

## RAILS' QUALITY IS GUARANTEED BY SUPPLY CONTRACT

**Palkin, Sergey V.**, TC EvrazHolding, non-profit partnership Association of Railway Machinery Manufacturers (NP OPZhT), Moscow, Russia.

**Kozyrev, Valentine A.**, Moscow State University of Railway Engineering (MIIT), Moscow, Russia.

### ABSTRACT

Using the example of track circuits operation, the authors consider the reliability factors of technical means in relation to train traffic safety. The dependences of technical requirements for operation and production of rails, reliability and quality indicators, standards and rules, designed to ensure a systematic order at the level of interaction between

the producer, supplier and consumer of the product, are assessed. Particular attention is drawn to the possibility of building relations on the basis of a supply contract, which allows to introduce quality guarantees in terms of gamma-percentage service life, to agree special requirements to the operational properties of rails and the operating conditions themselves.

**Keywords:** train safety, rails, reliability, life cycle, quality guarantees, gamma-percentage service life, prevention of defects.

**Background.** It is known that annually on the network of railways there are many thousands of train schedule failures due to equipment failures. In addition to economic losses, the level of such failures is also a characteristic of the state of preventive work to ensure traffic safety. Often, according to the laws of dialectics, the quantity here goes into quality, which leads to more severe consequences than mere failure, to cases of train wrecks and human losses.

The implementation of the task of increasing reliability of technical means, relevant for such cases, should be present at all stages of the product life cycle. To this end, in all newly developed product standards, in determining quantities consumed by rail, special requirements for reliability indicators have been introduced. Unfortunately, there are very few analogous examples in the field of standardization of the very processes of rail transportation. They are still not subject to assessment for compliance with traffic safety requirements, and these requirements themselves have not been reflected in the relevant technical regulations.

**Objective.** The objective of the authors is to consider the issues of quality guarantee in terms of railway operation.

**Methods.** The authors use general scientific and engineering methods, statistical method, comparative analysis, evaluation approach.

### Results.

#### 1.

In the period of operation, the indicators of reliability, durability, maintainability and their derivatives are of great practical importance. For example, the standard for rails GOST R51685–2013, in contrast to the similar version of 2000, provides for requirements for verification of reliability indicator for certification, gamma-percentage resource, criteria for maintainability, weldability, controllability etc. are introduced.

Together, the technical requirements for rails in the national standard of 2013 comply with the requirements of international standards EN and AREMA, and in terms of gas saturation characteristics of steel, the classification of species and the magnitude of non-metallic inclusions exceed the level of world standards.

Reliability indicators are complex, taking into account the cumulative effect on the quality of all technical requirements. In the level of reliability, the degree of completeness of performance of technical requirements for rails is reflected, and confirmation of compliance of rails with reliability

indicators in the process of operation becomes a process of a kind of voluntary certification, enforcement for which by legislation on technical regulation is prohibited.

The determination of the actual value of the reliability index in real operating conditions requires a period of time comparable to the duration of operational fitness of the product. For these reasons, reliability indicators, as a rule, are not mandatory product safety requirements, which are assessed for compliance with these requirements.

Such compliance is regularly confirmed by the manufacturer with the results of acceptance tests and certified by a quality passport which objectivity is certified by the reception representative from JSC Russian Railways, represented by the inspector-receiver of the CTA.

All established technical requirements provide quality assurance for rails' manufacturers. The totality of such guarantees can be conditionally divided into two main groups. The first is quality assurance, coming under the provisions of civil legislation, and the second – additional guarantees outside of obligations under law. They are called competitive, having commercial character, and come, as a rule, outside the warranty period established by normative-legal and technical documents.

In section 9 of GOST R51685–2013, the warranty period for rails is calculated by the number of tons of goods that have been processed (hours worked), this amount can be determined by the terms of the supply contract. Depending on the category of rails and the radius of the curves of the sections of the track, the warranty operating time under item 9.2 is from 320 to 500 million tons gross.

