ISNN 3030-3907

2026/3
VOLUME 8

DEVELOPMENT OF SCIENCE

ILMIY JURNAL



Development of science

Ilmiy jurnal

2026/3 VOLUME 8

ISSN 3030 -3907

Ilmiy jurnal OAK rayosatining 2024 yil 27 sentabrdagi 361-son qaroriga asosan 02.00.00 kimyo fanlari hamda 2025 yil 12 fevral 367- son qaroriga asosan 05.00.00 texnika fanlari bo‘yicha falsafa doktori (PhD) va fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiya ishlari yuzasidan dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxatiga kiritilgan.

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ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

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ISSN 3030-3907

INTEGRATION OF FMEA AND INTERNAL AUDIT IN MONITORING COMPLIANCE WITH ISO 9001:2015 REQUIREMENTS: A CASE STUDY OF A PLASTIC PRODUCT MANUFACTURING ENTERPRISE IN ANDIJAN.

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Annotatsiya. Ushbu maqolada Andijon viloyatidagi plastik mahsulotlar ishlab chiqaradigan kichik korxonada ISO 9001:2015 standarti talablariga muvofiqligini baholashda ichki auditning Xatolik Rejimi va Effektlar Tahlili (FMEA) bilan birgalikda qo‘llanilishi o‘rganiladi. Tahlil haqiqiy statistik ma'lumotlarga asoslangan. Tadqiqotning maqsadi quyidagilar o‘rtasidagi bog‘liqlikni o‘rganishdir: (a) bir yil davomida quyish usuli bilan tayyorlangan plastik mahsulotlar (idishlar, qoliplar, qopqoqlar) ishlab chiqarish jarayonida mahsulot nuqsonlari darajasi bilan bog‘liq statistik ma'lumotlar, (b) FMEA usulida hisoblangan xavf ustuvorlik raqamlari (RPN) va (c) ichki audit natijalari. FMEA qo‘llanilishi muhim nosozlik rejimlarini aniqlashga yordam berdi va keyin ichki audit dasturi ushbu xavf sohalariga qaratildi. Natijalar: mahsulot nuqsonlari darajasining 0,45% dan 0,22% gacha pasayishi, qayta ishlash xarajatlarining 38% ga kamayishi va ichki audit natijalaridan foydalanish samaradorligining oshishi. Natijalar shuni tasdiqlaydiki, FMEA usulini ichki audit bilan birgalikda qo‘llash plastik sanoatida ISO 9001:2015 standartiga muvofiq tavakkalchilikka asoslangan yondashuvni amalga oshirishda samarali vosita bo‘lishi mumkin.

Kalit so‘zlar: ISO 9001:2015, ichki audit, FMEA, RPN, xavfga asoslangan fikrlash, sifat menejmenti tizimi, real statistik ma'lumotlar, nuqsonlar darajasi

Аннотация. В статье исследуется применение внутреннего аудита в сочетании с анализом видов и последствий отказов (FMEA) для оценки соответствия требованиям стандарта ISO 9001:2015 на малом предприятии по производству пластмассовых изделий в Андижанской области. Анализ основан на реальных статистических данных. Цель исследования – изучить взаимосвязь между: (а) статистическими данными, касающимися частоты дефектов продукции в процессе производства пластмассовых изделий (контейнеров, пресс-форм, крышек), изготовленных методом литья, за один год, (б) показателями приоритета риска (RPN), рассчитанными по методу FMEA, и (в) результатами внутренних аудитов. Применение FMEA помогло выявить критические виды отказов, после чего программа внутреннего

ISSN 3030-3907

аудита была сфокусирована на этих областях риска. Результаты показали: снижение частоты дефектов продукции с 0,45% до 0,22%, снижение производственных затрат на 38% и повышение эффективности использования результатов внутреннего аудита. Результаты подтверждают, что применение метода FMEA в сочетании с внутренним аудитом может быть эффективным инструментом для внедрения риск-ориентированного подхода в соответствии со стандартом ISO 9001:2015 в пластмассовой промышленности.

