O ESTUDO DA AGRESSIVIDADE BIOLÓGICA DO PÓ DE COMPOSIÇÕES FORMADAS E SEM AMIANTO, AMBOS EM SUA PRODUÇÃO E OPERAÇÃO

THE STUDY OF THE BIOLOGICAL AGGRESSIVENESS OF DUST OF ASBESTOS-FORMED AND ASBESTOS-FREE COMPOSITIONS, BOTH IN THEIR PRODUCTION AND OPERATION

ИССЛЕДОВАНИЕ БИОЛОГИЧЕСКОЙ АГРЕССИВНОСТИ ПЫЛЕЙ АСБЕСТОФОРМОВАННЫХ И БЕЗАСБЕСТОВЫХ КОМПОЗИЦИЙ, КАК ПРИ ИХ ПРОИЗВОДСТВЕ, ТАК И ПРИ ИХ ЭКСПЛУАТАЦИИ.

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RESUMO

Este manuscrito fornece informações básicas sobre o uso do amianto. Algumas propriedades físico-químicas do principal componente do amianto serpentino (AS, 95% de todo o amianto usado) e a agressividade biológica dos seguintes itens são consideradas: tipos de poeira na tecnologia de criação de produtos que contêm amianto e durante sua operação. Também foi dada atenção ao uso de substitutos do amianto existentes em produtos similares. Os autores apresentam dados que verificam que a incidência de doenças relacionadas ao amianto, incluindo asbestose de natureza profissional e não profissional, aumenta, principalmente em idosos, nos locais de produção de uma variedade de SA - amianto crisotila {CA, silicato de magnésio aquoso - $Mg_6[Si_4O_{10}](OH)_8$ }. Os autores prestam atenção especial ao uso de CA na produção de peças / produtos formados por amianto (AFP), por exemplo, lonas de freio contendo CA e seus substitutos. Sabe-se que esses produtos sofrem tensões zonais significativas durante a operação. As fibras CA perdem água higroscópica e constitucional. ($H_2O = 13,04 - 14,80\%$) no processo de frenagem do carro devido à alta pressão e aumento da temperatura local. Como resultado, eles se transformam quase totalmente em um material não agressivo (no sentido biológico) chamado forsterita. Estudos de pó de freio emitidos durante a frenagem de veículos leves VAZ não revelaram transformações semelhantes da degradação de CA. Podem ocorrer ao travar veículos pesados com massa superior a 2,5 toneladas e ao travar trens de alta velocidade com massa superior a 60 toneladas.

Palavras-chave: Amianto crisotila (AC), itens de fricção por atrito, forsterita, asbestose, basalto.

ABSTRACT

This manuscript provides basic information on the use of asbestos. Some physicochemical properties of the main component of serpentine asbestos (SA, 95% of all used asbestos) and the biological aggressiveness of the following are considered: dust types in the technology of creating asbestos-containing products and during their operation. Attention is also paid to the use of existing asbestos substitutes in similar products. The authors present data verifying that the incidence of asbestos-related diseases, including asbestosis of a professional and unprofessional nature, is increased, especially in the elderly, in the places of production of an SA variety – chrysotile asbestos {CA, aqueous magnesium silicate - $Mg_6[Si_4O_{10}](OH)_8$ }. The authors pay particular attention to the use of CA in the production of asbestos-formed parts/products (AFP), for example, brake linings containing CA and its substitutes. It is known that such products undergo significant zonal stresses during operation. CA fibers lose hygroscopic and constitutional water ($H_2O = 13.04 - 14.80\%$) in the process of car braking due to high pressure and increased local temperature. As a result, they almost entirely turn into a non-aggressive (in the biological sense) material called forsterite. Studies of brake dust emitted during the braking of lightweight VAZ vehicles did not reveal similar transformations of CA degradation. They may occur when braking heavy vehicles with a mass of more than 2.5 tons and when braking high-speed trains with a mass of more than 60 tons.

