Practical application of RAMS studies of brake systems

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Implementation of IRIS international railway industry standard (ISO/TS 22163) at national railway machine building enterprises entailed the study of such disciplines as products' reliability, availability, maintainability and safety management, including products' life cycle cost management (RAMS/LCC), project management, configuration management, etc. Significant work has been carried out at the enterprises for implementation of RAMS/LCC: development of the regulatory base, reorganization of activities, improvement of the employees' qualification, including participation in foreign workshops and sharing experience.

Topicality of the question of formation and confirmation of RAMS indicators

IRIS international railway industry standard (integrated into the scope of ISO) [1], namely section 7.11 "Reliability, availability, maintainability and safety/life cycle cost (RAMS/LCC)" [2], establishes for railway enterprises certain requirements covering aspects of RAMS activities, including:

— calculations and documentation;

— data collection, analysis and a plan of improvement activities;

— fulfilment of set tasks in accordance with the plan of activities.

The main targets of OAO MTZ TRANSMASH as a manufacturer of brake systems guaranteeing the safety of railway traffic participants with regard to the RAMS set of tasks are:

— identification of design and technological deficiencies of a product reducing its reliability as well as weaknesses in the organization of maintenance, repair and operation;

— improvement of products' design, their manufacture process, rules and standards of maintenance, repair and operation;

— checking conformity of the achieved level of the product's reliability to the established requirements (RAMS indicators verification);

— refinement of failure criteria and limit states of products;

— taking corrective and preventive actions in case of occurrence of non-conformities at a level ensuring unconditional elimination of reasons causing them and exclusion of their reoccurrence;

— assessment of the effectiveness of reliability improvement measures.

Solution of the above tasks makes it possible to achieve the key target – improvement of quality, reliability and consumer properties of manufactured products. Each series of studies is needed today and is infinite in the future. However, there are activities that we should pay special attention to.

The ASTO brake equipment manufacturers and consumers association with the support of NP OPZhT developed a "Regulation on monitoring of the quality of maintenance, repair and operation of railway rolling stock brake equipment" document. Its creation pursued targets to improve the reliability of operation of brake systems and railway transport safety because it is the reliability of products passing scheduled types of repair that is in unsatisfactory condition.

Obtaining by the manufacturer of objective data on operation of products remains important, which is an indispensable condition of fulfilment of the requirements of IRIS standard (ISO/TS 22163) for management and confirmation of RAMS and LCC indicators.

Organizing activities for collection, analysis and confirmation of RAMS/LCC indicators

Achievement of primary targets is based on the fulfilment of characteristic tasks:

1. Provision of the manufacturer of railway machinery, including selectors, with complete, reliable, continuous and timely information on failures of the manufactured products.

2. Recording, processing, classification of obtained information. Subsequent analysis by areas of interest, using statistical methods.

3. Development and implementation of technical (design, process) and organizational measures by a cross-discipline team. On the manufacturing site – Reliability Department (RD), Technical Control Department (TCD), Special Brake Building Design Bureau (SBBDB), Chief Technologist's Department (CTD), manufacturing shops or under a standing manufactured products' quality commission, including, if necessary, with the involvement of ancillary equipment suppliers and expert organizations.

4. Analysis of processed operational information on the effectiveness of implemented measures for improvement of quality, reliability and safety of brake equipment products.

Analyzing approaches for fulfilment of the set of functional tasks for brake equipment products' quality, reliability and safety management, we come to the conclusion that this activity should be based on the following principal stages [4]:

—observation planning;
— carrying out observations, monitoring;
— collection of operational data on products' reliability;
— recordkeeping and documentation of operational data;
— processing of an array of information;
— analysis of an array of information;
— calculation of reliability and safety indicators;
— verification of reliability indicators;
— development of corrective and preventive measures;
— assessment of the effectiveness of implementation of corrective and preventive measures.

The planning of periodicity of observations proceeds from the task to be solved and excludes information losses with a tolerance probability. For the purpose of a common approach to the development of observation programs, basic requirements to their content should be determined. The following information is recommended to be reflected in observation programs:

— targets and tasks of information collection;
— list of observed products;
— number of products;

— duration of observations;
— nomenclature of indicators on which information is collected;
— periodicity of examinations;
— timelines of performance of works;
— number and location of places of collection of information;
— requirements to information collection and processing methods;
— periodicity and reporting forms;
— list of enterprises and organizations from which information is received and to which collected and processed data should be sent.

