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Ways to Improve the Drillers' Working Clothes as an Element of the Work Safety System

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Annotation. The article, based on the analysis of indicators of working conditions and risk factors that contribute to the development of occupational diseases in the oil producing industry, presents modern approaches to reduce the impact of harmful factors on the health of employees of the main profession - drillers as the most popular profession in the oil and gas industry. The requirements for working clothes and the prospects for their application are justified, as well as the necessity to implement the principle of multifunctionality, the use of modern achievements in various branches of knowledge and new technologies in the production of overalls as personal protective equipment.

1. Introduction

Work on oil and gas extraction is associated with unfavorable factors of industrial, domestic and communication nature and is characterized by harmful working conditions [1-3]. Workers of drilling rigs, including workers of operational and exploratory drilling of wells for oil and gas (drillers), are an element of the production system and its psychophysical state should be given sufficient attention in the face of increasing complexity of technical facilities and developing new territories with extreme climatic and geographical conditions. The problem of prophylaxis of occupational diseases is relevant and the scientific community is looking for system solutions that affect not only the working conditions, but also personal protective equipment (PPE), which includes working clothes. [4, 5]. At the state level, regulatory documents are adopted on the assessment of working conditions [6-9] and provision of workers with various PPE [10-13].

2. Relevance

In conditions when working clothes become increasingly important in the system of work safety, each enterprise independently establishes the criteria for its selection by adopting technical conditions (TC) that do not involve the use of innovative means to improve the safety of workers and that aim at meeting minimum protection requirements. To date, research has been carried out both in the field of PPE design [14] and in the detection of the incidence of occupational diseases and the factors that cause them. Among the most frequently observed occupational diseases of drillers there are ENT organs, the musculoskeletal system and the peripheral nervous system [15, 16]. In working out of overalls, attention is mainly paid to the protective properties of materials and the minimum



requirements of ergonomics and hygiene [17-22]. A significant block of research touches upon the issues of heat-protective and hygienic properties of working clothes [23, 24]. The modern level of engineering and technology development allows us to regard a production worker as an element of the system, while not forgetting that this is not a mechanism and it is not enough to protect it from harmful chemical influences for its safe functioning in this system.

3. Statement of the problem

A systematic approach to the study of the problem of work safety in extreme climatic conditions with heavy physical exertion is aimed at identifying the patterns of occurrence of occupational diseases by the example of drillers and ways to reduce the identified risks in creating safe working conditions, one of the components of which is special-purpose clothing. To ensure safe working conditions, it is necessary to take into account all factors of production: technology and equipment, job responsibilities, hierarchy of harmful factors in the work environment, health and morbidity indicators.

4. Theoretical part

In the total mass of workers in the oil and gas industry, drillers of various specializations have the largest number. Drilling rigs are mostly located in hard-to-reach uninhabited places and do not have protection against adverse natural factors. To ensure the work safety, collective protective equipment and workers' PPE are used. PPE includes clothing, footwear, headgear and other means [11]. Applying the system approach [25] to solving the problem of worker's integration into the production process, it is possible to single out the system "man-PPE-external environment", where the external environment includes climatic features, means of collective protection, equipment and adaptations of the production process.

4.1. Analysis of features of drillers' working conditions

Drillers work on a rotational basis, connected with long flights and moving to their place of employment, so it is necessary to note as extended working conditions in road vehicles off-road, which negatively affect the musculoskeletal system [16-18]. On drilling rigs there is heavy physical work in extreme climatic conditions [16, 18], accompanied by a significant level of noise and vibration [1, 16]. The driller's working time consists of two phases - the road to the place of employment and the performance of labor functions at the drilling rig. To reduce the risk of occupational diseases during the transportation of brigades, collective safety equipment is designed to provide protection against adverse factors on the road. Reduction of traumatism and occurrence of occupational diseases directly on the drilling rig is associated with ensuring the overall work safety and the development of PPE. So, in the event of emergency situations related with oil or gas emissions from the drilled well, fire occurrence in the conditions of production noise it is necessary to ensure uninterrupted communication of all workers. In addition, the performance of labor duties is associated with hazardous working conditions and increased physical exertion. Reduction of harmful and uncomfortable working conditions is ensured by PPE and additional protective devices: metal overlays for shoes and helmets.

Therefore, increasing the protective and preventive functions of the driller's suit is aimed at transforming the worker into a part of the production system by increasing the level of communication and improving working clothes [26].

4.2. Development of principles for the design of the driller's PPE

The driller's suit has a layered structure, each layer of which is aimed at countering certain negative factors of the production process, for example, the winter version of the suit (see Table 1) includes thermal underwear, jacket, trousers, headgear, ear protectors, helmet, footwear, work gauntlets [11].

