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HUMAN RELIABILITY AS MAIN REASON FOR RAILWAY ACCIDENTS

The modern development of science and technology has practically resolved the issue of ensuring the reliability of technical means, but the influence of man as an integral part of the man-machine man-technology system, remains not fully investigated.

The problem of the influence of the human factor is versatile, complex structurally and is currently far from being resolved.

Rail transport is a complex system in which the individual is the main element. Therefore, the nature and degree of influence of a person, as an element of such a system, on traffic safety is determined by the nature and degree of his participation in the processes of functioning of an automated railway transport system.

The «human factor» is considered in almost all processes of the railway transport system. It depends on a person the level of labor and technological discipline, timely control and proper hazard assessment, reasonableness and correctness of actions in the field of their professional activities to prevent and prevent railway accidents.

The variety of railway accidents that investigated in Lviv NDISE indicate that it is impossible to use standard mechanisms for cases where the «human factor« is considered, but requires a thoughtful individual approach to developing a mechanism for each case separately.

The task of the expert in the study of railway accidents, in which the influence of the «human factor« is considered, is to establish the degree of its influence on the implementation (realization) of the refusal of the mechanism of a railway accident at the moments when some railway situations turn into others.

Keywords: railroad accident, human factor, rolling stock, transport situation.

Formulation of Research Problem. There are about 500 railway accidents and events every year on the Ukrainian railways, each with a *human reliability*.

Human reliability refers to the actions or omissions of a person during his/her duties having a major impact on the safety of rolling stock on railway transport.

At the same time, the problem of the study of the influence of this factor on the occurrence of rail accidents is versatile, complex structurally and is far from being resolved. The variety of rail accidents analyzed on Ukrainian railways and investigated in Lviv RIFE indicates not the impossibility of applying typical mechanisms for cases where *human reliability* is considered, but requires a thoughtful individual approach to designing the mechanism on a case-by-case basis.

Analysis of recent research and publications. A considerable amount of work is devoted to the study of the impact of the *human reliability* on the occurrence of rail accidents.

Among them is the work of V. M. Samsonkin *Development of a method for effective monitoring of the main activity of the train driver*[1], which invented a mechanism for determining the conditions of work of the driver when performing train and shunting work. The author of the mentioned research paper developed an algorithm for monitoring the condition of the driver with the help of an individual norm and a mathematical model of the control system of operational activity, as well as presents a perspective direction of increasing the reliability of t*human reliability* in the management of traction rolling stock without additional technical means.

In the research paper of O. M. Troynikov *Approaches to the management of safety of transport processes on the railways*[2] by the author identified the main causes of railroad accidents, among which the impact of *human reliability*. In addition, in this work, railway safety is divided into four components: technological, industrial, environmental and railway safety.

In the work of V. A. Olentsevich and V. E Gozbenko: *The analysis of the reasons for the violation of the safety of the railway transport system* the authors investigated the state of safety on the railways of Russia over the past three years.

The authors also identified the main factors that affect the safety of the Russian rail transport system, and noted human activity as the root cause of almost all rail accidents.

Modern approaches in the field of railway safety improvement have been proposed by I. E. Skogarev in *Modern approaches to improving the safety of railway traffic*[3] which proposed to reduce rail accidents

[1] *Samsonkin V. N., Petinov Ja. P.* Razrabotka metoda jeffektivnogo monitoringa osnovnoj dejatel'nosti mashinista poezda [Development of a method for effective monitoring of the main activity of a train driver]. Vostochno-Evropejskij zhurnal peredovyh tehnologij. Harkiv, 2016. Vip. 81. S. 52–58 [in Russian].

[2] *Troinikova O. M.* Pidkhody do upravlinnia bezpekoiu transportnykh protsesiv na zaliznytsi [Approaches to the safety management of transport processes on the railway], NTP y эffektyvnost proyzvodstva. 2015. Vyp. 132. S. 54–60 [in Ukrainian].

[3] *Skogarev I. E., Kobozev A. Ja., Zhizhko V. V., Bogomazova E. A.* Sovremennye podhody v oblasti povyshenija bezopasnosti dvizhenija

associated with low training of railway workers, to use a modern software complex to test and test their knowledge.

