Methodology for collecting information in the study of vehicle safety

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Abstract. The article proposes a methodology for collecting information about the reliability and safety of the car during its operation. The proposed method allows manufacturers and motor transport enterprises to predict vehicle failures, determines the time period for its approach to current repairs and other types of technical impacts. Recommendations are given for determining reliability indicators, as well as part of the mathematical apparatus for calculating intervals and the probability of failures.

1 Introduction

Road transport and urban ground electric transport are an important part of the transport system of the Russian Federation, the effective functioning of which creates the necessary conditions for the modernization and innovative development of the national economy, to ensure that the transport needs of the population are met, as well as for Russia's integration into the world economic system. Road transport also determines the ability of the state to create conditions for equalizing the socio-economic development of the regions and ensuring the connectivity of the territory of the state.

The task of modernizing the Russian economy provides for a transition from an export-raw material to an innovative socially-oriented development model, the creation of conditions for the integration of the Russian Federation into the world economy, the transition to a full-scale implementation of import substitution programs in the country's economy. Under these conditions, increasing the requirements for the quality of transport services and ensuring the safety and sustainability of the functioning of the transport system is a modern challenge facing automotive and urban ground electric transport and requiring a clear definition of priorities, goals and objectives for the development of road and urban ground electric transport, as a sub-sector of the transport complex countries [1-2].

The equipment used in production is characterized by a significant dispersion of reliability indicators due to the instability of the quality of new or repaired machines and various operating conditions. As a result, all indicators of the reliability of any production equipment belong to the category of random variables, the processing and calculation of which is carried out using the methods of probability theory and mathematical statistics [3].

There are several methods for processing information. Some of them (for example, the maximum likelihood method) are complex, time-consuming, and require the use of electronic
computers. The use of such methods in production and at repair enterprises for processing information about the reliability of equipment is not only difficult, but also impractical, since their accuracy exceeds the accuracy of the original information [4].

The information processing methods recommended below are simple and reliable. They can be used by specialists in solving practical problems of assessing the reliability of machines [5].

The reliability of a car is its property to perform the specified functions, while maintaining its performance within the specified limits for the required period of time. The synonym is safety.

The main indicators characterizing safety can be guided by GOST 13377-75, these are such indicators as: failure, durability, resource, service life, time between failures, probability of failure-free operation. Performance indicators will be productivity, economy and profitability.

The solution to the problem of car safety is possible only if broad and reliable information is provided about the behavior of the car in operation, about the actual service life of its components, assemblies and parts, about the reasons for the emerging needs for repair effects. To do this, it is necessary to carry out proper accounting and, based on the analysis of its data, outline the main ways to improve the safety of cars.

2 Materials and methods

Complete and reliable information about the reliability of the car in real operating conditions will also benefit the factories that produce cars.

At the same time, for a car, an important problem of reliability has another important issue - this is its traffic safety.

The methodology aims to organize and collect information during the study of vehicle safety in real operating conditions.

The following sequence for collecting information is suggested:

1. Determine the number of cars required for a statistical sample. So the number of cars should be sufficient to determine and justify reliability indicators using probability theory and mathematical statistics.

2. Establish the required list of accounting documentation based on the analysis of all documentation. This documentation will be the source material for collecting statistical information on vehicle failures.

3. Determine the period for which it is necessary to collect information on the reliability of cars. The period will depend on the tasks set during the study and is usually equal to the mileage of cars before overhaul or before write-off. You can also use the method of one-time surveys.

4. Design and fill out a form for each car. In this form, include failures eliminated during the current repair of cars. Information on failures must be entered in the form: the date and reason for the failure, the mileage of the vehicle and units to failure, the number of failures, the catalog number and the complexity of repairing failed parts, the time spent in the repair of units and vehicles. Based on this form, all the information recorded in it is classified, it is possible to determine the failure rate, the failure flow parameter.

5. Develop and fill out the second form, which provides for the collection of information on vehicle maintenance. This form is compiled for each car and will allow you to determine the frequency of car maintenance for the selected period. When collecting information on vehicle failures in the first and second forms, it should be taken into account that a defect discovered and eliminated during the next maintenance of a vehicle that is not included in the nomenclature of this
maintenance should be considered a failure of the part (assembly, unit) in which the defect occurred. Therefore, it is necessary to analyze the consumption of spare parts in the production of vehicle maintenance. Each part replacement made during maintenance is considered a failure.

