New conceptual approaches to process management of an integrated management system in the refining industry

Sofia A. Tsareva

Candidate of Chemical Sciences, Associate Professor
Yaroslavl State Technical University, Yaroslavl, Russia
E-mail: tsarevasa@ystu.ru

Yuri V. Tsarev

Candidate of Chemical Sciences, Associate Professor
Yaroslavl State Technical University, Yaroslavl, Russia
E-mail: tsarevyuv@ystu.ru

Daria A. Poletova

JSC "R-Pharm" Production quality assurance specialist
Yaroslavl, Russia
E-mail: poletova.da@mail.ru

Abstract. The paper considers the issues of statistical process management of an integrated management system of a refinery under the conditions of a new conceptual approach of integration of statistical and qualimetric methods. The authors pay special attention to the scientific and methodological justification of the management processes of an integrated management system in the context of sector specific features. The authors show, using as an example the construction of control charts of individual values and sliding differences in Statistica Trial 13.3 for the process "Manufacture of products", that the highest correlation is characteristic for such quality indicators as kinematic viscosity at 700C and fractional composition 50%. Therefore, the process "Manufacture of products" should be managed and brought into a statistically manageable state by changing the values of the quality indicators noted. In order to ensure the stability of the production process and to improve the overall functioning of the IMS, the parameters of the main processes should be monitored regularly. The results of this methodical approach to process management will allow the justified corrective action for the effective functioning of the integrated management system, as well as increase the competitiveness of the enterprise.

Keywords: Statistical process control, integrated management system, quality control system.

JEL codes: C13, L15, L64

For citation: Sofia A. Tsareva & Yuri V. Tsarev & Daria A. Poletova (2022). New conceptual approaches to process management of an integrated management system in the refining industry. *Journal of regional and international competitiveness*, 3(3), 69. https://doi.org/10.52957/27821927_2022_3_69

DOI: 10.52957/27821927_2022_3_69

Introduction

Modern conditions, expressed in dynamic and complex management structures, determine the need to introduce modern mechanisms in order to improve the integrated management system, enhance the quality of the products, as well as increase competitiveness in the market segment. An integrated refinery management system is of considerable interest in this context. This system allows the implementation of a wide range of production tasks, the effectiveness and efficiency of which has been the subject of research. Integrated management systems are nowadays the most effective for increasing a company's competitiveness (Štofová, Szaryszová & Vilámová, 2017; Samoilenko, 2021; Salimova, 2019). Many researchers consider enterprise competitiveness in terms of the sustainability of enterprise business models and organizational management systems. Integrated management system models should be seen as the most effective and efficient ones (Salimova & Biryukova, 2020). This is explained by the fact that increased competition is affecting new production methods and shorter product life cycles, forcing manufacturing companies to adapt in a rapidly changing business environment by adopting a process and system approach. Transparency, better manageability, and continuous improvement of the company's activities are ensured by documenting, monitoring, and analyzing processes in accordance with the requirements of the international standards.

One of the effective methods for improving the performance of integrated management systems (IMS) and their processes is to introduce statistical methods for assessing and managing the processes.

Statistical methods are tools for collecting and processing data, as well as information about quality. The main purpose of the use of statistical methods by many industrial enterprises is to minimize process variability.

An analysis of the literature on research in the field of process control of integrated management systems shows a wide range of methodological approaches, among which statistical and qualimetric methods are actively used in various industrial sectors (Lahuta, Kardoš & Hudáková, 2021; Suarez-Paba & Cruz, 2022; Shtovba, 2020; Tsareva & Yuzhakova, 2018; Terano, Asai & Sugeno, 1989).

It should be noted that statistical methods are widely used at all stages of the product life cycle. However, each stage requires an individual approach to the selection and implementation of a particular method. Figure 1 shows the use of static methods of product quality management at the relevant stage of the product life cycle.

