An Empirical Study of Root-Cause Analysis in Automotive Supplier Organisation

DOI: 10.12776/QIP.V23I2.1243

Anna Nagyová, Hana Pačaiová, Anna Gobanová, Renáta Turisová

Received: 25 March 2019 Accepted: 25 June 2019 Published: 31 July 2019

ABSTRACT

Purpose: The paper aims to introduce the practical application of using Root-cause analysis (RCA) by chosen methods of continual improvement in solving non-conformity occurrence in an organisation operating in the automotive field.

Methodology/Approach: The chosen tools of (RCA), which includes an extended version of 5W2H and 5Whys were applied. Both tools were systematically applied step by step in case of claim solving, which occurred in automotive production.

Findings: Non-conformity, which occurred in this case, was analysed through RCA and helped not only to identify the problem but also solve it and find adequate preventive measures to avoid occurrence non-conformity in the future.

Research Limitation/implication: Practical application of chosen tools shows how problems and non-conformities should be solved using systematic steps of a different tool. In some cases, if it is needed, other methods and tools can be added, as well as metrology verifications.

Originality/Value of paper: The innovative element of these tools application is the introduction of the extended version of the 5W2H method from the customer's perspective as well as from the organisation perspective. It is also clear that to solve customer's claim, it is necessary to use a combination of more tools to make sure that that kind problem is not going to occur in the future.

Category: Case study

Keywords: method; non-conformity; continual improvement

1 INTRODUCTION

Beneath every problem is a cause for that problem. In order to solve a problem, one must identify the cause of the problem and take steps to eliminate the cause. If the root cause of a problem is not identified, then one is merely addressing the symptoms, and the problem will continue to exist (Dogget, 2006). RCA is a step-by-step method that leads to the discovery of faults or root cause. Wilson, Dell and Anderson (1993) have defined the RCA as an analytic tool that can be used to perform a comprehensive, system-based review of critical incidents. He also states that a root cause is the most fundamental reason for an undesirable condition or problem. Dew (1991) and Sproull (2001) state that identifying and eliminating the root causes of any problem is of utmost importance. According to them, RCA is the process of identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems. According to Duggett (2004), several RCA tools have emerged from the literature as generic standards for identifying root causes. As problems have increased in complexity, more tools have been developed to encourage employees to participate in the problem-solving process Zgodavova, Hudec and Palfy (2017). Some of the most common are the 5 Why Analysis (5WHY), Multi-Vari Analysis, Cause-and-Effect Diagram (CED), the Interrelationship Diagram (ID), and the Current Reality Tree (CRT). He has added that 5 WHY is the most simplistic RCA tool whereas current reality tree is used for possible failures of a system and it is commonly used in the design stages of a project and works well to identify causal relationships. DOE Guideline RCA Guidance Document February (1992) says that immediately after the occurrence identification, it is important to begin the data collection phase of the root cause process using these tools to ensure that data are not lost. The data should be collected even during an occurrence without compromising with safety or recovery. Anderson and Fagerhaug (2000) have simplified the RCA. They provide a comprehensive study of the theory and application of metrics in RCA. It it emphasises the difficulty in achieving process capability in the software domain and is cautious about SPC implementation. They mention that the use of control charts can be helpful for an organisation, especially as a supplementary tool to quality engineering models such as defect models and reliability models. However, it is not possible to provide control as in manufacturing since the parameters being charted are usually in-process measures instead of representing the final product quality. Arcaro (1997) has presented various tools for identifying root causes. He describes that RCA techniques are constrained within the domain and give a detailed tutorial by supporting theoretical knowledge with practical experiences. He states that all RCA techniques may not be applicable to all processes. Brown (1994) has used the root cause technique to analyse the assembly of commercial aircraft. He has concluded that it is the most effective tool to eliminate the causes in most vital assemblies like aircraft, where utmost safety and reliability is needed. Brassard (1996) and Brassard and Ritter (1994) have put their emphasis on continuous improvement and effective planning. They have pointed out that RCA tools give management to think ahead about failures

