# TECHNICAL SCIENCES

## SPECIFIC RELIABILITY INDICATORS OF CONSTRUCTION MECHANIZATION USED IN THE CONSTRUCTION OF MAIN (TRANSMISSION) PIPELINES - TYPES, DEFINITION AND ANALYSIS

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**Abstract**

The publication defines specific reliability indicators for construction machinery used in the construction of main pipelines for the transmission of natural gas, oil and petroleum products, and other fluids that require long-distance transportation, and the methods for their determination. Typical parameters characterizing the main reliability indicators of construction machines related to the construction of main pipelines have been derived.. The presented dependencies allow for effective and accurate calculation of the specific reliability indicators of construction machines that are planned to be used in the construction process. As a result of the data obtained, it is possible to perform a correct analysis to select the most suitable construction machines and thus achieve a high degree of effective use of construction mechanization in the construction of main pipelines.

**Keywords:** construction machinery; construction of main pipelines; reliability of construction machines for the construction of pipelines for natural gas, oil and petroleum products; ways to calculate the failure-free resource when using construction machinery; specific reliability indicators for the operation of construction machinery used in the construction of main pipelines

### 1. Introduction

To achieve full and effective use of construction machinery involved in the construction of pipelines for the transportation of natural gas, petroleum products and other liquid and gaseous fluids, it is necessary that they be properly selected and rationally used. In this way, it is possible to achieve increased efficiency and optimization of the overall construction process. The study of various indicators and behavior of construction machines during their active participation in the construction process is of particular importance for clarifying areas for improvement and increasing their reliability during operation.

The main objectives for increasing the reliability of construction machinery are related to increasing the quality indicators and increasing the rate of use, while increasing productivity and reducing the costs for this. Quality indicators are a set of parameters that determine the properties characterizing the capabilities of construction machinery used in the construction of main pipelines to satisfy the requirements placed on them in accordance with their specific purpose and specialization.

Increasing the reliability of construction machinery guarantees a reduction in repair time and an increase in the intervals between repairs, as well as a reduction in the cost of labor and spare parts during maintenance and scheduled repairs.

When determining the reliability of construction machinery, it is possible to use several methods: a method of theoretical data analysis; a method of data practical research, obtained from testing, both in laboratory conditions and in conditions of effective operation; a method of differential comparison at a minimum level, or by determining a generalized reliability indicator that characterizes several qualitative properties of a given construction machinery.

In a differentiated (single) assessment of the reliability of construction machines used in the construction of main pipelines, the most characteristic indicators are identified, by comparing and analyzing the results obtained during real operation and the values determined to be achieved, as a result of this assessment, real conclusions can be drawn about the reliability of the relevant construction machine and measures can be taken to increase , if it is found that this is necessary.

### 2. Determination of generalized specific reliability indicators

To achieve a sufficiently accurate and effective result when assessing the reliability of construction machinery used during the construction of main (transmission) pipelines, several parameters are used, which can be defined as follows: readiness, operational readiness and technical usability.

#### 2.1 Determining readiness (*Gr*)

***Readiness*** is determined statistically by accumulating sufficiently specific measured data, which can be summarized with sufficiently correctly aggregated values, and then applied to the corresponding formulated relationship. Readiness is the ratio of the total time during which the monitored objects (construction machines) are in working condition to the product of the number of these objects and the duration of their operation, excluding downtime for scheduled repairs and maintenance.

$$G_\Gamma = \frac{\sum_{i=1}^{N} T_i}{N.T_{раб}} \tag{1}$$

- $T_i$ - the total time the object was in working condition
- $i = 1,2,\dots\dots,N$

In cases where maintenance is required, which involves immediate action to restore a damaged object, readiness is calculated using the formula:

$$G_{Г} = \frac{T_o}{T_o + T_в} \quad (2)$$

- $T_o$ - average time between failures
- $T_в$ - average time to restore the machine to working condition

Readiness $G_{Г}$ Readiness can also be determined by the average service life (resource) $T_{ср.р}$. This indicator represents the total time of normal operation of the construction machine until the start of the first major repair. For convenience of calculation, this time should be measured in hours*(h)*.

$$G_{Г} = \frac{T_{ср.р}}{T_{ср.р} + T'_в} \quad (3)$$

- $T'_в$ - total time to restore the working capacity of the construction machine after the failure occurred (*h*)

The time $T'_в$ can also be determined from the period between scheduled repairs to the start time of the first major repair and should be reported in hours (*h*).

If the recovery time for the entire period of operation of the machine before the first major overhaul is unknown and cannot be determined, then the capabilities of calculating readiness can be used ($G_{Г}$) and the values of unplanned repairs $R_{нр}$ and scheduled repairs $R_{пр}$.

