MANAGEMENT OF ORGANIZATIONAL RISKS IN ENTERPRISES OF THE RUSSIAN OIL AND GAS SECTORBASED ON EXPERT ASSESSMENT RESULTS

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Abstract

For effective management of integrated safety at enterprises within the segment of the Russian oil and gas sector (ROGS), it has become a tradition to create an integrated safety system (ISS) designed to prevent conditions for the emergence of various risks (technical, organizational-technical, and organizational). The risk-oriented approach used at enterprises all-round has gained widespread recognition over the past decades, and any risk is considered a cause that transforms into a hazardous event (HE), such as an accident or fire. Currently, there exists a variety of methods for risk assessment. The article presents a justified approach for selecting a method to assess organizational risks in ISS, which will allow evaluating the activities of the security directions within its structure, identifying control points with significant shortcomings, forming measures to correct identified deviations, and observing the dynamics of improvement in impact indicators over the analyzed time interval. Aim and objectives. The purpose of the article is to justify a method for assessing organizational risks that have arisen due to deficiencies of personnel in directions implementing control measures concerning the personnel of production structural units. A scientific task has been solved in which the preference for using the expert assessment method, known as the priority ranking method, is justified. It has advantages over other methods. The use of the normal distribution functional together with this method allows experts to select an individual security direction in which organizational risk has arisen. A scientific task, in which an example demonstrating the impact indicators of security personnel directions on the overall state of an overall condition of ISS, has been solved. The possibility of using the priority ranking method in practice and obtaining results in quantitative value (measure) for organizational risks is justified.

Keywords: integrated security system, organizational risks, priority ranking method, normal distribution, expert decision, deficiencies

I. Introduction

For various cases of hazardous events (HE) (accidents and fires) that have occurred and may occur at enterprises of the Russian oil and gas sector (ROGS), a risk-oriented approach is required.

Currently, the state of integrated security at oil and gas enterprises in Russia is determined by the results of assessing technical, organizational-technical, and organizational risks [1]. A significant portion (about 75%) of all organizational-technical and organizational risks that arise is associated with the human factor (HF) [2]. If in the field of assessing technical and organizational-technical risks, results have been obtained from scientific schools:

– the Federal State Budgetary Institution of Science Institute of Machine Science of the

Russian Academy of Sciences on risk analysis and safety of hazardous production facilities, which, for instance, annually publishes new monographic collections "Safety of Russia," [3];

– the Closed Joint-Stock Company Scientific and Technical Center for Industrial Safety on the justification of safety of hazardous production facilities, as well as on risk analysis justification, justification and declaration of safety when providing services for a fee in the case of legal entities [4-6];

– the Federal State Budgetary Institution All-Russian Research Institute for Fire Protection on organizational and methodological support of work related to the independent assessment of fire risk when providing services for a fee in the case of legal entities [7-9];

– the Federal State Budgetary Institution All-Russian Research Institute for Civil Defense and Emergency Situations focuses on improving methods for managing risks of emergency situations (ES) considering the challenges and threats to Russia's national security in the development of regulatory legal acts (RLA) and standard documentation (SD) [10; 11].

In the field of organizational risk (OR) assessment, further research requires to enhance technosphere safety at the protection facilities of Russia's oil and gas complex enterprises [1]. This necessity is caused by the following circumstances:

1) Organizational risks arise and manifest when the management personnel of the management body (MB) influence the personnel belonging to the category of production structural units (PSU), i.e., their origin is based on information that is not formalized and represents a qualitative description. Here, certain difficulties arise in transforming the qualitative characteristics described for such risks into a quantitative form.

2) Organizational risks are currently identified and eliminated autonomously in separate areas of activity: – industrial safety (IS) and fire safety (FS); occupational safety (OS), which control the personnel of the PSU (CP PSU) both in daily activities and during investigations of accidents (Rostekhnadzor), fires (the EMERCOM of Russia), and incidents involving injuries and fatalities (Ministry of Labor). The reports lack information on the shortcomings of the personnel's work in a specific safety direction (SD) where such a risk arose and manifested into a hazardous event (HE).

A problematic situation is identified, consisting of the need to manage organizational risks manifested in ES (accidents and fires). The circumstances presented above are characterized by a high degree of relevance. A new result of scientific achievements will be the conclusion about the shortcomings in the practical use of existing methods for assessing organizational risks. Here the need to present a justified preference for a new method arises. To confirm the adequacy of the new method proposed for practical use, it is necessary to provide an example.