ISSN 1335-1745 (print) ISSN 1338-984X (online)

and plan accordingly. They emphasise that process improvement models implicitly direct companies implement RCA as a crucial step for project level process control and organisational level process improvement purposes. Cox and Spencer (1997) have advocated that RCA tools effectively give solution to handle constraints and arrive at an appropriate decision. Like Cox and Spencer (1998) and Dettmer (1997) have also used RCA on the management of constraints. He presents one of the earliest studies on the debate of applying RCA to processes. Lepore and Cohen (1999), Moran, Talbot and Benson (1990), Robson (1993) and Scheinkopf (1999) move ahead. The foundations of their studies are pioneering one as they question an accepted practice for RCA and the results of the example studies are encouraging. However, the studies are far from being a practical one, as they include too many parameters and assumptions. Smith (2000) has explained that Root Cause Tools can resolve conflicting strategies, policies, and measures. The perception is that one tool is as useful as another tool. While the literature was quite complete on each tool as a stand-alone application and their relationship with other problem-solving methods. There are very few works of literature available on the comparative study of various RCA tools and methods. Gano (2011) has presented some insight into the comparison of standard RCA tools and methods. He indicates that there are some comparative differences between tool and method of a RCA. He has added that tools are included along with methods because tools are often touted and used as a full-blown RCA.

2 METHODOLOGY

Two similar tools, such as 5WHY a 5W2H, were used in this case study as a part of RCA. 5WHY is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?". Each answer forms the basis of the next question. The technique was originally developed by Sakichi Toyoda and was used within the Toyota Motor Corporation during the evolution of its manufacturing methodologies. It is a critical component of problem-solving training, delivered as part of the induction into the Toyota Production System. The architect of the Toyota Production System, Taiichi Ohno, described the 5WHY as "the basis of Toyota's scientific approach" by repeating why five times the nature of the problem, as well as its solution, becomes clear (Taichi, 2006). The tool has seen widespread use beyond Toyota and is now used within Kaizen, lean manufacturing and Six Sigma. 5W2H is an already recognised methodology that aims to assist in the creation of efficient Action Plans. With Action Plans created by this method, it is possible to make better decisions and better understand what needs to be done to solve a problem or implement a new process (Fonseca, Limaand Silva, 2015). 5WHY and 5W2H may help to identify the problem but to find a solution is necessary to use other systematic tool or approach for nonconformity management.

Those mentioned tools were directly applied as a part of problem solving. The company that makes keys and locks for the automotive industry was informed of its nonconforming product that was the subject of customer complaints. Within this complaint, it was necessary to apply RCA, where the tools of improvement creating together a unified logical system, by means of which a cause of non-conformance was identified and utilizing which corrective and preventive measures were determined, were used. RCA includes the following tools:

- 5W2H (extended version),
- 5 WHYs.

The claim mentioned above made by the customer was related to the key, namely the separated blade of the key from its chrome head of the key (Fig. 1), while it was clear that the cause for its break-down was a missing pin connecting these two parts.

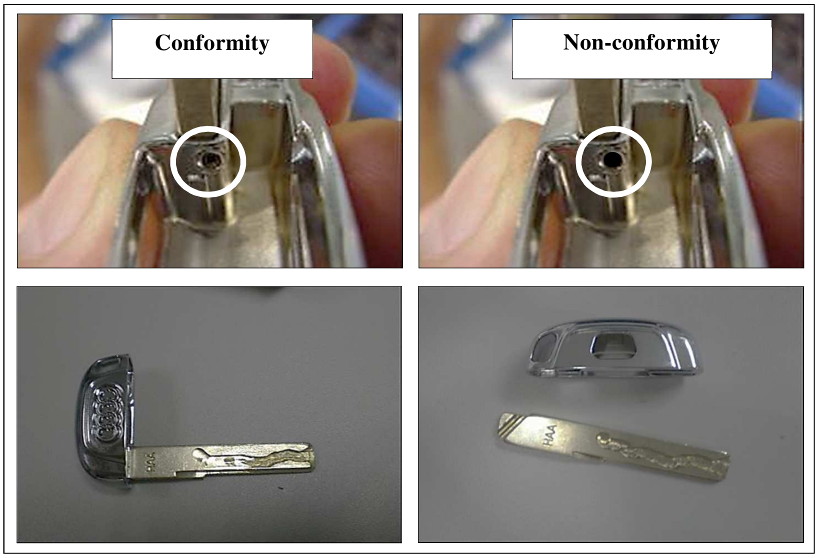

Figure 1 – Visualization of Missing Pin

2.1 5W2H Application

The first step was to identify this problem as a whole using the 5W2H tool in two separate views:

