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Increasing the safety of the transport process by minimizing the professional risk of a dump truck driver

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Abstract

Purpose. The aim of the study is to develop recommendations for reducing the probability of accidents during the transportation of rock by dump trucks based on the analysis of the consequences of changes in the psycho-physiological states of the driver.

Methods. The study used the method of "Hazard and operability studies" and the method of "Failure Mode and Effects Analysis" including the organizational, logical and mathematical, and statistical procedures aimed at obtaining the expert assessment of hazards from professional experts based on Grabs' criteria that affect to change the psychophysiological state of the driver while driving a dump truck, their analysis and generalization of the results in order to prepare reasonable decisions.

Findings. It is established that the psychophysiological state of the driver as a manifestation of fear, anxiety, doubt, uncertainty when performing discrete work, which is associated with frequent changes in the beginning of movement and stops of the vehicle (accumulation of a large number of dump trucks, complex route plan, etc.) leads to an increase in the risk of an emergency. It is determined that the highest level of emergency occurs due to emotional manifestations, that are associated with the relationship between employees, the presence of leadership support, psychological assistance, mobbing, conflict resolution and more. Recommendations have been developed to increase the level of transportation safety through the formation of an appropriate organizational culture at the enterprise, which ultimately shapes human social behaviour.

Originality. The scientific novelty lies in the establishment of the values of occupational risk of an accident while driving a dump truck by the driver, which depends not only on the probability of a dangerous event and the severity of its consequences, but also on changes in the psychophysiological state of the driver, which results from the organizational culture of occupational safety at the mining enterprise.

Practical implications. Consists in the development of a procedure for qualitative assessment of the risk of an accident from the psychophysiological state of the driver during the trucking of rock in the conditions of the mining enterprise. Recommendations for improving the safety of transportation through the formation of an appropriate organizational culture of the transport process are developed. An approach of taking into account the socio-psychological climate in the organization to assess the occurrence of the incident is proposed.

Keywords: *driver, occupational risk, psychophysiological condition, dump truck, danger, interaction, catalyst*

1. Introduction

Quarry road technology transport plays an important role in the moving of large volumes of rock in the mining environment. Therefore, the efficiency of its operation is subject to a number of different requirements aimed at ensuring the continuity of the mining process [1]-[3]. Effective use and productivity of dump trucks depend on the qualifications of the driver and staff involved in the organization of rock transportation. Their competencies include minimizing the time to eliminate various failures and hazards that are associated with the technological process of extraction and transportation of rock to the place of unloading. The urgency of this process is pointed up by the fact that the efficiency of the entire system of mining technology depends on the reliability of the driver [4]-[6].

There are many reasons of mining equipment being out of order, and as a result, it can lead to significant accidents, delays in production tasks and financial losses of the mining company [7]. These are technical failures, which are inherent in various mechanisms of large-scale technological quarry vehicles, as well as natural phenomena. But the greatest damage is caused by "human error" resulting from various psychophysiological reasons that require careful study [8]. The answer to this question determined the relevance of the research topic and allowed us to develop and recommend precautionary measures aimed at timely response to eliminate these dangers and allow correcting the situation without serious economic consequences for the mining company.

It is known that the safety of a dump truck depends on the main key elements that make up the system: "driver – car –

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road" (hereinafter – the DCR system). Failure of any element of the DCR system increases the probability of the change of its normal-functional state, and most importantly, will increase the risk of an emergency.

Specialists in transport technology identify the most important element of the DCR system being the driver, who needs an appropriate level of control of their psychophysiological condition while performing professional functions to reduce errors while driving [9]. Research [10] indicates that failures during the trucking are mostly related to the driver's behaviour while driving. Because the DCR system constantly exchanges information: from the technical condition of the vehicle and road conditions and the state of health of the driver, who provides driving commands and receives information about the results of their actions through feedback channels to take corrective action to change conditions in the environment [11]. Hence, the security and reliability of this system depends on the ability to perceive and process information. The authors of the study [12] suggest that the root cause of driver errors when driving a vehicle is due to changes in their psychophysiological state. Correction of this situation is seen in the strengthening of training requirements for drivers [11]. Another study [12] found that most road accidents are caused by drivers' lack of awareness of health hazards and their consequences. The authors point out that the technical systems of the car do not often fail, and those minor cases, again, are mostly related to the human factor. According to statistics, difficult road situations where the driver makes a mistake occur on average once a month, which in the general sense leads to one accident every five years [13], [14]. It is proposed to correct this situation with the help of the theory of driver behaviour planning based on studies of traffic conditions, cultural habits, which allows finding appropriate methods to supplement and correct the driver's reaction in difficult situation [15].

