As can be seen from the table, all possible faults are determined by ear (noise), tactually (heating) or visually (oil leakage). However, it should be noted that these methods are subjective and have a low level of reliability.

For more accurate and continuous monitoring of the gear-box and the main gear it is reasonable to use special stand-alone systems on a car that will monitor specific performance characteristics of the aggregates on a car.

Noise while operating. Noises associated with the worn-out pinion gears at early stages may be not audible to humans, and therefore it makes sense to implement the system for measuring noise into the construction of gearboxes and final drive.

Such system will detect the increased noise at early stages, which will serve as a signal to check the details of transmissions and final drives, and will prevent tough wear and carry out adjustment or reconditioning work to extend the service life.

Increased heat-up. The Increased heat-up of the transmission gear box and the main gears may be due to the insufficient level of the oil in the crankcase. The same tough heat- up occurs when there is a run-out or or incorrect adjustment of gear system.

To carry out continuous monitoring of the temperature of the oil in the crankcase of transmission gear boxes and final drives it is advisable to use transmission oil temperature sensors.

The use of autonomous systems to control transmission oil temperature and noise level in the gear system will allow the driver to monitor the status of transmission units in the real-time mode immediately during operation.

The deviation from the regulatory parameters of the sensors will serve as a signal for checking on the presence of the defects in aggregates , and their timely fixing will significantly extend the service life of the units as a whole and individual elements in particular.

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ASSESSMENT OF COMPLEX RISK IN MAIN PIPELINE TRANSPORT

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In this article was given a description of new method of complex risk assessment in the main pipeline transport. At the stage of structure analysis was proposed to use the methodology of functional modeling. At the stage of risk assessment at functioning of pipeline transport was shown practicability to use the logical-probabilistic calculus. At the stage of getting local probabilities of dangerous events was suggested to apply the method of expert evaluations.

The main pipeline transport is attributed to hazardous industrial facilities. In this connection it is necessary to systematically evaluate the safety of main pipelines. Considering that security is one of the quality indicators the methodological basis for risk management mechanisms may become the methodology of quality management from the position of the ISO 9000 series.

A systematic approach to the mechanism of evaluation, analysis, decision-making in relation to the effectiveness of risk management involves the identification of sources of risk, finding of communication functions between the resulting risk and local sources, quantitative risk assessment and decision on the need for measures to reduce risk.

In the context of the assigned task an identification procedure can be carried out by the various methods. The problem of identification and description of the processes which influence the activity of the enterprise of the main pipeline transport can be solved with use of a method of modeling. In this case it is convenient to use methodology of functional modeling of structure of processes IDEF0 which allows using the process and system approaches at drawing up model of activity of the enterprise of the main pipeline transport.

At process of building a model it is necessary to remember that the result of pipeline transportation service is provided not only by production processes but also by processes that ensure controlled conditions for its implementation. An important aspect in the activity of pipeline transport system is also the priority of information resources over all other resources as the primary control actions on further physical actions. In addition another feature is that at functioning of pipeline transport the process of safety evaluation and assessment of the state of objects has a separate agent who is not part of the organization which carries out activity.

The correct functional operation of pipeline transport which includes the processes of various categories, relationships and resources is the objective evidence that it was identified all sources of risks, clearly defined the structure of private risks. This together will allow building a reliable evaluation model.

Taking into account the specific features of functioning of pipeline transport as an integrated activity on the structure and interaction of its constituent processes it was identified three integrated sources of risk: risk of management, technological risk and risk of analysis.

A comprehensive assessment of risk in the operation of the main pipeline transport is efficiently implemented using the logical-probabilistic calculus. The theory of safety is closely connected with the modern applied mathematics because the mathematics is the means with the help of which a correct statement of a problem and an accurate formulation of conditions and assumptions is possible in most cases.

The logical-probabilistic methods which are the special section of the mathematics connected with a logical-mathematical calculus proved to be an intellectual kernel of scientific researches of structural problems of safety. At the first stage of application of the logic-probabilistic calculus for safety value the structure analysis can be used. On the traditional basis such methods as tree of failures, tree of events and structure scheme can be applied. The authors suggest using the new approach which is the methodology of functional modeling. This approach will allow assessing the safety of activity of pipeline objects. With the help of the equations of Boolean mathematics it is possible to describe the conditions of working capacity or danger of pipeline objects.

After creation of a model of a system it is necessary to apply logic operations of conjunction and disjunction to its elements for getting numerical values of risk. Boolean operations allow forming new expressions from several expressions. In the algebra of logic where the true values of expressions are points of interest the question is raised about a truth value of complex expression depending on the truth values of its constituent simple expressions. In the algebra of logic the truth values are usually denoted by numbers 1 (true) and 0 (false).

For calculation of the probability of reliability and safety of complex systems the method of structural analysis can be used. The scheme of the technical system can be structured with elements X and written as follows:

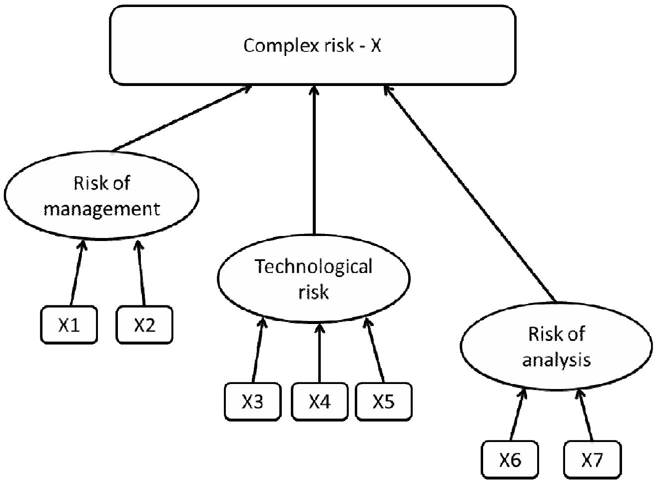

Fig. 1. Structure scheme of a system

Further, the structural form of system working capacity must be written in logical form by using the algebra of logic:

$$Y = X_1X_2 \vee X_3X_4X_5 \vee X_6X_7 \quad (1)$$

After formalization of system working capacity with usage of logical expression it is necessary to pass to the probabilistic expression. In general, the transition from the logical expression of system working capacity or system failure in an arbitrary form to the probabilistic expression is quite difficult.