1. Customer's view,
2. Internal specialist's view.

Table 1 – Comparison of the 5W2H Method Application

1. Customer's view	**2. Internal specialist's view**
1. What is the problem? Missing pin in a chrome head of the key.	*1. What is the difference conformity and non-conformity?* *Conformity*– the pin is not present in a chrome head of the key, there are residual traces of adhesive in a head of the key, and a trace after the pin pre-loading. *Non-conformity*– pin as well as an adhesive are present, the blade is firmly fixed in a head of the key without the possibility of falling out, the blade and the head make a right angle.
2. Why is this problem? Blade of the key is separated from a chrome head of the key (loss of required function).	*2. Was the piece under a complaint made in a standard process?* Yes, no approved deviation in the standard process was valid at that time.
3. When did the problem arise? 11/01/2010	*3. When was the piece under a complaint made?* The date and time are not specified due to lack of traceability from the customer.
4. Who revealed the problem? The operator of the customer helpline	*4. Who made the piece under complaint?* Company premises, assembly line, chrome head and metal key blade riveting post.
5. Where was the problem revealed? Customer assembly line.	*5. What, if the product under complaint is being also used in another process?* No, the key type (with chromium head) is specific only to this project.
6. How was the problem revealed? Visually.	*6. How are we able to capture the product with the defect in a standard process?* Yes, checking the presence of the pin is part of the standard output control from the process.
7. How many non-conformity components were found? One.	*7. How did we deal with a similar problem internally or externally in the past?* Yes, the complaint came on 15 June 2009 when 1 non-conformity component was found. The permanent measure was implemented in the form of a mechanical poka-yoke lever of the pin preload.

Since the missing pin poses a problem for all products on a given assembly line, they were immediately physically suspended in the warehouse and also blocked in SAP. Exactly 1480 pieces of key sets were included. In addition, a temporary instruction for sorting was made, on the basis of which the suspended products were checked and the compliant ones were released to the customer, as well as a temporary control instruction for supercontrol of the presence of pins on the line after starting the production. Regarding the method of control, a repeated visual inspection was ordered that is a standard part of the workflow.

2.2 Problem Analysis

The RCA was added by comparison of the “conformity” and the “non-conformity” (component) and the comparison of the obtained results with the specification (drawing documentation). A good piece as conformity is a component that is randomly selected from the current series, and the component returned by the customer is considered to be a non-conformity.

2.2.1 Dimensional Analysis of the Components

The key is composed of three components – the key blade, the chrome head of the key and the pin. The factors for these components that could lead to the problem rise were defined:

1. *Key blade* – on the key blade, the dimensions were taken into account: the groove depth for the pin and the groove angle for the pin.
2. *Chrome head of the key* – the following parameters were identified: hole diameter for the pin, hole depth for the pin and hole angle for the pin.
3. *Pin* – the diameter and the length of the pin were taken into account.

In the dimensional analysis, the dimensions of the conformity component and non-conformity were compared for all the factors and their parameters. The measurements were carried out with a sliding scale and all randomly selected pieces ranged within the specified tolerance, confirming that the components used in the production of the piece claimed did not affect the defect produced since all dimensions were in accordance with the drawing documentation.

2.2.2 Analysis of the Assembly Process

As part of the initial analysis, it was possible to conclude that the problem was due to the absence of a pin, that is to say, in the process of ripping it. As in the previous case, as well as in the analysis of the riveting process, factors were identified which could influence the absence of a pin in the chrome head of the key, and in particular the following factors: the depth of the pin preload, the stroke of the roller at the workload and the position of the chrome head in the carriage bed during riveting.

1. *Depth of pin preload* determines the fixation of the pin in the chrome head prior to the riveting process itself. The preload depth is not a default parameter, and its measurement can only be done based on the trace that the pin in the head will leave when preloaded. Measurement was performed using an optical measuring device, a camera on a coordinate measuring device. A piece from the customer and a piece from the serial process were compared again. In this case, it was found that the pin on the piece under complaint was preloaded to 0.9 mm and a conformity component to 2 mm, so the difference in preload is 1.1 mm. The preloaded pin on a non-conformity component is not firmly fixed in the chrome head

and may be dropped when the carriage is moved. The depth of the pin preload is given by the step of the mechanical lever. The lever was designed in such a way that the preload depth of the pin was constant so that the operator could not influence the depth of the preload. This is a modifiable mechanical lever which allows the release of the piece with the preloaded pin until the lever is pushed to the lower position. However, when testing a conformity component, it was found that the lever was damaged and lost its function. The depth of pin preload is not constant, and this factor was determined as a factor with a direct impact on the occurrence of a defect.