6. Develop and fill out the third form based on the above forms and according to the provided forms, and according to the provided classification of units, systems, groups of car parts. The so-called third form is filled out twice and includes the first failures of units, systems, groups of parts of each vehicle and all vehicle failures for the selected period. This form should provide for a certain classification of groups of parts, assemblies and systems of the car. The form shows the failure rate of cars depending on the mileage. The run interval is 5,000 km when rolling, then 15,000 km.

7. Design and complete the fourth form. It contains indicators on the operation of vehicles for a selected period of time and is filled in for each vehicle. Summary indicators in the form: total mileage of cars, mileage with cargo, weight of the transported cargo, car-days on the line. Generalizing indicators in the form are the mileage utilization coefficient, the load capacity utilization coefficient and the product of these coefficients.

8. Determine the safety-critical units and analyze each element separately according to the reliability criteria.

9. Organize monitoring of the details of units critical for reliability. To do this, it is necessary to determine the group of vehicles under study and the observation period, clarify the number of observed parts and select the necessary tool for micrometation. At each failure, the parts are measured and the measured data is compared to specifications. The measurement data is recorded in a micrometer card and determines the degree of use of the resource of the part by the time of its failure.

10. Take photographs of parts, assemblies, assemblies that have characteristic defects in case of vehicle failures. Plates are attached to the details, in which the car number and the date of refusal are recorded.

11. Enter information on failures of parts of each item in the form. This is how a short calculation method is given.

The most rational number of intervals used in practice is \( n = 6 \ldots 14 \).

All intervals should be the same, convenient in width, adjacent to each other and not have gaps.

With regard to information on the pre-repair resources of vehicles:

\[
 n = \sqrt{N} \pm 1, \tag{1}
\]

where \( N \) is the amount of information.

The width of the interval "A" is approximately determined by the formula:

\[
 A = \frac{t_{\max} - t_{\min}}{n}, \tag{2}
\]

where \( t_{\max} \) is the maximum value of the random variable; \( t_{\min} \) is the minimum value of the random variable.

The statistical series is a table of 4 rows. The first line indicates the boundaries of the intervals, the second - the number of cases of hitting a random variable in each interval (frequency) \( m_i \), the third - the experimental probability \( p_i \) of the random variable, the fourth - the accumulated experimental probability.

Experienced probability is defined as the ratio of the number of cases \( m_i \) to the total amount of information \( N \).

\[
 p_i = \frac{m_i}{N}, \tag{3}
\]

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\]
where $m_i$ is the number of cases in the interval.

The average value is the most important characteristic of the reliability index. On the basis of average values, the planning of the operation of machines, the determination of the scope of repair work, the preparation of requests for spare parts, etc. are carried out.

In the presence of a statistical series, the average value of the reliability indicator is determined by the equation:

$$
\bar{T} = \sum_{i=1}^{n} t_{ci} \cdot p_i, \quad \text{ (4)}
$$

where $n$ is the number of intervals in the statistical series;

$t_{ci}$ is the value of the middle of the $i$-th interval;

$p_i$ is the experimental probability of the $i$-th interval.

After determining the pre-repair resource, it is decided that the mathematical expectation of the studied reliability indicator, since in practice it is impossible to conduct tests for the entire general population, but an error is allowed, the value of which will be determined below.

The accuracy of calculating the average value increases as the repetition of information increases, approaching its limit - the mathematical expectation.

The root-mean-square deviation is an absolute characteristic of the dispersion of the reliability indicator, which makes it possible to move from the total population to the reliability indicators of individual machines. In the presence of a statistical series of information, the standard deviation is determined by the equation:

$$
\sigma = \sqrt{\sum_{i=1}^{n} (t_{ci} - \bar{T})^2 \cdot p_i} \ldots \quad \text{ (5)}
$$

### 3 Results and discussion

Information on the developed forms is collected directly from motor transport enterprises. In this case, the observer must be present during the elimination of each failure. The work of the observers should be organized in two shifts, since the elimination of failures during the current repair of vehicles is carried out in two shifts.

In order to ensure the necessary reliability of information, the observer should work in close contact with the engineering and technical staff of the motor transport enterprise, instructing them to monitor certain units and parts of vehicles during their disassembly, systematically analyze and check the data received on the spot. In order to familiarize the engineering and technical workers of a motor transport enterprise with the tasks assigned to them during observations, a memo should be developed - a brief instruction on collecting information in case of vehicle failures.

### 4 Conclusions

The proposed method for collecting information on the operational reliability and safety of vehicles can be used in motor transport and other enterprises. At the same time, this basis is an algorithm for developing a program for calculating it on a computer with further conclusions and recommendations. And this basis is an algorithm for developing a program for calculating it on a computer with subsequent automation of this process.

### References