The authors of the paper [16] considered the reasons for driver errors being dangerous actions or no action, using the method of "Hazard and operability studies" (hereinafter – the method "HAZOP"), which allowed them to evaluate the driver's performance according to the method "Failure Mode and Effects Analysis" (hereinafter referred to as the "FMEA" method) by means of a comprehensive indicator – the rank of the risk priority (RPN), which allows to determine the impact of all potential hazards in the transport process on the probability of error. In addition, it is possible to rank the hazardous factors during the cargo transportation as presented by the authors [17]. Based on a systematic approach to the identification of hazards that arise during the transport process, the authors set the criticality level of the system. After it is reached the accident occurs. On the other hand, considering the process of transportation and reliability support of logistics in the supply chain, the authors of [18] showed the relationship between the level of comfort in the driver's cab and transportation safety based on the analysis of the results obtained by the "FMEA" method. This has led to the development of guidelines for the reduction of injuries based on the elimination of hazards depending on the severity of the consequences for human health. A radical solution for this problem of reducing the number of incidents in the DCR system is the industrial production of fully autonomous dump trucks with artificial intelligence, which make independent decisions based on the collection of maximum information about the environment. At the same time, in order to increase the safety of such transportation it remains possible for the carrier company to control the movement of such vehicles [19].

From the analysis we can identify several main causes of accidents, where the most important is the change in physical or psychophysiological condition of the driver while driving a dump truck, which is characterized by fatigue from prolonged driving, high responsibility for timeliness, deterioration of psychomotor reactions from stress when driving a large vehicle, the manifestation of fatigue from monotonous movements and staying for a long time in a monotonous working position; change in emotional mood, loss of concentration and others. In addition, the deterioration of the physical health of the driver while driving may change due to the manifestation of symptoms of chronic disease, the sudden onset of viral disease; residual signs of alcohol or drug intoxication, from prolonged driving a dump truck without rest; the influence of harmful working factors: vibration, changes in temperature in the cab of the vehicle, noise, dust, etc. [11]-[15].

Based on the above, a serious consequence of the impact of hazardous factors that affect the dump truck driver in the performance of professional functions is a loss of concentration, which leads to a variety of errors that can result in dangerous accidents. And given the limited ability to spend financial resources to reduce the impact of occupational risk on the driver, there is a problem in ranking all the dangers that worsen the psycho-physiological condition, which will justify effective recommendations, measures to reduce the probability of accidents.

The aim of the paper is to develop recommendations for improving the safety of quarry technological road transport during the transportation of rocks based on the analysis of the consequences of changes in the psychophysiological states of the driver.

To achieve the aim of the study it is necessary to solve the following tasks:

– to determine the level of professional risk of the driver when transporting rock by quarry vehicles;

– to determine the priority rank of occupational risk of an emergency situation related to the psychophysiological condition of the driver of dump trucks;

– to develop recommendations for improving the safety of quarry technological road transport.

2. Methods

The "HAZOP" method and the "FMEA" method were chosen to assess occupational risks in rock transportation because they combine well with each other and allow detailing each stage of the production process to identify hazards and system performance as a whole, conducted by a specially selected experts group. In addition, their use to assess the degree of occupational risk of the driver is recommended by a number of regulatory requirements [20]-[23].

The first step is to identify the hazards and performance of the rock transportation system by dump trucks. To determine the undesirable event we use a few keywords of the "HAZOP" method (Fig. 1) [24].

For example, in the case of a negative deviation: the control word: "no" – the transportation process does not occur due to a logistical failure, or in the case of a deviation of the quantitative modification: the control words "more" – an increase in the temperature in the dump truck or speed. Indicative words are also used to study potential hazards.

