Analysis of optimization of labor protection measures aimed at improving workplace conditions

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Abstract. The article describes occupational safety measures that should be planned on the basis of management theory, which uses a systematic approach to develop goals, criteria, methods and controls. The methodology of the systematic approach allows revealing the internal connections of the process under study, determining the main functions of management. By striving to comply with such requirements, organizations improve the conditions in which their production is performed. In the effort to incorporate essential principles into their systems, employers can benefit from applying the ISO 45001 standard, which defines the systemic requirements that must be embraced in their business in the same manner as the requirements adopted in any other field of activity, such as production quality. The article refers to standards derived from ISO 45001 that facilitate manufacturing improvements. It outlines the impact of systemic enhancements on workers’ ability to perform work safely.

1 Introduction

For optimal planning of measures for labor protection in order to effectively use the available resources, it is necessary to create a management system that provides, on the basis of mathematical methods, the analysis of information, the adoption and implementation of management decisions.

Occupational safety management systems at the level of an enterprise, association, industry will allow to increase the efficiency of combating industrial injuries, general and occupational diseases, and will ensure the achievement of the most favorable working conditions.

In general, the control system consists of a control object, a control body, information processing tools and means for implementing control decisions.

The purpose of the functioning of the control system is to change the output parameters of the object in accordance with the specified criteria or the control program. In this case,

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input and output parameters are recorded, which are used to identify the object, that is, to build a sufficiently adequate mathematical model that allows predicting the values of output variables and developing the necessary control actions.

Organizations are responsible for identifying and either eliminating or mitigating threat impacts. To that end, they should select areas for monitoring so as to ensure that, among others, their effect on manufacturing is continuous and effective [1]. To make certain that the selected measures are indeed effective, it is essential to embrace occupational safety standards. One such standard is ISO 45001, which defines principles for systemic occupational health and safety management. The article outlines some of the key effects and applications of the above standard for shaping the manufacturing environment [1].

2 Materials and methods

The control object is considered as a converter of the vector of input random functions of time $x(t)$ the vector of output random functions $y(t)$:

$$y(t) = Ax(t),$$

$$R_x = Mg$$

$$C_x = f_{xy} = Mg$$

$$C_x = f_x(Re)$$

from here

$$R_y - Mg = M$$

$$C_y F = f(Mg - C_y F_{xy})$$

where $A_t$ is the object description operator.

Each output variable $y_i(t)$ $(i=1, m)$ is determined by a set of input variables $x_1(t)$, ..., $x_n(t)$, but it is practically impossible to take them into account completely. Therefore, it is necessary to limit oneself to a part of the defining variables, and to attribute the rest to uncontrolled noise [3].

Let us define some elements of the system for managing labor protection measures aimed at reducing morbidity.

The object of control in this system is the state of health of the studied contingent of workers.

This contingent is characterized by a certain length of service, age gender and professional structure, and is united according to the principle of qualitative homogeneity of the working conditions factors affecting it [4].

The purpose of the functioning of the system is to achieve harmless and safe working conditions that allow for given climatic and socio-economic conditions, taking into account the characteristics of the contingent of workers, to ensure the lowest possible levels of morbidity [5].

The input variables are the parameters of the environment and the working environment and the occupational and demographic characteristics of the workers. Output variables are indicators of morbidity characterizing the state of health of workers [6].
The criterion of efficiency in the system under consideration should be the provision of a background level of morbidity, which is not associated with the influence of production, but is determined by climatic, social, and other factors uncontrollable in this system.

Control actions are labor protection measures aimed at achieving the lowest possible levels of morbidity among workers. These measures can improve working conditions, compensate for damage caused by adverse effects, help protect workers, and regulate their work and rest regime.

The governing bodies in this system are labor protection services (safety and industrial sanitation), working together with the administration of the enterprise. They analyze the emerging information about working conditions and the health status of employees, consider possible options for management decisions, draw up action plans and monitor their implementation [7].

Information on the state of the control object contains data on compliance with the rules and norms of labor protection, on the implementation of planned activities, current values of working conditions factors, indicators of the health status of workers and economic data [11].

Information processing tools are organized, technical and software that allow you to generate and accumulate indicators, perform their comprehensive analysis and develop optimal recommendations for government bodies.

The means of implementing control actions are research, design and technical solutions, measures of moral and material incentives, means of individual and collective protection, medicines and equipment, etc., necessary for indicators of the health status of workers [8].

3 Results and discussion

To implement the main functions of labor protection management, an automated data processing system should be created, where the following tasks should be solved:

- registration, control and accumulation of information;
- calculation of statistical indicators and printing of information tables;
- identification of the management object in order to determine the relationship between the parameters of working conditions and morbidity indicators;
- determination of the minimum possible levels of morbidity and their corresponding optimal, but lying within the realistically achievable limits of the values of production factors;
- compilation of various options for preventive actions and selection of the optimal option;
- assessment of predicted morbidity levels;
- determination of the socio-economic effect of the system of optimal planning of preventive measures.

With the help of a functional calculation and a scheme, we will consider the sequence of stages of optimizing morbidity. Such optimization involves the use of an automated data processing system [9].

The control object is characterized by input variables-parameters of working conditions, and output variables- indicators of morbidity of workers. This information is accumulated in the corresponding data archives. Such archives are formed and used during the operation of the automated system in the information management mode.

