

G.E. Sadykanova<sup>1</sup> , S. Kumarbekuly<sup>2\*</sup> , K.Zh. Dakieva<sup>1</sup> 

<sup>1</sup> S. Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan

<sup>2</sup> Kazakh Agrotechnical Research University named after S. Seifullin, Astana, Kazakhstan

\*e-mail: sanat\_kv@mail.ru

## STUDY OF BERYLLIUM INFLUENCE ON PSYCHOPHYSIOLOGICAL PARAMETERS OF HUMAN ORGANISM

The leading place in research and forecasting of professional activity is occupied by the problem of diagnostics of psychophysiological properties of a person. The most typical state of workers engaged in hazardous production is emotional tension, which affects the efficiency of production activity. Highly toxic substances, which include beryllium used in beryllium production, can cause psychophysiological tension and can serve as a basis for acute and chronic emotional stress. The scientific article describes the influence of production factors on the psychophysiological status of workers of beryllium shop of JSC 'UMP' depending on age. The psychophysiological status of workers of the examined groups is distributed unevenly. The increase in the number of workers with values of high personal anxiety and low rate of motor activity is mutually conditioned by the work associated with a high degree of emotional tension. The highest level of reactive and personal anxiety in combination with a low rate of motor activity is observed in workers of the third group (aged 45-65 years), and is accompanied by an increase in stress values in the Lusher test and low values of mental efficiency. Inclusion of psychophysiological testing in the course of professional selection allows to reveal the peculiarities of protective and adaptive reactions in workers of different age groups.

**Key words:** beryllium production workers, toxic effect, anxiety level, reactive anxiety, personality anxiety.

Г.Е. Садыканова<sup>1</sup>, С. Құмарбекұлы<sup>2\*</sup>, К.Ж. Дакиева<sup>1</sup>

<sup>1</sup> С.Аманжолов атындағы Шығыс Қазақстан университеті, Өскемен, Қазақстан

<sup>2</sup> Сәкен Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана, Қазақстан

\*e-mail: sanat\_kv@mail.ru

## Бериллийдің адам ағзасының психофизиологиялық параметрлеріне әсерін зерттеу

Кәсіби қызметті зерттеу мен болжауда жетекші орынды адамның психофизиологиялық қасиеттерін диагностикалау мәселесі алады. Зиянды өндірістермен айналысатын жұмысшыларда жиі кездесетін жағдай – бұл өндірістік қызметтің тиімділігіне әсер ететін эмоционалды стресс. Бериллий өндірісінде қолданылатын бериллий сияқты уыттылығы жоғары заттар психофизиологиялық шиеленісті тудыруы мүмкін және жедел және созылмалы эмоционалды стресстің пайда болуына негіз болады. Ғылыми мақалада жасына, жұмыс өтіліне байланысты «ҮМЗ» АҚ бериллий цехы жұмысшыларының психофизиологиялық мәртебесіне өндірістік факторлардың әсері сипатталған. Зерттелген жұмыс топтарының психофизиологиялық мәртебесі біркелкі емес. Жеке мазасыздық деңгейі жоғары және моторлық белсенділіктің төмен қарқыны бар жұмысшылар санының артуы эмоционалды шиеленістің жоғары деңгейімен байланысты жұмыстарға байланысты. Реактивті және жеке мазасыздықтың ең жоғары деңгейі, мотор белсенділігінің төмен қарқыны үшінші топтағы жұмысшыларда (45-65 жас аралығындағы) байқалды. Бұл кезде Люшер сынағы бойынша стресс мәндерінің жоғарылап, ақыл-ой жұмысқабілетілігінің мәндері төмен болды. Кәсіби іріктеу кезінде психофизиологиялық тестілеуді қосу әртүрлі жастағы жұмысшыларда қорғаныс-бейімделу реакцияларының ерекшеліктерін анықтауға мүмкіндік береді.