The next stage, from the viewpoint of chronology, is the stage of immediate monitoring using which the carrying out of ongoing, periodic and one-time observations of brake equipment in operation is envisaged.

RAMS tasks in the information field

In existing conditions, active engagement of information systems for collection, recordkeeping and analysis of operational information for solving tasks of improvement of quality and reliability of all systems of railway rolling stock is one of priority targets. Principles of data collection and recording automation excluding the human factor together with objective analysis and provision of RAMS data allow us to consider this approach the most preferable and economically feasible.

Integration into the information analytic field and improvement of the existing information systems seems an entirely justified step. Specialists of the enterprise carry out on a regular basis monitoring of data received from KASANT, a complex automated system of recordkeeping, control of elimination of technical means' failures and analysis of their reliability, and the AS RB automated operation safety management system.

From the viewpoint of manufacturers of products for railway transport, the following information automated systems may be of additional interest:

— operation safety violation recording, ASU NBD;
— drivers' comments recordkeeping subsystem, ASUT NBD ZM;
— OAO RZhD locomotive resources management, ASU-T;
— OAO RZhD car complex management, ASU-V;
— special self-propelled rolling stock management, ASU SSPS.

Brake equipment quality and operational reliability management, as well as improvement of the transportation process safety in general requires, at the present stage of development, transition to the digital "plane" with automatization elements.

For the purpose of recordkeeping and documentation of operational data, requirements to the composition of recorded information should be established, as well as requirements to their forms should be regulated. To ensure the integrity of input data, primary information on a failure generally must contain the following minimum data:

— data of occurrence of the failure or problem;
— total service hours of the object from the start of its operation up to the time of establishment of the failure (identification of the problem);
— external signs and the nature of the occurrence of the failure or problem;
— conditions of operation and the type of work whereby the failure was identified or the problem was established;
— method of elimination of the failure and problem;

— taken or recommended measures for prevention of failures or problems.

The brake equipment operability recording form (fig. 1) has been successfully implemented and applied at the enterprise and is regulated by instruction No. 11-05 "Collection and processing of information on products' reliability in operation".

For the purpose of creation at the enterprise of an efficient information field in the sphere of ensuring the quality, reliability and safety of the manufactured equipment, we will single out the following sources of primary information:

1. Results of investigation of failure events in accordance with the requirements of STO RZhD 1.05.007 "Claim management. General procedure" which establishes the procedure of calling and reception of a representative of the supplier and contractor, rules of preparation and recordkeeping of claim documents (claim report, study report, technical means refurbishment certificate) and their standard forms as well as the procedure for refurbishment or replacement of defective goods, procedure for studying reasons for the occurrence of defects for the purpose of substantiation of the lodged claim for the goods' quality and completeness.

2. Information on scheduled maintenance and scheduled repairs.

3. Information on service hours from the start of operation and after the performance of scheduled repairs.

4. Nameplate data for products mounted on rolling stock.

5. Conformity to operating conditions and nominal ratings.

RECORDKEEPING OF INFORMATION ON RELIABILITY OF LOCOMOTIVE BRAKING DEVICES IN OPERATION AND COMMISSIONING

Fault of OAO MTZ TRANSMASH | Fault of a third party | Claim has not been confirmed

Item No.	Date of notification of the claim	Responsible notification management department	Notification No.	Place of identification of the failure	Locomotive series	Locomotive serial number	Product (node, part) name	Product designation (drawing number)	Product serial No.	Date of manufacture	Service hours until failure (ths km/h)	Brief description on the notification	No. reply to the claim	Reply date	Locomotive idle time	Defect category (manufacture, operational)	Scanned files (PDF)	Party in fault	Established defect	Corrective and preventive actions			Note
																				Responsible department	Scanned document (PDF)	Brief description of performed corrective and preventive actions	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Fig. 1. Example of a locomotive brake equipment reliability data recording form

When developing requirements to a modern information system, a number of significant functions has to be ensured:

— Identification of unserviceable equipment, failure types and reasons. Tracking of the dynamics of changes in their number – not only in absolute values but also in values reduced to a unit of rolling stock or respective service hours (or kilometers travelled).

— Efficient system of communications between design and engineering departments, manufacturing departments and organizations as well as operating and repair enterprises for the purpose of prompt solution of tasks to improve the level of quality, reliability and safety of railway transport

products. It is recommended to engage research and expert organizations in the data exchange and solution development system, if necessary.