2. *Compaction roller allowance at workload.* The examined roller was without any sign of the allowance when it was fully inserted and disengaged. This factor did not affect the occurrence of the defect.
3. *Position of the chrome head* in the carriage bed determines the position of the pin against the compaction *when riveting*. The examined beds of the carriage on the machine were free of wear and tear, and the chrome head was seated firmly and steadily in them.

The analysis of the assembly process selected the cause that was insufficient pin preload and thus in the process of moving the carriage or compaction itself, the pin dropped out of its position.

2.2.3 Analysis of Failure to Fix the Defect

The analysis of failure to fix the defect consists of verification of those process factors that are related to control in this process and are designed to detect any undesirable condition on the product and thus prevent it from being transported to the customer. Control points in the process are based on a control plan, which is also approved as a document for customers and is a direct connection with the process FMEA.

2.3 Application of 5WHY

In the case of this claim, we proceeded from the factors directly affecting the defect, namely: the insufficient depth of the pin preload and the inappropriate location of the presence of the pin in the process.

Insufficient depth of the pin:

1. Why?

   The step of the pin preload lever was not met.

2. Why?

   The device to prevent the lever from returning to the extreme position is not working properly.

3. Why?

   The device was damaged during its use – loose fastening screw (Fig. 2).

4. Why?

   No maintenance need was identified.

5. Why?

   There is no record of checking the mechanical lever before it is used.

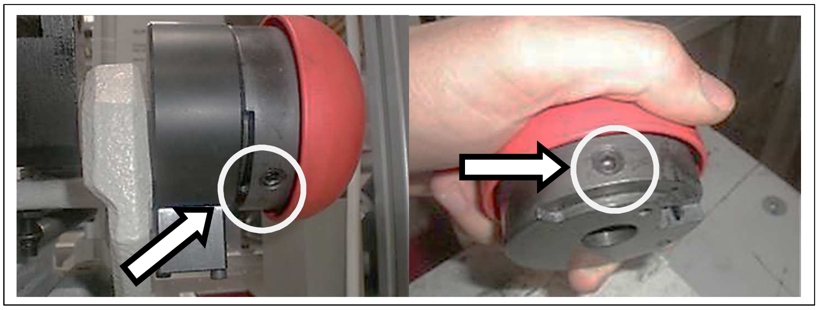

Figure 2 – Fixing Screw on Device

Inappropriate position of detection of the presence of the pin in a process:

1. Why?

   Check of the pin presence is performed by the machine at the beginning of the operation.

2. Why?

   The output from the process is a visual check of the presence of a pin.

3. Why?

   The process FMEA, used in the company did not take into account the risk of a visual check of the presence of a pin.

4. Why?

   Possibility of the pin falling out during operation was not taken into account.

5. Why?

   Insufficient information during the machine creation (the machine was developed and created independently of other line machines and similar projects).

The 5Whys analysis concludes that the absence of the pin in a chrome head of the key was caused by a long-term failure of device for blocking the lever return move prior to reaching the edge position at the pin preload. Since the failure of the device was detected only when the defect was reproduced, the root cause of its occurrence is the inability to detect a defect on the machine. The result of the analysis is also that the fact that the piece with the defect left the line and was sent to the customer significantly contributed to the absence of detection of the presence of the pin during the assembly process itself.

3 RESULTS AND CONCLUSION

The way how the organisation faces customer complaints significantly affects the organisation's loss of customer or changes the customer's initial dissatisfaction to renewed customer's confidence regarding the company, product, and so forth.. To have a complaint handling procedure that includes complaint evidence, assignment of competencies and responsibilities to competent persons, use of quality management methods and tools to identify root causes of nonconformity, including the proposal and implementation of effective measures is, therefore, an important condition for this success. Methods, used in this complaint are standard for issues solutions, especially for RCA. In this case, was an extended version of the 5W2H method used, which helped to identify the source of the cause (Fig. 3).