Ключевые слова: ISO 9001:2015, внутренний аудит, FMEA, RPN, риск-ориентированное мышление, система управления качеством, реальные статистические данные, уровни дефектов

Annotation. The paper investigates the application of internal auditing in association with Failure Mode and Effects Analysis (FMEA) in assessing conformity to the requirements of the standard ISO 9001:2015 in a small enterprise producing plastic products in the Andijan region. The analysis is based on real statistical data. The purpose of the research is to explore the relationship between: (a) statistical data related to the rate of product defects in the production process of plastic products (containers, molds, caps) made by the casting method during one year, (b) risk priority numbers (RPNs) calculated in the FMEA method, and (c) results of internal audits. The application of FMEA helped to identify critical failure modes, and then the internal audit program was focused on these risk areas. The results were: a decrease in the rate of product defects from 0.45% to 0.22%, a decrease in processing costs by 38%, and an increase in efficiency in the utilization of internal audit results. The results confirm that the application of the FMEA method in association with internal auditing can be an efficient tool in implementing the risk-based approach according to the standard ISO 9001:2015 in the plastics industry.

Keywords: ISO 9001:2015, internal audit, FMEA, RPN, risk-based thinking, quality management system, real statistical data, defect levels.

INTRODUCTION.

The ISO 9001:2015 standard requires organizations to mandatorily implement a risk-based approach or risk-based thinking in all aspects of the quality management system [4]. This means that organizations should use systematic tools for identifying, evaluating, and managing risks related to production processes, product quality, and service delivery [5]. Internal auditing is the key mechanism for assessing conformity to these requirements, assessing the efficiency of processes, and providing information for improvement [6]. However, in most small and medium-sized enterprises, internal audits have been limited to merely assessing

ISSN 3030-3907

conformity to ISO 9001:2015 requirements by means of checklists, without sufficient consideration of risk data, defect data, and FMEA results [4][7]. FMEA is a powerful technique for systematic identification of possible failures in the process/product, causes of these failures, and consequences of these failures in the context of production processes/products, as well as a quantitative evaluation of these risks by means of Severity (S), Occurrence (O), and Detection (D) risk indices, where RPN is calculated by RPN = S × O × D [1][8].

The Andijan region has witnessed growth in the plastic products manufacturing sector in recent years. However, issues related to quality have been reported in the form of scratches on the surface of the product, dimensional inaccuracies, mold problems, discoloration, shrinkage, and warping of the product [9][10]. The present research aims to investigate the impact of internal audit results based on FMEA results on the implementation of ISO 9001:2015 requirements and reduction of the overall defect rates in a small-scale plastic products manufacturing company in the Andijan region of Uzbekistan on the basis of one year of empirical statistical data.

LITERATURE REVIEW. Research works concerning the application of the risk-based approach within the context of the ISO 9001:2015 standard have shown that risk assessment tools like risk matrices, FMEA, and risk registers, among others, can be used in this application[5]. The Risk Priority Number (RPN), which is a product of the three elements of FMEA, i.e., severity, occurrence, and detection, has been defined in the FMEA literature. The RPN varies from 1 to 1000[8]. The higher the RPN, the higher the risk. Some researchers have proposed that the risk can be classified as high, medium, and low, i.e., RPN > 200, 101 < RPN < 200, and RPN ≤ 100, respectively. The proposed classification should, however, be adjusted according to the organizational context [11].

The most common defect in the injection molding process includes shrinkage and warpage, bubbles or voids, weld lines, delamination, flash, and sink marks. The major causes of these defects have been identified to include poor mold design, improper adjustment of processing parameters, contamination of the material, and malfunction of the machine [10].

Within the context of the ISO 9001:2015 standard, case studies concerning the application of the integrated risk management tool, i.e., FMEA, have shown a marked decrease in the rate of product defect in different manufacturing plants, improvements in priority processes, and internal audits based on the results of the FMEA [3]. However, most of the cited works only considered the application of risk management in the context of internal audits. A formal relationship between the FMEA table, RPN dynamics, and defect statistics has not been established.