— Calculation, formation and confirmation of the quantitative RAMS indicators in accordance with the established nomenclature, including checking the conformity of the achieved reliability level to the established requirements.

— Comprehensive and objective study of reasons for the occurrence of failures and processes of development of an impairment of serviceability of rolling stock, including deviations from rated values, outward appearances, reasons and consequences of failures.

— Correct assessment of the life of the manufactured equipment under existing operating conditions. It is particularly topical for products with the cyclic type of loading which is represented by brake equipment.

— Cross-discipline analysis of the effectiveness of implementation of measures for elimination or reduction of the rate of failures, problems of certain products, including measures for exclusion of reoccurrence of such failures.

At present, written notifications, telegrams and claims on facts of failures of technical means are the data sources for a developer. Based on them, analysis of the completeness and reliability of obtained information is carried out; the information is refined and detailed, if necessary. As a part of the decisions made, on-site visits by qualified specialists are paid or the product is returned for its further studying at the enterprise.

Collection and recordkeeping of operational data is immediately accompanied by the processing of the obtained array of information, which is conditioned by such priority tasks as generalization and structuring as well as control of its reliability and completeness.

The structure of activities for processing of information includes:

— classification and codification of input data;

— control of the completeness, reliability and homogeneity of information;

— adjustment of input data (if necessary);

— transfer of input data content to the enterprise's information field;

— assessment of reliability indicators;

— classification of failure reasons and limit states by types associated with manufacture, repair and operation, their analysis;

— preparation of input data for development of measures aimed at identification of deficiencies and improvement of products' reliability in operation.

In the course of analysis of reasons for failures and limit states of brake equipment, systematization of the processed information by key attributes (operating conditions, service hours, etc.) is carried out. As a result, we have the opportunity to make an objective assessment of the effectiveness of design and process and (or) organizational measures, identify cases of violation of requirements of operational documentation and develop a plan of recommendations for elimination of identified deficiencies.

Based on the results of operational information analysis, calculation of brake equipment reliability and safety indicators – verification of their reliability indicators rated in respective technical specifications is carried out. Fulfilment of set tasks proceeds from provisions of RD 50-690-89 "Methodology guidelines. Industrial product reliability. Methods of assessment of reliability indicators, using experimental data" [5].

In the area of analysis and calculation of technical means' reliability, deficiencies do exist. For the purpose of their elimination, uniform provisions on calculation and confirmation of RAMS

indicators should be developed, since requirements of GOST 27.301-95 "Industrial product reliability. Reliability calculation. Basic provisions" do not reveal the matter [6]. Developed provisions will bring the calculation process and results submission forms to a unified form and ensure the possibility of their reproduction and review. Specifically, these measures will exclude the point of disagreement when comparing RAMS indicators between interested parties for reasons of different methodologies of their assessment.

It common practice to carry out mandatory assessment of the effectiveness of implementation of corrective and preventive measures. If negative assessments of efficiency of the implemented measures are received, the failure management procedure is restarted until a positive effect is achieved.

Thus, as a result of implementation of RAMS study tools at the enterprise, a system approach to quality, reliability and safety management of the manufactured products has been developed. Key factors adversely affecting the operability of brake equipment at operation and after-sales maintenance stages have been identified. This knowledge has made it possible to focus the efforts of specialists on problem points and has made it possible to transfer such factors into a controlled plane.

In quantitative assessment, such criteria as a trend toward reduction of failures in a locomotive complex, the possibility of extension of warranty periods and turnaround intervals for newly developed brake equipment products may serve as a positive effect of implementation of the system approach to product life cycle management beyond the enterprise.

Data of the KASANT complex automated system of recording, control of elimination of technical means failure and analysis of their reliability may be considered as an objective evidence of the results of implementation of RAMS management processes.

Let's consider by the example of brake equipment mounted on freight railway rolling stock. In Figure 2, positive dynamics of the change in the number of attributed failures in the KASANT automated system is evident.

The same positive trend is observed in the locomotive complex as well. Based on the results of verification over the past reporting periods, the achievement of key reliability indicators (failure flow parameter) rated in the technical specifications was identified for the entire complex of brake equipment mounted on 2ES6 freight twin-unit DC electric locomotives and 2TE25KM freight main haulage twin-unit diesel locomotives, and 2TE25A "Vityaz". Specifically, according to the distribution of autobrake equipment failures on warranty-covered 2TE25A diesel locomotives over 12 months of 2016-2017, reduction of the number of failures reached 44%.

