Management mechanisms for development of personnel professional competencies at a loading and haulage company

S V Shishkina¹, Yu D Pristupa¹, L D Pavlova² and V N Fryanov²

¹"United Production and Transport Department of Kuzbass” LLC, 13 Kirova ave., Leninsk-Kuznetsk, 652518, Russia
²Siberian State Industrial University, 42 Kirova street, Novokuznetsk, 654007, Russia

E-mail: ld_pavlova@mail.ru

Abstract. The necessity for development a management mechanism for development of personnel professional competencies at a loading and haulage company in order to ensuring the compliance of competencies with labor functions, regulated by the current professional standards, is substantiated. A functional diagram of the organizational and technical system of the loading and haulage company was developed, that includes the interaction mechanism between the personnel and the objects of the main production. The problem of algorithm development to assess the correspondence of communicative competencies and labor functions of loading and haulage companies, ensuring the achievement of the management goal with a minimum risk of an emergency situation or an accident, was set and solved. The idea of management problem solving consists in the operational development and implementation of anticipatory measures at each deviation in personnel actions from normative or target indicators. The dependence of the risk of imbalance of communicative competences and labor functions in a given period of time is established. The effectiveness of the developed and implemented mechanism is confirmed by the positive dynamics of the test results.

1. Introduction
The necessity for development of a management mechanism for development of the personnel professional competencies at a loading and haulage company (LHC) follows from the need to ensure that the competencies of employees are in accordance with the labor functions regulated by the existing professional standards [1, 2, etc.].

Based on the results of the analysis of the target function, structure and activities of the LHC, the company can be identified as a complex organizational and technical system (OTS), the main functions of which are to provide loading and unloading and transport-expediting services for mines, open-pit mines, processing plants, current repair of railway tracks and adjustment of own diesel locomotives.

In accordance with the specifics of the company in the OTS structure three interacting subsystems can be distinguished: the main production, industrial and social infrastructures. The main production of the company includes the production processes of the company, during which materials or raw materials are transformed into products. In the context of LHC these processes are the storage, processing, loading and transportation of coal in wagons for sale to consumers.

The production infrastructure includes a complex of workshops, facilities and services that provide the necessary conditions for the main activity of the company: the rolling stock service, the track service, the material and technical supply department, the communication section, the production...
control and labor safety service, the production and technical department, department of the automated process control system (APCS).

The social infrastructure unites the divisions of the company, which provide for the sanitary and hygienic working conditions and social needs of workers, the level of their professional training, material support, social guarantees, personnel policy.

The detailed information on the conditions and features of the LHC functioning on the example of “United Production and Transport Department of Kuzbass” LLC is described in the works of the authors [3-6].

The efficiency and safety of functioning of all subsystems is ensured by the level of professional competence of personnel. The personnel policy of the LHC consists in the selection of personnel, assessment of its professional competencies, placement and training, preventive work, continuous monitoring of personnel actions in order to improve and develop occupational safety and production systems.

However, based on the results of the analysis of the dynamics and causes of defects and hazardous production situations, “United Production and Transport Department of Kuzbass” LLC for the period 2000-2014 detected 168 incidents, including:

- hitting people on the railways (24%);
- bursting open the switch (21%);
- derailing of rolling stock (21%);
- collisions of rolling stock (14%);
- other (20%).

It is established that one of the main causes of these incidents are violations of technological regimes, labor and production discipline by workers, that is, an insufficient level of professional competence is confirmed [7].

In this regard, the actual task is to create a mechanism for managing the development of personnel professional competencies at a loading and haulage company.

2. Setting and solving the problem of managing the development of personnel professional competencies

To set and describe the problem of managing the development of personnel professional competencies while minimizing the risks of emergency situations and incidents, the conditions for interaction of employees with the elements of production infrastructure in accordance with the target functions of “United Production and Transport Department of Kuzbass” LLC are considered.

According to professional standards and technological maps, labor functions and actions are systematized for the main activities of the company.