Keywords: *Chrysotile asbestos (CA), frictional braking items, forsterite, asbestosis, basalt.*

ABSTRACT

В статье представлены основные сведения об использовании асбеста. Рассмотрены некоторые физико-химические свойства основного компонента серпентинового асбеста (СА, 95% всего используемого), биологическая агрессивность: выделяющихся видов пыли в технологии создания асбестосодержащих изделий и при их эксплуатации, обращено также внимание на использование существующих заменителей асбеста в аналогичных изделиях. Представлены данные, что в местах добычи разновидности СА - хризотил-асбеста {ХА, водный силикат магния - $Mg_6[Si_4O_{10}](OH)_8$ } повышена заболеваемость асбест-обусловленными болезнями, а также асбестозом- профессионального и непрофессионального характера, особенно у лиц пожилого возраста. Особое внимание уделено использованию ХА в производстве асбестоформованных деталей/изделий (АФД), например, изготовление и использование тормозных накладок с содержанием ХА и его заменителей. Известно, что такие изделия в процессе эксплуатации подвергаются значительным зональным напряжениям. В процессе торможения автомашин в следствии возникающего высокого давления и повышенной локальной температуры в волокнах ХА происходит потеря гигроскопической и конституционной воды ($H_2O = 13,04 - 14,80\%$) в результате чего они практически полностью превращаются в неагрессивный в биологическом смысле материал под названием форстерит. Проведенные исследования тормозной пыли, выделяющейся при торможении легковых автомашин марки ВАЗ, подобные превращения деградации ХА не выявили, возможно они имеют место при торможении тяжеловесных автомашин с массой более 2,5 т и при торможении высокоскоростных, железнодорожных составов массой более 60 т.

Keywords: *Хризотил-асбест (ХА), Фрикционные тормозные изделия, Форстерит, Асбестоз, Базальт.*

1. INTRODUCTION

Chrysotile asbestos (CA) is a fine fiber mineral of the silicates class. Serpentine asbestos is of the greatest importance since it accounts for 95% of the asbestos that is used, commonly called "mountain flax". This is a mineral of the serpentine group – aqueous magnesium silicate $Mg_6[Si_4O_{10}](OH)_8$, which contains silicates of calcium, iron, sodium, and possibly other metals as impurities, and there is usually no free silicic acid (SiO_2), but it can appear in an amorphous form upon ignition. CA filamentary crystals are capable of splitting into very thin fibers, chemically resistant and resistant to high temperatures, which are widely used in engineering and in households: fireproof asbestos textile materials, types of workwear, asbestos cement products; friction products (brake linings, rings containing CA not less than 40-50%); paronite, electron for heat and electrical insulating gaskets, asbestos paper, and asbestos board; heat-insulating materials, asbestos-bitumen materials (roofing material, waterproofing materials).

The rapid development and improvement of all types of transport have led to an increase in the production of asbestos-formed parts (AFP), which are used in braking systems of various modes of transport, and in asbestos content, which can reach up to 75%. The latter depends on the mass and speed of a given means of transport:

the greater the speed and the weight of a given transport unit, the greater the amount of asbestos used in its CA brake linings.

During the operation of a transport unit, as well as in the manufacture of AFP (machining), a disintegration aerosol with CA content, which is officially recognized as professional harmful throughout the world, is released into the working area and the external environment. CA fibers can invade the epidermis, leading to the development of hyperkeratosis and cell proliferation. In asbestos textile production, asbestos formations are often localized on the flexion surfaces of the limbs. Car mechanics involved in the repair of braking systems and exposed to brake dust have shown an increased risk of cancer (pleural mesothelioma or lung cancer). CA long and short fibers, as well as coated with Bakelite or cement, have increased fibrogenicity and cytotoxicity compared to amphibole asbestos.