A great contribution to the study of the impact of the human factor on the onset of railroad accidents made E. M. Sokol. The monograph: *Steps from the rails and collisions of rolling stock*[1] established the influence on the reaction of the driver in case of sudden obstruction to the movement of rolling stock of several physiological and psychological factors. One of the results of the study is the derivation of a calculation formula for setting the response time of a driver to an obstacle to movement and the corresponding brake path of the train.

Thus, as the analysis of the above sources shows, the question of the influence of the *human reliability* in the onset of rail accidents is rather urgent and requires ongoing theoretical and practical research.

Article Purpose. Performing an analytical review of the «human factor» as a basis for railway safety, establishing the expert's main tasks in the study of rail accidents, which analyze the impact of *human reliability*.

Main content presentation.

In practice, the human factor is considered when a person makes any decision in a situation or as a set of certain personality traits.

According to Ukrainian Railways statistics, the human factor has a leading role in the safety issue, and the causes of many railway accidents (RA) are:

– miscalculations in the organization of movement;

– car control errors;

– insufficient level of professional training of employees;

– disturbance of the processes of interaction between the participants of the movement;

– insufficient control over the implementation of existing rules and regulations, as well as the prevention and elimination of various technical failures by officials, etc.

Person on the rail remains a weak link in this system. Its capabilities are limited by the physiology of the body and psychological features.

In the conditions of objective complexity of transport situations (high speed of their changes in time, shortage of time for decision-making, failure of safety systems) the level of reliability of employees is determined (Fig. 1):

– physiological capabilities of the human body, depending on its nature;

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zheleznodorozhnogo transporta[Modern approaches to improving the safety of railway traffic]. Visnik DNUZT. D., 2007. Vip. 17. S. 188–190 [in Russian].

[1] *Sokol Je. N.* Shody s. rel'sov i stolknovenija podvizhnogo sostava (Sudebnaja jekspertiza. Jelementy teorii i praktiki) [Descent from rails and collisions of rolling stock (Forensic examination. Elements of theory and practice)]. Kiev, Transport України, 2004. 368 s. [in Russian].

– psychological capabilities of the individual;
– physiological and psychological state of the employee;
– professional training;
– consistency of actions of the members of the teams, their psychological compatibility.

Fig. 1. Model of human motivational behavior

The problem of influence of employees on the work process on the railway is becoming more urgent, because recently the number of control systems in which the leading function is performed by the person has increased significantly, and therefore the price of his mistakes has increased immensely. Since the reliability of the system of management of technical means is largely determined by the correctness of the employee's actions, the more complex the system, the more pronounced this dependence. In the face of increasing complexity and stress of work, the correctness of human actions can diminish and over time, even very significantly.

This leads to the fact that increasing the reliability of the technical part of the control system most often makes no sense, since the reliability of the whole system is limited by the characteristics of this property in humans, which in turn creates objective conditions to increase the risk of accidents. The reasons for the occurrence of railway accidents are most often the psychological characteristics of a person. Sometimes in dangerous transport situations (NTS) a person is unable to act properly. In life-threatening conditions, not everyone is able to adequately respond to an evolving situation, to work in it steadily, productively, without taking erroneous actions.

Among the psychological causes of conscious violations of safe work rules are the following: saving energy, saving time, habit of danger or its underestimation, orientation to ideals, tendency to copy norms of group behavior, habit of working with violations, reassessment of one's own experience and skill, desire to assert oneself stressful states, risk aversion, unmotivated risk. Human behavior, its actions in any situation, even in the most dangerous, indirectly through a complex psychological process of motivation, determine its needs according to the model of

motivational behavior, which is based on the principles of Maslow and Herzberg theories.

Curently there are several theories of meeting human needs: the most common of these is Maslow's hierarchy of needs which determining the priority of meeting the five major human needs: physiological (material)→ needs for security→, social needs→ for recognizing the need for →self-realization (Fig. 2). To justify the proper motivation of workers to work effectively and safely, they often use the provisions of Hertzberg's theory, according to which all the needs of an employee are grouped into two groups: motivational factors and factors of working conditions.