II. Research methodology

The activities of Russian oil and gas companies aimed at preventing the conditions for the occurrence and manifestation of organizational risks follow the following sequence (Fig. 1). The developed sequence of actions will allow considering the dynamics of damage reduction—U_{0C} from the occurrence and manifestation of organizational risk—R_0 ES (accidents and fires), when values with indicators of negative impact presented in quantitative form (measure) will become known. Then:

$$U_{0C} = F_{U_{0C}}\{R_0, P\} = \sum_i \left[F_{U_i}(R_{0_i}, P_i) \right] = \int C(R_0)P(R_0)dR_0 = \int C(P)R_0(P)dP, \qquad (1)$$

where P – the probability of occurrence of ES (accidents and fires); i – groups of negative factors affecting the outcome in the form of ES (accidents and fires); C – weight functions considering the mutual influence of risks.
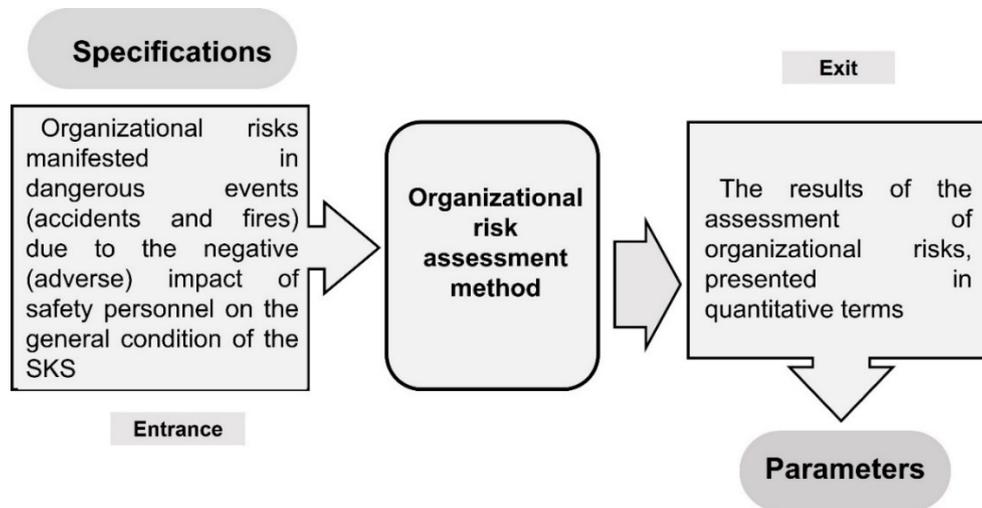

Figure 1: *The sequence of transformation of risks from characteristics to parameters*

The purpose of the article is to justify the choice of an expert method that allows transforming organizational risks with qualitative descriptions into a quantitative value (a measure of negative impact). Therefore, it is necessary to use the magnitude—M the magnitude of the negative impact of organizational risk in the range of change ($M_{min} = 0,001$; $BM_{max} = 0,999$), then:

$$R_0 = \int_{Mmin}^{Mmax} f(M) \cdot P(M) dM, \tag{2}$$

where $f(M)$– the density distribution of groups of organizational risks considering the frequency of their occurrence in the ES. $P(M)$– the probability of occurrence of organizational risks in the ES is determined using the functionality of Bayesian belief networks [12-14].

Based on the analysis of various risk assessment methodologies used in practice, certain conclusions have been made (Table 1). The information confirms the presence of significant shortcomings in the practical use of a limited number of methods. To analyze the presence of limitations for experts was necessary when conducting sequential activities for risk assessment. Under the general definition of risks, we will understand a recognized danger (threat) of the occurrence of a negative event in any system with consequences defined in time and space[1]. It is advisable to consider the conditions of manifestation (escalation) of risk as the recognized danger (threat), which tend to transfer into the final phase, resulting due to hazardous factors, such as accidents or fires. Considering the specifics of organizational risk assessment, it is recommended to consider them in two directions:

    – as deficiencies (D) of the safety personnel controlling the personnel of production structural units (PSU) - R_{ISA};

    – as well as staff shortcomings (SC) in the implementation of the requirements of R_{SC} RLA and SD.

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[1] Dictionary of Terms and Definitions of the EMERCOM of Russia. The information is provided via the internet link: https://mchs.gov.ru/ministerstvo/o-ministerstve/terminy-mchs-rossii/term/3579. The information is valid as of July 13, 2025

Table 1: *Disadvantages identified when using the developed methods in practice*

Order of Rostekhnadzor dated November 3, 2022, No. 387	Order of the EMERCOM of Russia dated June 26, 2024, No. 533	Order of the Ministry of Labor of Russia dated December 28, 2021, No. 926	Disadvantages
Results with the presentation of values with a qualitative description:			
Risk prioritization, based on the categorization of hazards from accidents, the priority value by risk (1;2;3)	is not present	is present	Lack of completeness in the relationships between types of activities. There is no risk result presented as a weighted value in quantitative form, which means there is no possibility to determine the priority of the risk when forming the overall ranked series.
Values of risks from negligibly small to above permissible risk, magnitude by risk (A; B; C; D)		is present	
Values of risks with criticality of deviations, magnitude by risk (high; medium; low)		is present	
Results with representation of values in quantitative form:			
Values of risks for the frequency of depressurization of technical pipelines, magnitude by risk,10^{-n}/year where –n is a power function.	is present	is not present	Sensitivity to errors in measurements. They have significant inaccuracies. They do not take into account the conditions of independence of preferences between alternatives considering the influence of external factors
Values of risks for causing harm to people, magnitude by risk probability of realization (1-100%), magnitude by risk,10^{-n}/год where –n is a power function.	Values of risks in determining the calculated evacuation time, magnitude by risk (min.)	is not present	

The overall indicator for organizational risks R_0 for the selected period can be calculated using the formula:

$$R_0(t) = \frac{\sum_{i=1}^{j}(R_{AIT}) + \sum_{i=1}^{j}(R_{NI})}{n \cdot (R_{AIT}) + n \cdot (R_{NI})}(t), \tag{3}$$

where $n \cdot (R_{AIT})$ and $-n \cdot (R_{NI})$ the number of accident reports under consideration included in the sample, (units); t – the period under consideration, (month, quarter, year).