However, information on the incidence of asbestosis among these workers is controversial: from the recognition of a moderate asbestos hazard to a pronounced risk of its development after a relatively short exposure period. At the same time, in several epidemiological studies, even with prolonged dust exposure, and the increased oncological risk was not detected; however, some data in the literature indicate pronounced toxic, fibrogenic, and carcinogenic effects of CA, effects which are greatest on the cell

structure of macrophages and erythrocyte suspension (Yatsenko, 1995). Consequently, the biological aggressiveness of dust containing CA requires further in-depth study.

The term asbestos is currently understood to mean a group of minerals having a fibrous structure. Most of the mined asbestos belongs to the serpentine group – the serpentine and is called chrysotile asbestos CA – white asbestos (Fig. 1, 2) (Nikitina, 1991).

Figure 1. Chrysotile asbestos

Source: Nikitina, 1991

Figure 2. Asbestos vein in a mountain mineral

Source: Nikitina, 1991

The amphibole (hornblende) asbestos group differs significantly from the latter in several physicochemical properties. This group includes the following: anthophyllite, amosite, tremolite, actinolite, crocidolite, cape blue asbestos, rhodusite, and magnesio-arfvedsonite. The amphibole group of asbestos, which is practically not excreted from the lungs, poses the greatest danger to human health. CA, unlike amphiboles,

decomposes under the influence of tissue fluids and therefore is more rapidly excreted from the body and can pose a lower risk to human health. The greatest industrial value, both in Russia and abroad, is accounted for by CA. Currently, deposits in Bazhenovskoye (Sverdlovsk region, Russia), Quebec (Canada), Zimbabwe, South Africa, northern Kazakhstan, China, the United States, Brazil, Italy, and Japan are of the greatest global importance. However, at present, due to the increased consumption of asbestos in large cities, in addition to asbestosis, the number of malignant tumors – pleural mesothelioma and peritoneum – is also increasing. Therefore, asbestos is considered by many countries as characteristic of the hazards of contemporary urban life (Modern urban hazard) (Khazbiev, 2012). Such a statement is undoubtedly exaggerated.

International Labor Organization (ILO) Convention No. 162 (Geneva, 72nd Session of the ILO General Conference, 1986) on Occupational Health and Safety when Using Asbestos, covering all activities related to the effects of asbestos on workers, defined measures to prevent harmful effects on human health. In addition, in the Recommendations of the above conference, it was determined that the prohibition or authorization of the use of asbestos and asbestos-containing products should be based on a scientific assessment of their health hazards. Based on studies of carcinogens, The International Agency for Research on Cancer classifies asbestos in the first, most dangerous category of the list of carcinogens.

The most dangerous asbestos amphibole minerals are Amosite and Crocidolite (blue asbestos). Chrysotile fiber is easy to fluff in the air and in water, has a high adsorption capacity, and exhibits active adhesion to several carcinogens. This fiber is endlessly divided into very small sizes and is carried over very long distances in the air. The presence of CA fibers was established even at the north and south poles, where there is no human activity. Such negligibly small CA fibers easily penetrate the human body and carry various carcinogens.

The biological carcinogenic effect of CA substantially depends on its fiber length and diameter, which affects retention, clearance, and phagocytosis (Le Bouffant, 1980). For many years, the prevailing opinion abroad was that only hard, relatively long particles of asbestos penetrated the lung tissue, violating its integrity and causing proliferative inflammation with the gradual development of fibrosis in the area of fiber accumulation in bronchioles and in places where

the ciliated epithelium becomes cuboid. Short fibers ($<3\ \mu\text{m}$) cause a very weak reaction. Long particles cannot be removed by phagocytosis. Lingering in bronchioles, these long particles cause permanent tissue injury with respiratory movements. However, the introduction of short asbestos fibers also develops fibrosis, both nodular and diffuse-interstitial types.

Electron microscopy of sections of the lungs of experimental animals revealed a huge number of submicroscopic particles, which are hardly capable of injuring tissues. The development of fibrosis in areas where very long asbestos fibers very rarely settle does not have an explanation: around blood vessels, interalveolar septa, etc. A correlation between 1 gram of mineral residue in a dry lung and the severity of asbestosis has not been established (Nikitina, 1991). In addition, the decisive biological aggression is determined not by the needle structure and hardness of the asbestos, but by its solubility in tissue fluids.