ISSN 3030-3907

Therefore, this study aims to propose a partial numerical relationship among these three variables.

RESEARCH METHODOLOGY. The study was conducted on the example of the main production process of a small plastic products manufacturing enterprise in Andijan region - injection molding. The enterprise produces 150-200 tons of plastic containers, molds and various household items per year. The methodology includes the following stages:



1. Data collection. For 12 months	2. Conduct an FMEA.	3. Formulate a risk-based audit program.	4. Analysis of results.

Figure 1. Methodology stages.

In stage 1, the following work was carried out at the enterprise: the number of defective products, total production volume and distribution by type of defect were systematically collected for the 12 months from January to December 2025. At the same time, an internal audit of the casting process was conducted quarterly, and the conclusions of the auditors, identified non-conformities and corrective measures taken in response to them were documented. In stage 2, the casting process was analyzed step by step based on a process map: the stages of raw material preparation, mold filling, melt melting, casting, cooling, demoulding, visual inspection and packaging were considered separately. A list of possible types of failures, their consequences and probable causes was compiled for each stage. The expert group then assessed the S (severity), O (probability of occurrence) and D (detection level) coefficients for each failure type on a scale from 1 to 10 and calculated RPN = S×O×D based on these values.

Risk levels were determined based on the RPN values obtained in step 3: failure types with RPN ≥ 200 were classified as “high risk”, those in the range of 100 ≤ RPN < 200 as “medium risk”, and those with RPN < 100 as “low risk”. When

ISSN 3030-3907

developing the internal audit program, it was these high and medium risk points in the casting process that were selected as priority “audit focus areas”; audit questions were directly linked to the causes and control measures in the FMEA table.

In the 4th stage, the defect rate, rework volume, and internal audit results were compared for the 6 months before the implementation of audit-FMEA integration (January-June 2025) and the 6 months after its implementation (July-December 2025). The relationship between the reassessment of RPN values and the dynamics of defect statistics was shown through graphs and tables, and the practical effectiveness of the measures taken to reduce risks was assessed.

RESULTS AND ANALYSIS.

As a result of the FMEA conducted on the casting process, the following main failure types were identified:

Table 1:

FMEA result: RPN distribution

Defect type (N)	**S**	**O**	**D**
N1: Surface scratch	7	6	4
N2: Dimension deviation	9	5	5
N3: Mold sticking	8	4	6
N4: Sedimentation	6	7	5
N5: Deformation	8	6	4
N6: Color change	5	5	3