In the first case, the archives of data on working conditions and morbidity data are replenished and adjusted with a given frequency. If it is necessary to compile reports or obtain operational summaries for a given sample, the values of production factors are estimated and morbidity rates are calculated. At the same time, it becomes possible not only to promptly obtain the necessary information, but also to compare working conditions and morbidity of
individual groups of workers with the help of common signs, identify the most disadvantaged areas of production and thereby facilitate the planning of targeted preventive measures [10].

When the system is operating in control mode, it is supplemented with identification blocks (5), optimization (6-8) and forecasting (9-11). The parameters of working conditions and morbidity indicators after their statistical processing and grouping, which allows for comparative analysis, serve as the initial basis for the identification model. Here, using the methods of factor and regression analysis, quantitative dependencies are determined [11]:

- where is the intensive indicator of the form of the disease?
- vector of parameters of working conditions;
- the number of forms of diseases registered in the studied contingent of workers [12].

Each of the morbidity indicators (5) characterizes the particular properties of the control object, therefore, for a complete description of the object, models should be built according to the indicators.

Morbidity indicators (4) were functions of the parameters of working conditions (2) with an appropriate optimum of independent variables, they can take minimum values. These values (6) can be defined as the minimum possible levels of morbidity, provided that at these points they are continuous, differentiable and have global positive minima, and the corresponding optimal values of arguments (4) are in a realistically achievable area determined by technical and economic constraints.

In cases where the minima of the function do not satisfy the specified conditions or the values of the corresponding arguments lie outside the really achievable area, the minimum possible incidence levels are determined by the boundary values of the real area in the direction of the optimum.

Thus, to determine the minimum level of morbidity in the form, it is necessary to solve the following problem.

Where is the lower edge (the exact smallest value) of the morbidity indicator function – the vector of working conditions parameters;

\[ X \text{ is the set of really achievable values on which the minimization problem is solved. The vector minimizes the function } [17]: \]

Each of the obtained in solving the problem of minimizing the partial optimal vectors of the parameters of working conditions minimizes the indicators of the form of the disease. To minimize the total morbidity rate equal to the sum of intensive indicators for individual nosological forms, it is necessary to determine the overall optimal vector of parameters of working conditions, all components of which belong to private vectors:

Thus, the general optimal vector of working conditions for the studied contingent of workers can be as a combination of partial optimal vectors minimizing individual forms of diseases [7].

The parameters that make up the overall optimal vector should be used when planning preventive measures. For the automated compilation of individual variants of the plan, classifiers developed for specific production facilities (workshops, sites, professions, etc.) are indispensable. In these classifiers, not only the harmful factors of working conditions that they counteract, but also the proportion of specific weakening of these factors, as well as the cost of measures, must be matched to each preventive measure. To achieve the calculated optimal values of the parameters of working conditions, with the help of classifiers, variants of prevention plans are compiled, differing in the composition of measures, the total cost and the resulting health effect [6]:

In order to determine the most rational variant of the action plan, the optimization problem is solved with a given efficiency criterion, taking into account technical and economic constraints. In the present task, these conditions are the criterion of the minimum possible level of the total morbidity index with limited costs for prevention [15]:

Where is the amount of expenses for events;
- total number of events;
- resources.

Assuming that after carrying out a set of optimal measures, the minimum possible levels of morbidity will be reached after some time, we take this time for the forecasting period. Having estimated by expert means the values that the parameters of working conditions will have over time (without carrying out optimal measures), using the identification model (1) we will determine the real forecast of morbidity indicators [14]:

Where is the prognostic value of the morbidity index according to the nosological form after a time without carrying out measures; \( \text{prognostic values of factors of working conditions through without carrying out activities.} \)

The calculation of prognostic values of morbidity indicators makes it possible to determine the socio-economic effect that can be achieved as a result of optimizing preventive measures. Assuming that as a result of optimal measures, the incidence rates will decrease to the lowest possible values, we will determine the magnitude of this decrease by individual nosological forms [7]:

Summing up this decrease in all the forms of diseases identified for the object under study, we get a general decrease in morbidity as a result of optimizing preventive measures:

The social effect of health-improving measures should be determined by the number of workers removed from the influence of harmful and harsh working conditions, which directly affects the reduction of morbidity rates. Thus, the calculated decrease in indicators for the number of sick people, the number of cases of diseases can be considered the equivalent of one of the types of social effect, taught by ritmazation. The reduction in the number of working days lost as a result of diseases will be considered an indicator of the socio-economic effect, since, indicating a reduction in the severity of diseases, it means a reduction in the loss of working time, and hence a decrease in under-production. Knowing the cost of one working day, according to this indicator, it is possible to calculate the economic efficiency of optimal planning of measures aimed at reducing the morbidity of workers [9].

The first stage of the automated system of accounting and analysis of information on working conditions and morbidity of workers has been introduced into industrial operation in the main workshops of the production association. This system implements the following stages of the above-described approach to optimizing labor protection measures: statistical processing of data on working conditions of workers and on morbidity with temporary disability; printing of information tabulograms; modeling of quantitative dependencies between factors of working conditions and morbidity indicators. The approbation of the subsequent stages of the described approach to the optimization of labor protection measures is expected in the implementation of [11].

4 Conclusions

Optimal planning of preventive measures aimed at reducing the morbidity of workers should be based on the functioning of an automated control system.

The management system of occupational safety measures aimed at reducing morbidity should contain blocks of statistical processing of information, modeling of quantitative levels of morbidity associated with production, classification and optimization of preventive measures.

Optimization of measures aimed at reducing the morbidity of workers should be based on the criteria of maximum health effect and carried out taking into account technical and economic constraints.

The first stage of the automated control system, including the stages of statistical processing and modeling.
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