In the case of prolonged contact of CA with tissue fluid, some dissolution of silicic acid occurs, causing damage and death of lung tissue cells. The above-mentioned effects of asbestos on the body led to a decrease and even a complete stoppage of its use in advanced countries of Europe (Platnova, 2018). For example, in 1997, asbestos was completely banned in France, and since 2005, the countries of the European Union refuse to use asbestos (Dodson and Hammer, 2011; Castleman and Berger, 2005). However, for many products containing CA, there is no substitute for its properties today, and they are extremely necessary for several industries.

Previously accumulated asbestos-containing products in these countries should be regulated to neutralize the biological effects of asbestos or bury it in special places. Numerous methods have been proposed for special processing of asbestos-containing materials and their waste and use, such as CA calcination at 600-800°C, microwave radiation (Colangelo *et al.*, 2011; Gramat *et al.*, 2011), sulfuric acid treatment (Nam Nam *et al.*, 2014) and carbonization (Gadikota *et al.*, 2014), which alter the chemical and biological properties that reduce fibrogenicity and cytotoxicity.

After special treatment, asbestos-containing cement materials can be used as additives in building structures. For the disposal of asbestos-containing materials and their waste, the use of inactive mines has been proposed, which is being used in Greece, England, Italy, Germany,

and other EU countries (Gidakos *et al.*, 2008). However, despite the West recognizing asbestos as dangerous, the Rotterdam Convention does not include CA in the list of hazardous substances, and it continues to be used in the national economy in Russia and in developing countries, where up to 80% of the world's population lives. It should also be noted that based on ILO Convention No. 162, in many countries, another way has been proposed, consisting of replacing asbestos with other artificial mineral fibers. In Russia, Nikitina O.V. (1991) carried out such works by replacing CA with basalt fibers (AFC, Fig. 3, 4). In an animal experiment, it was possible to reduce the number of peritoneal mesotheliomas, but, unfortunately, the number of other malignant neoplasms increased about the same amount, especially in comparison with super-thin basalt fibers (STBF). In a comparative assessment of fibrogenicity, the results obtained also indicated relatively high rates compared with the control.

Figure 3. Characteristic columnar separateness of basalt
Source: Nikitina, 1991

Figure 4. Basalt
Source: Nikitina, 1991

Considering all the above, it can be inferred

that when replacing CA with AFC, where it is expedient from a technical and economic point of view, the requirements for safety measures should be similar to those in production with CA. Therefore, it is not yet possible to completely replace CA in technology. For example, when replacing CA with basalt fibers in brake products, the stopping distance of cars will be significantly increased, the latter, given the number of vehicles, speed limits, and tension on roads, of course, cannot be allowed. Basalt fibers can be used as a substitute for CA only where appropriate (Muzafarov, 1979).

The possible effect of dust on the nearby human and animal populations should also be considered in the hygienic assessment of asbestos processing plants. The former also confirms the increase in pleural forms of unprofessional asbestosis, mainly in older people (Ginzburg, 1970). The authors attribute this pathology to the weathering of the soil, and in particular, asbestos, which is likely present in these areas (Republic of Khakassia). A substantial amount of manufactured road and rail transportation can be a source of CA, both in residential zones and in the whole environment.

The purpose of the research is to study the biological aggressiveness of asbestos-containing and asbestos-free friction products in both their production and actual use.

Technological progress, including the rapid development of all types of transportation, steadily leads to an increase in the production of asbestos-molded parts intended for use in brake and vehicle coupling systems.

For the first time, it has been experimentally shown that the dust of asbestos-containing and basalt-containing (non-asbestos) compositions of friction products has equally pronounced moderate fibrogenic, weak carcinogenic, and noticeable toxic effects (Sudo, 2011). Additionally, in first-time animal experiments, the biological aggressiveness of dust was compared with the content of asbestos and non-asbestos dust based on basalt fibers (including those that were artificially created) (Nikitina, 1991; Yatsenko, 1994).