During performance of works, processes and operations, due to the interaction of workers and elements of the production infrastructure, there is an accumulation of inconsistencies in the actions of personnel with the requirements for the operation of infrastructure elements because of the influence of the following factors and events:

- wear out of equipment;
- deviation of the level of engineering solutions from industrial safety requirements and technical instructions for the operation of machinery and equipment;
- unsatisfactory operational control of compliance of actual technological parameters with regulatory ones;
- noncompliance of actions of workers to regulatory technological regimes (violation of technological discipline);
- imperfection of the system of preventive measures to prevent the development of production violations and hazards;
- skills mismatch of an employee when using production resources.
Accumulation of noncompliance of personnel actions with the requirements of infrastructure elements operation for a given time (shift, day, month, year) contributes to the increase in the risk of incidents, pre-emergency situations, occupational diseases, trauma of workers, which is accompanied by negative economic and social consequences for the company in whole. To solve this problem it is possible to use the model of conformity of communicative competences and labor functions of loading and haulage companies.

Three interacting subsystems of the OTS and a set of proactive preventive measures are given (figure 1). Personnel and infrastructure elements in the process of performing labor functions interact when performing control actions taking into account the state and changes in the external environment. At the same time, as part of the liquidation plan for accidents and technological maps for the implementation of certain processes and operations, implementation of pre-existing measures previously developed and approved in accordance with the established procedure is carried out.

![Figure 1](image)

**Figure 1.** Scheme for processes management of subsystems interaction in the structure of OTS of a loading and haulage company.

It is required to establish the dependence of the risk of imbalance of communicative competencies and labor functions during interaction for a given time period \(\Delta T = T_n - T_i\) of personnel \(S\), infrastructure elements \(W\) and preventive measures \(F\), that is,

\[
S + W - F \leq R_n,
\]

where \(T_i\) – the start time of the process or operation; \(T_n\) – the end time of the process or operation; \(R_n\) – acceptable risk, is established in accordance with the objective management function of OTS and “Methodological Recommendations ...” [8].

**Initial conditions and limitations.** The state of the control object in the initial period \(T_i\) is assumed to be stable. This is fixed by the results of production control during the period \(T< T_i\) and the current monitoring (figure 1). During the period \(\Delta T = T_n - T_i\) the professional level and competences of the personnel can be changed by means of raising the level of skills, instructing, changing the working conditions of the personnel. The state of infrastructure facilities also does not remain constant due to
wear out of equipment, technical re-equipment of infrastructure elements. Control actions in the form of preventive measures can be developed and implemented step-by-step or discretely according to the recommendations of controlling agents-centers.

**Solution to the problem.** The idea of the problem solving consists in the continuous improvement of the social safety management system through the operational development and implementation of preventive measures at each deviation of personnel actions and actual operating modes of infrastructure elements from normative or target indicators.

The solution of the problem in general form is as follows:

$$
\sum_{j} \sum_{i} ^{T_n} \left( p_1 (s_1 - f_{s_1}) + p_2 (s_2 - f_{s_2}) + p_3 (s_3 - f_{s_3}) + \cdots + p_m (s_m - f_{s_m}) \right) \\
+ \sum_{j} ^{T_n} \left( q_1 (w_1 - f_{w_1}) + q_2 (w_2 - f_{w_2}) + q_3 (w_3 - f_{w_3}) + \cdots + q_{\nu} (w_{\nu} - f_{w_{\nu}}) \right) \leq R_n ,
$$

where $p_m$ – the risk of an emergency when the personnel actions deviate from the requirements of labor functions when the $m$-th operation of the $j$-th service is performed; $s_m$ – the deviation of the personnel competence from the requirements of labor functions when performing the $m$-th operation of the $j$-th service; $f_{s_m}$ – measures to prevent the deviations of personnel actions from the requirements of labor functions when the performing the $m$-th operation of the $j$-th service; $q_{\nu}$ – the influence of the $\nu$-th deviation of actual operating modes of the infrastructure elements from the normative ones on the risk of an emergency situation or an incident of the $j$-th service; $w_\nu$ – the $\nu$-th deviation of the actual operating modes of the infrastructure elements from the normative ones of the $j$-th service; $f_{w_\nu}$ – measures to prevent the $\nu$-th deviation of the actual operating modes of the infrastructure elements from the normative ones of the $j$-th service.