Under new conditions from manufacturers, the warranty liability is valid outside the established in GOST operating time. On the rails of new categories of DT, the warranty hours worked is additionally increased by 1.4 times from the normative – up to 700 million tons gross tonnage processed in the straight sections of the track and up to 350 million tons gross in the curved sections.

The current conditions of the guarantee for rails in the Russian Federation in terms of indicators and content have no analogues in world practice and far exceed them. And, guaranteeing the compliance of its products with technical requirements for all established indicators, domestic manufacturers have in mind the real achievement of reliability indicators in rails in operation.

Nevertheless, according to JSC RZD, due to defectiveness, about 100 thousand rails in 25-meter



calculation are excluded from operation annually. In fact, this number is about 1,5 times higher. On the seized rails defects reached such a limiting state that their operation is inadmissible precisely under the conditions of traffic safety.

To replace defective rails, which constitute about 0.5 % of all laid on the infrastructure of Russian Railways, about 3.0 billion rubles are spent each year. According to the experts of the CTA, about half of the seized rails have metallurgical reasons for formation and development of defects. And although there are no documents with objective data confirming such statements, against the backdrop of such statements, JSC RZD regularly offers a variety of proposals to strengthen the manufacturers' liability, up to creation of conditions under which replacement of all defective and severely defective rails will be carried out mainly at the expense of manufacturer or supplier.

However, giving great importance to guarantee liability as an effective tool for motivation to improve the quality, competitiveness and commercial attractiveness of products, one cannot ignore the results of the actual implementation of the already existing warranty terms.

Thus, about 100 complaints of quality are issued by the operating departments of JSC Russian Railways annually, which is 0.1 % of all seized rails. Of the claims submitted, only 20 % are actually confirmed by metallurgical research, and as a result, annual claims of the manufacturers of JSC Russian Railways do not exceed 2 million rubles.

The given data testify that detection of defective rails is very weakly related to quality of manufacture, reliability of rails and to a large extent depends on quality of operation, attention to the rail as a high-tech product, which requires strict adherence to technological rules.

The incompatibility of data on the number of seized rails and recognized warranty cases, apparently, does not cause aspiration to improve the operating conditions of rails. Relying only on the amount of expenses for the early replacement of rails, the opinion is increasingly being formed that it is necessary to further improve the quality requirements and strengthen the guarantee liability of rail manufacturers. At the same time, foreign experience is not considered, the circumstances under which the level of guarantees on the rails is so unprecedented in world practice are not taken into account.

The most effective, in the opinion of certain specialists of JSC Russian Railways, can be introduction of quality guarantee on the rails according to the gamma-percentage service life indicator. It is believed that by identifying this discrepancy in operation, it will be possible to demand from the manufacturer not only compensation for a separately seized rail, but also a complete replacement and compensation of expenses for the whole lot of substandard rails. It is important to prove the discrepancy of each unit of production in a defective lot.

Obviously, replacing a batch of rails in service costs a lot of money. But even these costs, huge and unacceptable for business, without system solutions for operating conditions of rails, will not provide Russian Railways with the required reliability of the railway track.

## 2.

The main problems that require a solution to introduce quality assurance in terms of gamma-percentage service life stem from an analysis of

existing contractual conditions, legal and technical prerequisites in regulatory and technical documents on rails.

The content of the term «quality assurance» is defined by articles 469 and 470 of the Civil Code of the Russian Federation, which establish the duty of the seller in transferring to the buyer the goods meeting the quality requirements and terms of the supply contract during the warranty period.

The established mandatory requirements are provisions of the legislation on technical regulation. In the case of rails, this is compliance with the requirements of technical regulations, which is documented by a certificate of compliance with a standard form issued by an accredited conformity assessment body.

Under the terms of the current supply agreement, the rails must be manufactured in accordance with GOST R51685–2013 (or 2000) and in accordance with the technical conditions agreed with the customer (JSC RZD), which, according to the provisions of the legislation on standardization, since July 2015 are the documents of the manufacturers with STO status (Organization standard).

