Action Priority in new FMEA as factor for Resources Management in Risk Reduction

Filip Anackovski, Ivo Kuzmanov, Roberto Pasic

Abstract— Failure Mode and Effects Analysis - (FMEA) is an analytical methodology used to ensure that potential issues are addressed and resolved during product and process development. Automotive Industry Action Group (AIAG) and Verband der Automobilindustrie (VDA) jointly published a FMEA handbook to be used by automotive suppliers to assist them in development of FMEA. The handbook newly published in June 2019, provides a systematic framework for implementing technical risk on the production process, as well as assessment to prevent failure. The new 7-step approach to performing FMEA gives the form a better look, better organized and described, defined and with better structured separate items and functions, which will make it easier for users to work with FMEA. One of the important changes is replacement of Risk Priority Number (RPN) with the new Action Priority (AP). This paper explores the benefits of the implementation of AP with special focus on prioritization of resources in risk reduction on the most dangerous risks. The introduction of AP avoids the issues that organizations and teams have had, where for every RPN action, for example RPN>100, regardless of the combination of whether something is serious or not, had the same weight and demand for execution. With the new combination methodology, which prioritizes high-Severity risks, then frequency of Occurrence, and then Detection, it will be easier for teams to know which actions to focus their resources and time on.

Index Terms— AP, quality, Severity, RPN, Risk Assessment, Risk Management, Focus.

1 Introduction

FMEA is an analytical methodology used to ensure that potential issues are addressed and resolved during product and process development.

This methodology was first used in the United States Army in November 1949 as a methodology that determines the effect of equipment and system errors (errors were classified based on their impact on mission success as well as equipment and personnel safety). In 1963 it was first used in the aerospace industry at Apollo missions to minimize the errors of expensive prototypes. It first appeared in the automotive industry in 1970 and its first implementer was the company Ford [1].

Manufacturers consider different types of risks, including technical, financial, weather and strategic risks. FMEA is used for technical risk analysis to reduce defects and improve product and process safety.

The purpose of the FMEA is to identify product features or process steps and related methods, effects and causes of error. It is further used to assess whether prevention and detection controls are already planned and to recommend additional activities. The FMEA documents and monitors the actions taken to reduce the risk. The FMEA methodology helps engineers prioritize and focus on preventing product and/or process issues [2].

The FMEA team consists of multidisciplinary (cross-functional) members who cover the required subject knowledge. This should include expertise in facilitating and knowing the FMEA process. The success of the FMEA depends on the active participation of the cross-functional team, as needed, to focus on the topics of discussion.

A reference manual describing the Failure Mode and Effects Analysis (FMEA) published by the Automotive Action Group (AIAG) 4th Edition in 2008 has been updated with a new manual. The new manual was published jointly by AIAG, based in the United States and Verband der Automobilindustrie (VDA) based in Germany in June 2019. The handbook newly published in June 2019, provides a systematic framework for implementing technical risk on the production process, as well as assessment to prevent failure [3].

The new 7-step approach to performing FMEA gives the form a better look, better organized and described, defined and with better structured separate items and functions, which will make it easier for users to work with FMEA.

One of the important changes is replacement of Risk Priority Number (RPN) with the new Action Priority (AP). This paper explores the benefits of the implementation of AP with special focus on prioritization of resources in risk reduction on the most dangerous risks.

2 New 7 Step Approach PFMEA Execution

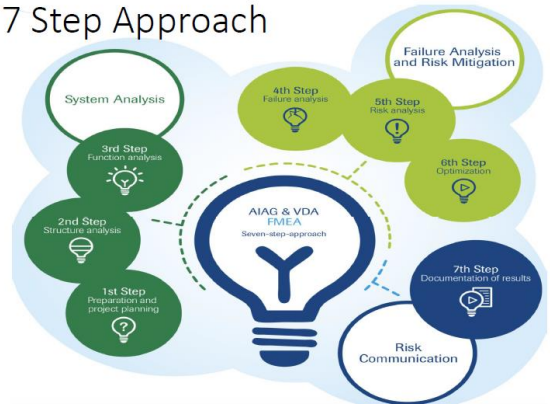

Fig. 1. New 7 Step Approach FMEA Execution.

