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Setting a problem on the rational allocation of a resource, intended to ensure integrated enterprise security

This article introduces the resources of an enterprise as a rich internal potential, which is aimed at the sustainable functioning of the production process. For the first time, in the form of a problem, a new consolidated methodologically described direction is presented, the solution of problems in which is focused on the resource provision of subsystems included in the complex security of an enterprise. Approaches using existing methods in the integrated security of enterprises are analyzed, peculiarities of their application are considered. Justification for choice of the Lagrange multiplier method is presented, with the use of which statement of a problem for the rational distribution of the resource intended to ensure the sustainable functioning and development of departmental (industry) subsystems included in the integrated security of the enterprise is formed. The article presents a statement of the problem of the rational allocation of resources (material, economic, time, labor, information, the rational use of which allows the integrated security system to move to a higher level of development. The solution of particular problems that are part of the content of the methodologically described problem will make it possible to develop a methodology for the synthesizing of integrated security that can adapt to various conditions of enterprise functioning (routines of daily activities, as well as threats and emergencies of a natural and man-made nature), which has important economic value for Russia.

Keywords: *problem statement, rational distribution, particular tasks, integrated security system, interdisciplinary approach*

INTRODUCTION

A rather long period, covering the beginning of the 19th century and up to the present, is marked by a constant increase in interest in technosphere safety, the solution of tasks in which requires constant improvement and development. Recently, the focus of fundamental, systemic and applied research in the field of analysis and management of technospheric safety, taking into account the accumulated experience of setting and solving this problem, has acquired a new importance in connection with the transition from 2018 to a fundamentally new level of solving issues of scientific analysis, regulation, regulation and ensuring of technosphere safety and protection against emergencies in accordance with the Decrees of the President of the Russian Federation on the basis of state policy in these areas for the period up to 2030 and beyond [1, 2].

The analysis of the statistics of accidents, fires, damage to health or the death of personnel working at the enterprise allows us to conclude that the solution of tasks related to improving the safety of the functioning of industrial safety (IndS), fire safety (FS), labour protection (LP) at enterprises is of exceptional importance for the state and society, their solution is one of the priority areas for ensuring the national security of Russia [3]. The introduction of a new approach to safety management at an enterprise requires the development of an appropriate scientific and methodological apparatus (methods, techniques) that allows you to manage this state [4]. It is obvious that stabilization of the situation in departmental (sectoral) subsystems (IndS, FS, LP) at industrial enterprises of

Russia will be able to occur when, in general, for the integrated security (hereinafter — IS) of these enterprises, a course is chosen according to its purposeful and comprehensive development [5]. The development of the security of any enterprise is a change in the old approach to its management formed over the years and the introduction of such a new approach that would be based on the results of introducing innovations, advanced knowledge in science, application of new technologies [6]. The key idea in solving the problem of ensuring the qualitative level of safety at the enterprises of the Russian petroleum industry is directly related to the development of an integrated intersectoral approach based not only on scientific and technical achievements and methodological approaches in the field of reliability, safety, survivability functioning of physical objects [4, 7, 8], but also in building adequate tools for organizational and technical work for the transition of IS system of industrial enterprises to a new qualitative level of development [9]. Previous studies indicate the fact that the problems of providing IS system for oil and gas sector (OGS) in Russia are complex and multifaceted, their solution requires consideration of the interaction between industry subsystems (IndS, FS, LP), which have the properties of adaptation to counteract accidents and fires [3, 5, 10]. The circumstances presented above are characterized by a high degree of relevance, have a direct relation to the management of IS at industrial enterprises, require a detailed in-depth study of the mechanism of functioning of industry subsystems (IndS, FS, LP), included in the content of IS of enterprises OGS in Russia.

METHODS

In this study, the method of analyzing and criterion of Hegel were used. Any developing management system strives to achieve a compromise, based on rationality, between stability and development in the course of its operation. Everything that develops is contradictory, and “contradiction is the criterion of truth, the absence of contradiction is the criterion of delusion” (Hegel).

The increase in the number and technical complexity of hazardous production facilities at the enterprises of the OGS requires the use of various types of resource means (material, economic, time, labor, information, etc.) designed to ensure the stable functioning of the IS [11, 12]. In turn, stability and development (based on rationality), used in the field of IS, are two extreme points of interrelation, as they reflect the dialectical unity of opposites, namely:

- stability denies development, at the same time it acts as a foundation, without which it is impossible;
- development destroys stability, as it requires the introduction of a new scientific and methodological apparatus used in the form of procedural knowledge for subsystems (IndS, FS, LP), which makes it possible to ensure the adaptation of subsystems to counteract accidents and fires for their more stable functioning [13–15].

