# Metrology risk of product quality at manufacturing stage

*M. Mykyychuk, P. Stolyarchuk*

"Lviv Politechnic" of National University, Ukraine, Lviv mykolamm@ukr.net

Abstract. The article shows that an effective tool of minimization of losses from non-probability measurements at the stage of production is the use of risk management system. The expediency of evaluation of metrology risk of quality of products on the manufacturing stage in a kind of the generalized relative index - index of metrology risk - was grounded. This index must represent the loss of efficiency and effectiveness of the system of production metrology provision. The expressions for the estimation of the metrological risk index were offered and methodology of ranking production by the level of metrology risk was developed.

Key words: metrology risk, quality, metrology provision, efficiency, effectiveness.

## INTRODUCTION

The modern stage of development of society is characterized by growth of requirements as to quality of products. Globalization processes are instrumental in the operative reacting of world market on the changing of quality of products. Only high-quality products become competitive. The basic requirement in the process of creation of products of necessary quality is minimization of charges on their production. It promotes requirement of providing the optimum interrelation between quality and charges on production. Modern changes in approaching the organization of production, large-scale introduction of quality control system to a great extent promote requirements of organization of metrology activity during production [1]. It predetermines the search of ways of upgrading and efficiency of measurement processes at the manufacturing stage of products and integration of them in the normative provision of products quality.

## EXPEDIENCE OF INTRODUCTION OF METROLOGY RISK CONCEPT IN PRODUCTS QUALITY

Primary development of risk management took place in a financial bank sphere, however lately actuality of management risks grows in other spheres ( management of enterprises risks, technological risks) [2-5]. The process of risk management engulfs the different aspects of work with a risk, from authentication and analysis of risk to the estimation of its admission and determination of potential possibilities of risk reduction by the choice, realization and control of the proper managers of actions. Currently, an especially significant question is management metrology risk, as by basic risks which determine the degree of controllability of technological processes, product quality control levels and, consequently, expenditure on its production are influenced [6, 7].

For the construction of effective control system of metrology risks providing the quality of products at the stage of manufacture it is necessary to define the concept of this risk. In dictionaries [8, 9], publications [10, 11] and normative documents [12, 13] determinations of risk are resulted for different industries of activity, where different maintenance is appropriated by a risk concept: probability of losses, possibility of failure to achieve the goal, deviation from the norm, measure of uncertainty of a combination of probability of occurrence and its consequences.

Consequently, there exist various ambiguities related to the disclosure of the nature of risk and related concepts. In general, the concept of risk describes the probability of occurrence of certain events in the future and the risk reflects the potential loss [9, 10].

At the stage of production adverse events decide on claiming worthless the products that are really suitable (producer risk) and a decision on the suitability of

products which are actually useless (consumer risk) [14]. As acceptance of these decisions is carried out on the basis of results of measurements during quality control, metrology risk will be the determined probabilities of origin of risk of producer and risk of user as a result of inauthenticity of control. Thus, it is possible to define metrology risk at the manufacturing stage as probability of influence of measurement results on the decision about the suitability of products, and the measure of metrology risk can be losses of production resulting from inauthenticity of control.

However, taking into account complication of modern technological processes, it is hard to provide the adequate estimation of risks brought about by the metrology provision in quality control of products. It concerns both the determination of influence of metrology activity on the quality of products and the evaluation of quality loss levels caused by inauthenticity of control.

Therefore, for the increase of adequacy of evaluation of product quality metrology risks at the stage of manufacture it is expedient to analyze metrology provision as an organizationally difficult technical system integrated into the system of quality management.

## RESEARCH ON THE PROVISION OF METROLOGY AS AN ELEMENT OF QUALITY CONTROL SYSTEM

A rational way of improving product quality at the level of individual enterprise is the introduction of quality control system in accordance with the standard requirements [15]. Traditionally, measurement efficiency in the process of products manufacturing is determined by correlation of expenditures on the provision of necessary measurement exactness and losses from measurement inaccuracy [16]. The problem of measurement efficiency increase at the stage of products manufacture is not new,

however no synonymous decision has been found as yet. It is predefined mainly by the complication of the processes of realization of product quality metrology provision, involving a lot of normative, legal, organizational, technical and scientific methodical factors which determine the terms of achievement of unity and necessary exactness of measuring at the stage of manufacture. As the efficiency of industrial measurement is largely determined by the efficiency of metrology provision, there is a necessity of the use of modern instruments of minimization of losses in an enterprise from the inauthenticity of quality control of production processes.