In order to assess organizational risks with the help of experts, using of methods of individual and group evaluation is advisable. In addition, it is necessary to provide mandatory conditions for risk assessment in which explanations on the components are presented to experts:

    – assessment of the priority of qualitative risk characteristics and the type of a scale;

    – the sequence of techniques or operations subordinated to the task of expressing judgments;

   − the sequence of techniques or operations subordinated to the task of processing the results of expert evaluation.

A new method proposed by the author of the article for practical use is a method from a new group of *expert-calculation methods*, namely the *priority ranking method* [15], which will allow the results of qualitative expert evaluation to be transformed into a quantitative form (measure of negative impact). The practical use of the proposed method will allow:

   − with the help of a group of experts, select an autonomous direction (IS; FS; OS; CP PSU) in which organizational risk arose due to deficiencies during the implementation of control measures, which manifested in a joint ES. Here, experts have the opportunity to determine the affiliation of such a risk to one of the security directions when answering the question: "In which of the directions (PrB; PB; OT) as well as a separate control direction consisting of the leadership of the PSU (RS PSU) did the organizational risk arise, to which the direction has: - direct (*absolute affiliation)*; indirect (*priority affiliation*); indirect (*relative affiliation*) relation;

   − obtain an individual numerical value for each organizational risk in the form M of the magnitude of the negative impact of the organizational risk in the range of change $M_{min} = 0,001$; $M_{max} = 0,999$). Here, the presence of elements of novelty is clearly confirmed when compared with existing solutions used in practice.

III. Theoretical basis for conducting research

In practice, expert methods mainly involve solving tasks based on prioritization, where one type of expert opinion expression becomes the pairwise comparison of evaluated objects to identify the preference of one over the other. Experts invited for evaluation are not imposed with a priori conditions, and they are given minimal limitations [16]. Mathematically, the solution of expert tasks is described as the effectiveness of the evaluated object in relation to another in the form of a directed graph (see Fig. 2).
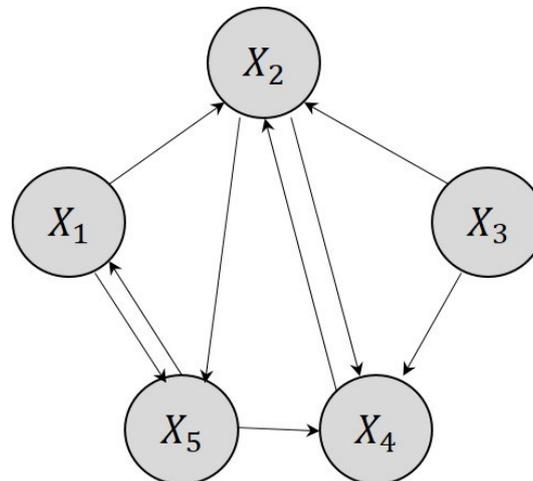

Figure 2: *Graph of the n -object evaluation result*

   The presented connections in the form of directed vectors (see Fig. 2) will be considered as a set of complex numbers [17], in the form of:

$$x = \left\| \begin{matrix} x_1 \\ x_2 \\ ... \\ x_n \end{matrix} \right\|. \tag{4}$$

We note the equality of vectors x and y or the case of equality of their components, using the addition operation for two vectors:

$$x + y = \left\| \begin{matrix} x_1 + y_1 \\ x_2 + y_2 \\ \vdots \\ x_N + y_N \end{matrix} \right\|. \tag{5}$$

A scalar function of two vectors x will y be called a scalar product, and the notation will be represented in the form of a formula:

$$(x, y) \sum_{i=1}^{N} x_i y_i.$$

The importance of using the scalar product lies in the fact that the magnitude (x, y) can be considered as the square of the length of the vector plotted on the Re scale of real numbers laid out on the axis x (Fig. 3).
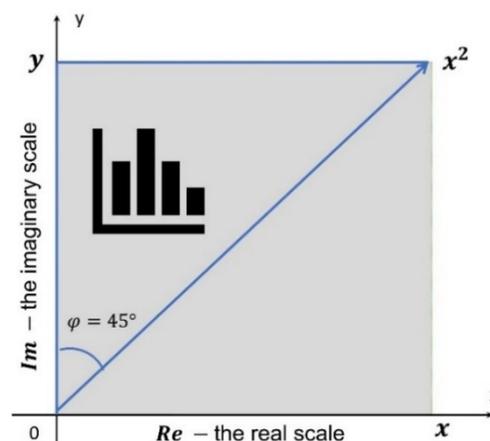
Figure 3: *The vector x, as a square value plotted on a real scale*