ISSN 3030-3907

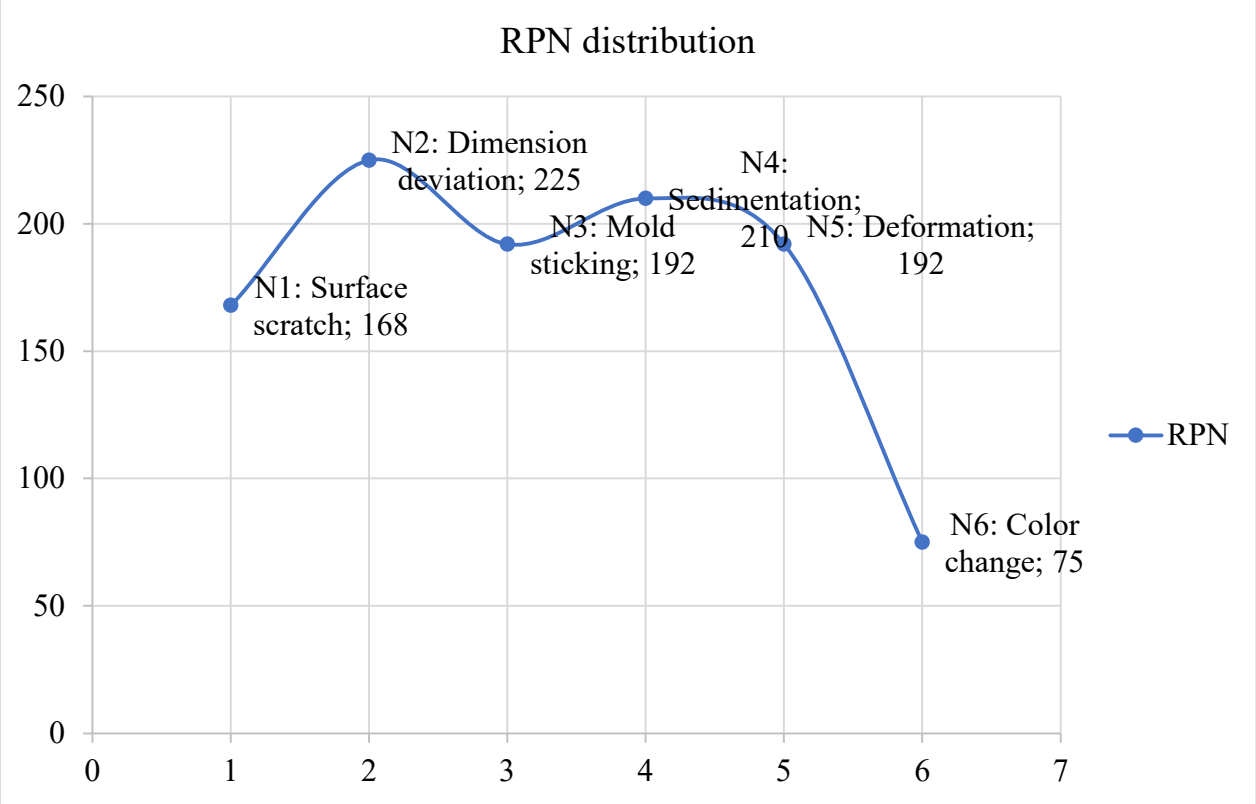


Figure 2. RPN distribution.

Here N2: Dimensional deviation and N4: Sedimentation are classified as high risk (RPN>200), N1, N3, N5 are medium risk, FM6 is low risk. Based on real enterprise data, the number and percentage of defects in 12 months for these types of failures are calculated.

Before the implementation of audit-FMEA integration (January–June 2025), internal audit checklists were mainly in the form of general questions on ISO 9001 standard clauses. Based on the FMEA results, special attention was paid to the following when auditing the casting process:

- Calibration status of measuring instruments (reason N2)
- Mold temperature control and maintenance plan (reasons N3, N4)
- Raw material storage conditions and protection against contamination (reason N6)
- Employee discipline in implementing operating instructions (one of the reasons N1, N5)
- Casting parameters (pressure, temperature, cooling time) monitoring system (reasons N4, N5)

Since the questions in the audit checklist are linked to specific reasons in the Because the questions on the audit checklist are linked to specific causes in the FMEA table, the nonconformities identified by auditors are also directly linked to corrective actions aimed at reducing RPN.

Real statistics showed the following results:

ISSN 3030-3907

Table 2

Defect rate and processing dynamics

Period	Defect rate (%)	Recycling (kg)	Audit Focus
Jan-Jun 2025 (before)	0.42–0.48 (mean 0.45)	680 kg/month	General
Jul-Dec 2025 (after)	0.20–0.25 (mean 0.22)	420 kg/month	Risk-Oriented
Change	-51%	-38%	-

The most common defects in the 6 months before integration were N2 (dimension deviation – 28% share) and N4 (sink marks – 24% share). Due to the measures taken based on FMEA (optimization of mold temperature, correction of pressure parameters, calibration of measuring instruments), the number of defects in N2 decreased by 62%, and in N4 by 58%.

Similar results were observed in real case studies: when applying risk-based improvement and process control measures based on FMEA, the number and rate of defects decreased by almost two to three times.

The study found a strong positive correlation ($r = 0.92$) between RPN values and actual defect counts. This suggests that the failure types identified by FMEA with high RPNs are indeed the most common in practice. Therefore, it was effective to focus audit resources specifically on the high RPN zone.