More and more attention paid to the issues of rational use of various types of resource funds intended to ensure the stable functioning of the IS of oil and gas companies of Russia, knowledge of the characteristics relevant to the rational use of resources can support the search for the right tools to bring Russian industrial enterprises to a new qualitative state.

The article will not present the whole complex of tasks solved at the enterprise related to the distribution of the resource in monetary or material terms, but only part of it related to the potential of the working personnel performing labor duties to ensure departmental (sectoral) subsystems included in IS of the enterprise, where with the help of the indicated potential it will be possible to:

- analyze the statistics of hazard occurrence in industry areas (Rostekhnadzor, the Ministry of Emergency Situations of Russia, the Ministry of Labor, etc.), to build a structural diagram of the factor relations between sources of occurrence and receivers of hazards, to determine the parameters of the susceptibility of these areas to the impact of hazards, their initiation of secondary influencing factors;
- to assess the reserve of reliable functioning of departmental areas included in the IS of the enterprise, which will allow the formation of a resource for sending to those points in the first place, which have the highest risk indicators.

The structural content of the system study on the distribution of the resource intended for the IS of the enterprise is presented (see Fig. 1).

The consistent description of the block elements included in the content of the blocks (Fig. 1) will allow the development of methodology as a science that studies the pattern of emergence and development of methods for cognition of IS. Methodology as a particular system of knowledge that arises at the methodological stages of cognition is the study of methods and theories that arise at the corresponding stages of cognition [16]. Some of the most important points of application to the methodology of the IS of an enterprise as a science include the formulation of a scientific problem will be presented in this research.