Considerable practical interest is presented by researches of the managements in development of the risk control systems integrated in the regular quality control system model of their enterprise [17].

Basic tasks of the metrology provision for products quality at the stage of manufacture can be presented in the following way (Figure 1).

Such a way of organization of metrology activity in an enterprise allows: firstly, to set rational connection of the metrology provision system in an enterprise with the requirements of the state system of measurements unity provision; secondly, to effectively integrate the elements of metrology provision in the quality control system.

For authentication of the metrology provision elements in the manufacturing process it is expedient to recognize such basic features of the system as:

1)   metrology activity is an organizational constituent of co-operation of metrology service with production in view of metrology provision,

2)   provision is a process of establishment and observance of metrology requirements and rules during the manufacturing of products,

3)   quality and efficiency of measuring is the state of optimum combination of quality and efficiency of measuring is needed, that is predefined requirements of production.
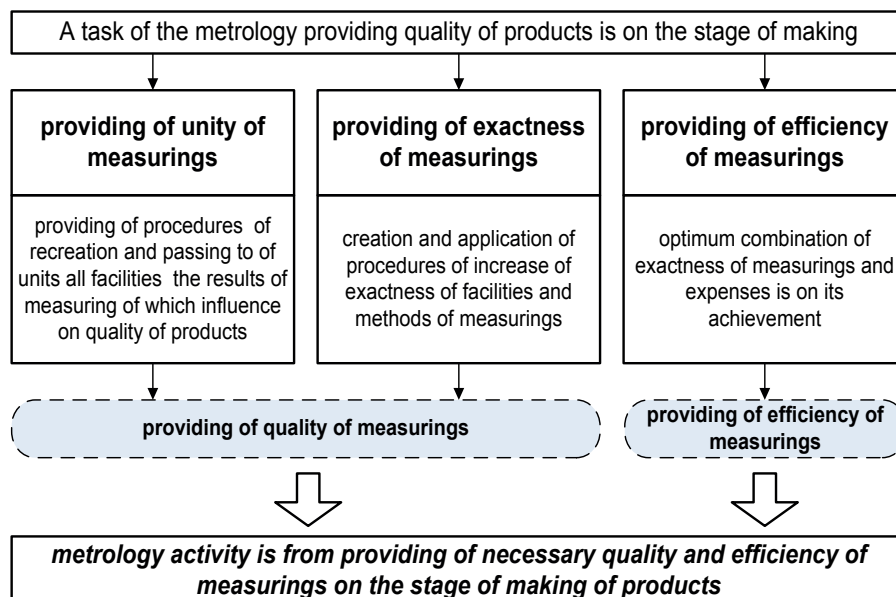


**Fig. 1.** A task of the metrology provision for products quality at the stage of manufacture

Presentation of the metrology provision system of the offered kind will allow to systematize requirements of the measurement processes and rationally implement the provision risk management for the minimization of products quality losses at the manufacturing stage.

## DETERMINATION OF METROLOGY RISK AND INDEXES FOR ITS EVALUATION

During a long time the analysis of metrology risks at the stage of production was limited to the probabilistic analysis of risks of a producer and user [18] and consisted in the determination of dependences between the estimations of losses of production from the indicated risks for a certain period of time and estimation of average exactness of control. Such approach gave the generalized descriptions of metrology risk and was not instrumental in creation of the effective systems of their operative management. With applying of control in industry, the system of quality control [15] and the measurement system [18] have become new terms for the effective management of production risk, and in particular, metrology risk.