The Herzberg model adapts Maslow model to the study of the motivation of workers in the manufacturing sphere, since the factors of working conditions in the theory of Hertzberg cover the physiological (material) needs and security needs of the Maslow theory, and the motivating factors in the theory of Hertzberg; all other Maslow theory.

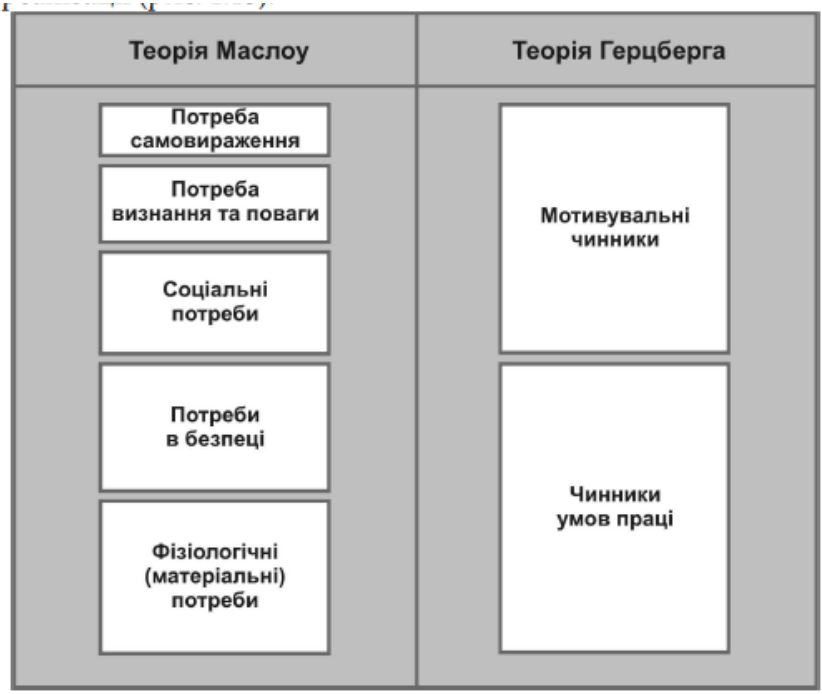

Fig. 2. The relationship between human needs in Maslow and Herzberg models

Working conditions alone cannot motivate a person to take any action, but if they are improper, the employee has a feeling of dissatisfaction that causes a disincentive effect and degrades the role of

motivating factors. Mismatch of mental and psychophysiological characteristics to working conditions, lack of proper level of safety at work and poor psychological relations in the team, stress, fatigue, illness, lack of education and lack of professional skills, financial and financial problems, decrease of professional ability in extreme conditions after extreme conditions psychophysiological factors that most often lead to rail accidents. For example, the work of the next station at the station on physical grounds does not seem difficult and intense.

Although in the absence of visualization of the course of events at the object of observation leads to emotional tension, which in turn reduces the time of decision. However, it is understood that constant nervous tension causes a violation of the normal physiological and mental state of the employee, and this can turn into a risk of emergencies. All the work of the station depends on the actions of the station, so the risk in the production environment arises in any stressful situation.

Every technological operation needs an immediate reaction, and the slightest mistake or inattention causes inevitable consequences. From this it follows that each action of the next one affects the safety of train traffic. However, as practice shows, good psychophysiological qualities are not enough, as the cause of a railway accident may be the physiological capabilities of members of the locomotive crew.

It may not be the receiving of the necessary information by the sensory organs (through hearing, sight, touch) due to the weak warning, forbidding signal or its absence. For example, the sharp changes in the light and brightness of objects encountered near the railway tracks take time to adapt the visual analyzers of the members of the locomotive crews to these conditions. During this time, the ability to distinguish objects deteriorates and the number of errors when managing the rolling stock increases sharply. It should be noted that both light and night adaptations are dangerous. At night, the perception of the colors of objects is almost completely disturbed, they differ not in color but in brightness. It also degrades the ability to estimate the distance to and between objects, the speed of their movement.