Table 1 – Application of statistical methods at each stage of the product life cycle

Marketing	QFD method, stratification, correlation and regression analysis
Projecting	7 simple tools, Taguchi methods, QFD method, stratification, FMEA analysis
Planning and design	Taguchi methods, expert judgement, FMEA analysis
Purchasing	Taguchi methods, QFD method, Ishikawa chart
Production	7 Simple Tools, Taguchi methods, analysis of variance and correlation, repeatability indices
Quality Control & Testing	Quality Control Sampling, QFD Method, 7 Simple Tools
Packaging & Storage	Acceptance Random Inspection
Product Delivery	Mass Service Theory
After Sales Activities	7 simple tools
Disposal	QFD method

Source: composed by authors

The relevance of the research subject is caused by the activity of oil refineries. Increasing of production efficiency and products competitiveness are achieved by improving the automated quality control systems as finished products so as raw materials in terms of implementation the statistical process control and quality indicators correlation analysis.

It is necessary to analyze the applied methods of integrated management system processes, develop a conceptual model of statistical management for enterprise activity improvement, and increase of effectiveness and efficiency indicators of IMS processes in connection with functioning of quality control systems at the oil refining industry.

The input information for statistical control contains the values of the quality indicators that determine the finished product quality. Quality measurements are made at various stages of the process cycle and processed in automated systems for industry management. The traditional approach to quality control of finished products based on inspection after the identification of defective products shows the inefficiency and frequent losses.

One of the major issues facing domestic refineries is the transformation from product quality management to process quality management. The industrial experience shows that only 15 % of the causes of process variability can be eliminated by local actions of the process performer, most of the causes require management decisions (Bykov et al., 2011).

The main objective of statistical process control is to ensure stability, maintain quality indicators, and process parameters at an acceptable level that will ensure established requirements of the manufactured products (Vetter & Morrice, 2019).

At present, a whole set of normative and methodological documents on statistical methods of process control have been developed, including standards for statistical acceptance control, control charts, statistical methods for regulating technological processes, organization of their implementation in industries, etc. (GOST R ISO 7870-1-2011; GOST R ISO 7870-2-2015; GOST R ISO 22514-1-2015; GOST R ISO 22514-2-2015).

Methods

The object of the study is "Slavneft-YaNOS", one of the Central Russia's largest refinery products producers. A significant competitive advantage of the company, both regional and international markets, is the additive integrated management system in use, which includes, in accordance with the specific nature of the business: the quality management system (QMS), the environmental management system (EMS), and the occupational health and safety management system (EHSMS).

The integrated management system of the refinery under consideration optimally provides quality, environmental, occupational health and safety improvement requirements and considers the requirements of the following standards:

– GOST R ISO 9001-2015 (ISO 9001:2015) "Quality management systems. Requirements";
– GOST R ISO 14001-2016 (ISO14001:2015) "Environmental management systems. Requirements and guidelines for use";
– GOST R ISO 45001-2020 (ISO 45001:2018) "Occupational health and safety management systems. Requirements".

Two approaches to quality control are used by the factory under consideration:

1) technical supervision means verification of the conformity of a product or process with established technical requirements;

2) automated control improves the speed and accuracy of measurement as well as the objectivity of control operations.

The collection, processing, and presentation of information on the quality of raw materials, secondary and commercial oil products, emission, and effluent analyses from process facilities is conducted in the quality control system (hereinafter referred to as QCS), the main characteristics of which are presented in the following section.

Statistical methods have a wide range of applications and in the field of product quality management cover the entire product lifecycle.

One of the most important issues in the implementation of statistical methods for managing the processes of an integrated management system in an industrial enterprise is to determine the role of each structural unit in this process.

The algorithm for implementing statistical methods in an industrial enterprise is shown in Figure 1.

Results

The national standard GOST R ISO 11462-2-2012 is a regulatory document for the implementation of statistical process control methods.

A quality plan for the implementation of statistical methods for managing IMS processes may include the following points:

– the choice of processes and quality indicators to be statistically managed;
– the development of process management plans;
– conducting assessment of the accuracy and stability of the processes;

– evaluating the effectiveness and efficiency of the implementation of statistical methods.