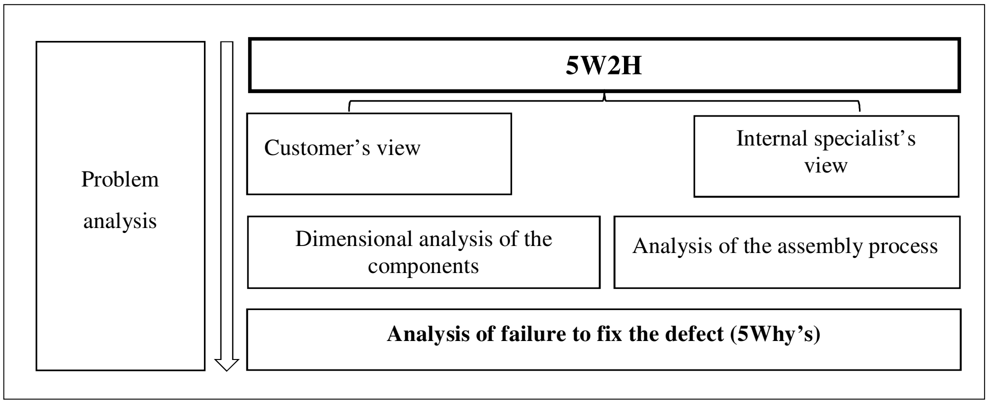

Figure 3 – Steps of 5W2H Analysis

According to analysis, it was clear that the source of the problem was the insufficient depth of the pin preload and the inappropriate location of the presence of the pin in the process. The analysis of failure to fix the defect showed that a piece without a pin could leave the process if a visual check of the presence of a pin failed and also because the proposed machine detection in the process does not provide a 100% finding of non-conformance since the pin can fall out after detecting its presence even before or during the pushing of the compaction roller. Since the failure of the device was detected only when the defect was reproduced, the root cause of its occurrence is the inability to detect a defect on the machine. The result of the analysis is also that the fact that the piece with the defect left the line and was sent to the customer significantly contributed to the absence of detection of the presence of the pin during the assembly process itself. Corrective and preventive measures are a response to identified root causes resulting from the conclusions of the cause analysis and the use of the 5Whys method. Measures must be designed to fully eliminate the possibility of repeating a defect.

In the case of a missing pin, the following measures were defined:

- Repair of a device for the pins preloading into the chrome heads.
- Adding the frequency control of the device functionality.
- Implementation of the detection of the presence of a pin during the pushing process directly on the pushing cylinder.
- Adding a frequency check of the pin presence detection functionality on the to the compaction roller.
- P FMEA updating – for the identified riveting process, pin presence detection was added directly to the compaction cylinder and therefore the risk of absence of the pin had to be reassessed. By adding detection, it was reduced from 98 to 48.

In this case study, the customer has taken the proposed measures. The effectiveness of these measures was monitored one month after their implementation, and none non-conformity component was discovered in the reference period with the described defect in the production process and was also not recorded by the customer, so we can state that the proposed measures are maximally effective and not only prevent a defect occurrence with the customer, but also a defect in the production process itself.

Generally, it must be clear that any non-conformities must be solved step by step with a systematic approach using chosen tools or also the combination of different methods to make sure that non-conformity is identified and also the appropriate measures are taken to avoid occurrence in the future.

ACKNOWLEDGEMENTS

This paper was developed within the project VEGA 1/0904/16 “The utilisation of processes capability and performance and products dimensional tolerances in the management of material consumption and related economic, energy and environmental consequences (MINIMAX-3E)”, supported by the Slovak Ministry of Education and Sport.

REFERENCES

Anderson, B. and Fagerhaug, T., 2000. *Root Cause Analysis: Simplified Tools and Techniques.* Milwaukee: ASQ Quality Press.

Arcaro, J.S., 1997. *TQM Facilitator's Guide*. Boca Raton,FL: St. Lucie Press.

Brassard, M. and Ritter, D., 1994. *The Memory Jogger II: A Pocket Guide of Tools for Continuous Improvement and Effective Planning*. Salem, NH: GOAL/QPC.

Brassard, M., 1996. *The Memory Jogger Plus+: Featuring The Seven Management and Planning Tools*. Salem, NH: Goal/QPC.Cox.

Brown, J.I., 1994. Root-Cause Analysis in Commercial Aircraft Final Assembly. *Master's Abstracts International,* 33(6), p.1901.