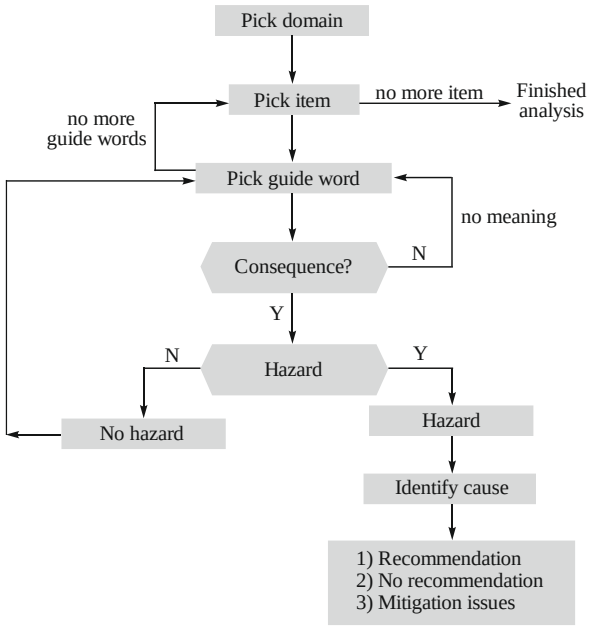

Figure 1. Algorithm of actions at carrying out of an estimation by the HAZOP method [24]

For example, we analyse the technological units of the process until we exhaust all the possibilities of analysis. Then, the procedure moves to the next node, where we again search for potential hazards. To do this we study the causes of already known incidents, investigate reports and articles that describe the factors that lead to complete or partial loss of serviceability of technological equipment in accordance with the declared results and working conditions. At the same time, for the convenience the transportation process is divided into several parts: technical, organizational and production. We consider each selected part separately to find out possible violations, the reasons for their occurrence and the probable consequences of these deviations. The failure rate analysis was made on the basis of estimates of the occurrence probability of negative scenarios, which were predicted by dangerous situations. Moreover, the frequencies were synthesized using an evaluation scale, based on the definition of combinations of failures and circumstances that may occur during transportation. To determine the consequences we used the statistically estimated results of the target population on the risk of deteriorating safety or health, economic component, and the occurrence of an emergency. Impact assessments were performed according to the risk assessment matrix (Table 1). The proposed protective barriers to prevent the realization of certain consequences of the identified risks were based on modern opportunities of industrial progress.

Table 1. Risk assessment matrix

Risk classification		Frequencies				
	Matrix	Unlikely	Remote	Casual	Likely	Frequent
Severities	Catastrophic	Moderate	Moderate	High	High	High
	Critical	Moderate	Moderate	Moderate	High	High
	Average	Low	Moderate	Moderate	Moderate	High
	Moderate	Low	Low	Moderate	Moderate	Moderate
	Low	Low	Low	Low	Moderate	Moderate

The second step is dedicated to the quantitative assessment of occupational risks arising from changes in the psychophysiological state of the driver while driving a dump truck. To do this we use the algorithm of the method "FMEA", which allows based on the use of organizational, logical and mathematical-statistical procedures to calculate the priority of occupational risk of dangerous situation based on three indicators of severity (*S*), probability of failure/ incident (*O*) and possibility detection of a defect that is associated with dangerous action or no action (*D*). The last indicator is related to determining the impact of the driver's psychosocial state on the occurrence of human error – dangerous action or no action when driving a dump truck. According to the priority of the risk rank, the choice and substantiation of rational decisions is made to improve the safety of trucking through the generalization of the estimates.

The actions of experts according to the algorithm of the method "FMEA" (Fig. 2) are described in detail in the standard [25].