In obedience to modern approach, an analysis of risk is the systematic use of information for determination of sources of risk and their quantitative estimations [19]. At present there are no generally accepted methods of metrological risk evaluation. Taking into account the necessity of presentation of metrology risk for the type of the generalized relative index which can be integrated in the modern systems of management of quality, it is expedient to estimate a metrology risk in the type of the index of metrology risk of quality of products at the manufacturing stage.

Integration of the metrology provision system of production in the systems of quality management allows to analyze the metrology risk of quality of products as risk of disparity of the system of the metrology provision by the indexes of efficiency and effectiveness [20]. According to the methodology presented above, the evaluation of metrological support in terms of efficiency and effectiveness, metrological risk index should include two components: an index of metrology risk of loss of effectiveness and index of metrology risk of loss of efficiency of the system of the metrology provision in the products quality at the stage of manufacturing.

Analytical expression for metrological evaluation index of products quality loss can be presented in the form:

$$I_M = \sqrt{I_R \cdot I_E}, \qquad (1)$$

where: $I_R$ is an index of loss of effectiveness; $I_E$ is an index of loss of efficiency.

The index of loss of effectiveness is determined as a relation of difference of complex index of effectiveness in the present moment of control $E_R^1$ to effectiveness in the previous moment of control $E_R^0$ to the complex index of effectiveness in previous moment of control $E_R^0$ to effectiveness:

$$I_R = \frac{E_R^0 - E_R^1}{E_R^0}. \qquad (2)$$

The index of loss of efficiency is determined as a relation of difference of values of the generalized indexes of quality of the system of the metrology provision in the present moment of evaluation $G^1$ to the previous moment of evaluation $G^0$ to the generalized index in the previous moment of control $G^0$:

$$I_E = \frac{G^0 - G^1}{G^0}. \qquad (3)$$

With the purpose of increase of products quality control system's efficiency at the manufacturing stage, it is expedient to carry out the appropriation of production category by the level of index of metrology risk and perform the recommended steps to minimize it.

**Table 1.** Appropriations of production category according to the level of metrology risk index and measures taken towards its minimization.

| Value of index of metrology risk | A category of production according to metrology risk | Measures taken towards the minimization of metrology risks |
|---|---|---|
| 0,0 - 0,2 | **A -** is practical absence of metrology risk | Periodic monitoring of metrology risk |
| 0,2 - 0,4 | **B -** is an insignificant metrology risk | An estimation of accordance of the system of the metrology providing is on the indexes of effectiveness |
| 0,4 - 0,6 | **C -** is a middle metrology risk | An analysis of metrology risk is a that estimation of accordance of the system of the metrology providing on the indexes of efficiency |
| 0,6 - 0,8 | **D -** is a considerable metrology risk | Minimization of sources of metrology risk is an estimation of accordance of the system of the metrology provision with the indexes of efficiency and effectiveness |
| 0,80 - 1,00 | **F -** is an impermissible metrology risk | Reformation of the system of the metrology provision and evaluation of its accordance influences the indexes of efficiency and effectiveness |

For an analysis and management of metrology risks it is necessary to carry out their authentication, determine measures for the decision of problems which they can cause and use, here, objective information. Analysis of metrological risk can be used by experts for enterprise decision in assessing the admissibility of these risks, as well as the choice of measures to reduce or eliminate the production loss from non- reliable quality control during its manufacture.

CONCLUSIONS

The primary purpose of evaluation of metrology risk is systematization of possible disparities which can arise at control of quality of products and conditioning for ranking of technological processes according to the level of products quality losses resulting from the inauthenticity of measuring.

Importance of the stage of metrology risk reduction consists in the necessity of the formalized ground for decision-making processes and planning of effective actions for minimization of metrology risk in the quality of products at the manufacturing stage. It is also necessary to organize the process of permanent control of level of metrology risk which will allow for an operational reaction to its changes and taking proper correcting action in time.

Introduction of control of the system by metrology risks production will be instrumental in the increase of efficiency of the industrial measurement systems and diminishing of expenditures on products quality provision. For effective application of control of the system of risk metrology in the quality of products at the stage of manufacturing, it is necessary to create a list of metrology risks indexes, and also proper normative provision for their grounded application in the control of the system quality.