There are several forms of transition from a logic expression to a probabilistic expression: an absolute disjunctive normal form, an orthogonal disjunctive normal form, repetition-free logic expressions on the basis conjunction-negation.

If a logic expression is presented in a function of full substitution the transition to probability expression is carried out by the following rules:

1) each letter in a function of full substitution is replaced by the probability of its equality to 1:

$$P\{X_i = 1\} = R_i, P\{X_i = 0\} = P\{X_i^{/} = 1\} = Q_i = 1 - R_i \quad (2)$$

2) negation of an expression is replaced by the difference between 1 and the probability of equality of this expression to 1:

$$\begin{aligned} &P\{f(X_1,....,X_7) = [(X_1X_2)^{/}(X_3X_4)^{/}(X_5(X_6^{/}X_7^{/})^{/})^{/}]^{/} = 1\} = \\ &= 1-(1-R_1R_2)(1-R_3R_4)[1-R_5(1-Q_6Q_7)] \end{aligned} \quad (3)$$

where R – probability of reliability (safety) of any element in a system;

Q – probability of failure (danger) of any element in a system.

Upon receipt of the probabilistic form of writing complex risk the problem arises in the definition of the local probabilities of each of the negative events that can lead to emergency situations in main pipeline transport. To determine the probability of initial events is real by various ways.

Obviously that the company of main pipeline transport contains both as production and non-production processes. As a result its activity can be attributed to semi-structured domains where qualitative, fuzzy factors tend to dominate. This circumstance gives the basis for the application of method of expert estimations.

The main drawback of this method is that the information received by experts is subjective. To increase the objectivity of the evaluation can be made by comparing opinions of different experts. However, even with proper organization of the group the expert survey has several disadvantages. First of all, this form requires large expenditures of resources including financial costs and time costs. In addition, it requires special training of organizers and experts themselves. Also there is the risk of manifestation of various psychological effects. At the same time this method can be applied only in the case in which there are no historical statistics and dangerous factors are of different etiological nature.

Thus, the advantage of the proposed method for the determination of complex risk is that both technical and organizational dangerous factors can be taken into account. In this research an open question remains to determine the initial probability of negative events using the expert evaluation method with the involvement of experts in the field of the main pipeline transport.

REFERENCES

1. Методы менеджмента качества. Методология управления риском стандартизации : моногр. / П.С. Серенков [и др.]. – Минск : БНТУ, 2014. – 244 с.
2. Серенков, П.С. Методы менеджмента качества. Методология описания сети процессов : моногр. / П.С. Серенков, А.Г. Курьян, В.Л. Соломахо. – Минск : БНТУ, 2006. – 484 с.
3. Соложенцев, Е.Д. Сценарное логико-вероятностное управление риском в бизнесе и технике / Е.Д. Соложенцев. – Изд. 2-е. – СПб. : Бизнес-пресса, 2006. – 530 с.
4. Рябинин, И.А. Надежность и безопасность структурно-сложных систем / И.А. Рябинин. – СПб. : Политехника, 2000. – 248 с.

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PLANE COORDINATE TRANSFORMATION ON THE BASIS OF THE STATISTICAL CHARACTERISTICS OF MULTIVARIATE VALUES

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As an alternative to the traditional method of the plane coordinate transformation there are two solutions of the transformation task, based on the fact that the transformation is a special case of multivariate regression. The identity of the obtained transformation coefficients and estimate of accuracy were shown. The expediency of the application of these methods in geodetic practice is justified.

The task of coordinate transformation on the plane as a special case of linear transformations can be stated as follows. There are coordinates *(x, y)* for *n* points in the old coordinate system K_c and there are coordinates *(X, Y)* for the same points in the new system $K_н$. It is necessary to find the optimal transition function *f* from the old to the new coordinate system

$$(X, Y) = f(x, y), \quad \text{or} \quad K_H = f(K_C).$$

Most of coordinate transformations for geodetic tasks can be reduced to ordinary linear transformation, which in the most general case involves shifts and scale changes in two axes, rotation of the axes of one coordinate system with respect to the other. Then, a linear function with the transformation matrix *A* and the vector of shift *b* is used as a conversion function

$$K_H = A \cdot K_C + b \tag{1}$$

This kind of transformation is called affine. In formula (1) $A = \begin{bmatrix} a & b \\ d & e \end{bmatrix}$, $b = \begin{bmatrix} c \\ f \end{bmatrix}$, *a, b, c, d, e* and *f* – coefficients of linear affine transformation on the plane.

The system (1) can be unfolded for *i*-th point as [1]

$$\begin{bmatrix} X_i \\ Y_i \end{bmatrix} = \begin{bmatrix} a \cdot x_i + b \cdot y_i + c \\ d \cdot x_i + e \cdot y_i + f \end{bmatrix} \tag{2}$$

where X_i, Y_i, x_i, y_i - coordinates in old and new system, respectively.