**Түйін сөздер:** бериллий, уытты әсер, мазасыздық деңгейі, реактивті мазасыздық, жеке мазасыздық.

Г.Е. Садыканова<sup>1</sup>, С. Құмарбекұлы<sup>2\*</sup>, К.Ж. Дакиева<sup>1</sup>

<sup>1</sup>Восточно-Казахстанский университет им. С. Аманжолова, Оскемен, Казахстан

<sup>2</sup>Казахский агротехнический исследовательский университет имени С. Сейфуллина, Астана, Казахстан

\*e-mail: sanat\_kv@mail.ru

### Изучение влияния бериллия на психофизиологические параметры организма человека

Ведущее место в исследованиях и прогнозировании профессиональной деятельности занимает проблема диагностики психофизиологических свойств человека. У рабочих, занятых на вредных производствах, наиболее типичным состоянием является эмоциональное напряжение, которое отражается на эффективности производственной деятельности. Высокотоксичные вещества, к которым относится бериллий, используемый в бериллиевом производстве способны вызвать психофизиологическую напряженность, и могут служить основой для возникновения острого и хронического эмоционального стресса. В научной статье описывается влияние производственных факторов на психофизиологический статус рабочих бериллиевого цеха АО «УМЗ» в зависимости от возраста. Психофизиологический статус рабочих обследованных групп распределен неравномерно. Увеличение числа рабочих со значениями высокой личностной тревожности и низким темпом моторной деятельности взаимообусловлено работой, связанной с высокой степенью эмоционального напряжения. Наиболее высокий уровень реактивной и личностной тревожности в сочетании с низким темпом моторной деятельности наблюдается у рабочих третьей группы (в возрасте 45–65 лет), и сопровождается с увеличением значений стресса по тесту Люшера, низкими значениями умственной работоспособности. Включение психофизиологического тестирования при проведении профессионального отбора позволяют выявить особенности протекания защитно-приспособительных реакций у рабочих разновозрастных групп.

**Ключевые слова:** рабочие бериллиевого производства, токсический эффект, уровень тревожности, реактивная тревожность, личностная тревожность.

## Introduction

Beryllium is a light grey metal with high strength but is brittle, especially at low temperatures and in the presence of impurities. At elevated temperatures it can be forged and rolled. It is easily permeable to X-rays, reflects neutrons well, and emits neutrons when irradiated with  $\alpha$ -particles. Owing to its valuable physical and chemical properties, it is widely used in industry. It is widely used in aviation, space technology, rocket construction, as well as in the nuclear industry, the production of X-ray tubes, radio lamps, and the manufacture of fluorescent compositions [1]. The International Agency for Research on Cancer (IARC) classifies beryllium as carcinogenic to humans [2], belongs to the first class of extremely hazardous substances, which even in small doses can have toxic effects.

Both beryllium and its salts are very toxic, and their toxicity depends not only on dispersibility and solubility, but also on the type of beryllium compound and the way it enters the body [3]. As a rule, soluble beryllium is highly toxic and insoluble beryllium is less toxic. It is most toxic when ingested into the blood, then into the respiratory tract, and least toxic when ingested into the digestive tract and skin. Beryllium oxide, beryllium fluoride, beryllium chloride, beryllium sulfate, and beryllium nitrate are

all toxic, while metallic beryllium is relatively less toxic. Once beryllium is ingested, insoluble beryllium oxide mainly accumulates in the lungs, which can lead to chemical bronchitis and pneumonia. Soluble beryllium compounds are mainly stored in the bones, liver, kidneys and lymph nodes. Beryllium in lungs and bones can be a carcinogen.

The main source of harmful impact of beryllium in Ust-Kamenogorsk city is Ulba Metallurgical Plant JSC (UMP JSC), which includes beryllium production. Beryllium production of UMP JSC is one of three enterprises in the world that has a full production cycle from ore concentrate processing to the production of finished products with specified quality parameters. The technological scheme developed at the enterprise allows processing almost any type of beryllium-containing raw materials [4]. Highly toxic substances used in beryllium production can serve as a basis for acute and chronic emotional stress and pathological conditions [5]. Emotional stress is the most typical condition in workers engaged in hazardous production, which affects the efficiency of production [6]. When functional systems are exhausted, professional reliability may decrease. Therefore, it is important to identify the signs that reflect psychophysiological adaptation and resistance to the action of adverse environmental factors.