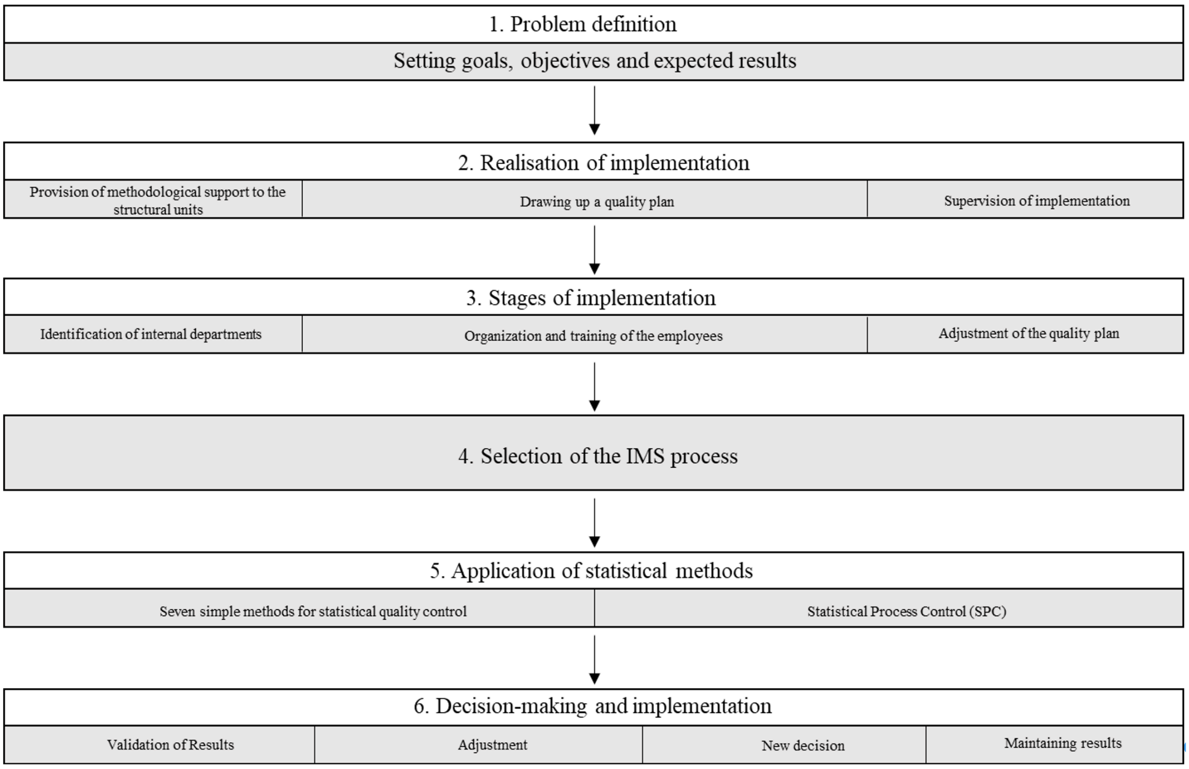

Figure 1. Algorithm for implementing statistical methods for process quality management
Source: composed by authors

In accordance with technological innovations and increased attention to the development and improvement of process control systems, such as the quality control process model developed in (Rylov, 2015), quality indicator calculations allow laboratory analyses to be filtered out and those that have been performed with significant inaccuracy or incorrectly entered to be eliminated. The plant operators can analyze the causes of quality changes within a given time period and take the appropriate corrective action.

In order to improve the performance of IMS processes, there is a necessity to automate the refine systems that focus on statistical process control and analysis of the correlation between quality indicators. In this reason, the development of a statistical process control methodology is of great relevance.

Development and implementation of the methodology for statistical process control of the integrated management system for PJSC "Slavneft-YANOS" will make it possible to analyze the processes and determine whether they are in a statistically manageable state with identification of the correlation between the quality indicators of the process under study. The implementation of this algorithm will serve as a more accurate approach to assessing the performance indicators of the IMS processes.