2.1 Process FMEA 1st Step: Planning and Preparation

The purpose of the Process Planning and Preparation Step is to describe what product/processes are to be included or

excluded for review in the PFMEA project. The process takes into account that all processes within the facility can be analyzed or reanalyzed using PFMEA. This process allows an organization to review all processes at a high level and to make a final determination for which processes will be analyzed. The overall advantage of Preparation is to focus resources on processes with the highest priority [4].

2.2 Process FMEA 2nd Step: Structure Analysis

The purpose of Process Structure Analysis is to identify and breakdown the manufacturing system into Process items, Process steps, and Process Work Elements. Process Flow Diagram is a tool that can be used as input to Structure Analysis.

2.3 Process FMEA 3rd Step: Function Analysis

The purpose of the Process Function Analysis is to ensure that the intended functions/requirements of the product/process are appropriately allocated. A function describes what the process item or process step is intended to do. There may be more than one function for each process item or process step. Prior to beginning the Function Analysis, information to be gathered could include but is not limited to; product and process functions, product/process requirements, manufacturing environment conditions, cycle time, occupational or operator safety requirements, environmental impact, etc.

2.4 Process FMEA 4th Step: Failure Analysis

The purpose of the Process Failure Analysis is to identify failure causes, modes, and effects, and show their relationships to enable risk assessment. Failure Effects are described in terms of what the customer might notice or experience. Failures that could impact safety or cause noncompliance to regulations should be clearly identified in the PFMEA. A (Process) Failure Mode is defined as the manner in which the process could cause the product not to deliver or provide the intended function. A failure cause is an indication of why a failure mode could occur.

2.5 Process FMEA 5th Step: Risk Analysis

The purpose of Process Risk Analysis is to estimate risk by evaluating Severity, Occurrence and Detection, in order to prioritize the need for actions. Each Failure Mode, Cause and Effect relationship (failure chain or net) is assessed for its independent risk. There are three rating criteria for the evaluation of risk:

Severity (S): stands for the Severity of the Failure Effect

Occurrence (O): stands for the Occurrence of the Failure Cause

• *Filip Anackovski, Ivo Kuzmanov and Roberto Pasic are with the St. Kliment Ohridski University, Faculty of Technical Sciences – Bitola, Makedonska Falanga 33, Bitola 7000, Republic of Macedonia, E-mail: filip.anackovski@gmail.com*

Detection (D): stands for the Detection of the occurred Failure Cause and/or Failure Mode

Evaluation numbers from 1 to 10 are used for S, O, and D respectively, in which 10 stands for the highest risk contribution. The tables with criteria for S, O, D evaluation can be found in 1st edition FMEA handbook AIAG&VDA.

2.5.1 Severity (S)

Severity is a rating number associated with the most serious effect for a given failure mode for the process step being evaluated. It is a relative rating within the scope of the individual FMEA and is determined without regard for Occurrence or Detection.

2.5.2 Occurrence (O)

The Occurrence rating (O) describes the occurrence of Failure Cause in the process, taking into account the associated current prevention controls. The occurrence rating number is a relative rating within the scope of the FMEA and may not reflect the actual occurrence. The Occurrence rating describes the potential of the failure cause to occur, according to the rating table, without regard to the detection controls.

2.5.3 Detection (D)

Detection is the rating associated with a prediction of the most effective process control from the listed detection-type process controls. Detection is a relative rating, within the scope of the individual FMEA and is determined without regard for Severity or Occurrence.

2.5.4 Detection (D)

The Action Priority (AP) method is introduced for first time in the new FMEA handbook 2019. It is replacement for previously used Risk Priority Number (RPN). Detail explanation for AP is described in Section 3.

2.6 Process FMEA 6th Step: Optimization

The purpose of the Process Optimization Step is to determine actions to mitigate risk and assess the effectiveness of those actions. The end result is a process which minimizes the risk of producing and delivering products that do not meet the customer and stakeholder expectations.