Asbestos, undoubtedly, is one of the leaders among materials that symbolize the progress of science and technology. Due to its unique properties (strength, the elasticity of fibers, heat and electrical conductivity, and chemical and thermal resistance), it is widely used in various industries. In industrialized countries, around 10% of asbestos is used for the preparation of

asbestos-shaped parts containing 15–72% of chrysotile asbestos. Technological progress, including the rapid development of all types of transportation, is steadily leading to an increase in the production of asbestos-molded parts intended for the brake and vehicle clutch system sectors (Yatsenko, 1994).

It was also experimentally shown for the first time that the dust from asbestos-containing and basalt-containing (asbestos-free) compositions of friction products, as well as the dust released during the repair of brake systems, have equally pronounced moderate fibrogenic, weak carcinogenic, and noticeable toxic effects. In this case, the degree of toxicity is determined by the content of chrysotile asbestos and phenol in the dust. The fibrogenicity does not depend on the presence of chemical additives used in the production of asbestos-formed parts. In addition, the biological aggressiveness of dust with asbestos and asbestos-free dust based on basalt fibers and artificially created ones was first experimentally compared in animals.

2. MATERIALS AND METHODS

The study of the degradation of chemical agents during the mechanical processing of brake products in production and their abrasion during braking of vehicles was carried out on ordinary asbestos-formed products of the Vehicle Textile Goods Plant in the town of Asbest, Russia. The study of structural changes in the CA crystal structure was carried out by X-ray phase analysis using a powder method (Gorelik, 1994; Mikheev, 1957; Mirkin, 1976) in the angle range V from 5 to 50° on a DRON-2.0 diffractometer by Burevestnik Research and Production Enterprise, St. Petersburg) in filtered copper $K\alpha$ -radiation and infrared spectroscopic analysis on a spectrometer "Specord JK-75" (manufactured by Analytik Jena, Germany) in the range of 400 - 4,000 cm^{-1} using pastes in paraffin oil in air at room temperature.

The authors used "Statistics in hygienic research Express method for estimating average values" by E. L. Notkin to assess the statistical significance. In acute and long-term experiments on toxicity, fibrogenicity, and carcinogenicity, the dust of brake products, containing CA and its substitutes, mice and white outbred rats were used.

The severity of the toxic effect was studied in an acute experiment on LD 50 (lethal dose = death of 50% of animals) with intraperitoneal administration in mice. The fibrogenic effect of

brake dust samples was studied in rats with an initial weight of 160-180 g, which were injected with 50 mg of various types of dust, in the form of a suspension in 1 ml of physiological solution. The control group of rats, respectively, was administered 1 ml of saline, without dust. Oncogenic evaluation of dust was studied in chronic experiments on similar rats, with an intraperitoneal injection. This experiment used two types of control: A). Rats that were injected with Bazhenov's CA powder, the carcinogenicity of which has been proven in several scientific studies and B). Rats that were injected with physiological saline only. Asbestos and asbestos-free dust samples were injected twice, in a single dose of 25 mg, with an interval of one month (Yatsenko and Sherstyuchenko, 2019).

Observation of animals lasted until the end of their lives (Yatsenko, 2017). The severity of the toxic effect was studied in an acute experiment on LD50 with intraperitoneal injection.

3. RESULTS AND DISCUSSION:

Brake dust released both during braking and machining does not lose its biological aggressiveness. CA does not turn into biologically safe forsterite. According to the data of IR spectroscopy, CA fibers do not completely lose constitutional water during mechanical processing. This is especially evident when considering the interval of deformation vibrations of water at $1,600\text{--}1,650\text{ cm}^{-1}$. Intense absorption in the region of $3,200\text{--}3,500\text{ cm}^{-1}$ and a weak band with a maximum at $1,600\text{ cm}^{-1}$ in the spectrum of asbestos and bakelite dust are due to the presence of labile interlayer water coordinated to metal (Figs. 5 and 6) (Mikheev, 1957).