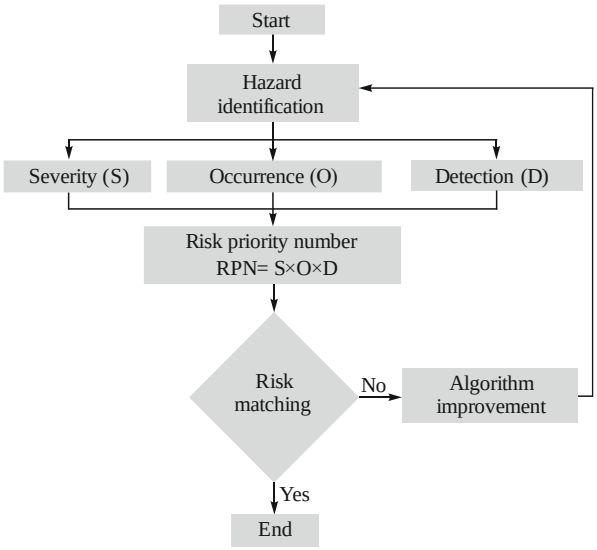

Figure 2. Algorithm of actions when conducting risk assessment by the "FMEA" method [25]

The group of experts (Table 2) assesses three main occupational risk factors for the mode of possible potential hazards: severity of consequences (*S*), probability of failure / incident (*O*), and detection of defect (*D*). The product of these components *S*, *O* and *D* allows you to determine the value of *RPN* by the Formula 1 [25]:

$$RPN = S \cdot O \cdot D \cdot \qquad (1)$$

Table 2. Data from experts who participated in the study

Information	Number
Number of experts	6
Experience in transport logistics positions	from 10 to 14 years
Education of experts	higher in transport technologies
Work experience	more than 10 years
Availability of an auditor's certificate on quality management systems and company safety	yes
Advanced training in risk assessment in accordance with the requirements [23]	yes

The assessment of occupational risk, which is obtained by the algorithm of the method "FMEA" continues until the full identification of the *RPN* value indicating the highest values of occupational risk. The most influential factors are those in which the RPN value exceeds 150 points [25]. A scale from 1 to 10 is used to determine the indicators of severity of consequences (*S*), the probability of failure/incident (*O*) and the possibility of detecting a dangerous psychosocial condition (*D*), where 1 is the smallest value of the indicator and 10 is the highest one.

Grabbs' test was used to process the results provided by the experts and to verify their estimates of emissions:

$$G_{\max} = \frac{X_n - \bar{X}}{s}, \quad (2)$$

where:

X_n – proposed expert assessments;

$\bar{X}$ – the average value of the sample; *S* is standard deviation.

Where it is necessary to calculate the mathematical expectation or the average value of the obtained results:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i . \quad (3)$$

It is also necessary to calculate the standard deviation:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2} . \quad (4)$$

Using the following formulae, we check the maximum and minimum results of expert assessments for emissions, provided that the indicator exceeds the critical value:

$$s = \begin{cases} G_{\max} \geq G_{n,1-\alpha} \\ G_{\min} \geq G_{1,\,1-\alpha} \end{cases}, \quad (5)$$

where:

α – the level of significance, which is determined in accordance with the requirements [26].

In case of non-fulfilment of the specified inequality the results of estimates will be considered as emissions which need to be excluded. However, the experts who gave such an assessment are clarified to identify the reasons for the validity of their choice of points during the examination. The critical values of statistics are selected based on the law of distribution of a random variable. These values can be found for the normal distribution in accordance with the requirements [26]. In case of suspicion of two emissions, an assessment of the totality of results for two Grabbs emission statistics is performed.

3. Results

As a result of the conducted analysis of information sources [3], [27]-[33] from the description of the most widespread emergencies with dump trucks, which are selectively given in Table 3, hazards and dangerous situations were identified and the main causes of incidents were identified as well, based on the causal links of the development of events by the method of "HAZOP" including:

– human error due to loss of attention resulting from distractions or fatigue of the driver while driving a dump truck;

– failure of technical dump truck systems related to design defects or inadequate maintenance or operation of vehicles;

– road conditions that are associated with the formation of the roadway, ledges, turns, elevation angles, power grids and other infrastructure facilities that may restrict the movement, visibility or loading and unloading procedures of the dump truck.