Accordingly, the distance at which the members of the locomotive crew can detect the vehicle, the person is halved compared to the distance of their detection in the daylight hours. As a result, they create the illusion that the obstacle to movement is at a great distance, which poses a real risk of an accident. The subjective reasons, which include a low level of training and knowledge, play an important role in the occurrence of rail accidents. Lack of knowledge makes it impossible to track and evaluate a dangerous traffic situation, as well as identify the possible consequences of a mistake, quickly respond to the situation and find the right solutions.

Ineffective and unskilled actions of a person in a dangerous traffic situation contribute to the implementation of the mechanism of a railway

accident – a set of ordered fragmented elements of a railway accident (actions, events, states) with links of interaction between them.

At the same time, effective and skilled human actions in rail accidents prevent them from occurring. It should be noted that *human reliability* in a railway accident can be active and passive. Such traffic events as vehicle collisions, rolling stock strikes on fixed obstacles and people are characterized by the fact that *human reliability* is active and the moments of transformation of some situations into others are within the limits of perception by officials and the measures for preventing (CTS). In this case, the formation of a mechanism of a railway accident occurs in short time frames (hours, minutes, seconds). The other group of rail accidents include those in which the formation of a traffic safety threat (TST), the development of NTS and KTS and the moments of transformation of ZBR into NTS, NTS in KTS (the first and second critical points, respectively) are beyond the perception of these processes by officials. For example, in adventures with ladders, the role of *human reliability* is passive.

Rolling stock rails occur regardless of the actions of the participants of the CTA or these actions contribute immediately; in this case, the operation of the ZTP mechanism occurs in extended time frames, that is, its formation takes days, weeks, months. The role of the *human reliability* is significant both in the triggering and in the failure of the train accident mechanism. The dominant role of *human reliability* is not to prevent a catastrophic transport situation, but to a dangerous transport situation, that is, to eliminate the threat of safe movement. The task of the expert is to establish the time at which one transport situation is transformed into another, as well as to establish a transport situation (NTS or CTS) in which the *human reliability* is involved. If it is found that *human reliability* was involved in the CTS, then consideration should be given to mitigating the effects of *human reliability*.

If *human reliability* was involved in the NTS conditions, then the problem should be solved about the reasons that did not lead to the prevention of the traffic accident, that is, to establish the degree of influence of *human reliability* on the implementation (implementation) of refusal to actuate the mechanism of the railway accident at the time of occurrence dangerous transport situation. Thus, the form of a PTS mechanism with stable cause and effect links allows to establish the immediate technical cause of the mechanism of the PTS mechanism, and the content, ie the dynamic transformation of one transport situation into another, allows to solve the problem of the possibility of preventing a railway accident.

Conclusions. The problem of *human reliability* influence is urgent and requires strict control, since it is involved in almost all processes of operation of the rail system. The level of labor and technological discipline, timely control and correct assessment of danger, thoughtfulness and correctness of actions in the field of the professional activity on prevention and prevention of railway accidents depend on the person. The task of the expert in the study of railroad accidents having influence of *human reliability* is to study the extent of its impact on the circumstances and the development of the railway accident at the time of transformation of one transport situation in another.

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«ЛЮДСЬКИЙ ФАКТОР» ЯК ОСНОВНА ПРИЧИНА ЗАЛІЗНИЧНО-ТРАНСПОРТНИХ ПРИГОД

Проблема дослідження впливу «людського фактора» на виникнення залізнично-транспортних пригоди є різносторонньою, складною структурно та на сьогодні далекою від вирішення.

Різноманіття залізнично-транспортних пригод, які досліджуються у Львівському НДІСЕ, вказує на неможливість застосування типових механізмів для випадків, де присутній «людський фактор».

Завданням експерта при дослідженні таких залізнично-транспортних пригод полягає у встановленні ступеня впливу зазначеного фактора на здійснення (реалізацію) відмови в спрацюванні механізму залізнично-транспортної пригоди.

Ключові слова: залізнично-транспортна пригода, людський фактор, рухомий склад, транспортна ситуація.

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