The introduction of metrological risk level rankings will organize corrective actions to improve the system of quality losses due to the non- reliability of control of process parameters and quality of finished products. Together, this will increase the efficiency of corrective actions and consumer confidence in the results of quality control at the stage of manufacture process.

REFERENCES

4.  **Markov B.F. 2008.** The main directions of development of the State metrolohycheskoy system. / B.F.Markov, H.S.Sydorenko / / Ukrainian Metrology magazine. № 3. 7-11.
5.   **Dunayev B.B. 1981.** Measurement accuracy for quality control / B.B. Dunayev / / K.: Tehnika. 152.
6.  **Gray V.I. 2009.** The quality and effectiveness of metrological provision of facilities and services Sveti / V.I.Seryh, L.V.Grebtsova, EI Chernyshevskaya / / Infosphere. № 44. 66 - 69.
7.  **Lisin S.K. 2007.** Postoperative evaluation of the reliability of the results of quality control of industrial products / S.K Lisin / / Measuring equipment. № 8. 18.
8.  **Nazarov N.G. 2007.** The method of creating the optimal control plan the party based on a random sample of the serial / N.G Nazarov, A. Popov / / Measuring tehnika. № 10. 12-14.
9.  **Danylevych S.B. 2007.** Metrolohycheskoe Securing production and quality of products / S. Danylevych, S. Kolesnikov / / Legislature and Applied Metrology. № 2. 6-9.
10. **Mykyychuk M.M. 2011.** Metrological risks of quality control at the manufacturing stage. Methods and devices QA / M.M Mykyychuk / / Scientific and technical journal Ivano-Frankivsk National Technical University of Oil and Gas. № 26. 120-123.
11. Dictionary of Psychology [electronic resource] - Access mode to the dictionary: http://www.slovarik.kiev.ua/psychology/r/123726.html.
12. Economics and Mathematics dictionary [electronic resource] / L. Lopatnikov - 2003 - Mode of access to the dictionary: http://slovari.yandex.ru/dict/lopatnikov.
13. On the question of the definition of "risk" [electronic resource] / V.V.Indeeva / / SMU them. Acad. Pavlov, Ryazan. Russia. Mode of access to the article: http://www.rae.ru/zk/arj/2007/02/indeeva.pdf.
14. Seriya «Ekologichna BEZPEKA» Ekologichna BEZPEKA Ukrainy [electronic resource] AB Kachinsky - 2001. - Rozdil 3 / / Analiz riziku - metodologichna basis for rozv'yazannya BEZPEKA Person of problems that dovkillya - Mode of access: http://www.niss.gov.ua/book/Kachin/1-3.htm.
15. GOST R 51897-2002 Risk Management. Terms and definitions. Access mode: http://sklad-zakonov.ru/gost/Gr51897-2002.htm.
16. ISO / IEC Guide 73:2002. Risk management - Vocabulary - Guidelines for use in standards.
17. **Pronenko V.I. 1979.** Metrology in industry / V.I Pronenko, R.V Yakyryn / / Technology. 223.
18. EN ISO 9001:2008 Quality Management System. Requirements. - Enter. in effect 04/01/2009. K. Standard. 2009. 39.
19. State system for ensuring the uniformity of measurements. Ensuring the efficiency measurements for process control. Key points: MI 2233-2000. - Moscow: Publishing House of Standards - 2000. – 19 p.
20. **Vitlinskyy V.V. and Velykoivanenko G.I. 2004.** And risk in the economy and entrepreneurship: Monograph. K.: MBK. 480.
21. BS ISO 10012:2005 Requirements for measurement processes and measuring equipment. - Enter. in effect 01/01/2006. K. Standard. 2006. 39.
22. GOST R 51901.1-2002. Risk management. Risk analysis of technological systems. Moscow: Publishing House of Standards. 2002. 40.
23. **M. Lut. 2012.** Measuring equipment and software products in vibrodiagnostics / M. Lut, A. Mrachkovskyy, V. Taran // ECONTECHMOD. An international quarterly journal on economics in technology, new technologies and modelling processes. Vol. I, No 1. 67