These technical documents contain all the exhaustive technical requirements to which the rails under the supply contract must comply. The indicator «gamma-percentage service life of rails» is not established in the regulatory legal and technical documents for rails. For this reason, there is no reason to introduce a new quality assurance on properties to which the technical documentation does not contain the necessary requirements.

The problem of lack of reliability indicator and requirements for it can be realized by means of an agreement of the parties concerned on entering essential conditions into the supply contract. Based on such an agreement (producer and consumer), taking into account the mutual risks of increasing non-productive losses, the magnitude of the indicator and the corresponding guarantee liability are determined. The envisaged indicator will not have any relation to the normative value, since it is established arbitrarily and is contractual, its validity will require a certain analysis.

Mutual recognition of the results of risk assessment is expedient to carry out based on the analysis of an array of long-term data on the reasons for actual removal of rails from the track by categories, melting numbers and years of supply. But such a detailed analysis cannot be carried out because of the lack of orders from JSC RZD to VNIIZhT for relevant observations and scientific and technical studies that take into account the operating conditions, the track plan and profile, freight traffic intensity, climatic features of the railway lines, etc.

Insufficiency of data on reliability indicators of rails in operation does not allow to establish a really justified value for entering into technical and regulatory documents, as well as a supply contract, which would provide technical and legal grounds for introducing a guarantee liability for the indicator of gamma-percentage service life of rails.

For these reasons, it will be necessary to determine the value of the reliability index at first by calculations, and then by real exploitation. After the validation procedures with positive results, the gamma-percentage service life indicator should be entered in the established order in the legal

documents and technical conditions for manufacture of rails. Such work is not made within one year, it may take even several years.

Thus, on the experimental ring of JSC VNIIZhT with an annual operating time of 240 million tons gross, which significantly exceeds the maximum freight traffic intensity on the railway network and 6 times the average network, the rails of category DT 350 for two and a half years have reached operating time just above 600 million tons gross. This value is clearly insufficient to estimate reliability indicators, including gamma-percentage service life.

The available data from the reporting statistics of PCh for the removed rails characterize the reliability index of mainly rails of the category OT. For new categories of rails (DT), actual data due to a small volume of supplies do not meet the requirements of representativeness. For these reasons, the evaluation of the indicator of their reliability will be very conditional.

To obtain the value of the reliability index close to the real one, it is necessary to estimate the operating data of new categories of rails that should be at least 20–25 % of all used ones on the network. With the existing volume of supplies, it will take at least 3–5 years to fulfill these conditions.

### 3.

The lack of data on the actual operation of rails of new categories makes it very difficult to reach a consensus on changing the terms of the contract with establishment of the rail manufacturer's liability for gamma-percentage resource.

It is also not possible to apply the known experience of regression analysis of the polygon test data to establish the value of the gamma-percentage service life indicator due to the lack of a starting point in the form of the first failure of the tested rail DT 350.

The use of these tests is inadvisable because of differences in operating conditions of rails in a real operating railway track and on a test site.

Point 5.13 of GOST R51685–2013 (with amendment No. 1) established that the gamma percentage of operating hours of rails before failure is determined in the field tests, and for certification it should be 150 million tons gross with a gamma of 100 %, and then it is determined by the amount of operating time at reaching 80 %.

In accordance with point 6.9 in GOST 27.002–89 «Reliability in technology. Basic concepts. Terms and definitions» and point 70 in GOST 32 192–2013 «Reliability of railway equipment. Basic concepts. Terms and definitions» gamma-percentage operating hours before failure is the operating time, during which the failure of the object does not arise with a probability expressed in percentage.

The above definition from GOST confirms that the requirements for railway tracks in accordance with GOST R51685–2013 set the gamma percentage time between failures, which is used for certification, and not the indicator of gamma-percentage service life.

It is not entirely correct to apply the indicator of gamma-percentage service life to rails, since for rails the service life is determined not in the calendar calculation, but in terms of the amount of running time of the processed tonnage. Hence the correct indicator for rails is the gamma-percentage resource [1].

