Logistics Systems in Operational Reliability of Pipelines and their Risks

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Abstract. The main issue of the study is the problem of reliable operation of pipelines and ensuring their stable operation by optimizing the operation of logistics systems. In the process of operation, the leading function of logistics to address organizational and technical issues is carried out by material and information flows. At the moment, due to the use of outdated methods of diagnosis and repair of pipelines, risks increase during the operation of logistics systems. There is a decrease in the efficiency of supply and material support due to the lack of optimization of logistics flows. The purpose of the study is to determine the role of logistics systems in the management of operational reliability of pipelines and to consider possible methods of their optimization and elimination of risks. The use of modern methods in the diagnosis and repair can significantly reduce economic costs, logistics risks, the environmental damage caused by the operation of pipelines. To minimize damage to the logistics system, it is necessary to use the latest technology in the operation of pipelines and modern methods to reduce the cost of logistical operations, which will have a direct impact on the quality of logistics systems.

1. Introduction

Engineering systems are brought to each object of operation, the features of operation of which are associated with their characteristic: high concentration, length, a feature of geological factors and the complexity of solutions for the technology of construction of these systems.

Most gas pipelines, water supply, and sewerage systems are laid underground. The area of laying near highways is recognized as a territory for special environmental to guarantee environmental safety. The main aim is to prevent accidents and maintain good technical conditions to ensures smooth operations [1-3].

During the operation of pipelines, a number of organizational and technical measures combined into a single logistics system. The functions carried out by this system include ensuring a constant flow of information from the object of operation to the state control point, providing variable material flow directly to the pipeline installation zone, ensuring the availability of permanent reserves for system maintenance.

The aim of this article is to study the work of logistics systems during the operation of pipelines for various purposes to eliminate potential risks.
2. Materials and Methods

The logistics system involves the management of the operational reliability of pipelines. The essence of this system is to address the issues of material and information support, transport and resource issues, and issues of rational use of available resources in the course of the operation and elimination of risks. The logistics system is required to maintain the stable state of the pipeline systems with the help of organizational and technical tasks and with the full preservation of the components of nature, ranging from the diagnosis of technical problems of the system to the solution of accidents [5-6]. Operational reliability implies the possibility of performing technical tasks and preserving the main properties of engineering networks during their operation.

An important part of the logistics system is information flow [2, 7]. Information flow runs between the logistics system and the external environment. In the organization and operation of pipelines, information flow is necessary to control the stable operation of the pipeline without risk. For implementation of the functions of the logistics system, the speed of information flow and its informativeness are important. Optimization of information flows is carried out through the organization of diagnostic processes, which is based on completely trenchless methods such as aerospace methods and in-line diagnostic sound and magnetic systems (figure 1), gathered from geographic information systems (GIS) (figure 2) and global geodetic and geographical positioning systems.

![Figure 1. The principle of operation of geographic information systems](image1)

![Figure 2. Detection of oil leakage (No. 3) using visualization in GIS.](image2)

GIS are not only becoming widespread in the Russian Federation, but they also have a successful use in European countries. These are automated systems, the functions of which include the collection, storage, analysis and graphical visualization in the form of maps or diagrams, as well as information about objects on graphic materials [3,8]. The creation of specialized GIS for pipeline systems will allow view of the overall picture and the situation for a particular site (figure 2) and contributes to the optimization of actions in emergency areas, which reduce the time necessary to identify and solve environmental problems.

For the safety of the natural environment near the operated pipelines, environmental monitoring is necessary in accordance with the Federal law (FZ) “On environmental protection” dated 10.01.2002 № 7-FZ. Monitoring includes logistical procedures that are directly related to the information flow: assessment of the effectiveness of environmental measures; search, receipt (collection), storage, processing (generalization, systematization) and analysis of information about objects that have a
negative impact on the environment, the nature, types and volume of such effects, assessment of the environment and forecasting its changes under the influence of natural and (or) anthropogenic factors.

Part of the logistics system is the management of material flow. Management includes the maintenance and acquisition of the necessary range of goods in the control of the cost of placing orders, storage of materials, control over their implementation.

The Logistics Department of the operating company is responsible for its formation. Optimization of the process of organization of material flow and its formation and use as a whole leads the logistics system to stability in the operation of the facility and increases the rational use of system capacity [4] [9-10].