At present, practical medicine has accumulated experience in studying the influence of harmful industrial environments on morphophysiological parameters and psychophysiological state of a person [7-9]. At the same time in the described literature there are single works devoted to the study of the influence of industrial wastes of beryllium production on morphofunctional indices of a person. In the available literature it was not possible to find works devoted to the influence of beryllium production conditions on human psychophysiological reactions, which was the reason for this study.

### Materials and methods

A total of 139 people working in the beryllium production shop were examined. The workers were divided into 3 groups: group I included workers aged 18-30 years (26 persons, 18,7 % (per cent)); group II – workers aged 31-44 years (57 persons, 41 %), group III – workers aged 45-65 years (56 persons, 40,3%). The average duration of work in the shop is  $4,0 \pm 0,2$  years in group I,  $1,4 \pm 0,82$  in group II,  $25,5 \pm 1,21$  years in group III. The first group served as a comparison group. The examination was carried out in the morning at the same time in autumn.

Taking into account that workers of Ulba Metallurgical Plant (UMP) are exposed to a number of unfavourable factors of production, such as harmfulness of production, shift nature of work, high demands for work performance, basic psychophysiological functions were investigated.

Indicators of individual-typological features of the emotional sphere of personality, indicators of functional state and subjective indicators of well-being were determined using standard methods of C.D. Spielberg and Y.I. Khanin, as well as Lusher [10]. The Spielberger method was used to assess the level of personality and reactive anxiety as indicators of basic personality characteristics. The method allows us to find out the level of personal anxiety, which depends on the character traits of the tested person, the test is a reliable and informative way of self-assessment of anxiety levels.

The Lusher colour test is used to study individual typological features of the human organism, to reveal the functional state, the degree of adaptability to various situations. The test in a short time can give a deep and extensive, and free from the conscious control of the test subject, characterisation. Correlations of colour diagrams for studying mood at the moment of examination and personal character-

istics of psychoemotional sphere were considered. Three parameters were assessed by the correlation of colours – the level of stress, anxiety and vegetative balance. This method belongs to non-verbal and allows individual and group examination within a short period of time. It demonstrates the connection between constitutionally inherent properties and the type of response to environmental influences.

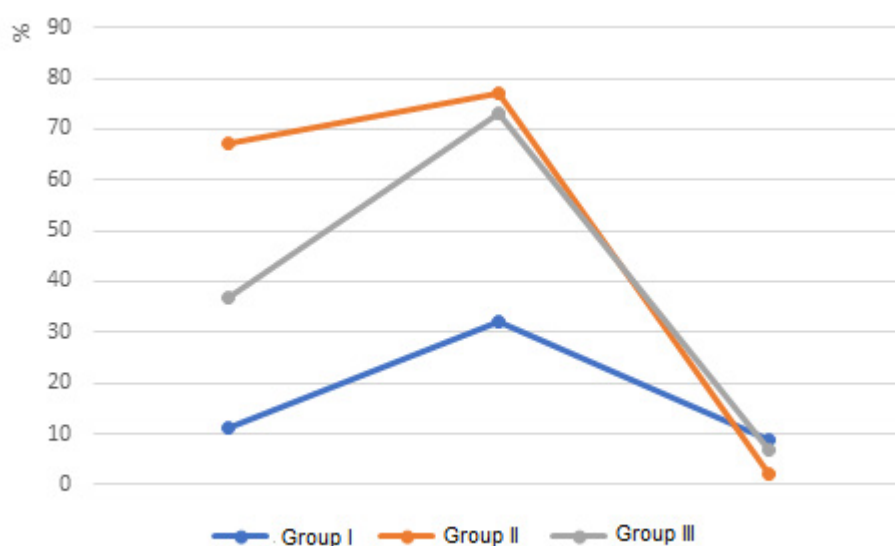
The strength of nervous processes is an indicator of the efficiency of nerve cells and the nervous system as a whole. A strong nervous system withstands a greater load in magnitude and duration than a weak one. To diagnose the strength of the nervous system we used the tapping test method [11]. It is based on determining the dynamics of the maximum tempo of hand movements. The experiment is carried out sequentially first with the right and then with the left hand.