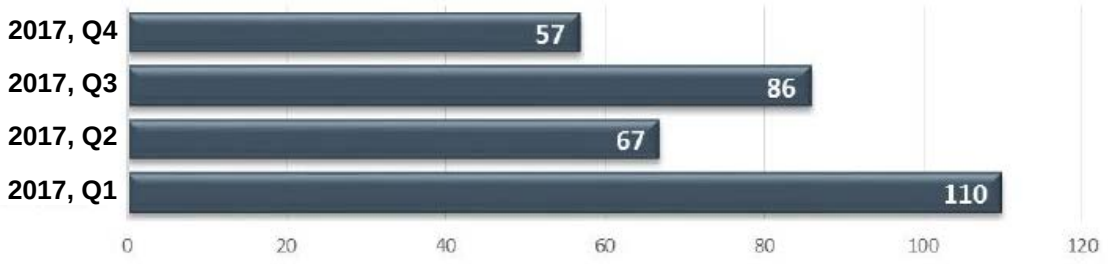

Fig. 2. Dynamics of the change in the number of attributed failures in KASANT

The concept of brake equipment quality, reliability and safety information flows

The structure and order of formation of information flows are based on principles of cyclic management (Fig. 3).

The architecture of collection quality, reliability and safety data of brake equipment manufactured by OAO MTZ TRANSMASH

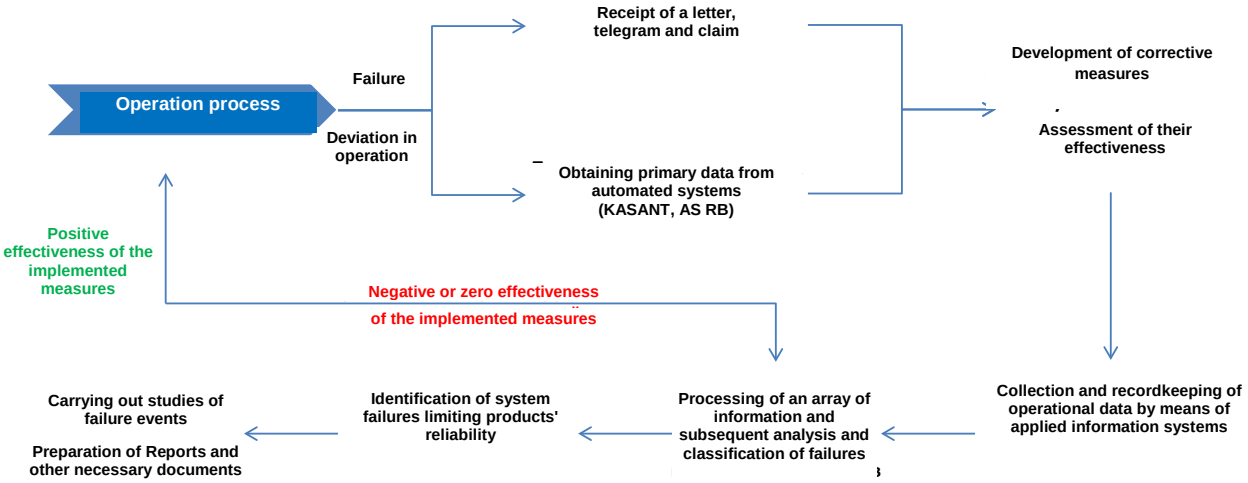

Fig. 3. Information collection architecture

In the course of the process of both warranty and post-warranty operation, targeted observation of operability of brake devices by way of receipt of claims, telegrams and notifications as well as data from information automated systems such as KASANT and AS RB is carried out. Carrying out studies of reasons for failures by highly qualified employees makes it possible to obtain objective information on reasons that initiated adverse events in the form of a failure. The efficiency of application of data is ensured by creation of a single information space at the enterprise with access for and areas of responsibility of respective departments.

The distribution of information flows is built depending on the stage of the product's life cycle (Fig. 4).