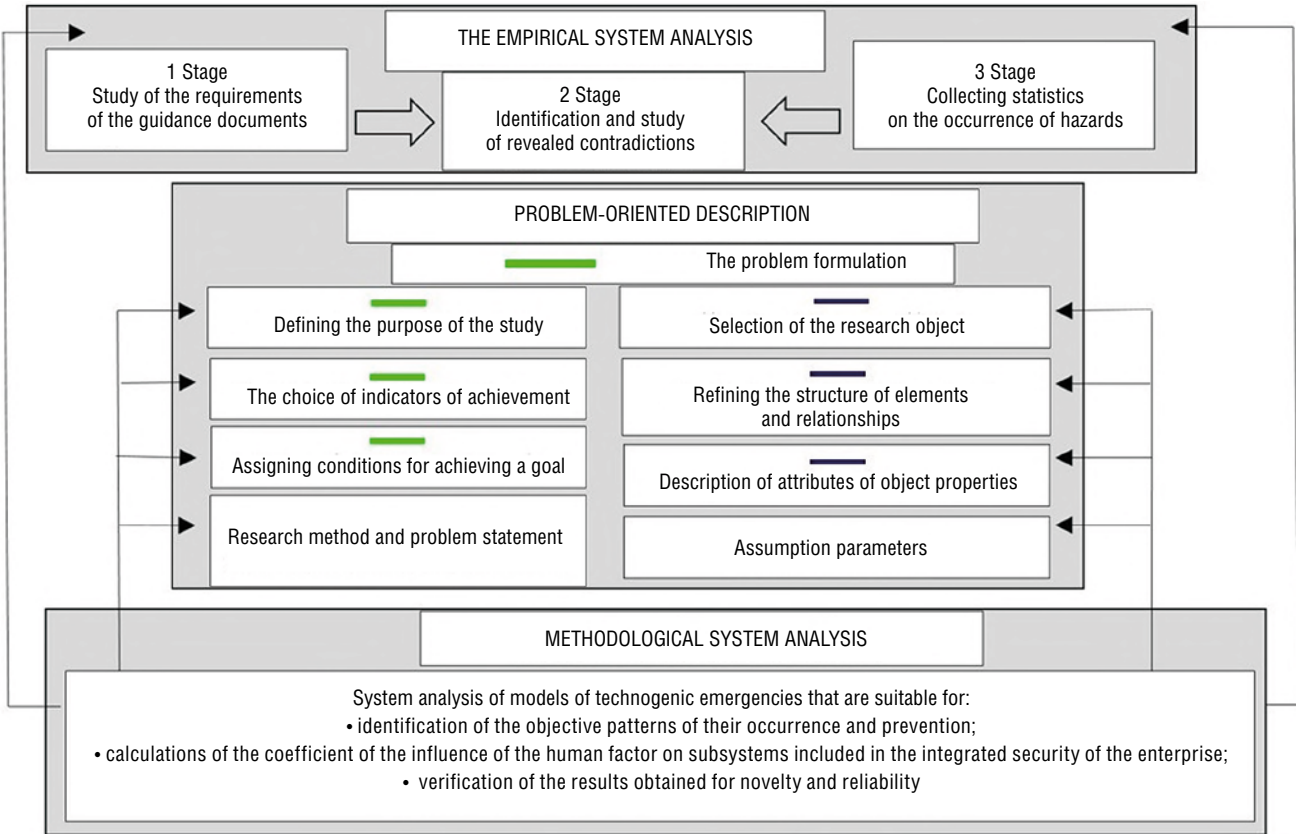


Fig. 1. The structural content of the system study on the distribution of the resource intended for the IS of the enterprise

RESULTS

Statement of the problem of the rational distribution of resources to ensure the IS system at the enterprises of the OGS of Russia in the conditions of development demonstrated below. Task is to reduce accidents and fires at Russian oil and gas companies, a common limited resource is allocated equal to the general indicator S , which combines all resource private volumes S_n in the form of targeted resource investments in departmental (industry) subsystems (IndS, FS, LP), included in the IS enterprises:

$$S = \sum_{n=1}^N S_n. \quad (1)$$

A problem to be solved: how to allocate the common resource S , allocated by the enterprise for the stable functioning of the IS system, in such a way among the elements of departmental (industry) subsystems (IndS, FS, LP) in order to obtain the greatest effect in the development of a stable system of IS functioning at the oil and gas company of Russia in conditions of restrictions on its total volume of resource provision:

$$\sum_{n=1}^N S_n < S. \quad (2)$$

In order to obtain the best indicator of the development of a stable functioning IS system of OGS of Russia (P), it was necessary to redistribute the order of resource allocation so that it would be targeted to eliminate violations of precisely those activities in the ranking list that have a high index of impact on the occurrence of events (accidents and fires) with maximum damage.

There is a mathematical problem of finding the largest value of the function:

$$P = F(S_1, S_2, \dots, S_N), \quad (3)$$

subject to the following restrictions:

- for the total amount of resource provision, represented by variables in the form:

$$S_1 + S_2 + \dots + S_N = S; \quad (4)$$

- for allocated private volumes of resource support intended for departmental (industry) subsystems (IndS, FS, LP) in the form:

$$S_1 > 0, S_2 > 0, \dots, S_N > 0. \quad (5)$$

Values in the form of indicators of partial volumes $S_1, S_2, \dots, S_N$, subject to the restrictions represented by expressions (4), (5), are considered as uniformly overhanging from the central point $M(S_1, S_2, \dots, S_N)$ weights (loads) related to indicators private volumes $S_1, S_2, \dots, S_N$ adjacent to the lateral surface of the cylinder (Fig. 2).

The maximum value of the function represented by expression (3) is on the surface of downwardly sloping lines supporting weights at the top of the cylinder (point M_k), where all coordinates except one are equal to zero, and the zero coordinate $S_k = S$. At this point of the top of the cylinder (point M_k) the equality:

$$dP = E_k \Delta S, \quad (6)$$

where E_k — the significance of the contribution to the k industry (IndS, FS, LP), the value of which is directly proportional to the distance (from the lowest point of the weight (load) to the point M_k ,

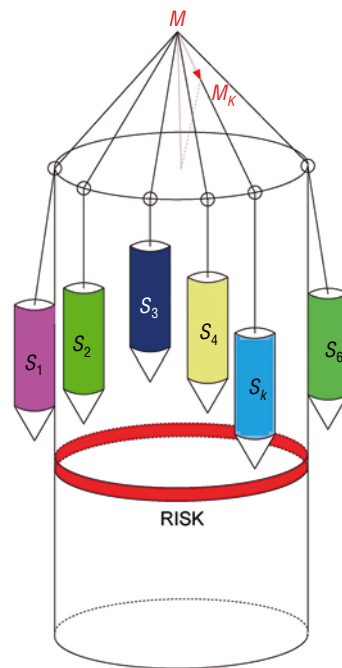


Fig. 2. The Steady State Weighting Factor of subsystems of IS of oil and gas companies of Russia

located at the top of the cylinder (see Fig. 2). Thus, the greatest value of the function represented by expression (3) has the stress vector in the direction of the line downwards, the weight (load) of which is as close as possible to the risk line.