Two vectors plotted in relation to the Re scale with real numbers will be called orthogonal if they are brought to the relation:

$$(x, y) = 0.$$

The importance of using vector orthogonality to assess organizational risks can be easily confirmed by obvious established results. If we consider $\{x^i\}$ a set of mutually orthogonal vectors plotted on a plane under the condition that the $(x^i, x^j) = 0$, при $i \neq j$ se vectors are normalized under the condition: $(x^i, x^j) = 1$. Then the overall vector x will be resented as the sum of vectors by the formula:

$$x = \sum_{i=1}^{M} c_i x^i, \tag{6}$$

where c_i are numerical coefficients, then it becomes obvious to consider the equation in the form:

$$c_i = (x, x^i). \tag{7}$$

It is also valid to consider the relationship in the form:

$$(x, x) = \sum_{i=1}^{M} c_i^2. \tag{8}$$

If we take as a basis the case with representation on the plane of an N-dimensional Euclidean space, which is defined by vectors:

$$y^1 = \left\|\begin{matrix}1\\0\\\vdots\\0\end{matrix}\right\|, \quad y^2 = \left\|\begin{matrix}0\\1\\\vdots\\0\end{matrix}\right\|, \quad y^N = \left\|\begin{matrix}0\\0\\\vdots\\1\end{matrix}\right\|, \tag{9}$$

then their orthogonality will become the resulting directed graph, laid off from the Im imaginary scale of the axis at y an angle (see $\varphi = 45°$ Fig. 3). The normalized directed graph will be along the axis, y which is laid off on the imaginary scale - (Im see Fig. 4).
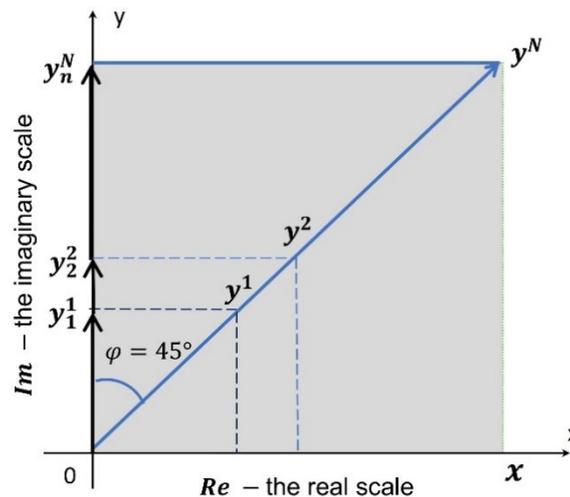

Figure 4: *The y vector represented in orthogonal and normalized directions*

For such an orthogonal and normalized (normorthogonal) representation on the plane of directed vectors (see Fig. 4), we will consider it valid to use the equation:

$$x = \sum_{i=1}^{N} c_i \, y^i.$$

The representation of vectors on the plane in the form of graphical (orthogonal and normalized) directions acquires scientific significance for assessing organizational risks in the SDB at enterprises of ROGS. There arises the possibility:

  – *on one hand*, to use the *orthogonal* vector-directed scale as the initial one, on which the emerging risks have no influence, i.e., $\lambda_I = 0$ the influence indicator;

  – o*n the other hand,* the impact of security directions implemented to prevent conditions

for the emergence of organizational risks will allow bringing the SDB at enterprises of the Russian NGC to a standardized state, i.e.:

$$\lambda_{\text{Вл}}\{IS; FS; OS; CP \; PSU\} \Rightarrow 1.$$

IV. Justification for the preference in choosing the priority ranking method to assess organizational risks

Each of the n objects $(X_1, X_2, \ldots, X_n$ (see Fig. 2) corresponds to a vertex of a graph, which expresses the result of the preference of one evaluated object in relation to another (Fig. 2). Here, it is required to find the maximum of functions of several variables, represented in relation to each other in a ranked dependency. If we consider any computational model from the perspective of its simplification, then it is advisable to consider a quadratic form under the conditions of preference:

$$A = \begin{vmatrix} a_{11} & a_{12}\ldots & a_{1j}\ldots & a_{1N} \\ a_{21} & a_{23}\ldots & a_{2j}\ldots & a_{2N} \\ \ldots & \ldots \; \ldots & \ldots \; \ldots & \ldots \\ a_{i1} & a_{i2}\ldots & a_{ij}\ldots & a_{iN} \\ \ldots & \ldots \; \ldots & \ldots \; \ldots & \ldots \\ a_{n1} & a_{n2}\ldots & a_{nj}\ldots & a_{nN} \end{vmatrix}, \text{where}$$

a_{ij}- risk indicators based on pairwise comparisons;
N – rank of the matrix;
$a_{n1}, a_{n2}, \ldots, a_{nj}, a_{nN}$ – risk indicators included in the $j - th$ row of the matrix A;
$a_{1N}, a_{2N}, \ldots, a_{iN} \; a_{nN}$ – risk indicators included in the j - th column of the matrix A.