Thermal underwear is a layer of clothing, adjacent to the body, providing comfortable hygienic conditions. [24] To effectively discharge the excess moisture, it must fit tightly to the skin, which causes negative psychological sensations, especially when using materials with a minimum content of

natural fibers. Constructive shortcomings of thermal underwear are expressed in the repetition of the main joints of the next layers of the suit that increases the feeling of the clothing's excessive pressure. When designing thermal underwear, it is proposed to use the raglan sleeve cut of and, if necessary, to introduce a gusset that can be made of other materials, including composite ones.

The jacket and trousers are designed to protect against adverse environmental influences, to ensure ergonomic compliance with the work performed [22, 31]. The main disadvantage of the jacket is the unreliable protection of the wrist area.

The headgear represents a helmet liner for providing comfortable use of the helmet.

The helmet performs protective functions against impact on the worker's head. The main disadvantage of it is a rigid internal surface, resulting in redistribution of the impact and insufficient mitigation.

Table 1. Results of analysis of the driller's suit.

Parts of the suit	Performed functions	Disadvantages
Thermal underwear	hygienic	excess pressure, sensations of reduction of cutaneous respiration
Jacket	protective, ergonomic, information	insufficient protection of wrists, from shock loads
Trousers	protective, ergonomic, information	insufficient protection of shock loads
Headgear	hygienic, protective	insufficient protection against noise
Ear protectors	protective	insufficient protection against noise, reduced communication
Helmet	protective	insufficient protection
Footwear	protective, ergonomic	
Gauntlets	protective, ergonomic	insufficient protection of wrists

Ear protectors are designed to reduce the noise load on the hearing of a worker and provide about 20% reduction in noise, while significantly worsening the communication capabilities of a worker, which negatively affects the work safety.

The footwear performs protective functions and provides safety when moving on different surfaces. Work gauntlets protect hands from exposure to harmful factors, ensuring ergonomic compliance with the work performed. The main disadvantage of them is the unreliable protection of the wrist area and the lack of protection from vibration.

4.3. Directions to improve the safety of working conditions in terms of preventing the occurrence of occupational diseases

Studies of the frequency of occurrence of drillers' occupational diseases have shown that 80% is accounted for by the musculoskeletal system and disorders of the central nervous system [1, 15]. Analysis of the conditions of occurrence of these diseases allows us to identify a number of factors that are reduced by means of protection and which have the greatest impact on the occurrence of occupational diseases of drillers: prolonged off-road trips, heavy physical exertion and high noise level, mainly as a factor in obtaining occupational injuries.

5. Practical significance

The application of the stated approach to the design of special-purpose clothing that provides work safety is realized in several aspects: ergonomic and psychological comfort [20], protective functions from various factors, and provision of injury safety. For all components of the suit, it is necessary to

comply with the terms of its mass, which should not increase. Based on the analysis of PPE, measures are proposed to increase the protective and preventive properties of drillers' PPE (see Table 2)

Table 2. Expected results of improving the driller's PPE

Parts of the suit	Changes introduced	Expected results
Thermal underwear	supplemented with gloves and socks, equipped with magnetic zones	increase of protective and hygienic properties, prevention of musculoskeletal disorders
Jacket and trousers	zonal impact protection [27-29]	injury reduction
Headgear	sound-proof materials [30], built-in communication facilities	increase of communication level, reduction of ENT and central nervous system diseases
Helmet	insertion of cushioning layer, addition of antenna	reducing the level of injuries, increasing of communication level
Gauntlets	use of vibration damping materials [23], change in the design of funnels	prevention of diseases of the central nervous system, protection from oil leakage

Application of magnetic zones is supported by research and practical use of magnetic fields for prevention of various diseases, their use in thermal underwear in accordance with medical recommendations is aimed at reducing the negative effects on the musculoskeletal system that arise in conditions of heavy physical labor. The design of trousers and jackets provides for the overlays of the elbow and knee, which protect clothing from damage in this area, but do not carry protective functions for the worker. The use of cushioning materials in these areas will protect the worker from injury due to impacts and falls. The proposed exclusion of ear protectors from the PPE is based on their low ergonomics and inefficient noise reduction. Under such conditions, the use of sound-proof materials in the headgear (helmet liner) and equipping it with communication facilities will lead to a more significant noise reduction and will allow the introduction of communication technologies.

6. Conclusion

Based on the theoretical and experimental studies and polls conducted, shortcomings in overalls of varying degrees of anxiety, from psychological and ergonomic inconveniences to lack of protection from some factors of occupational risks and insufficiency of work safety, have been revealed. Innovative developments in various industries allow not only to increase the level of the driller's PPE, but to achieve its safe and efficient functioning.

Thus, an effective increase in the safety of working conditions is based on a synergetic modernization of equipment and individual and collective protection facilities of workers.

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