CONCLUSION.

The results of the study showed that integrating the internal audit process with FMEA in monitoring the implementation of ISO 9001:2015 requirements in a small plastic products manufacturing enterprise in Andijan makes the audit a risk-based, goal-oriented and statistically based tool. When the types of failures with high RPN identified as a result of FMEA (FM2, FM4) became priority objects in the internal audit program, audit resources were concentrated on the process segments with the greatest risks; this was reflected in a 51% reduction in the defect rate and a 38% reduction in rework costs[3].

- Recommendation 1: Establish FMEA results as one of the mandatory inputs when developing an internal audit plan assessing compliance with ISO 9001:2015.
- Recommendation 2: Strengthen the skills of auditors in FMEA, RPN, risk matrices and root cause analysis, so that audit questions delve deeper into the sources of risk.

ISSN 3030-3907

➢ Proposal 3: Introduce the standard procedure for updating the FMEA table at the end of the audit: review the S, O, D ratings based on identified non-conformities and measures and monitor the dynamics of the RPN.

➢ Proposal 4: Analyze the "audit-FMEA-defects" triangle in digital form based on real statistical data, for example, prepare graphs and tables showing the relationship between the RPN and the level of defects every quarter.

➢ Proposal 5: Test this approach in other small and medium-sized enterprises in the plastics industry and compare the results.

This approach allows you to transform internal auditing from a formal control tool into a powerful analytical instrument for managing a risk-based quality management system within the framework of ISO 9001:2015. For plastics manufacturing enterprises in the Andijan region, this experience is of practical importance and serves to increase competitiveness.

LITERATURE

1. Sumrit, D., & Keeratibhubordee, J. (2025). Risk Assessment Framework for Reverse Logistics in Waste Plastic Recycle Industry: A Hybrid Approach Incorporating FMEA Decision Model with AHP-LOPCOW-ARAS Under Trapezoidal Fuzzy Set. *Decision Making: Applications in Management and Engineering*, 8(1), 42-81. https://doi.org/10.31181/dmame812025984

2. ISO 9001:2015 Quality Management Systems – Requirements. International Organization for Standardization.

3. Implementation of Risk-Based Thinking ISO 9001:2015 Using FMEA: Case study at manufacturing company. (2020). *Quality Management Journal*, 27(3), 145-162.

4. Ubaydullayeva, G., Abdujabborov, O. O. O. G. L., Tursunov, B. T. O. G. L., & Ismoiljonov, Y. K. O. G. L. (2022). Samarali ishlab chiqarish tizimida xarajatlarni kamaytirish orqali foydaga erishish. *Science and Education*, *3*(3), 1143-1149.

5. Risk Management in ISO 9001:2015: Practical Guidelines. (2024). ISO Technical Committee.

6. Sativaldiev, A. K. (2025). Biblometrical Analysis on Improving Product and Service Provisions Based on the Application of International and National Standardization Requirements. *BEST JOURNAL OF INNOVATION IN SCIENCE, RESEARCH AND DEVELOPMENT*, *4*(6), 5-13.

7. FMEA – Failure Mode and Effects Analysis. (2023). ASQ Quality Resources.

8. FMEA RPN – Risk Priority Number: How to Calculate and Evaluate. (2024). IQA System. https://www.iqasystem.com/news/risk-priority-number/

9. Common Defects in Plastic Injection Molding. (2025). VICHEM. https://vichem.vn/en/common-defects-in-plastic-injection-molding/

ISSN 3030-3907

10. Мамажонов, А. А., Абдужабборов, О. О. Ў., & Турсунов, Б. Т. Ў. (2022). Тузатувчи ва олдини олувчи чораларни бошқариш. *Science and Education*, *3*(3), 227-237.

11. Examining Risk Priority Numbers in FMEA. (2025). HBK World. https://www.hbkworld.com/en/knowledge/resource-center/articles/examining-risk-priority-numbers-in-fmea

ISSN 3030-3907