### Results and discussion

Nowadays it is known that when ecological conditions of human habitat change, there is a change in psychophysiological properties of a person. The study of these properties in conditions of ecological disadvantage will allow solving the problems of vocational guidance, forecasting the state of human performance and individual-psychological properties of personality. Since the basis of psychophysiological properties of a personality is formed by individual-typological features of higher nervous activity, therefore, an important issue in the study of psychophysiological properties of a person is to determine the influence of heredity and environment on the properties of different constitutional levels.

Since the test of C.D. Spielberg and Y.I. Khanin well reveals the peculiarities of states of the emotional sphere of personality and their changes in each group, the obtained results show that the level of reactive anxiety is higher in the workers of the second group by 35 % (Figure 1).

Moderate level of personal anxiety is noted in all the surveyed groups, and it is the highest in the workers of the third group. Analysis of the results shows that the level of personal anxiety exceeds reactive anxiety by 25.2%. The dynamics of indicators is characterised by a peak of moderate reactive and personality anxiety. Low reactive anxiety is most pronounced in workers of the second and third groups. Indicators of high reactive anxiety differ insignificantly in the groups. High personal anxiety prevails in the second and third groups.



**Figure 1** – Reactive anxiety level of beryllium shop workers

Along with the values of low and moderate anxiety, workers in the second and third groups have high reactive and personal anxiety, and these indicators are distributed as follows: in the second

group reactive anxiety is equal to 2.94 %, personal anxiety – 32.35%. In the third group reactive anxiety is equal to 4.76 %, personal anxiety – 28.5 % (Table 1).

**Table 1** – Indicators of reactive and personality anxiety according to the test C.D. Spielberg and Y.I. Khanin in beryllium shop workers

Indicators	Age group		
	I	II	III
<b>Reactive Anxiety:</b>			
low	2,99±0,39	14,87±2,97	9,99±1,99
moderate	19,01±2,8	40,51±4,10	43,3±4,66
high	4,0±0,81	1,62±0,32	2,71±0,54
<b>Personality Anxiety:</b>			
low	3,57±0,6	3,97±0,67	2,79±0,13
moderate	16,04±0,31	34,63±6,68	36,97±0,73
high	6,38±0,1	18,43±3,68	16,24±0,32

High level of anxiety is a predisposing moment to manifestation of emotional breakdowns leading to stress. The nature of industrial stress is caused by many factors, and first of all, undoubtedly, the influence of unfavourable production conditions. High level of personal anxiety is caused by changes in somatic state of human organism and characterises personal peculiarities of individual-typological properties of personality. Most likely, changes

in the level of anxiety cause maladaptation in the psychoemotional sphere, which is reflected in other psychophysiological reactions and contributes to changes not only in the psychological state of a person, but also in other morphophysiological indicators, which forms a risk group.

Measurement of stress and balance indicators on the basis of the Lusher test showed that in the groups of examined workers of the first group and consti-

tute 35.3 % of the total number of examined workers in this group with a gradual decrease in stress data in the second and third groups. Such changes are also characteristic of the trait characterising anxiety

with a subsequent decrease in the older age groups of workers. The character of the balance indicator is characterised by increasing values with increasing age (Table 2).

**Table 2** – Correlation of stress and balance according to the Lusher test in beryllium shop workers

Age group	Stress	Anxiety	Balance
I	9,17±0,45	8,39±0,41	8,65±0,43
II	13,3±0,66	11,68±0,58	31,8±1,59
III	5,33±0,26	15,96±0,79	34,66±1,73

The highest variability of the trait was observed in the balance indices in the third group of workers and makes 64.31±7.81. Lusher test in complex with other methods is currently used to assess the functional state. Assessment of balance shows good correlation of this indicator with other studied psychophysiological reactions.