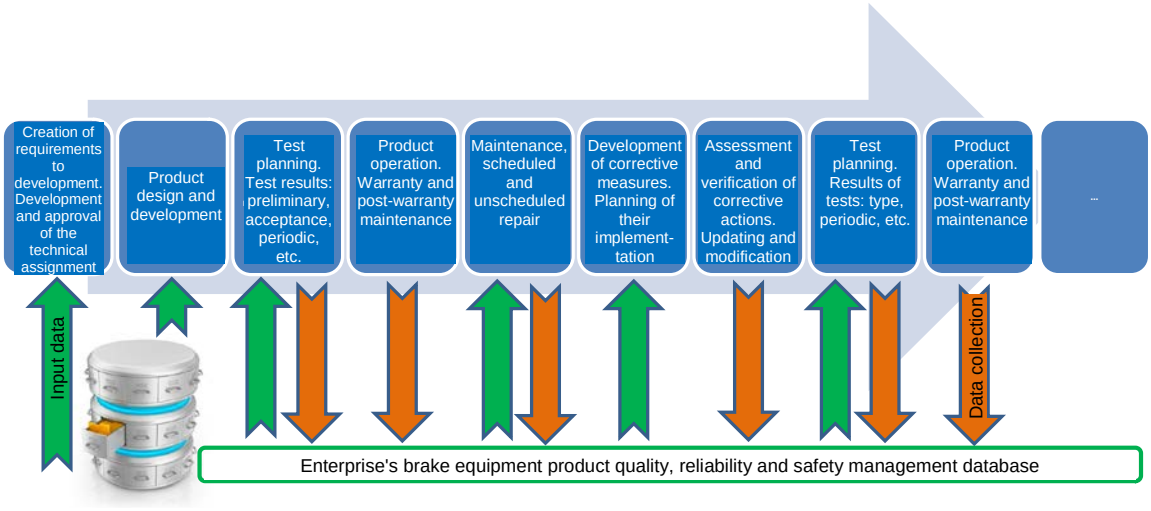

Fig. 4. RAMS data at life cycle stages

At the dawn of a concept and at the stage of pre-project working out of technical solutions, a certain component of the array of information on reliability and safety of such functional systems is used. The technical assignment is developed and approved, indicating target values of technical characteristics of the object being designed. In the course of designing and development, proven design solutions that accounted well for themselves on operated rolling stock are used among others.

Necessary information regarding conditions of operation and loading modes is taken from the single database for correct and efficient planning of control tests on the works' test-bench equipment. Establishment of a testing plan based on substantiation of operation requirements is especially necessary for products with the cyclic form of loading. Verification of reliability and safety indicators at stages of attestation of research and development works in conditions close to operating makes it possible to minimize the expenditure of both material and labor resources at later stages.

Formalized records of results of tests of various nature (preliminary, acceptance, periodical, etc.) are fixed within the single base, processed and analyzed. Subsequently, data obtained as a part of bench tests is compared with actual operating indicators. Based on the results of the comparative analysis, testing methods may be reasonably adjusted, if necessary.

Warranty and post-warranty stages of operation provide the opportunity to get a full and objective picture of achieved indicators of quality, reliability and safety of the manufactured products. However, in addition, quality and timeliness of maintenance factors, impact on a product's operability of scheduled and unscheduled rolling stock repairs and, of course, conformity to the established operation conditions should be taken into account. The effectiveness of communications of the developer enterprise with operating and repair organizations is the primary factor of improvement of the scheduled preventive maintenance and repair system. One can judge on the degree of impact of these factors on the operability of railway transport facilities, based on available statistical data.

Using the adopted data base management system and established procedures, important data relating to each failure are recorded, and the process of their processing is initiated. Necessary corrective actions are jointly determined, including tracking of the development and implementation process and the results of a corrective actions plan aimed at reducing the probability or complete exclusion of reoccurrence of the failure. Reversely, the information flow on the assessment and control of taken corrective measures is formed.

Making changes to the basic configuration of products is pursued by mandatory actions for planning of tests, type tests in the present case, as well as carrying out such tests with recording and analysis of obtained results based on which a decision on implementation is made. Subsequently, the quality, reliability and safety management process follows the described processes with a random frequency up to discontinuation of these products and their disposal. The built-up database for such product will be subsequently used as input information for perspective projects.

The described complex approach will make it possible to move toward digital control, since it is the quality and reliability of designed and manufactured sophisticated technical systems for railway transport responsible for railway traffic safety that are the most important target of all participants of the life cycle.

List of References

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