Table 3. The results of grouping the dangers of the transport process of rock transportation by a dump truck by the "HAZOP" method (fragment)

Parameter	Keyword	Hazards	Dangerous event	Severity of consequences	Probability	Risk	Precautions	Reference
Dump truck speed	More	Difficulty of driving, inability to identify the quality of the roadway, road signs, inability to drive a dump truck	Dump truck leaving the road surface, overturning, the occurrence of an emergency situation	IV Life and health of the driver, damage to the vehicle, loss of cargo, damage to the road surface, higher fuel consumption	D	H	Apply speed control elements for dump truck	[3], [27], [28]
Technical condition of the dump truck	Less	Malfunction of mechanical, electrical, hydraulic components of the dump truck	Defective condition of the dump truck, inability to install a standing brake, inability to lower the body of the dump truck, lack of lighting		C	M	Apply control elements for the technical condition of the dump truck	[28]
	Part	Failure to comply with the maintenance procedure, violation of the mode of replacement of components and elements of the dump truck			B	L		[2], [29]
Visibility	Less	Lighting system malfunction, inability to identify hazards while driving a dump truck	Dump truck leaving the road surface, overturning, emergency situation		B	L	Apply control elements for the dump truck lighting system	[27], [30]
	Other	Traffic in the area near a powerful power grid	Electric shock, damage to electronic systems, electrical network, emergency		B	L	Apply control elements for the route of the dump truck	[28], [29]
Road condition	Other	Violation of the road surface, uneven coverage	Chassis breakdowns, dump truck overturning, emergency situation		B	L	Apply road surface control elements	[31]

However, the "HAZOP" method, which is based on the use of five keywords, does not allow the assessment of occupational risk to take into account this component – the ability to monitor hazards. For example, the level of occupational risk of an accident due to limited visibility or exposure to difficult weather conditions calculated by the "HAZOP" method is low. However, its assessment of the two criteria of severity and probability of an accident will be incomplete without taking into account the level of ability to monitor driver training, experience and psychophysiological condition while driving, which increases the likelihood of human error, despite the good technical condition of the car system.

Unfortunately, the psychological state of the driver is difficult to predict, because it can change for various reasons: mood, emotional colour, working conditions, well-being, workload, rhythm of work and more. In a general sense, it is significantly influenced by the organizational culture of the enterprise, which is formed of small particles - a set of certain attitudes, aspects, symbols, artefacts, which makes it holistic. Organizational culture covers all important issues related to risk, learning, business, people management, climate, internal integration, and external differentiation, organic and mechanistic processes. It creates a system of commitments and trade-offs to avoid tensions between processes, service and integration, positioning and differentiation, and responds adequately to internal and external threats. Of course, these aspects are only a certain part of the influences that lie on the surface. Organizational culture also contains common/individual language/knowledge, accepted technical solutions, common values, views, explicit/implicit symbols, common experience, social customs and social norms, "meaning maps" that make public life understandable to its members. Observations are needed on the socio-psychological phenomena that occur at the mining enterprise: relationships, connections, beliefs, policies, activities and relationships of groups.

When assessing the risk of the driver's psychological state, it is proposed to conduct "monitoring" using the "FMEA" method by replacing the "defect detection" indicator [24] with determining the "possibility of establishing" – a certain psychophysiological state of the driver while driving.

Therefore, in order to determine the occupational risk of an emergency situation – the descent of a dump truck from the road surface, its overturning, it is necessary to establish the severity of the consequences, which will be quite significant – loss of life and health of the driver. Moreover, the probability of such a situation in accordance with statistical data processed by experts from various sources of information is high due to the difficulty of identifying the quality of the road surface, road signs. At the same time, the danger of an accident, which significantly increases the risk, can be several psychophysiological states of the driver (Table 4), among which, experts highlight the emotional state of the driver resulting from conflicts, misunderstandings, high responsibility as the most influential ones determined by organizational culture at the mining enterprise.

Table 4. Example of assessing the priority rank of occupational risk of an emergency situation by the "FMEA" method