The obtained results show a high percentage of workers in the first group who are stressed according to the Lusher test. The smallest percentage of workers with low stress values is observed in the

third group. The index reflecting the anxiety of the workers does not differ significantly in all the three groups examined. ‘Balance’ increases with age, as evidenced by the values of this indicator in the second and third groups.

The assessment of nervous system strength, i.e. the study of motor activity as a temperament trait, was recorded using the tapping test and characterised as follows (Table 3). In the first group, the indicators of typological properties of the nervous system are unevenly distributed.

**Table 3** – Distribution of indicators by tapping test

Age group	Low	Medium	High
I	8,6±0,43	6,3±0,43	12,610,43
II	25,1311,25	18,43±0,55	13,4010,40
III	31,9910,95	18,64±0,54	5,3310,26

The second group is dominated by workers with a low rate of 44.1 per cent followed by a decrease in the rates i.e. medium rate of 32.35 per cent and high rate of 23.52 per cent.

In the third group, the highest percentage – 57.14 per cent are workers who can be classified as the group with low rate of working capacity. The group with average performance includes 33.3 %, a small percentage of 9.52 % are workers with a high rate of performance.

The analysis of the obtained results shows that in the second and third groups under study the indicators of nervous system strength are distributed unevenly with the predominance of typological properties characterising as ‘weak’ type of nervous system. This index is especially high in the workers of the third group and amounts to 57.14 % with a de-

crease in the second and first groups. The indicators of the strength of nervous activity, characterising the ‘average’ type, are characterised by a smaller scatter of data. The lowest percentage is found in workers of the first group with some increase in average values in the second and third groups. As for the indicator of the ‘strong’ type, a significant decrease in the third group (9.52 per cent) and an increase in the second (23.52 per cent) and first groups (48.46 per cent) can be noted.

### Conclusion

The following conclusions were made on the basis of the conducted research: 1) psychophysiological reactions in beryllium shop workers are characterised by a slight increase in reactive anxiety



with age, a decrease in the value of 'stress' and an increase in 'balance'; 2) evaluation of the nervous system strength according to the change in the rate of motor activity shows a decrease in working capacity with age. Workers of the first group have the highest working capacity; 3) the indicators of balance coincide with the indicators of low efficiency and increased reactive anxiety. This indicates a predisposition to the occurrence of cardiovascular dis-

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### Information about authors:

G.E. Sadykanova – candidate of Biological Sciences, Associate Professor, Sarsen Amanzholov East Kazakhstan University, 30th Gvardeiskoy Divisii Street, 34, 070002, Ust-Kamenogorsk, Kazakhstan.

S. Kumarbekuly – corresponding author, Master of Technical Sciences, Senior Lecturer, Department of Ecology, Seyfullin University, Zhenis ave. 62, 010000, Astana, Kazakhstan.

K.Zh. Dakieva – doctor of biological sciences, Associate Professor, Sarsen Amanzholov East Kazakhstan University, 30th Gvardeiskoy Divisii Street, 34, 070002, Ust-Kamenogorsk, Kazakhstan

### Авторлар туралы мәліметтер:

Г.Е. Садыканова – биология ғылымдарының кандидаты, қауымдастырылған профессор, С. Аманжолов атындағы ШҚУ, 30-шы Гвардиялық дивизия к., 34, 070002, Өскемен, Қазақстан.

С. Құмарбекұлы – корреспонденция үшін автор, техника ғылымдарының магистрі, экология кафедрасының аға оқытушысы, С.Сейфуллин атындағы ҚазАТЗУ, Жеңіс даңғылы 62., 010000, Астана, Қазақстан.

К.Ж. Дакиева – биология ғылымдарының докторы, қауымдастырылған профессор, С. Аманжолов атындағы ШҚУ, 30-шы Гвардиялық дивизия к., 34, 070002, Өскемен, Қазақстан.

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