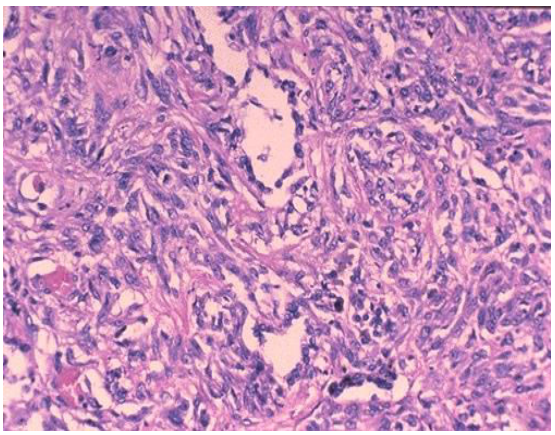

Figure 2. Tissue affected by mesothelioma [3].

Lung cancer is a malignant disease resulting from asbestosis.

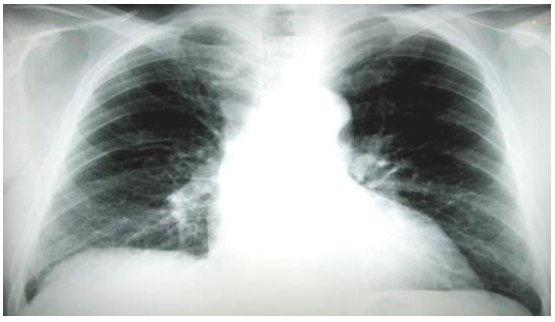

Figure 3. X-ray image of lung cancer [3].

Smokers are at greater risk of lung cancer due to synergetic effects of cigarette smoke and asbestos. High risk populations for lung cancer also include workers in mines, amphibole and crocidolite mills, textile plants, wokers handling cement, and workers in construction and shipbuilding. The risk of disease for these workers occurs only 15 to 19 years after the initial exposure to asbestos.

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5.ASBESTOS EXPOSURE LEGISLATION

Short descriptions of the most significant legal and sub-legal acts on asbestos exposure control are given below.

Regulation on Preventive Measures for Safe and Healthy Work during Asbestos Exposure [7]

The Regulation prescribes the requirements the employer has to meet by ensuring the implementation of preventive measures for the purpose of eliminating or minimizing the risk of harmful health effects on employees due to occupational exposure to asbestos. The regulation also establishes the limit value of asbestos exposure and other specific requirements.

Rules on Handling Waste Containing Asbestos [8]

The Rules prescribe the manner of packaging, criteria, conditions, and manner of the final disposal of waste containing asbestos, as well as other measures of prevention of asbestos fibres and dust dispersion in the environment. The provisions of the Regulation pertain to waste raw asbestos and to asbestos-containing waste.

Rules on Limits and Bans on Production, Sale and Use of Chemicals That Pose Unacceptable Risk to Human Health and the Environment [9]

The Rules prescribe limits and bans on production, sale, and use of chemicals, banned and permitted ways of use, as well as other requirements for production, sale, and use of substances, mixtures, and products that pose unacceptable risk to human health and the environment.

Rules on Preventive Measures for Safe and Healthy Work during Asbestos Exposure [10]

The Rules prescribe minimum requirements the employer has to meet by ensuring the implementation of preventive measures for the purpose of eliminating or minimizing the risk of injury or damaged health of employees due to occupational exposure to asbestos; requirements imposed on legal entities licensed to preventively and periodically; limit values of asbestos exposure.

Regulation on the Manner and Procedures for Managing Asbestos-containing Waste [11]

The Regulation prescribes the manner of managing waste asbestos and asbestos-containing waste, as well as procedures of preventing environmental pollution from asbestos. The goal of the Regulation is to ensure the implementation of measures aimed at preventing and reducing asbestos pollution and to establish an asbestos-containing waste management system in accordance with the legislation governing human and environmental health protection.

6. CONCLUSION

Asbestos poses a health risk only when it is dispersed. In most products containing asbestos, it is not present in its pure form but is bound to form a composite material. Over time, the material wears out, leading to composite matrix disintegration and dispersal of asbestos fibres in the air. Occupational exposure to asbestos poses a great risk to human health and it can have serious consequences, such as

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professional respiratory diseases, because dispersed asbestos fibres easily reach the lungs due to their specific structure. The three most common diseases associated with asbestos exposure are asbestosis, a chronic obstructive lung disease, which can even be fatal, mesothelioma, and lung cancer. The level of exposure can be reduced by replacing asbestos materials with other materials with similar properties. Exposure can also be reduced through the use of personal protective equipment. Disease prevention requires the adherence to strict procedures of asbestos removal, a ban on any further use of asbestos, and creation of a registry of all buildings containing asbestos and of all persons exposed to asbestos, including their periodical and preventive medical examinations.

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