At the same time

$$a_{ij} = \begin{cases} 1, if \; X_i > X_j \\ 0,5, if \; X_i = X_j, \text{where} \\ 0, if \; X_i < X_j \end{cases}$$

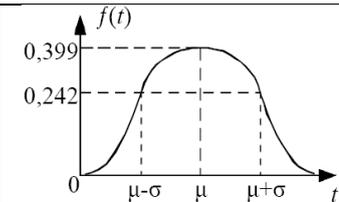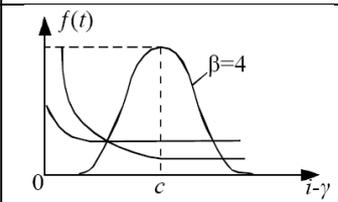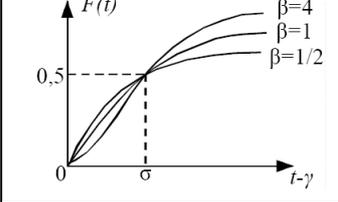$i = j \rightarrow \{1,2, \ldots, n\}$; $a_{ij} = 0,5$. For organizational risks being compared to each other, in the case of a ranking priority of one over the other, it becomes necessary to present such a comparison in a ratio $X_i > X_j$, and if priority is not observed, this means an equilibrium relationship of one organizational risk to another; accordingly, such a comparison will be presented in the form of a ratio: $X_i = X_j$.

In the case under consideration, there arises a need to use a ratio scale with a description of organizational risks in the form of qualitative characteristics, used by experts for evaluation. It is then required to provide experts with such a new evaluation method that would allow each assessed risk to be endowed with a parameter, i.e., to assign a numerical value to such a risk in the form of a magnitude (measure) of negative impact on the state of the SDB at enterprises of ROGS. For qualitative assessment of organizational risks, the priority ranking method (PRM)remains the preferred priority [15]. However, to obtain new results in the assessment of organizational risks, which would be presented in the form of a magnitude (measure) of negative impact on the state of the SDB at enterprises of ROGS, it was necessary to expand the capabilities of the MPR, i.e., to use it together with the functionality of statistical distributions (tables 2; 3).

Table 2: *Disadvantages identified when using the developed methods in practice*

Parameter	Exponential	Normal (Gaussian)	Weibull
Density of distribution. $f(t)$	$\lambda e^{-\lambda t}$	$\dfrac{1}{\sigma\sqrt{2\pi}} e\left[-\dfrac{1}{2}\left(\dfrac{t-\mu}{\sigma}\right)^2\right]$	$\dfrac{\beta(t-\gamma)^{\beta-1}}{\sigma^\beta} e\left[\left(-\dfrac{t-\gamma}{\sigma}\right)^\beta\right]$
Distribution function. $F(t)$	$1-e^{-\lambda t}$	$\dfrac{1}{\sigma\sqrt{2\pi}}\displaystyle\int_{-\infty}^{t} e^{-\frac{1}{2}\left(\frac{t-\mu}{\sigma}\right)^2} dx,$ $(-\infty < t < \infty)$	$1-e\left[-\left(\dfrac{t-\gamma}{\sigma}\right)^\beta\right]$
Value of random variable.	λ	$\dfrac{f(t)}{1-F(t)}$	$\dfrac{\beta(t-\gamma)^{\beta-1}}{\sigma^t}$

Table 3: *Statistical distributions used in practice are presented in the form of graphs*
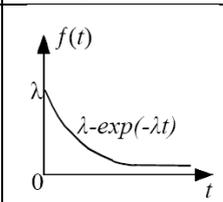
Parameter	Exponential	Normal (Gaussian)	Weibull
Density of distribution. $f(t)$			
Distribution function. $F(t)$			
Value of random variable.			
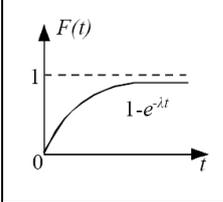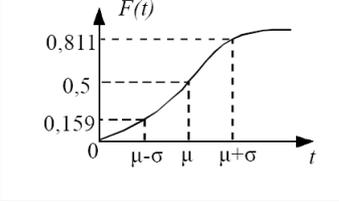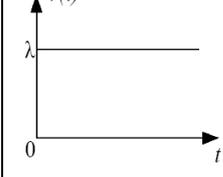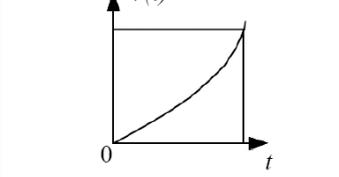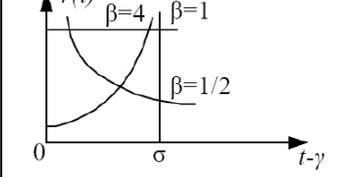
Given into account that experts will provide a non-numerical and qualitative characteristic, when determining the quantitative value for each qualitative value presented above, using the functionality of the Gaussian normal distribution (the three-sigma rule for a Gaussian random variable) [18; 19], a specific maximum value from the sample for each of the presented qualitative characteristics will belong (see Fig. 5).