For the efficient use of the enterprise resource intended to provide the IS system, the application of the Lagrange multiplier method is justified [17–21]:

$$L(S_1, S_2, \dots, S_N, \Lambda) = F(S_1, S_2, \dots, S_N, \Lambda) + \Lambda \left(S - \sum_{n=1}^N S_n \right), \quad (7)$$

where Λ — Lagrange multiplier.

The extremum condition for expression (8) was written as:

$$\begin{cases} \frac{\partial L}{\partial S_n} = \frac{\partial F}{\partial S_n}((S_1, S_2, \dots, S_N) - \Lambda) = E_n - \Lambda = 0 \quad (n = 1, 2, \dots, N) \\ \frac{\partial L}{\partial S_n} = S - \sum_{n=1}^N S_n. \end{cases} \quad (8)$$

With an increase in the resource contribution — S by dS for industry subsystems (IndS, FS, LP), when the extreme point from the point $M(S_1, S_2, \dots, S_N)$ moves to the point $M_k(S_1 + dS_1, S_2 + dS_2, \dots, S_N + dS_N)$ (Fig. 6), the mathematical expression is:

$$dS = \sum_{n=1}^N E_n, \quad (9)$$

where E_n — the efficiency of the resource's contribution to the subsystems (IndS, FS, LP). Hence, the development of a stable IS system functioning at an oil and gas company of Russia can be represented as:

$$dS = \sum_{n=1}^N E_n dS_n = \Lambda \sum_{n=1}^N dS_n = \Lambda dS. \quad (10)$$

It follows from the ratio presented by formula (10): $dP = \Lambda dS$, which confirms the meaning of using Lagrange multipliers (Λ),

which is considered as the efficiency of the resource’s contribution to the development of a stable functioning IS system at Russian oil and gas companies.

This leads to the conclusion that if we consider the development indicator for a stable functioning IS system of an OGS of Russia as one of the most important safety indicators, then based on the use of the Lagrange multiplier method, factor indicators (weights) that affect the occurrence of joint events (accidents and fires) can be determined:

$$P = F(\lambda_1(S_1), \lambda_2(S_2), \dots, \lambda_N(S_N)) = F(S_1, S_2, \dots, S_N), \quad (11)$$

which can be used to derive all the causal factors affecting the state of the IS system functioning at the enterprises of the OGS of Russia can be obtained.

CONCLUSIONS

The author of the article, in order to solve the tasks, included in the content of the presented problem, guided by a methodology that includes in its content both previously known methods and newly proposed ones [4], tried to achieve results in obtaining new scientific knowledge, based on the presentation justification of the chosen methods to obtain new results, which included in the content of the developed scientific and methodological apparatus, which is understood as part of the theory in the form of an arsenal of procedural knowledge, the main elements of which are the methods and techniques used to solve scientific and practical problems [16].

The sequence of solutions to the problem presented above consists in solving particular scientific problems:

- particular scientific task No. 1, related to the development of models for assessing the state of the existing stable-functioning IS system at the enterprises of the OGS of Russia;
- particular scientific task No. 2, related to the development of a methodology for assessing the state of the IS system at the enterprises of the OGS of Russia.

Information about the content of setting and solving particular scientific problems is presented with the help of an arsenal of tools included in the content of the scientific and methodological apparatus used to obtain new scientific results (Fig. 3).

Previous studies indicate that the problems of ensuring the IS of oil and gas companies of Russia are complex and multifaceted, the results of modern research used in the practical activities of enterprises indicate the need to develop a full arsenal of tools that can counteract accidents and fires at oil and gas companies of Russia.

The article presents a theoretical justification and develops a problem statement for the rational distribution of the resource, to ensure the IS system at the enterprises of the OGS of Russia. To achieve the goal, it is necessary to use an arsenal of tools (models, methods, techniques, etc.) included in the content of the scientific and methodological apparatus, the adequacy of the use of which was confirmed when solving particular problems.