The statistical process control methodology is based on tools and techniques such as the Schuchart control charts and the correlation analysis of quality indicators. The main stages of statistical management of IMS processes are:

– establishing an expert body;
– process choice and its decomposition;
– determination of process quality indicators;
– collection and primary processing of data on quality indicators;
– analysis of the quality indicator data;
– undertaking the corrective action to manage the process by changing the values of the key quality indicators.

The conceptual model for statistical management of refinery IMS processes proposed in this study is shown in Figure 2.

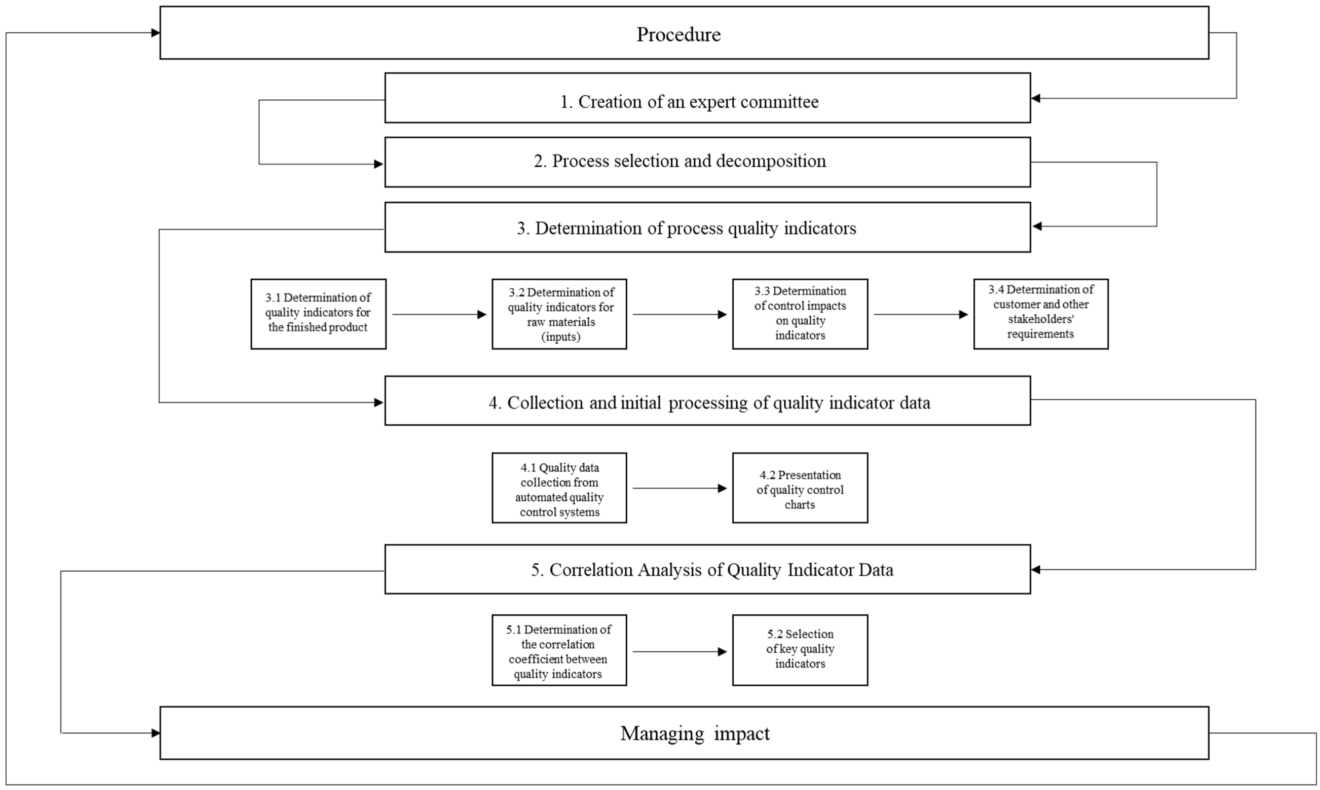

Figure 2. Conceptual model of statistical process control

Source: composed by authors

Discussion

Summarizing the results of the analysis of the refinery quality control systems under consideration, it should be noted that they are identical, with standard forms and functionalities, which indicate limited conditions in process control.