In the definition of a gamma-percentage resource, the concept of failure is sometimes used, which is not

entirely correct, since the concept of failure is more suited to the notion of failure-free operation. In the definition of the indicator of longevity, the concept of underestimating the limit state is used with gamma probability expressed in percentage. Failure and the limit state are absolutely different concepts and the second requires a whole system of own criteria. It is understandable that the development of a defect in the rail due to a poor-quality track panel without taking appropriate measures for maintenance and repair is problematic to incur under warranty liability after the rail reaches the limit state.

This indicator cannot be applied as an indicator of quality in operation, in which, in case of non-compliance, warranty liability may arise. The reason for this is definition of this indicator in special conditions of field tests, which differ significantly from the conditions of operation. For operating conditions, such an indicator is not yet known and there is no technical documentation for the rails.

The absence of such an indicator in normative legal documents on the rails is not accidental. After all, it is very difficult for the practical definition of its magnitude, the representation of it is ensured by the correspondence of all other indicators of the quality of the rails.

The gamma-percentage service life in accordance with GOST 27.002–89 in point 6.17 and point 101 according to GOST 32 192–2013 is the calendar duration of operation of the object, during which it will not reach the limit state with a probability expressed in percentage.

But even at a high similarity with the requirements of point 5.13 of GOST R51685–2013 to determine the operating time to reach a gamma of 80 %, this indicator obtained under the special conditions of the polygon tests cannot be applied to the conditions of actual operation to assess the quality assurance.

The definition of gamma-percentage service life implies the achievement of a certain limit state in the operation of rails. Point 2.5 GOST 27.002–89 and point 18 GOST 32 192–2013 establish that the limit state is the state of the object in which its further operation is unacceptable or impractical, or restoration of its operable state is impossible or impractical.

From the above definitions it follows that for rails the criteria of the limit state must be established. In point 2.6 GOST 27.002–89 and point 19 in GOST 32 192–2013 the criterion of the limit state is a feature or set of features established by technical and (or) design (project) documentation. The current technical documentation on the rails has not established such criteria and the very limit states of rails yet. The existing requirements for the removal of the rail from the track are determined by the regulatory legal documents of the consumer and have no relation to the technical documentation for the rails.

In GOST R51685–2013 and in the technical documentation used in manufacture of products, there are no criteria and descriptions of the limit states of the rails. The criteria used for limit states in determining the amount of operating time before reaching gamma of 80 % under the conditions of field tests cannot be used for evaluation in actual operation conditions due to significant differences.

### 4.

Limit states of rails in field tests using the method established the facts of the appearance of defects, according to which the rail is classified according to the classifier as defective or severely defective in







accordance with a certain code. Such a classifier, being accepted by JSC Russian Railways, was not coordinated with the manufacturer and compilers of technical documentation for rails.

In field tests, the appearance of a defect with a certain code according to the classifier is considered the limit state and the rail is taken out of the test track. In operation mode, the detection of a similar defect is not its limit state, and the rail is operated with a decrease in the speed of movement according to the established gradation, depending on the size of the defect. This continues to the limit state determined by the conditions of traffic safety.

The analysis shows that even if there were no requirements in the technical documentation for the rails, it would be possible, temporarily, for the period of their development and establishment to use the separate criteria for the limit state established for severely defective rails by the Russian Railways classifier. But at the same time the problem of establishing the value of gamma, expressed in percents, and the value of the tonnage of the processed cargo in real operating conditions remains unresolved.

The available value of the limit amount of rails' removal for the purpose of overhauling the track with a complete change of rails is expressed in the number of seized rails per kilometer of the railway track. The use of this indicator as gamma values, expressed as a percentage, contradicts the definition of gamma-percentage service life, which also provides for the amount of operating time.

For the value of the operating time, for the period of establishing the operational reliability indicators of rails, it is possible to take the tonnage to the capital repair with a total rail change of 700 million tons gross for rails of the category OT, and 1.5 billion tons gross for DT rails. Taking into account that such operating hours significantly exceed the established warranty under GOST R51685-2013, changes in the terms of the supply contract, including the indicators of operational reliability and quality assurance will be required.