Using the graph (see Fig. 5), it becomes possible to associate quantitative values for the following qualitative characteristics:

– having a *direct* (*absolute belonging*) relation to the emergence and increase of conditions for causing damage from accidents and fires in terms of volume,≈ 68,2% or ≈ 0,682, this indicator is assigned to one direction (IS; FS; OS; CP PSU);

– having an *indirect* (*priority belonging*) relation≈ 27,2%, or ≈ 0,272, this indicator is assigned to one direction (IS; FS; OS; CP PSU), even to the one that was previously characterized as

having a direct relation;

 – having an *indirect (relative belonging)* relation,≈ 4,6% or ≈ 0,046, this indicator is assigned to one direction (IS; FS; OS; CP PSU);

 – having *no relation,* for the selection of a direction to which none of the presented relations with a negative impact indicator was assigned ≈ 0 [20; 21].
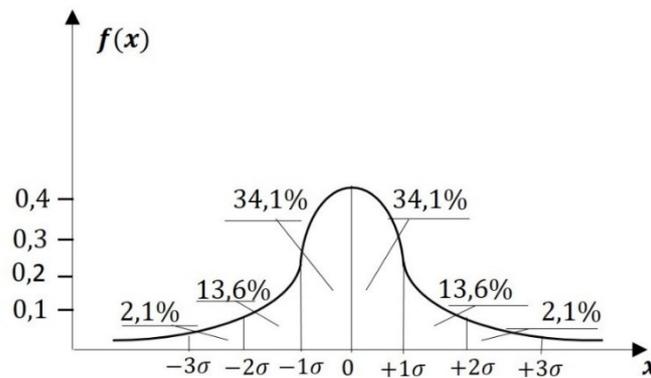

Figure 5: *A graph of the density of the distribution of the normalized value*
with a representation of the volume ratio

V. Justification of the quality of expert assessment and confirmation of the reliability of research results

In the case of inviting experts to assess organizational risks at oil and gas companies in Russia, it becomes necessary to confirm the quality of the expert evaluation based on its results.

 For this purpose, it is considered advisable to apply methods such as:
–   analysis of the consistency of responses received from experts;
–   assessment of the reproducibility of survey results obtained from experts.

 If the second method largely depends on the choice of various resulting coefficients, such as: variation; rank correlation; concordance; association, etc. [22], then the first method is important because the quality of expert evaluation depends on the consensus judgment of the experts. The result obtained is directly dependent on the consistency (selectivity) among the experts. The consistency (selectivity) of individual expert evaluation results in relation to the overall (integral) indicator should correspond to the values of indicators within the acceptable range(reliability) of values, which should differ from the overall (integral) indicator by no more or less than 10% of a certain value. Before approving the main composition of the working group, at the preliminary stage, the head of the expert group (EG) needs to calculate its size using the formula:

$$n_\text{т} = \frac{c\bar{a}_n - b}{\bar{a}_n(1-c)}, \tag{10}$$

where $n_\text{т}$ – the number of experts (required), persons; $\bar{a}_n$ – the value of expert assessments in the arithmetic mean calculation; $\bar{a}_{n+1}$ – the value of the assessment from the $(n+1)$-th expert, which significantly differs from the assessments of other experts; c – the measure of influence on the group assessment of one result in the form of the assessment value from the $(n+1)$-th expert, which is considered as a ratio:

$$c = \frac{\bar{a}_{n+1}}{\bar{a}_n}. \tag{11}$$

If $\bar{a}_{n+1}$ expressed through and $\bar{a}_n$, the b ratio will be described as:

$$\bar{a}_{n+1} = \frac{n\bar{a}_n + b}{n+1}. \tag{12}$$

The final value of the measure of influence will be presented as:

$$c = \frac{n\bar{a}_n + b}{(n+1)\bar{a}_n}. \tag{13}$$

At the preliminary stage, experts filled out a questionnaire, which presented the results of the commission investigating the accident at the PJSC "Nizhnekamskneftekhim" enterprise in 2016. The organizational causes taken from the report are presented as organizational risks (Table 4).

Table 4: *List of organizational risks taken from accidents*

No	Organizational risks
1	Failure to ensure the sealing of fittings on the installed section of the pipeline at the bottom of the tank
2	Presence of ignition sources inside the tank farm area (welding post not disconnected), leading to the ignition of a combustible environment.
3	Unsatisfactory organization of the acceptance of completed work after equipment installation
4	Violation of the procedure for the safe commissioning of the tank after installation
5	Ineffectiveness of production control

In the standardized form of organizational risk assessments, the assigned organizational risk assessments largely depend on the competence and number of experts using the functionality of Gaussian probability distribution (Table 5).