To study the base oil production process of PJSC "Slavneft-YaNOS", control charts of individual values and moving ranges were drawn in the Statistica Trial 13.3 programme.

The X-MR charts for the base oil quality indicator – kinematic viscosity, are shown in Figure 3.

Analysis of the X-MR charts shows that there are points outside the USL and LSL control lines. This shows the possibility of some special causes of variation. The process is not in a condition of statistical controllability (C2 model).

Based on the requirements given in the form of tolerance levels with USL and LSL margins, the maximum and minimum values for the quality index Kinematic viscosity at 1000 C are 4.5 mm2/s and 3.8 mm2/s, respectively.

The following usability indices have been calculated: Pp = 1.205; Ppk = 0.0344 (see Figure 3). The resulting value Prk< Pp indicates a process deviation from the nominal level. The process is unstable. Stabilization measures need to be taken, removing the influence of special causes.

The X-MR charts for the quality indicators viscosity index, kinematic viscosity at 400 C, kinematic viscosity at 700 C, and kinematic viscosity at 1000 C show that the processes are not controlled statistically. According to the technical data of the base oil, the viscosity index is a quantitative description of the change in viscosity of the oil in dependence on temperature. Kinematic viscosity and density also depend on the chemical and fractional composition. It is worth considering that the analysis showed the highest correlation between kinematic viscosity at 700 C and fractional composition of 50%. Therefore, the process "Manufacture of products" should be managed and brought into a statistically manageable state by changing the values of the quality indicators noted.