2.7 Process FMEA 7th Step: Result Documentation

The purpose of the results documentation step is to summarize and communicate the results of the Failure Mode and Effects Analysis activity.

3 Action Priority (AP) as Factor for Resources Management in Risk Reduction

Once the team has completed the initial identification of failure modes and effects, causes and controls, including ratings for severity, occurrence, and detection, they must decide if further efforts are needed to reduce the risk. Due to the inherent limitations on resources, time, technology, and other factors, they must choose how to best prioritize these efforts.

The **Action Priority (AP)** method is introduced for first time in the new FMEA handbook 2019. It accounts for all 1000 possible combinations of S, O, and D. It was created to give more emphasis on **Severity first**, then Occurrence, then Detec-

tion. This logic follows the failure-prevention intent of FMEA. The AP table offers a suggested high-medium-low priority for action. Companies can use a single system to evaluate action priorities instead of multiple systems required from multiple customers.

Risk Priority Numbers are the product of S x O x D and range from 1 to 1000. The RPN distribution can provide some information about the range of ratings, but RPN alone is not an adequate method to determine the need for more actions since RPN gives equal weight to S, O, and D. For this reason, RPN could result in similar risk numbers for very different combinations of S, O, and D leaving the team uncertain about how to prioritize. When using RPN it is recommended to use an additional method to prioritize like RPN results such as S x O. The use of a Risk Priority Number (RPN) threshold is not a recommended practice for determining the need for actions [5].

AP is not a prioritization of risk, it's a prioritization of the need for actions to reduce the risk.

Priority High (H): The team **needs** to either identify an appropriate action to improve prevention and/or detection controls or justify and document why current controls are adequate.

Priority Medium (M): The team **should** identify appropriate actions to improve prevention and/or detection controls, or, at the discretion of the company, justify and document why controls are adequate.

Priority Low (L): The team **could** identify actions to improve prevention or detection controls.

It is recommended that potential **Severity 9-10** failure effects with **Action Priority High** and **Medium**, at a minimum, be reviewed by **management including** any recommended actions that were taken.

This is not the prioritization of High, Medium, or Low risk, **it is the prioritization of the need for actions to reduce risk**.

Each recommended measure defined must have a person in charge as well as a target date for the completion. These data must be entered in the relevant FMEA columns. The effectiveness of each measure must be verified following its introduction and completed in the FMEA by setting the status to 100%.

The efficiency of the action must be proven, and the result must be documented in the FMEA (e.g., link to test report #, process capability, assembly of prototypes at customer, etc.).

TABLE 1
ACTION PRIORITY FOR DFMEA AND PFMEA (AIAG/VDA 1ST EDITION)

Effect	S	Prediction of Failure Cause Occurring	O	Ability to detect	D	Action Priority (AP)
Product or Plant Effect Very High	9-10	Very High	8-10	Low - Very Low	7-10	H
				Moderate	5-6	H
				High	2-4	H
				Very High	1	H
		High	6-7	Low - Very Low	7-10	H
				Moderate	5-6	H
				High	2-4	H
				Very High	1	H
		Moderate	4-5	Low - Very Low	7-10	H
				Moderate	5-6	H
				High	2-4	H
				Very High	1	M
		Low	2-3	Low - Very Low	7-10	H
				Moderate	5-6	M
				High	2-4	L
				Very High	1	L
		Very Low	1	Very High - Very Low	1-10	L
Product or Plant Effect High	7-8	Very High	8-10	Low - Very Low	7-10	H
				Moderate	5-6	H
				High	2-4	H
				Very High	1	H
		High	6-7	Low - Very Low	7-10	H
				Moderate	5-6	H
				High	2-4	H