The item being evaluated	Dangerous situation	Severity of consequences		Probability of occurrence/ interaction		Detection of psychological state		("RPN" = "S"×"O"×"D")
		Description of symptoms	"S"	Description of origin	"O"	Description of psychological influences	"D"	"RPN"
Transportation safety, " Visibility"	Dump truck leaving the road surface, overturning, emergency situation	Life and health of the driver, damage to the vehicle, loss of cargo, damage	9	Difficulty of driving a dump truck, impossibility to identify the quality of the road surface, road signs	4	Psychophysiological stress due to the fact that the dump truck is a high-risk vehicle, a manifestation of fear, anxiety, doubt, insecurity (typical for beginners)	5	180
						Haste, loss of attention due to driving a dump truck in the conditions of imposed pace and lack of time, violation of the schedule due to failures of loading and unloading operations, temperament or emotional colouring	7	252
						Fatigue, loss of attention due to the shortcomings of the rest regime, the presence of harmful factors, lack of comfort at the workplace	7	252
						Emotional manifestations, distraction due to conflicts, misunderstandings, high responsibility	8	288
						Changes in the psychophysiological state due to the temperament of the character of the dump truck driver	5	180

As you can see, the probability of an accident depends on various psychological influences. Moreover, experts, based on the conducted behavioural audits to identify dangerous actions or situations, the manifestation of certain traits of drivers, their competence, and attitude to compliance with regulations, health status, sanitary and hygienic analysis of working conditions, are determined according to using a scoring system, which indicator will have the greatest impact on the final result. This approach, unlike the existing ones, is widely used to identify potential hazards and establish cause-and-effect relationships with the emergence of an emergency situation, and allows you to take into account the psychophysiological state of a particular driver when driving a dump truck. That is, as a result of the assessment of occupational risk, the result will be obtained for each production unit and not the average ephemeral value for the technological cycle. This approach will allow the point-by-point implementation of certain tools/precautions that provide the maximum possible desired outcome.

From the analysis of the results (Table 4) we can conclude that the highest level of emergency occurs due to emotional manifestations, which are associated with the relation-

ship between employees, the presence of management support, psychological assistance, mobbing, conflict resolution and more. All of the above determines the organizational culture at the mining enterprise, which ultimately shapes the social behaviour of man. To better understand these relationships, we use a special template called "iCue" developed by Professor R. Long, which takes into account not only the physical hazards that affect the driver, but also psychological and even social factors that are interrelated (Fig. 3) [34]. In the future, this approach allows you to prescribe in more detail the precautions and benchmarks to improve safety.

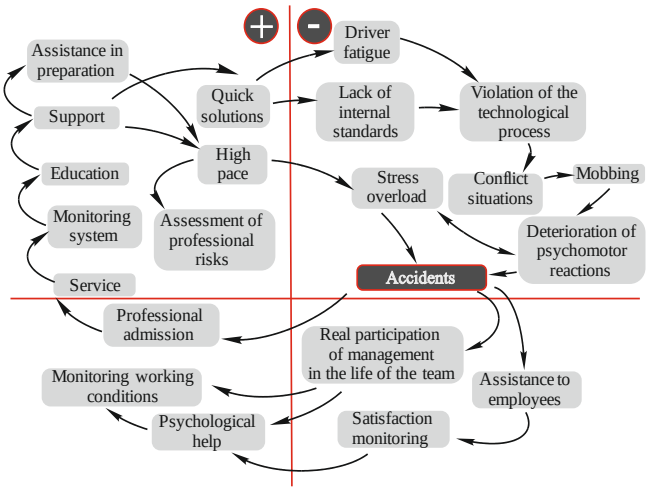

Figure 3. ICue card to establish the relationship between different factors in the transport process management system at the mining company

4. Discussion

Most of the world's mining companies implement road safety programs to reduce accidents, which are based on three steps: plan, act, check that meets the requirements of the standard [32]. A mandatory component of these programs is occupational risk assessment, which includes the identification of hazards inherent in technical vehicles, the driver and road conditions. In this case, in accordance with the requirements of the standard [23], the magnitude of occupational risk is calculated as the product of the probability of a dangerous situation and the severity of the consequences. This approach in determining the risk of an accident while driving leads to errors in the calculations, because it does not take into account the possibility of monitoring the psychophysiological state of the driver, which act as a "catalyst" for a dangerous event. In the proposed approach, based on the known method "FMEA" it was possible to take into account the above-mentioned component, which is its main peculiarity.