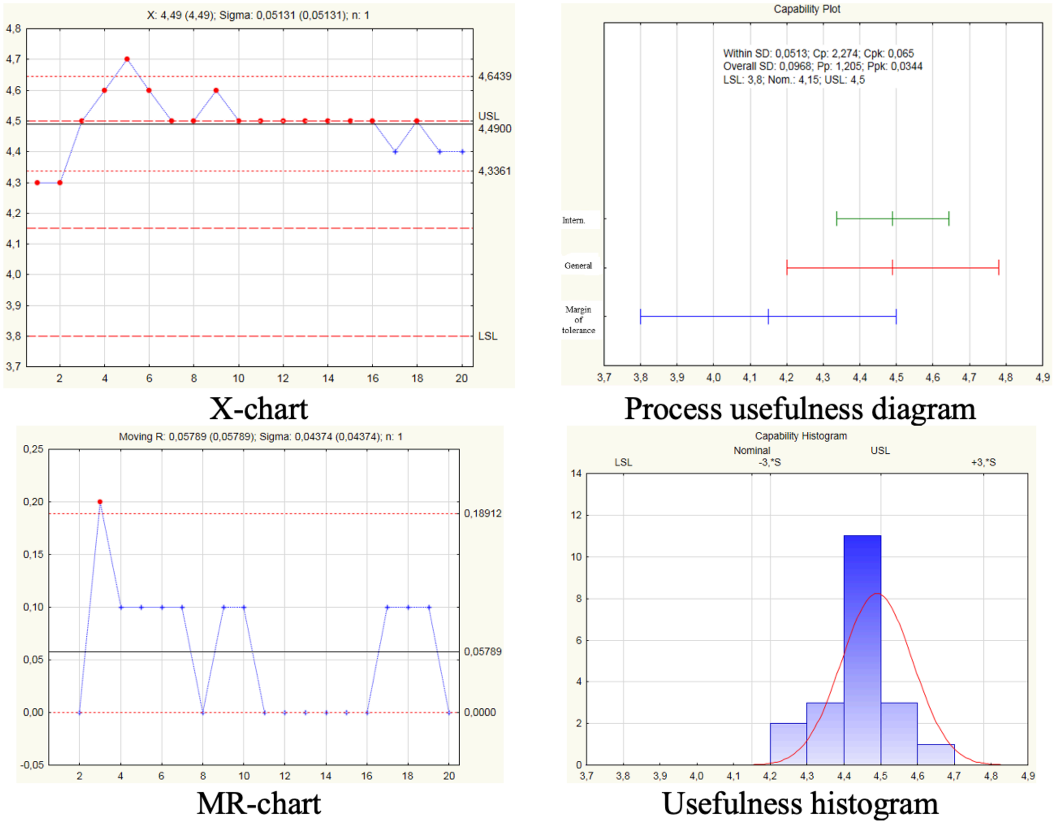

Figure 3. X-MR charts for base oil quality indicator – kinematic viscosity

Source: composed by authors

It should be noted that in order to ensure the stability of the "Production Process" and improve the functioning of the IMS as a whole. The quality indicators of this process should be regularly monitored according to the algorithm described above. The results of this methodological approach to process management will enable corrective action to be reasonably taken and, if necessary, changes to the technology of the process under study.

The implementation of regular monitoring of quality indicators of IMS processes will ensure the following:

– the accumulation of objective data on the process;
– monitoring the progress of the processes and their sub-processes;
– regulating the process in accordance with the aims to be achieved;
– reducing the deviation of the quality indicators of finished products from the target values;
– assessing the performance of the actions undertaken as part of the application of the IMS statistical process management methodology;
– monitoring the evolution of the significance of key process quality indicators, in order to identify new ones that have a significant contribution to the outcomes of the IMS process.

Conclusions

A study of current models and approaches to integrated management system process revealed that the improvement of quality management system processes and the IMS are developed. However, the analysis and synthesis of methodological approaches has highlighted the special role of integrating statistical and qualimetric approaches.

A study of selected process control approaches has shown that statistical methods allow the process participant to monitor the processes in progress and provide the facts for adjusting and improving them. To improve the capacity of the process, it is necessary to improve its components, namely quality indicators. This is when the need arises to identify the key quality indicators that have the highest correlation.

Development and implementation of the methodology for statistical process control of the integrated management system will make it possible to analyze the processes and determine whether they are in a statistically manageable state with identification of the correlation between the quality indicators of the process under study. The implementation of this algorithm will serve as a more accurate approach to assessing the performance indicators of the IMS processes.

Increasing the competitiveness of PJSC "Slavneft-YaNOS" by implementing statistical management of IMS processes is due to the following factors:

- the optimal use of resources;
- the modular approach for the sustainability of an integrated management system makes it easier to change it in order to improve both individual processes and the IMS as a whole;
- possible synergies in the effective functioning of the IMS;
- expanding the market to include new customer requirements, due to the objective identification of a correlation between product quality indicators and the performance of the priority IMS process;
- functioning of an integrated quality management system, guaranteeing the implementation of innovative technologies and management methods.

In addition, PJSC "Slavneft-YaNOS", in order to improve its competitiveness, should to refine automated systems focused on statistical process control and analysis of the correlation between product quality indicators and IMS process performance indicators.

References

1 Štofová, L., Szaryszová, P., & Vilámová, S. (2017). Development of the integrated quality management model for increasing the strategic performance of enterprises in the automotive industry. *Problems and Perspectives in Management*, *15*(3), 4-15. DOI: 10.21511/ppm.15(3).2017.01.

2 Samoilenko, V. (2021). Management competitiveness of the enterprise in modern conditions. *Intellect XXI*. DOI: 10.32782/2415-8801/2021-1.11.

3 Salimova, T.A. (2019). Formation of an integrated management system in the context of ensuring the sustainable development of the organization. *Upravlenie kachestvom v obrazovanii i promyshlennosti. sbornik statej Vserossijskoj nauchno-tekhnicheskoj konferencii. Sevastopol', 16–17 maya 2019 goda.* (pp. 158-162) Sevastopol': Izd-vo FGAOU VO «Sevastopol'skij gosudarstvennyj universitet» (in Russian).