				Very High	1	M
		Moderate	4-5	Low - Very Low	7-10	H
				Moderate	5-6	M
				High	2-4	M
				Very High	1	M
		Low	2-3	Low - Very Low	7-10	M
				Moderate	5-6	M
				High	2-4	L
				Very High	1	L
		Very Low	1	Very High - Very Low	1-10	L
Product or Plant Effect Moderate	4-6	Very High	8-10	Low - Very Low	7-10	H
				Moderate	5-6	H
				High	2-4	M
				Very High	1	M
		High	6-7	Low - Very Low	7-10	M
				Moderate	5-6	M
				High	2-4	M
				Very High	1	L
		Moderate	4-5	Low - Very Low	7-10	M
				Moderate	5-6	L
				High	2-4	L
				Very High	1	L

		Low	2-3	Low - Very Low	7-10	L
				Moderate	5-6	L
				High	2-4	L
				Very High	1	L
		Very Low	1	Very High - Very Low	1-10	L
Product or Plant Effect Low	2-3	Very High	8-10	Low - Very Low	7-10	L
				Moderate	5-6	L
				High	2-4	L
				Very High	1	L
		High	6-7	Low - Very Low	7-10	L
				Moderate	5-6	L
				High	2-4	L
				Very High	1	L
		Moderate	4-5	Low - Very Low	7-10	L
				Moderate	5-6	L
				High	2-4	L
				Very High	1	L
		Low	2-3	Low - Very Low	7-10	L
				Moderate	5-6	L
				High	2-4	L
				Very High	1	L
		Very Low	1	Very High - Very Low	1-10	L

No dis-cernible Effect	1	Very Low - Very High	1-10	Very High - Very Low	1-10	L

In the *Table 1.* are shown results of combination on Severity, Occurrence and Detection for Action Priority – high, medium and low. According new FMEA handbook (AIAG/VDA 1st Edition), it's given more emphasis on Severity first, then Occurrence, then Detection and that combination dictate Action Priority. The RPN alone was not an adequate method to determine the need for more actions since RPN gives equal weight to S, O, and D. For this reason, RPN could result in similar risk numbers for very different combinations of S, O, and D leaving the team uncertain about how to prioritize.

4 Conclusion

FMEA is an important preventive method for quality assurance, and this methodology ensures that decisions are made based on the severity, likelihood of occurrence and detection of failure modes. With the risk analysis made with FMEA have opportunity to focus resources and time on the actions with the highest priority, which are the most important, most serious and need to be addressed first.

The new AIAG/VDA FMEA Manual 2019 provides the systematic framework for implementing technical risk on the production process, as well as assessment to prevent failure. The new 7-step approach to performing FMEA gives the form a better look, better organized and described, defined and with better structured separate items and functions, which will make it easier for users to work with FMEA.

Commonly adopted Severity, Occurrence and Detection assessment tables will avoid organizations' problems in dealing with different markets, requirements and standards. This creates global standardization that makes it easier to develop a product.

The introduction of AP (Priority Action) avoids the issues that organizations and teams have had, where for every RPN (Priority Risk Number) action, for example RPN> 100, regardless of the combination of whether something is serious or not, had the same weight and demand for execution. With the new combination methodology, which prioritizes high-Severity risks, then frequency of Occurrence, and then Detection, it will be easier for teams to know which actions to focus their resources and time on.

The new Severity scoreboard is simplified by having a score of 10 for all risks where human life is endangered, and if the risk is contrary to legislation – 9, the team is avoided deciding whether there has been a signal/warning or not.

In the next period it should be seen how the functioning and interaction with other quality tools will be, as well as the possibility to connect integrated software, where from PFD (Process Flow Diagram), DFMEA, PFMEA, as well as Control and Inspection Plans, which would reduce the possibility of errors between these tools/documents.

References

[1] McDermott, R. E. (2009). *THE BASICS OF FMEA* (Volume 2).
[2] AIAG/VDA. (2019). *Failure Mode and Effects Analysis - FMEA Handbook* (Volume 1). Southfield, Michigan.
[3] Ramly, E. (2020). *FMEA AIAG-VDA - Commentary and Case Study*. https://www.researchgate.net/publication/339498831
[4] Halleck, L. (2019). *Quality Support Group*. https://qualitysupportgroup.com/
[5] AIAG - Chrysler LLC, F. M. (2008). *AIAG Advanced Product Quality Planning and Control Plan* (Volume 4). Southfield,, MI