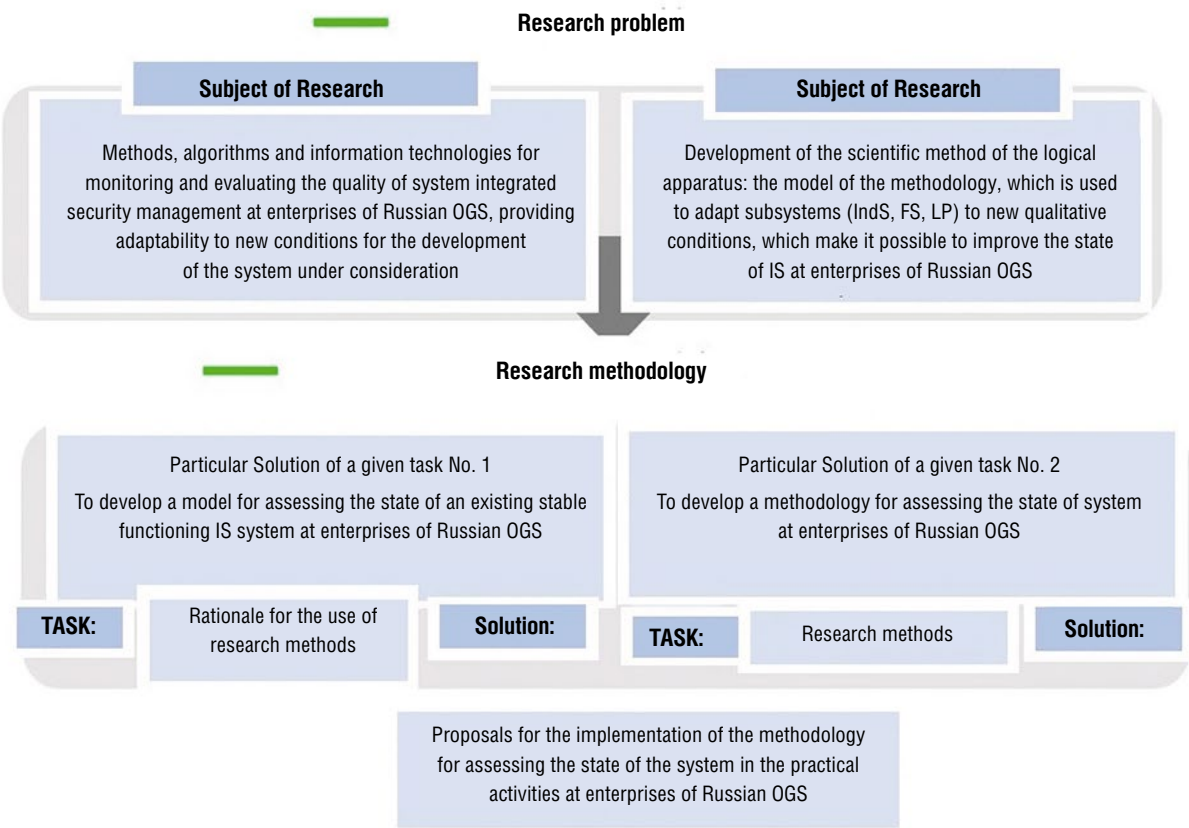


Fig. 3. The model of solving particular scientific problems

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Постановка проблемы по рациональному распределению ресурса, предназначенного для обеспечения комплексной безопасности предприятий

Ресурсы предприятия — это его богатый внутренний потенциал, который нацелен на устойчивое функционирование производственного процесса. Впервые в виде проблемы представлено новое укрупненное методологически описанное направление, решение задач в котором сосредоточено на ресурсном обеспечении подсистем, входящих в комплексную безопасность предприятия. Проанализированы подходы с использованием существующих методов в комплексной безопасности предприятий, рассмотрены особенности их применения. Представлено обоснование по выбору метода множителей Лагранжа, с применением которого сформирована постановка проблемы по рациональному распределению ресурса, предназначенного для обеспечения устойчивого функционирования и развития ведомственных (отраслевых) подсистем, входящих в комплексную безопасность предприятия. В статье представлена постановка проблемы по рациональному распределению ресурсных средств (материальных, экономических, временных, трудовых, информационных и т. д.), рациональное использование которых позволяет системе КБ перемещаться на вышестоящий уровень развития. Решение частных задач, входящих в содержание методологически описанной проблемы, даст возможность разработать методологию синтеза комплексной безопасности, способной адаптироваться к различным условиям функционирования предприятия (режимы повседневной деятельности, а также угрозы и возникновения чрезвычайных ситуаций природного и техногенного характера), что имеет важное хозяйственное для России значение.

Ключевые слова: постановка проблемы, рациональное распределение, частные задачи, интегрированная система безопасности, междисциплинарный подход

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For citation: Gvozdev E.V. Setting a problem on the rational allocation of a resource, intended to ensure integrated enterprise security. *Real Estate: Economics, Management*. 2023; 2:52-57.

Для цитирования: **Гвоздев Е.В.** Setting a problem on the rational allocation of a resource, intended to ensure integrated enterprise security // Недвижимость: экономика, управление. 2023. № 2. С. 52–57.



Л.И. Павлова. Москва. Благовещенский собор . Рисунок, тушь перо