Figure 5. IR transmission spectra of samples of Bazhenovsky CA (No. 1) and CA calcined in a muffle furnace at $T = 900^{\circ}\text{C}$ (Fig. 2)

Source: Mikheev, 1957

Figure 6. IR transmission spectra of dust samples collected from brake drums of cars (No. 4) and brake pad (Fig. 3)

Source: Mikheev, 1957

Based on the X-ray mineral determinant (Mikheev, 1957), the three lines related to forsterite and all the studied samples have very close interplanar spacings. In this regard, unambiguous radiographic identification of forsterite is difficult. The authors can only assume that if the latter is present, then its content is less than 10%.

The results of the toxic effect are presented in Table 1.

Table 1. Toxic effect of dust from friction products

Dust sample	The toxic effect of dust brake composites, depending on the dose, %					LD50, g/kg
	0.5	2.0	6.0	10.0	14.0	
Chrysotile-asbestos (CA)	20	80	100	100	-	1.5 ± 0.3
Asbestos Bakelite (AB)	-	16.6	50	100	-	5.4 ± 0.5
Basalt-containing compositions	-	-	50	70	100	6.2 ± 0.8
407-10	-	0	40	90	-	6.5 ± 0.4
E-251	-	-	-	-	-	-
Asbestos rubber	-	-	-	-	-	-

(AR)	-	0	33.	80	-	7.2 ±
T-167	-	-	3	60	93.	0.5
42-975			0		3	10.2 ± 0.5
Basalt fibers (STBF)	-	0	0	0	-	Over 10.0

Notes: 0 – no fallen animals

(-) – the specified dose was not injected

The fibrogenicity of dust released both during the production of AFP and during their usage was measured by the total hydroxyproline content in rat lungs, three and six months after injecting the test samples. The oxyproline content in rat lungs is shown in Tables 2 and 3.

Table 2. The content of oxyproline in the rat lungs with an intratracheal dusting (per 100 g of body weight) 3 months after injection

Samples of injected dust	Oxyproline, mcg
CA	2,290.0 ± 130.0
AR	1,890.0 ± 60.0
AB	3,199.5 ± 212.6
Dust collected from brake drums	3,208.2 ± 177.2
Control	1,220.0 ± 900
Asbestos-free compositions (AFC)	2,180.0 ± 210.0

Table 3. The content of oxyproline in the rat lungs with an intratracheal dusting (per 100 g of body weight) 6 months after injection

Samples of injected dust	Oxyproline, mcg
Control	1,520.0 ± 100.0
AR	2,150.0 ± 190.0
AB	3,924.2 ± 203.8
Dust collected from brake drums	3,527.4 ± 97.4
CA	2,980.0 ± 100.0
Quartz	4,600.0 ± 240.0
Asbestos-free compositions (based on basalt)	1,960.6 ± 160.6

Indicators of total hydroxyproline in the lungs make it possible to judge the degree of development of the fibrous process and, therefore, dust fibrogenicity. Tables 2 and 3 show that the dust collected from the brake drums has significant fibrogenic potential, even compared with CA, particularly with asbestos-free compositions. However, the fibrogenic potential of quartz is the highest. The data of experiments to determine the oncogenicity of the studied dust samples are presented in Table 4.

Table 4. The results of experiments on the comparative assessment of oncogenic properties of the studied dust

No. of the experiment	Injected substances	Number of rats	% of rats with malignant tumors
1	Control	110	-
	CA	60	45.0 ± 6.4
2	AR dust collected from the brake drums (T-167)	65	3.0 ± 2.1
	Basalt-containing composition s:		
	407-10	64	3.1 ± 2.1
	E-251	65	4.6 ± 2.5
	Superthin basalt fiber	50	14.0 ± 1.6

Table 4 shows that asbestos-containing dust released during the braking of vehicles has a significantly lower potential for oncogenicity compared to CA and even compared to basalt-containing compositions.