A qualitative schedule for changing the accumulated deviations of inconsistencies in the actions of personnel to the requirements of labor functions in the $j$-th service is shown in figure 2.

![Figure 2. Diagram of accumulation of deviations in the personnel actions from the labor functions regulated by professional standards.](image-url)
The upper graphs in figure 3 show the changes in the total deviation of non-compliance of personnel actions $S$ with the requirements of labor functions and the deviations of the non-compliance of the actual results of the labor functions performance $W$ from those regulated by professional standards and technological maps. At simultaneous performance of multiple labor functions with deviations from the processes and operations indicated in the technological maps within the period $\Delta T = T_n - T_i$ there is an accumulation of risks causing imbalance of the compliance of communicative competences models with labor functions, which leads to violation of the LHC design operation mode.

The total impacts on personnel and infrastructure elements through the development and implementation of preventive measures $F$ are presented by the lower graph in figure 2. After superposition of the specified graphs of emergency risk, the wavy dotted line $F$ is obtained in figure 2, the position of which should not be above the line of acceptable risk $R_n$.

The upper boundary of the zone of acceptable risk is proposed to be considered as the boundary of the balance area of communicative competencies and regulated by professional standards of labor functions.

The results of the implementation of the developed mechanism for managing the development of personnel professional competences of the loading and haulage company are presented in figure 3.

![Graph](image)

**Figure 3.** Dynamics of the professional competences of the personnel at “United Production and Transport Department of Kuzbass” LLC.

The graphs in figure 3 were obtained from the test results according to a 100-point assessment of employees. For the survey the international system of independent assessment of individual was used to select and develop the personnel of Hoqan Safety Assessment. As it can be seen from the graphs, during the last three years for almost all professions there is a rise in the level of competencies by 1.3-1.5 times, which confirms the effectiveness of the developed management mechanism for development of personnel professional competences.

**3. Conclusion**

As a result of solving the problem of managing the development of personnel professional competences, a mechanism was developed that minimizes the risks of emergency situations and accidents in the context of interaction between the workers of a loading and haulage department and production infrastructure elements. When implementing preventive measures that ensure that the risk is reduced to an acceptable one, it is proposed to take into account the influences of deviations in the
actual operating modes of the infrastructure elements from the normative ones regulated by labor functions.

References

[1] Professional standard: 27.092 Specialist in Operation of Railway Transport in the Mining and Metallurgical Industry approved on 01.02.2017, No. 121n

[2] Professional standard: 593 Locksmith on Inspection and Repair of Rolling Stock of Railway Transport approved on 02.12.2015, No. 954n

[3] Pristupa Yu D, Pavlova L D and V N Fryanov 2014 Modeling the Process of Managing the Transport Flows of a Coal Holding under Uncertainty (Moscow: Nauchnoye Obozrenie) p 216

[4] Pristupa Yu D, Shishkina S V et al 2015 Proc. of the Intern. Sci. and Practical Conf in Knowledge based Tech. for the Development and Use of Resources (Novokuznetsk: SibSIU) pp 195–200

[5] Shishkina S V et al 2015 Proc. Xth All-Russian Conf. on Automation Systems in Education, Science and Production (Novokuznetsk: SibSIU) 2015 166–173

[6] Shishkina S V, Pristupa Yu D, Pavlova L D and Fryanov V N 2016 Proc. IVth All-Russian Conf. on Modeling and Knowledge-based IT in Tech. and Socio-economic Systems (Novokuznetsk: SibSIU) pp 8–14

[7] Pristupa Yu D et al 2014 Coal 12 50–52

[8] RD 03-357-00 Methodological Recommendations on Drawing up a Declaration of Industrial Safety of a Hazardous Production Facility approved by the resolution of the Gosgortekhnadzor of Russia on 26.04.2000 N 23