Table 5: *Results of expert risk assessments*

Experts	1	2	3	4	5
Expert assessment in standardized form	0.318	0.318	0.682	0.728	0.318

Here (see Table 5), the consistency (selectivity) of individual expert assessment results is not ensured in relation to the general (integral) indicator, as the organizational risk indicator for experts 3 and 4 exceeded the values within the acceptable range(reliability) of values. Using formula (12), the measure of influence on the group assessment of one result in the form of an assessment value from the $(n+1)$-th expert was found, and it amounted to $c = 1,08$.

The calculation results confirmed the need to expand the group of experts to seven people with calculated confirmation:

$$n_t = \frac{1,08 \cdot 0,47 - 0,728}{0,47(1 - 1,08)} \approx 7.$$

The minimum expert group composition was determined, which can ensure the required influence of an individual expert's judgment on the group assessment [23]. When processing data from experts in each analyzed accident report, indicators (coefficients) of the negative impact of organizational risks - R_0 are formed for the directions (IS; FS; OS; CP PSU) according to the formula:

$$R_0\{IS; FS; OS; CP\ PSU\} \approx \lambda_{I_{\{1;2;3;4\}}} \in \{IS; FS; OS; CP\ PSU\}, \tag{14}$$

where $\lambda_{I_1} = 0,682; \lambda_{I_2} = 0,272; \lambda_{I_3} = 0,046; \lambda_{I_4} \approx 0.$

The results of the values obtained from experts for the analyzed accident reports in the period of 2014 and 2015 at the enterprises of the Russian oil and gas sector are presented (Fig. 6).
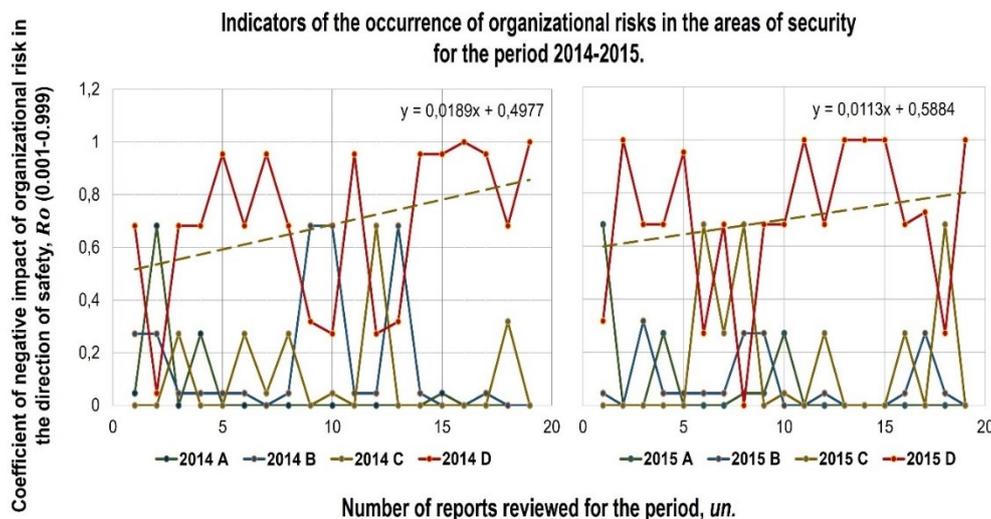

Figure 6: *Indicators of the negative impact of security trends in 2014 – 2015*

The letter designations are assigned to the security directions in the following order: **A** for *OS*; **B** for *IS*; **C** for *FS*; **D** for *control the personnel of the PSU*. In general mathematical form, the calculated value for determining the impact indicator of each security direction $\lambda_{impact}\{IS, FS, OS, CP\ PSU\}$ will be recorded by the equation:

$$\lambda_{impact}\{IS, FS, OS, CP\ PSU\} = \frac{1 - \sum_1^4 R_0\{IS, FS, OS, CP\ PSU\}}{3}, \tag{15}$$

where λ_{impact} is the indicator of the effectiveness of the influence of each direction (IS; FS; OS; CP PSU) is obtained based on the difference in the ratios between the indicator of organizational risk manifested in the ES a($1 - as\ 100\%\ influence$) and the indicator obtained based on the decision of experts on the (di*rect, indirect, or mediated)* relation of the direction having a negative impact.

The overall resulting indicator of the work of the direction (IS; FS; OS; CP PSU) for the period*t, months*, is calculated with reference to the functioning of types of technological production

processes (D - *extraction*; T - *transportation*; P - *processing*; S - *storage*; Oth - *others*). The presented information (see Fig. 5) confirms the possibility of focusing on those organizational risks that have arisen in the safety directions and have a high coefficient K_{BMI}. Using formula (10), values with effectiveness indicators of influence λ_{impact} were obtained for the directions (IS; FS; OS; CP PSU). Demonstrative information representing the performance indicators of the impact of security directions in processing accident reports in ROGS for 2014 and 2015 (Fig. 7).