That is, "the ability to detect the psychophysiological state of the driver" in this method was replaced by the indicator of "defect detection" – in accordance with the classical approach. However, the question arises as to what exactly should be considered the cause, as there are at least five main causes of accidents. Therefore, it was decided to assess occupational risk, taking into account each possible identified cause in the assessment of any identified hazards inherent in the vehicle, or driver, or road conditions. As the combination of these components can lead to different results in the elements of the system "DCR: (Fig. 4), the analysis of the obtained results for the conditional mining enterprise allows revealing gaps in the road safety system.

Table 5. Development of recommendations on precautionary measures to improve the transport process of rock transportation by quarry dump trucks at the mining enterprise

Factors	Strengths	Challenges	Threats	Precautions	Indicators
Production	The assessment of professional risks of the driver during transportation of cargo is carried out. His training and assistance in preparation for the trip are provided. There is a monitoring system for sanitary and hygienic, ergonomic indicators. Dump truck maintenance is provided	Violation of the technological process, failure to include safety standards in the work profiles of drivers. Untimely delivery of the extracted rock to the place of unloading due to emergencies caused by road conditions, miscalculations in the route, technical condition of the dump truck	Life and health of the driver, damage to the vehicle, loss of cargo, damage to the road surface, higher fuel consumption	Develop internal safety standards in accordance with production tasks, provide for control over the transportation of goods using the "Trip Check" procedure and the established systems of warning about leaving the oncoming lane	The number of procedures performed to support the prevention system for accident or road accident
Psychological	Control of professional admission of the driver; control of a psychophysiological condition of the driver, psychological support during performance of professional activity	Errors when driving a dump truck due to the accumulation of driver fatigue, stress because of the increased risk of rock transportation, manifestations of fear, anxiety, doubt, insecurity, loss of concentration while driving a dump truck resulting from deteriorating psychomotor reactions	Development of professional burnout of drivers, the appearance of somatic diseases due to increased stress	Improving the system of employee motivation through the introduction of an incentive system for conscientious performance of professional tasks	Time control system of human-machine systems interaction
Social	The management of the mining enterprise takes an active part in the process of safety management, provides support and assistance to employees, promotes cooperation between employees, monitors social satisfaction with the professional activities of drivers	Conflict situations, mobbing, inclusion	Development of apathy, frustration, manifestations of depression, abuse of psychotropic substances, lack of goals, deterioration of living standards	Ensure a variety of production tasks, strengthen monitoring of the health of workers through the use of digital technologies, maintaining the well-being of drivers' families	Catalyst control system that affects the level of safety culture at the mining enterprise

For example, from Figure 4 it can be concluded that most issues to the road safety system arise due to emotional manifestations that are associated with the organizational culture of the mining company: inconsistency of work schedule, conflict situations between employees due to failures in the technological process.

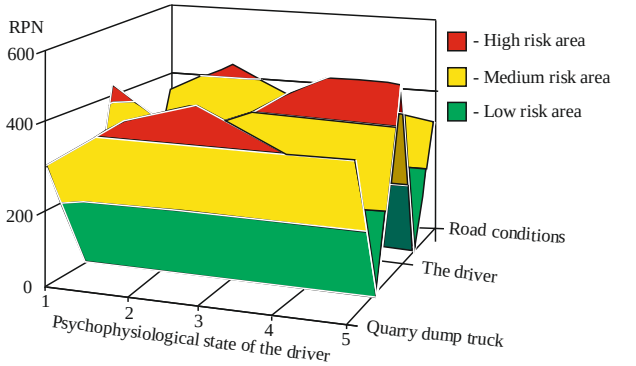

Figure 4. Distribution of risk priority by elements of the "DCR" system taking into account: psychophysiological stress (1); haste, loss of attention due to driving a dump truck (2); fatigue, loss of attention due to the shortcomings of the work regime (3); emotional manifestations, distractions (4); change of psychophysiological state (5)

The identified dangers without taking into account the psychophysiological component, social interaction do not allow identifying these relationships, which under certain conditions can significantly worsen the situation and increase the likelihood of a dangerous event. Therefore, the next difference of the proposed approach is the establishment of relationships between various factors in the transport process management system at the mining enterprise, which allows to establish precautions and control indicators based on the level of culture, and not only on the basis of risk. This in turn will allow you to plan resources, actions, identify those responsible persons, control dates and track the implementation of tasks.