The time for calculating unplanned repairs can be determined as follows:

$$R_{нр} = \frac{T_в}{T_{пп} + T_{ор}} \quad (4)$$

- $T_{пп}$ - the total time for performing preventive maintenance until the start of the major repair *(h)*
- $T_{ор}$ - time to carry out major repair *(h)*

When calculating the time required to carry out scheduled repairs, the following dependencecan be used (5):

$$R_{пр} = \frac{T_{пп} + T_{ор}}{T_{нр}} \quad (5)$$

- $T_{нр}$ - time of normal operation of the machine until the start of a major repair

To fully perform the calculation, it is also necessary to determine the value of the parameter ***usability*** of the construction machine ($T_{изп}$). This parameter characterizes the time for effective operation of the machine, during which it is able to maintain all safety and reliability indicators, while achieving the set operating mode. Using the parameters $R_{нр}$ and $R_{пр}$ and if the usability value of the construction machine ($T_{изп}$) is determined, we can write the following dependence:

$$G_{Г} = \frac{T_{изп}}{T_{изп} + R_{нр} + R_{пр}} \quad (6)$$

**2.2. Determining operational readiness ($G_{ОГ}$)**

Operational readiness $G_{ОГ}$ determines the need for immediate use of the construction machine, but after the start of this use it must be able to maintain its normal operating capacity throughout the entire period of time $t_{бр}$ without failures occurring. To fulfill this condition, it is important that the construction machine is in working condition at the time when the need for use is appear.

The probability of failure-free operation of the construction machine $P(t_{бр})$ for a period of time $t_{бр}$ does not depend on the moment of commencement of operation $t$. As a result, operational readiness can be calculated as follows:

$$G_{ОГ} = G_{Г} + P(t_{бр}) \quad (7)$$

**2.3 Determining technical usability ($G_{ТИ}$)**

Technical usability is the time during which the construction machine is in a state of normal working capacity. It can be determined by the ratio of the total time during which the construction machine is in working condition to the product of the total number of construction machines designated for operation(*N*) and the designated time for normal operation ($T_{не}$).

$$G_{ТИ} = \frac{\sum_{i=1}^{N} T_i}{N T_{не}} \quad (8)$$

- $T_{не}$ - normal operating time, consisting of the periods of time for operation, maintenance and repair

At different values of $T_{не}$, according to formula (9) the value of technical usability for each construction machine can be determined.

$$G_{ТИ} = \frac{T_t}{T_t + T_p + T_o} \quad (10)$$

- $T_t$ - total operating time of all construction machines
- $T_p$ - total downtime due to planned and unplanned repairs on all machines
- $T_o$ - total downtime due to scheduled and unscheduled maintenance of all construction machinery

It is important to note that this formula does not include downtime due to organizational reasons. This is because these reasons are not purely technical in nature and may not be taken into account when analyzing the reliability of the construction machine..

From the formulas for calculating the readiness $G_{Г}$ and, if we determine the average resource $T_{ср}$, of the construction machine, we can calculate the technical usability $G_{ТИ}$ according to the following dependence

$$G_{ТИ} = \frac{T_{ср}}{T_{ср} + T_в + T_{пп} + T_p} \quad (11)$$

Formula (11) could also be written in the form

$$T_{пп} + T_{op} = T_{cp} - \frac{G_{Г} - G_{ТИ}}{G_{Г}.G_{ТИ}} \tag{12}$$

To determine the average recovery time for all failures that occurred in the period between maintenance and scheduled repairs, but up to the time of starting a major repair, the following dependence can be used:

$$T_{в} = \frac{T_{cp}\left(1 - G_{Г}\right)}{G_{Г}} \tag{13}$$

$$T_{в} + T_{пп} + T_{op} = \frac{T_{cp}\left(1 - G_{ТИ}\right)}{G_{ТИ}} \tag{14}$$

$$T_{пп} + T_{op} = T_{cp} - \frac{G_{Г} - G_{ТИ}}{G_{Г}.G_{ТИ}} \tag{15}$$

The above formulas (13), (14) and (15) provide sufficient accuracy and clarity when necessary to calculate the duration of all types of technical maintenance and repairs. This option guarantees a good level of planning for the construction machines that would be involved in the implementation of the construction process for the construction of main pipelines while ensuring compliance with a high level of reliability.

## 3. Conclusion

The level of reliability of a construction machine is determined by its design, technical and technological characteristics, as well as by its method of operation.

The level of high technological capability of the construction machine and its construction is determined by the ratio of the indicators achieved during its production related to the values of the technical specifications and indicators previously determined at the design level. These indicators may include the use of typical technological processes for production, various forms of current maintenance, repairs, the use of standard and unified parts of various assembly units, assemblies and aggregates and their interchangeability, the need for spare parts, materials used, accessibility to the elements of the machine's construction when troubleshooting and during its maintenance and repair, labor intensity during operation and repair, the cost of its productivity, etc..

The level of technological efficiency in the operation process is characterized by its adaptability to working conditions, operational indicators, general or related to a unit of time or unit of production.

With the formulas and dependencies shown in this article, the specific generalized reliability indicators of construction machines used in the construction process of main (transmission) pipelines can be determined with a high degree of accuracy and correctness. This provides new opportunities for optimizing planning and determining the exact type and number of necessary construction machines and creates a basis for further, more effective research into these processes.

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