Figure 7: *Indicators of the effectiveness of the impact of security trends in 2014 – 2015*

The final resulting indicator, representing the impact indicator of λ_I of the directions (IS; FS; OS; CP PSU) for the period (year$t$, quarter, month, etc.) linked to the functioning of the production technological process, can be obtained using the equation:

$$\lambda_{I\ (D;T;P;S;Oth)}\{IS;FS;OS;OP\ PSU\}t = \frac{\sum_1^m R_0\{IS;FS;OS;OP\ PSU\}}{n},$$ (16)

where m– the numbered extreme indicator belonging to the sample; n – the number of reports considered for the period.

The final resulting indicator can be represented on a plane in the form of a norm-orthogonal model (Fig. 8).
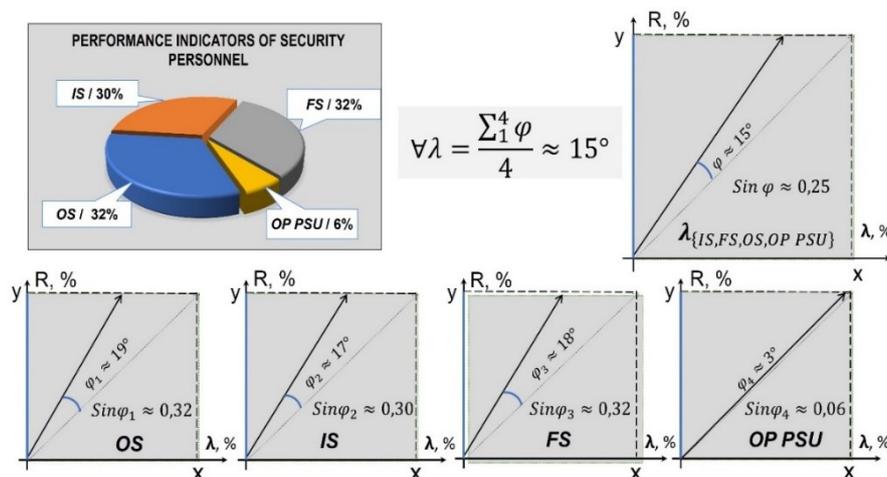

Figure 8: *Performance indicators of security areas for the period 2014 – 2015*

It is possible to calculate the effect of measures taken to reduce organizational risks by considering the total number of accidents (Fig. 6) using ratios

$$\frac{Sin\ \varphi = 15\%}{Sin\ \varphi = 45\%} \cdot 100\% = \frac{0,25}{0,707} \cdot 100\% \approx 35\%$$

Here, the effect of 35% is viewed as the dynamics of the influence of security areas for an orthogonal system with 100% risks. However, considering that we examine about 20% of all accidents and fires (Fig. 4), the effect of measures taken to reduce organizational risks at ROGS enterprises will amount $35\%/5 = 7\%$. Such a significant indicator that allows saving billions of resources in the material-production complex of VPO enterprises (rubles).

The reliability is confirmed by the correctness of using the improved priority ranking method, which is enhanced by the functionality of Gaussian probability distribution (Table 6).

Table 6: *Mathematical apparatus that substantiates the reliability and sensitivity of data processing*

Reliability		
Priority ranking method	$\frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{t} e^{-\frac{1}{2}\left(\frac{t-\mu}{\sigma}\right)^2} dx,$ $(-\infty < t < \infty)$	$\sigma_1 = 0,682$ $\sigma_2 = 0,272$ $\sigma_3 = 0,046$ $\sigma_4 \approx 0$
Sensitivity analysis		
$\bar{x}_a = \frac{\sum_{S=1}^{S=n} x_S m_S}{\sum_{S=1}^{S=n} m_S},$		$\sigma^2 = \frac{\sum_{S=1}^{S=n}(x_S - \bar{x}_a)^2 \cdot m_S}{\sum_{S=1}^{S=n} m_S},$

where
μ – mathematical expectation; $(\sigma_1; \sigma_2; \sigma_3; \sigma_4)$ – indicators taking into account the standard deviation; $\bar{x}_a$ – indicator of the average value for the data sample; x_S – risk indicator in the middle of the intervals (S) of the interval series; m_S – indicator of the probability of risk occurrence (frequency, recurrence) of the set of features for the interval series; n – list of risks for the sample object; σ^2 – variance estimate for the data sample

V. Conclusions

The study is dedicated to reducing damages at oil and gas companies in Russia by assessing and managing organizational risks arising from deficiencies and shortcomings of personnel ensuring the quality functioning of the control and safety systems. An analysis of retrospective, current, and expert information in the field of safe operation of enterprises was conducted, and the feasibility of scientifically and practically implementing a risk-oriented approach was substantiated.

An improved priority ranking method used for assessing organizational risks arising from personnel deficiencies, R_{ISA} which exercises control over the personnel of production structural units, is justified for practical use.

To reduce the risks of damage from accidents and fires at oil and gas companies in Russia, it is advisable to create a SCS, a new system endowed with the ability to diagnose problematic situations, promptly prepare high-quality projects with management actions to prevent organizational risks for decision-makers, thereby reducing damage from ES (accidents and fires).

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