4 Salimova, T. A., & Biryukova, L. I. (2020). On the question of the content of the concept of "sustainable competitiveness". *Nauka i biznes: puti razvitiya,* (5), 148-151 (in Russian).

5 Lahuta, P., Kardoš, P., & Hudáková, M. (2021). Integrated Risk Management System in Transport. 4th International scientific conference on sustainable, modern and safe transport. *Transportation Research Procedia*, 55, 1530–1537. Retrieved from: https://doi.org/10.1016/j.trpro.2021.07.142.

6 Suarez-Paba, M. C., & Cruz, A. M. (2022). A paradigm shift in Natech risk management: Development of a rating system framework for evaluating the performance of industry. *Journal of Loss Prevention in the Process Industries*, 74, 104615. Retrieved from: https://doi.org/10.1016/j.jlp.2021.104615

7 Shtovba S.D. (2020). *Introduction to fuzzy set theory and fuzzy logic* [in Russian], http://matlab.exponenta.ru/fuzzylogic/book1/index.php (accessed: 30.07.2020).

8 Tsareva, S. A., & Yuzhakova, Yu. O. (2018). *Performance assessment of the integrated management system at NPP "Burservis" Upravlenie kachestvom v obrazovanii i promyshlennosti. sbornik statej Vserossijskoj nauchno-tekhnicheskoj konferencii. Sevastopol', 17–18 maya 2018 goda.* (pp. 140-146). Sevastopol': Izd-vo FGAOU VO «Sevastopol'skij gosudarstvennyj universitet» (in Russian).

9 Terano, T., Asai, K., & Sugeno, M. (1989). *Applied fuzzy systems.* Academic Press. Retrieved from: https://doi.org/10.1016/B978-0-12-685242-4.50002-6

10 Bykov, Yu. M., Skhirtladze, A. G., Bykov, S. Yu., & Skhirtladze, S. A. (2011). *Analiz tochnosti i stabil'nosti processov: uchebnoe posobie.* Staryj Oskol: TNT (in Russian).

11 Vetter, T. R. & Morrice, D. (2019). Statistical Process Control: No Hits, No Runs, No Errors?

Anesthesia & Analgesia, *128*(2), 374-382. DOI: 10.1213/ANE.0000000000003977.

12 HOST R ISO 7870-1-2011. (2012). *Statistical methods. Control cards. Part 1. General principles.* M.: Standartinform (in Russian).

13 HOST R ISO 7870-2-2015. (2016). *Statistical methods. Control cards. Part 2. Shuhart control cards.* M.: Standartinform (in Russian).

14 HOST R ISO 22514-1-2015. (2016). *Statistical methods. Process management. Part 1. General principles.* M.: Standartinform (in Russian).

15 HOST R ISO 22514-2-2015. (2016). *Statistical methods. Process management. Part 2. Assessment of the suitability and reproducibility of the process based on the model of its change over time.* M.: Standartinform (in Russian).

16 HOST R ISO 9001-2015 (ISO 9001:2015). (2015). *Quality management systems. Requirements*. M.: Standartinform (in Russian).

17 HOST R ISO 14001-2016. (2016). *Environmental management systems. Requirements and application guidelines.* M.: Standartinform (in Russian).

18 HOST R ISO 45001-2020 (2020). *Occupational safety and health management systems. Requirements and application guidelines.* M.: Standartinform (in Russian).

19 HOST R ISO 11462-2-2012 (2014). *Statistical methods. Guidelines for the implementation of statistical process management. Part 2. Methods and techniques.* M.: Standartinform (in Russian).

20 Rylov, M. A. (2015). Information system for product quality control at the gasoline catalytic reforming plant. *Candidate's thesis*. Moscow (in Russian).

Received 01.08.2022
Revised 01.09.2022
Accepted 10.09.2022