Optimization requires use of forecasting and monitoring of the stability of the operation of pipelines, to examine popular issues and to find the locus of greatest risk. Based on the data obtained, it is necessary to establish the nature of the material flow, to calculate the necessary materials, to determine options for rational storage [11].

An important criterion for the operation of the logistics system is the option of repair work to be carried out during the operation of pipelines. Traditional (trench) and trenchless methods are available.

The traditional method for repairs is the use of trench methods (figure 3). In comparison with the latest trenchless systems, the traditional method has a number of visible shortcomings in the organization of the logistics system: increasing the number of materials and transport for use in the course of excavation, the complexity of the organization of the work itself, and the need to increase the efficiency of the warehouse. At the same time, there is a shortage in the form of high economic costs and time of repair work [5].

![Figure 3. Trench piping replacement method](image)

Trenchless sanitation provides a limited space to improve the productivity, efficiency and environmental process (figure 4), during which the natural occurrence of the soil is not disturbed, the existing green spaces and the vegetation layer are preserved [13]. In comparison with trench methods of repair, the risk of damage to neighboring communications is also reduced. Its use is possible in a dense urban environment and repair work in unstable soil conditions, which preserves solid coatings [14-15]. From the logistics side: the number of materials used and transport is significantly reduced due to the reduction of the volume of land works, mobility and compactness of equipment used for repair by these methods, as well as there is a uniform load on the material and information flow, since the transfer of information is carried out by mobile means.
Also, to reduce logistical risks during the repair process, a continuous environmental impact assessment should be carried out [16,17].

3. Results and discussions

Modern economic conditions require companies to promptly prevent, identify and manage risks in various fields of activity. As this study shows, many best practices in the operation of pipeline reliability, taking into account the risks have taken root, and are used in large Russian companies in various sectors of industry. At the same time, the results of the study demonstrate the availability of opportunities for further development.

Qualitative risk assessment characterizes the degree of importance of risk through the choice of response. The availability of accompanying information makes it easier to prioritize different risk categories.

It is necessary to determine the type of program, that is, qualitative risk assessments of probability, damage, and impact. Assume that the damages of individual projects are summarized. The degree of influence of the program risks is equal to the sum of the degrees of influence of individual projects (the mathematical expectation of the sum of independent random variables is equal to the sum of the mathematical expectations of these values).

Damage can occur as a result of the following the risks:

\[ U = \sum_{i=1}^{n} U_i . \]  

Program risk impact:

\[ W = \sum_{i=1}^{n} W_i \lambda_i , \]  

\[ \lambda_i = \frac{c_i}{\sum_j c_j} . \]

The total probability of risks of the program

\[ P = \frac{W}{U} . \]

More detailed analysis and calculations can be considered in the following two articles: Risk reduction strategy, and risk management on the basis of quality assessments [18] and Qualitative risk assessment of projects in the organization and management of the construction of electric power facilities [19].

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**Figure 4.** Trenchless method of pipeline repair
The impact assessment involves measures to determine the level of environmental safety of system replacement or repair works. During the determination of the impact assessment, account should be taken of the day-to-day and special operating conditions of the equipment; the activities of the repair manufacturers; human factors; the infrastructure, materials, and equipment used at the repair site; and the hazards. The global meaning of the assessment is precautionary and consistent [20-22].

As asserted in this paper, logistics systems structure the ordering of material and information flows to ensure the operational reliability of pipelines. A method of automation of information obtained by aerospace diagnostic methods using geographic information systems (GIS) was considered. The shortcomings, risks and positive aspects of trench and trenchless sanitation were reviewed from a logistical point of view. The proposed methods for assessing risk of the reliability of pipelines meet the safety requirements for environmental impact assessment in the vicinity of pipelines.

4. Conclusions

With the combination of accurate methods of diagnostics of engineering systems and the latest repair technologies, it is possible to carry out the activities of the logistics system, which manages the operational reliability of pipelines. This will significantly modernize the operation of engineering systems and help to avoid multiple logistical problems arising in the way of stable operation of pipelines. Increasing the ability to diagnose problems and minimize risks not only reduces the cost of resources but also reduces the cost of material flows used in the course of solving problems. Modern methods of trenchless repair make it possible to eliminate leaks, to make partial or complete replacement of the pipeline in any conditions with minimal logistics costs.

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