The toxic effect of asbestos-containing dust is determined by the percentage of CA in

them. There is no significant difference in the LD50 values between compositions based on asbestos and basalt. The mortality rate depends on the duration of contact with CA, the dustiness of the working area and the dust content, and also, apparently, on the impurities present in asbestos (tenths and hundredths of a percent) (e.g., zinc, chromium, vanadium, and other metals). It can be assumed that the inflammatory reaction with the activation of macrophages and leukocytes, and the increased release of oxygen compounds (i.e., radicals that can damage DNA and proteins and cause lipid peroxidation), can play a major role in the development of the toxic effect of CA (Platonova, 2018).

No significant difference was found in the fibrogenic activity of dust samples on both an asbestos and asbestos-free basis. The additives used in the manufacture of brake products do not have a noticeable effect on the fibrogenic activity of dust. Indicators and oxyproline content, as well as histological observations (Yatsenko, 2017), clearly demonstrate the significantly lower fibrogenic activity of dust released during the production of AFP and their operation, in comparison with Bazhenov's CA.

A significant decrease in the fibrogenicity of dust on an asbestos-free basis has not been established. The dust released during braking, as can be seen from the experiments, does not lose its biological aggressiveness and shows a sufficiently high fibrogenic activity. The quartz dust also shows its fibrogenic potential. The oncogenic properties of the studied dust samples show a significantly lower potential compared to chrysotile asbestos. This is due to the coating of CA fibers with binders: either Bakelite or rubber. Repeated experiments on oncogenic potential prove this (Yatsenko, 1994). When replacing chrysotile asbestos with basalt fibers, it was not possible to reduce the oncogenic potential of friction products, and when using super thin basalt fibers, oncogenicity even increased.

An epidemic analysis of mortality from malignant diseases, of both sexes, found that neither the workers of the Ural Vehicle Textile Goods Plant nor the workers of the Yaroslavl Vehicle Textile Goods Plant faced an increased oncological risk, according to the indicators of standardized relative risk (SRR). However, when analyzing mortality from oncological diseases in various subcohorts, differing in the predominance of different types of asbestos-containing dust, an increased risk was established among people of both sexes, where CA dust predominates (preparatory workshops). In the other subcohorts,

where there is mainly asbestos-Bakelite or asbestos-rubber dust, there is no increased cancer risk - these are workers engaged in molding, pressing, and machining (Yatsenko, 1994). Also, in general, it should be noted that cancer mortality rates are at the control level at both plants.

4. CONCLUSIONS:

Given the technical characteristics of CA and natural deposits, both in Russia and abroad, and the absence of substitutes that completely satisfy the main areas of production associated with CA in technical properties and biological aggressiveness, the authors can assume that it will be used for a long time in the national economy. Currently, there have been significant changes in the technology of friction products, which can significantly affect the physico-chemical properties of the dust emitted during machining. The speed of vehicles has also changed, and the mass of vehicles has increased significantly.

The studies were carried out on dust samples released during the operation of VAZ passenger cars weighing no more than 700 kg. Currently, jeeps weighing ~ 3 tons are being used more and more, and the number of freight rail and motor vehicles is also increasing. The weight of which can exceed 60 tons, which increases pressure and increases local temperature during braking. These factors in the released dust will ensure the conversion of CA to forsterite, and the dust will lose its biological and potential aggressiveness.

In addition, it is well known that some workers with a comparatively low dust exposure developed malignant tumors relatively quickly, while others with extensive work experience did not. This means that it can be assumed that the potential of antimutational mechanisms in the oncologically exposed workers varies significantly, which is the basis for explaining the occurrence of malignant tumors. Therefore, in this direction, it is also necessary to research the following: identifying criteria for the risk of tumors, which can subsequently be used in professional medical screenings for cancer hazardous professions.

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