When the parties (the producer, the consumer) reach such agreements before the railway units

operating the railway tracks, the problem arises of strict compliance with the laying of rails by categories, by fusions, taking into account the year of delivery.

In the event of warranty liability, the consumer has the right, under Article 475 of the Civil Code of the Russian Federation, to demand a commensurate reduction in the price of the goods, the uncompensated elimination of deficiencies within a reasonable time, or reimbursement of expenses for the elimination of deficiencies.

Under the terms of the guarantee, it is established that a 25-meter-long rail is taken as a unit of production, and if a warranty case on a rail of 100 meters is considered, then only part of it with a defect of 12.5 meters in length is recognized as not corresponding in quality. From here the following task arises – determination of gamma-percentage service life for rails of 100 meters, which is only possible in real operation.

The transition of a 100-meter-long rail into the limit state takes on a slightly different meaning than that described in the defect classifier for rails of 25 meters. It is not advisable to remove the entire 100-meter rail, for example, even for fracture. Therefore, the criteria of the limit state will have a completely different character than for rails of 25 meters in length. The development of these criteria is extremely important for introduction of quality assurance in terms of gamma-percentage service life.

The determinant to ensure the onset of the manufacturer's warranty liability on the indicator of the gamma-percentage service life of rails becomes strict compliance with the requirements of the operational document. Such a document is the operating manual prepared by RZD. Given that this document appeared for the first time, it significantly changed the old system of rails maintenance and contains a considerable number of compromise provisions, which are designed to promote operational reliability of rails.

According to the manufacturers of rails, the system of operation is absolutely unacceptable, when the consumer does not care about preventing defects

arising from natural wear and tear. In many cases, the system contradicts the requirements for the maintenance of rails at the initial stages of the occurrence of microdefects, especially those eliminated by local grinding. Preventive measures are not taken to the detected initial diagnostic tools. This practice contributes to the growth of defects and the development of wear and tear to the ultimate condition of the rail, which, in order to ensure safety, requires immediate removal from the track.

**Conclusions.**

1. The conformity of rails to actual reliability indicators is confirmed by the performance of a set of technical requirements, the assessment of which is carried out by acceptance tests.

2. The technical documentation for rails does not provide for normatively established indicators of reliability for operation.

3. Development of such indicators based on the requirements of standards (GOST and GOST R) and with the use of methods of verification and validation will be a guarantee of their achievement during the operation of rails.

4. The introduction of additional indicators of reliability on the basis of an agreement between the manufacturer and the consumer stipulates the process of reconciling the new product cost and the new quality, special requirements for the operational properties of the rails.

5. The expediency of introducing a quality guarantee by the gamma-percentage service life indicator should be assessed by the presence of a positive economic effect.

6. Warranty obligations for gamma-percentage service life can be realized only after the corresponding changes in the contract for the supply of rails have been made in a prescribed manner.

7. The supply contract should provide for the monitoring procedure, the frequency of the evaluation, the conditions for the objectivity of the results, the rules for disseminating the results to rails of different lengths, and certificates of compliance with the requirements of the operating manual.

8. The implementation of the requirements for the reliability index causes the strengthening of the operating manual for maintenance and maintenance of the rails in good condition.

9. The implementation of the quality guarantee by the gamma-percentage service life indicator requires the parties to adopt a special interaction procedure in identifying warranty cases.

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Information about the authors:

**Palkin, Sergey V.** – D.Sc. (Economics), Ph.D. (Eng.), Director for Technical Regulation of TC EvrazHolding, Vice-President of the non-profit partnership Association of Railway Machinery Manufacturers (NP OPZhT), Moscow, Russia, [palkin77@gmail.com](mailto:palkin77@gmail.com).

**Kozyrev, Valentine A.** – D.Sc. (Eng.), Professor, Head of the department of Personnel Management and Management of the Organization of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, [miit\\_menagment@mail.ru](mailto:miit_menagment@mail.ru).

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