Cox, J.F.III and Spencer,M.S., 1997. *The constraints management handbook. Boca Raton*, Fla.: St. Lucie Press.

Dettmer, H.W., 1997. *Goldratt's Theory of Constraints*. Milwaukee: ASQC Press.

Dew, J.R., 1991. In Search of the Root Cause. *Quality Progress*, 24(3), pp.97-107.

DOE Guideline, 1992. *Root Cause Analysis Guidance Document.* US Department of Energy: Washington.

Duggett, M., 2004. A statistical Comparison of Three Root Cause Tools. *Journal of Industrial Technology*, 20(2), pp.1-9.

Doggett, M., 2006. *Root Cause Analysis: A Framework for Tool Selection. Quality Management Journal*, [e-journal] 12(4), pp.34-45. https://doi.org/10.1080/10686967.2005.11919269.

Fonseca. L., Lima, V. and Silva, M.M., 2015. *Utilization of quality tools: Does Sector and Size matter? International Journal for Quality Research*, 9(4), pp.605-620.

Gano, L.D., 2011. *Reality Charting: Seven Steps to Effective Problem-Solving and Strategies for Personal Success.* s.l.: Apollonian Publications.

Lepore, D. andCohen, O., 1999. *Deming and Goldratt: The Theory of Constraints and the System of Profound Knowledge: The Decalogue.* Great Barrington, MA: North River Press.

Moran, J.W., Talbot, R.P. and Benson, R.M., 1990. *A Guide to Graphical Problem-Solving Processes.* Milwaukee: ASQC Quality Press.

Robson, M., 1993. *Problem Solving In Groups*. 2nd ed. Brookfield, VT: Gower.

Scheinkopf, L.J., 1999. *Thinking For A Change: Putting The TOC Thinking Processes to Use.* Boca Raton, FL: St. Lucie Press.

Smith, D., 2000. *The Measurement Nightmare: How the Theory of Constraints Can Resolve Conflicting Strategies, Policies, and Measures.* Boca Raton, FL: St. Lucie Press.

Sproull, B., 2001. *Process Problem Solving: A Guide for Maintenance and Operations Teams*. Portland: Productivity Press.Taichi, O., 2006. *Ask 'why' five times about every matter*. [online]. Available at: <https://www.toyota-global.com/company/toyota_traditions/quality/mar_apr_2006.html> [Accessed 15 March 2018].

Wilson, P.F., Dell, L.D. and Anderson, G.F., 1993. *Root Cause Analysis: A Tool for Total Quality Management.* Milwaukee: ASQC Quality Press.

Zgodavová, K., Hudec, O. and Palfy, P., 2017. Culture of quality: insight into foreign organisations in Slovakia. *Total Quality Management and Business Excellence*, [e-journal] 28(8-9), pp.1054-1075. https://doi.org/10.1080/14783363.2017.1309120.

ABOUT AUTHORS

Anna Nagyová – The lecturer as well as the internal auditor for the quality management system (QMS) at Technical University of Košice. Her main topic is project management as well as different management systems. She was a team member of several national and international projects and author of more than 80 publications. E-mail: anna.nagyova@tuke.sk, Author's ORCID: https://orcid.org/0000-0003-3936-4517.

Hana Pačaiová – Deputy Head of the Department of Safety and Quality at Faculty of Mechanical Engineering, Technical University of Košice. Her professional orientation is focused on Risk Management, Quality and Safety management systems, Machinery safety, Asset and Maintenance management (RCM, TPM, RBI). She is a team leader and member of several national and international projects and author of more than 20 scientific books and 300 publications. E-mail: hana.pacaiova@tuke.sk, Author's ORCID: https://orcid.org/0000-0002-0308-1980.

Anna Gobanová – Quality manager in the company, which provides metrological service. Her professional orientation is focused on quality tools in the automotive industry. E-mail: nagyovaanna@hotmail.com, Author's ORCID: https://orcid.org/0000-0003-0040-7997.

Renáta Turisová – Associate professor at the Faculty of Mechanical Engineering, Department of Safety and Quality, Technical University of Kosice. She is engaged in integrated management with the focus on quality and safety as well as statistical and quantitative methods. E-mail: renata.turisova@tuke.sk, Author's ORCID: https://orcid.org/0000-0003-3333-0914.