5. Conclusions

Factors that affect the level of occupational risk in the transportation of rock by quarry technological vehicles, which include: the psychological state of the driver due to loss of attention associated with distractions, or driver fatigue while driving a dump truck; failure of technical dump truck systems related to design defects or inadequate maintenance or operation of vehicles; road conditions associated with the formation of the roadway, ledges, turns, elevation angles, power grids and other infrastructure facilities that may restrict the movement, visibility or loading and unloading procedures of the dump truck.

It is established that the psychophysiological state of the driver of a career dump truck, as a manifestation of fear, anxiety, doubt, insecurity; performing discrete work, which is associated with frequent changes in the beginning of move and stops (accumulation of a large number of cars, a complex plan of the route of transportation, etc.) leads to an increase in the level of occupational risk of an accident.

The highest level of emergency is due to emotional manifestations, which are associated with the relationship between employees, lack of support from management, psychological assistance, mobbing, conflict situations and more. All of the above determines the level of organizational culture in the mining enterprise, which ultimately shapes the social behaviour of person.

Recommendations for improving the safety of quarry technological road transport during the transportation of rocks were developed based on the formation of an appropriate organizational culture at the mining enterprise, which provides a system of commitments and compromises to avoid tensions between processes, maintenance and integration, positioning and differentiation, as well as to adequately respond to internal and external threats to stabilize the psychophysiological state of the driver.

Recommendations for determining the impact of psychophysiological conditions of the driver on the magnitude of occupational risk, as well as for the formation of an appropriate organizational culture to improve traffic safety were developed. An approach to take into account the sociopsychological climate in the organization to assess the occurrence of the incident is proposed.

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Підвищення безпеки транспортного процесу за рахунок мінімізації професійного ризику водія кар'єрного самоскиду

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Мета. Метою дослідження є розробка рекомендацій щодо зниження ймовірності виникнення аварійних ситуацій під час перевезення гірської породи кар'єрними самоскидами на основі аналізу наслідків зміни психофізіологічних станів водія.

Методика. Для проведення дослідження використано метод "Hazard and operability studies" та метод "Failure Mode and Effects Analysis", який включає організаційні, логічні і математико-статистичні процедури, що спрямовані на отримання від фахівців-експертів оцінки факторів небезпеки з урахуванням критерія Грабсса, які впливають на зміну психофізіологічного стану водія під час керування кар'єрним самоскидом, їх аналіз і узагальнення отриманих результатів з метою підготовки раціональних рішень.

Результати. Встановлено, що психофізіологічний стан водія як прояв страху, тривоги, сумніву, невпевненості при виконанні дискретної роботи, яка пов'язана з частими змінами початку руху і зупинками транспортного засобу (скупчення великої кількості кар'єрних самоскидів, складний план траси транспортування та ін.) призводить до збільшення рівня ризику виникнення аварійної ситуації. Визначено, що найвищий рівень настання аварійної ситуації відбувається через емоційні прояви, які пов'язані з взаємовідносинами між співробітниками, наявністю підтримки керівництва, психологічної допомоги, мобінгу, вирішення конфліктних ситуацій та інше. Розроблені рекомендації, щодо підвищення рівня безпеки перевезень через формування відповідної організаційної культури на підприємстві, що в кінцевому результаті формує соціальну поведінку людини.

Наукова новизна. Наукова новизна полягає у встановлені величини професійного ризику залежності виникнення аварійної ситуації під час керування водієм кар'єрним самоскидом не тільки від ймовірності настання небезпечної події та важкості наслідків, ай від зміни його психофізіологічного стану, який зумовлений організаційною культурою безпеки праці на гірничодобувному підприємстві.

Практична значимість. Полягає у розробці процедури з якісної оцінки ризику настання аварійної ситуації від дії психофізіологічного стану водія під час вантажних автомобільних перевезень гірської породи в умовах гірничодобувного підприємства. Розроблено рекомендації щодо підвищення безпеки перевезень через формування відповідної організаційної культури транспортного процесу. Запропоновано підхід врахування соціально-психологічного клімату в організації на оцінку виникнення інциденту.

Ключові слова: *водій, психофізіологічний стан, кар'єрний самоскид, небезпека, взаємодія, каталізатор*